GfÖ 2019

SCIENCE MEETS PRACTICE

49th Annual Meeting of the Ecological Society of Germany, Austria and Switzerland

University of Münster

9 - 13 September 2019

Book of Abstracts

The 49th Annual Meeting of the Ecological Society of Germany, Austria and Switzerland (GfÖ) is held from 9 to 13 September 2019 at the University of Münster. Host of the conference is the Institute of Landscape Ecology, Faculty of Geosciences.

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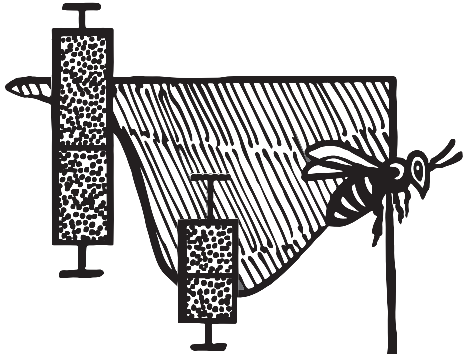

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PREFACE

Dear colleagues and friends, dear guests,

we are happy to welcome you to the 49th Annual Meeting of the Ecological Society of Germany, Austria & Switzerland (GfÖ) at the University of Münster. This is the first time that Münster hosts the annual meeting of the GfÖ. Our university was founded in 1902 by the Prussian King Wilhelm II as a Protestant academic institution in a Catholic environment. Presently, we host more than 44.000 students. Most scientific disciplines, with the exception of the engineering sciences, are represented at the University of Münster. They are organized into 15 faculties. The Institute of Landscape Ecology, the organizer of this year's conference, belongs to the Faculty of Geosciences, which looks a bit unusual at first glance.

The Institute originates from the split of a large Geography Department in 1994 and is celebrating its 25th anniversary this year. The Institute of Landscape Ecology was founded following initiatives of Friedrich-Karl Holtmeier and Karl-Friedrich Schreiber with the intention to give biotic and ecological aspects a greater emphasis. Karl-Friedrich Schreiber has also been a founding member of the GfÖ in 1970. Both seniors, who are now 80 and 93 years old, respectively, will be present at the conference. During the past 25 years, the Institute of Landscape Ecology has gradually shifted towards more quantitative and analytical approaches and an international orientation in research and publications. Today, the Institute comprise seven research groups dealing with different aspects of ecosystems and ecological communities such as climatology, eco-hydrology and biogeochemistry, soil ecology, animal and vegetation ecology and ecological planning. Quantitative approaches have been further fostered by the establishment of a new analytical lab in 2013 with high-end equipment and the recent appointment of a new professor for Remote Sensing and Spatial Modelling that will start this autumn. The timeliness of the Institute´s concept is not only reflected by an increasing publication record and international recognition but also by overbooked Bachelor´s- and Master´s study programs in Landscape Ecology.

The Institute for Landscape Ecology at the University of Münster traditionally collaborates closely with a range of conservation organizations, agriculture, forestry and practitioners and involves them in academic research projects. The 49th Annual Meeting is therefore held under the motto **"Science meets practice"** and aims to stimulate exchange between the academic ecological community and practitioners in order to find applied solutions to environmental problems. To overcome language barriers, several sessions specifically addressing questions relevant for practitioners will be held in German language. These sessions are bundled on a so-called "practitioners day" with reduced fees in the middle of the conference. We hope that this new concept will allow us to attract more people from the applied side of ecology. Additionally, we will hold discussion forums and public plenary sessions on pressing topics such as urban air pollution and insect biodiversity declines.

We would like to thank the many people who have contributed to the successful organization of the conference here in Münster. First of all, we have to mention Julia Tiede who has taken over the main burden of organizing the meeting, together with Heike Kuhlmann. Special thanks goes to Dora Schilling for designing the conference logo, Theresa Klein-Raufhake for laying out the program, and to Beate Keplin, Anastasia Austermann and Claudia Meyer for support in administrative issues.

Furthermore, we would like to express our appreciation both to the keynote speakers for providing us with a comprehensive framework about topical developments in ecological sciences and to the chairs of the 40 sessions for suggesting exiting topics and guiding the sessions.

Finally, we would like to mention that Münster exhibits a scenic medieval city center with numerous spectacular historical buildings such as the famous town hall that have been reconstructed after almost complete destruction during the second world war. The city offers many possibilities for sightseeing, cultural and recreational activities.

Overall, we hope that the meeting in Münster will offer a stimulating atmosphere not only for discussions during the conference, but also for personal exchange with colleagues. Welcome to Münster!

Norbert Hölzel & Christoph Scherber
Institute of Landscape Ecology
Faculty of Geosciences
University of Münster

Dear friends and colleagues,

I cordially welcome you to the 49th Annual Meeting of the Ecological Society of Germany, Austria & Switzerland at the University of Münster – one of the largest universities in Germany and a leading center of German intellectual life. The GfÖ would like to thank all the local people for the willingness to accept the enormous burden of organizing such a large and diverse conference.

Our friends in Münster have done a marvelous job and put together an exciting and highly topical program. Compared to last year's meeting in Vienna under the ambitious heading "Ecology - meeting the scientific challenges of a complex world" our motto in 2019 is much more down-to-earth "Science meets practice". Without ignoring the need to discuss the complex issues of our discipline, we would like to signal that the environmental problems of our time inevitably force an intensive exchange between scientific and applied ecology. Considering that the University of Münster has a long tradition in the research of biogeochemical fluxes, vegetation ecology, community ecology and ecological planning, there could not be a better place to meet this challenge.

The program includes very interesting keynote lectures, a huge number of high-profile sessions and a variety of poster presentations. Topics range from the synthesis of large-scale biodiversity patterns to tree-associated microbes. In particular, an astonishing variety of applied themes is addressed: urban air pollution, conservation practice, microplastic, enticing farmers for ecological intensification or citizen science in ecology (just to name a few). I am already having trouble putting together my own personal selection!

However, I hope that despite the attractive conference program you will find some time to enjoy the beauty of Münster. A well-known landmark of the city is the 13th-century St. Paul's Cathedral with Gothic and Romanesque elements. The Prinzipalmarkt is surrounded by gabled houses, the gothic town hall and the Lambertikirche from the late Middle Ages. In the park of the baroque Fürstbischöflichen Schloss there are greenhouses of the botanical garden. The Pablo Picasso Art Museum houses a collection of lithographs by the painter. Finally yet importantly, Münster is the site of the signing of the "Treaty of Westphalia" ending the Thirty Years' War in 1648. I do not want to overdo it, but I hope that an ecological conference in this historically important place can do a bit to end the increasingly catastrophic war of humans against nature.

Volkmar Wolters
President of the GfÖ

The impact of nitrogen deposition on ecosystems

Carly Stevens[1]

[1]Lancaster University, Lancaster, UK, c.stevens@lancaster.ac.uk

Atmospheric deposition of nitrogen represents a serious threat to ecosystems globally, impacting on both directly and indirectly on plant species richness and composition, invertebrate communities, soil microbial communities and soil chemistry. Although nitrogen deposition levels in parts of Europe have declined in recent years in many regions they have only stabilised or continue to increase. Critical loads for nitrogen deposition (the levels below which no harm can be detected) continue to be exceeded in many habitats. As a consequence nitrogen deposition continues to be a major threat to ecosystems in Europe and I will show evidence from a range of ecosystems that demonstrates these impacts at an ecosystem and individual species level.
Much research to date has focussed on impacts of nitrogen deposition on plants and soils but evidence is also building that impacts can be seem at higher trophic levels. There are a number of mechanisms for how both herbivorous and non-herbivorous invertebrates are being impacted and impacts on pollinator species are becoming increasingly apparent. In light of global trends in pollinators and their importance for food security this is a particularly pressing concern.
In recent years policy makers have become particularly concerned with what might happen to ecosystems as N deposition levels begin to decline and the extent to which there is potential for ecosystems to recover from the impacts of N deposition. I will demonstrate that although there is some potential for recovery this is likely to be very slow and some habitats have potentially reached alternative stable states offering little prospect of recovery to previous conditions.
Management of nitrogen deposition and it's impacts on the environment is a very complex problem presenting us with many challenges. Finally I will explore some of these issues and consider what we should be focussing on in order to raise awareness of this environmental problem.

Effective biodiversity restoration requires a landscape-level multi-stakeholder approach

David Kleijn[1]

[1]Wageningen University and Research, Wageningen, NL, David.Kleijn@wur.nl

The last few decades, efforts to conserve biodiversity have increased rapidly and significantly but have nevertheless failed to halt the biodiversity decline. Action to halt further decline is urgently needed because wild species of animals and plants have intrinsic value, are a source of inspiration and provide key ecosystem services such as pollination, pest control and nutrient cycling. The ongoing decline is largely attributed to the fact that conservation is currently implemented in complete separation from other activities in the landscape that adversely affect biodiversity (e.g. agriculture, urbanization, transport) and may counteract positive effects of conservation. In agricultural landscapes, populations of many wild plants and animals depend on combinations of farm and non-farm habitats. Reversing the ongoing biodiversity decline therefore requires integrated nature-inclusive management of farmland, public space and protected areas. Adoption of such integrated nature-inclusive landscape management depends on support from local communities. This in turn depends at least partially on the socio-economic impacts it will have. Finding ways to make biodiversity conservation more effective therefore needs a participatory research approach that examines under real world conditions and together with stakeholders, the key environmental, economic and social processes determining the success of nature-inclusive landscape management.

Wild plant evolution under natural and unnatural selection

Julie Etterson[1]

[1]University of Minnesota, Duluth, US, jetterso@d.umn.edu

Although it is widely hypothesized that anthropogenic stressors are driving plant evolution, it is difficult to observe. The resurrection approach, where ancestral populations are revived (e.g. using old seed) and grown side-by-side with descendant populations, is a powerful way of directly observing temporal change. In this seminar I will presnt a case study that illustrates the value of this approach in the context of inadvertent evolution of plant material for ecological restoration. The high demand for native plant material for restoration that has led to an increasing dependence upon commercially grown sources. Although this shift away from wild-collected seed may protect natural population demographics, it may have unforeseen consequences at the restoration site. During farm propagation, populations are subject to sampling effects as well as unconscious artificial selection. Both processes can constrict genetic diversity and change the type of genetic variation present in the populations resulting in phenotypes that may contrast sharply with those found in wild populations. We compared plants grown from seed collected from the original wild populations to plants grown from seed harvested after eight generations of commercial propagation. Overall, the relative fitness of the wild plants was more than twice as high than farmed plants which strongly suggests that unconscious selection on native seed farms can undermine restoration success. Although such antecedent-successor comparisons are extremely informative, the ancestral seed necessary to do the experiments is rarely available. To solve this problem, a team of plant ecological and evolutionary geneticists established a research seed bank, Project Baseline, which will provide old seed for resurrection ecology research for the next 50 years. This collection includes 10-20 populations across the US continental ranges of 65 plant species with diverse life history attributes. With this valuable resource secured, biologists will be able to grow genetically representative samples of past populations contemporaneously with modern samples. This living genome bank will vastly expand the opportunities to use this research approach to learn about plant evolution across time and space.

The forest herb layer: more than a step-over

Kris Verheyen[1]

[1]Ghent University - Forest & Nature Lab, Gontrode-Melle, BE,
kris.verheyen@ugent.be

The forest herb layer is an underappreciated stratum in forests. It is less well studied than the tree layer and is also rarely considered when taking management decisions. This is surprising since a high share of the total forest plant diversity is contained in this stratum. Besides, the herb layer has a non-negligible impact on forest functioning, e.g. by acting as a filter for tree regeneration and through its role in biogeochemical cycles. The stratum's diversity, composition and functioning is, however, strongly affected by global change drivers, such as climate warming and increased atmospheric deposition of nitrogen, interacting with the effects of changing forest management regimes. In this talk I will take you to the temperate forest and show how the composition and functions of the herb layer have changed during the last decades, explain what is driving these dynamics, and demonstrate how this information can be used for a future-oriented management of our forest heritage.

Group Living and Infectious Diseases

Andrew P. Dobson[1,2]

[1]EEB Princeton University, Santa Fe Institute, Santa Fe, New Mexico, US, dobber@Princeton.EDU
[2]IMeRA, Marseilles, FR, dobber@Princeton.EDU

Many species live in social groups. This has subtle and important consequences both for their population dynamics and for the dynamics of their pathogens. In this talk I'll present some new mathematical models for the dynamics of group living species, they are based on results obtained from the reintroduction of wolves into Yellowstone National Park. The simplest version of the models can be solved analytically, they suggest group-living species exhibit different dynamics from those assumed by simple models of logistic growth, this principally occurs because regulation occurs at two different hierarchical levels: within groups and between social groups. I'll then extend the model framework to consider the dynamics of two different types of pathogen: a simple pathogen such as mange, where hosts can be divided into susceptible and infected individuals, and a more complex pathogen such as canine distemper, where the host population has to be divided into Susceptible, Infected and Recovered individuals. The group structure of the host population again changes the dynamics of these pathogens from those we see when we assume homogenous and well mixed populations. Throughout I will compare the assumptions underlying the model structure with data from studies of wolves in Yellowstone and wild dogs in Serengeti National Park, Tanzania. In the last part of the talk I will expand the framework and consider how the modelling framework can be modified to examine the social systems of different primate species and their pathogens.

Searching for the win-win of sustainable food production: habitat conservation and landscape scale pest management

Nancy A. Schellhorn[1]

[1]RapidAIM Pty Ltd, CSIRO, Brisbane, AU, nancy@rapidaim.io

Insecticide use continues to rise with little change in the loss and damage that is caused by insect pests. Managing tiny, highly mobile, fast reproducing organisms that fail to recognize field, farm and Government borders is a massive challenge. Research into insect pest management beyond the spatial scale of a field has a long history with many practical example, successful and unsuccessful, of pest control applied at an area wide basis. More recently, researchers have drawn on principles from landscape ecology to consider crop fields in the context of habitats surrounding the farm. The motivation stemming from the desire to conserve biodiversity and natural biological pest control. Natural and semi-natural habitat diversity, landscape composition and landscape structure have figured prominently as means to support the organisms that provide pest control. However, despite decades of study, on-farm adoption of conservation biocontrol is far from widespread, and incentives for large-scale landscape coordination to support conservation biocontrol efforts are virtually non-existent. Challenges abound. Area-wide management of pests needs support from many stakeholders, and from the community; target landscapes are often spatially and temporally heterogenous; and knowing where and when pests show up is still a guessing game. In this key note address, Dr Schellhorn will use examples from the literature, and case studies to examine the tools, technologies and transdisciplinary science that is needed to meet the challenges and achieve area-wide suppression of pests while supporting conservation.

Nicht nur die Biene -
Ursachen und Folgen des Insektensterbens

Nico Blüthgen

Head of the Ecological Networks Lab, Department of Biology, Technische Universität Darmstadt, Germany

Das „Insektensterben“ ist nun seit fast zwei Jahren sehr prominent in vielen Medien und wird seitdem gesellschaftlich und politisch kontrovers diskutiert. Während die Zahl der Honigbienenvölker sogar zunimmt, sind viele wildlebenden Insektenarten stark rückläufig oder lokal verschwunden. Die globale Krise der Artenvielfalt ist bereits seit längerem bekannt, das Ausmaß des Verlusts an der Zahl der Insekten in unserer Landschaft ist aber erst durch eine Studie von Krefelder Entomologen deutlich geworden und wird seitdem durch andere Untersuchungen bestätigt. Welche Ursachen sind heute bekannt für einen derart rapiden Rückgang? Vor allem die intensive Landwirtschaft steht im Mittelpunkt der Debatte, und es kommen weitere Faktoren hinzu. Welche Folgen hat der Rückgang für die Funktion von Ökosystemen? Welche Verantwortung ergibt sich aus der ökologischen Krise für unser eigenes Handeln? Und was hat diese Krise mit unserer Ernährung, vor allem dem Konsum von Fleisch zu tun?

SESSION 1

Biodiversity change in Central Europe: how to make use of citizen science, historical surveys and big data?

Chairs: Diana Bowler, Aletta Bonn, Helge Bruelheide, Florian Jansen

Biodiversity monitoring data have revealed large changes in species' abundances and distributions within many parts of Europe during the past century. However, national-scale standardized data are only available for select taxa (such as birds and butterflies). Monitoring programs for other taxa tend to be more patchy, in both space and time. To make a comprehensive assessment of how biological communities have changed over time, ecologists are increasingly drawing on a broader range of data sources than only classical long-term standardized monitoring. For instance, opportunistic citizen science data cover a much larger range of taxa than structured data; moreover, they reach further back in time and cover a large geographic extent. Resurveys at locations of historical surveys have also been applied to test hypotheses about biodiversity change. Further data sources appropriate to study past change may include eDNA and historical literature.
In this session, we will share research findings based on different data sources to advance our understanding of how biodiversity has changed within central Europe. We are especially interested in studies that focus on the statistical challenges of the data analysis. Biodiversity change may include species' abundance, distribution, phenology as well as community composition or biomass, of any taxa. We hope to illustrate the massive potential of synthesis of the existing available data to document and understand the impacts of anthropogenic environmental change on biodiversity.

Session 1-O1 - Data for biodiversity change assessment

Systematic loss of Archaeophytes – An analysis of the composition of the German flora across six decades

David Eichenberg[1,2], Helge Bruelheide[2,4], David Harter[3], Rudolf May[3], Florian Jansen[5], Aletta Bonn[7]

[1]University of Leipzig, Leipzig, DE, david.eichenberg@idiv.de
[2]iDiv, Leipzig, DE, david.eichenberg@idiv.de
[3]Bundesamt für Naturschutz Deuschland (BfN), Bonn, DE
[4]Martin Luther Univerität Halle-Wittenberg, Halle (Saale), DE
[5]Universität Rostock, Rostock, DE
[6]Helmholtz Zentrum für Umweltforschung (UfZ), Leipzig, DE
[7]Friedrich-Schiller Universität Jena, Jena, DE

We complied an extensive dataset on plant occurrence records between 1960 and 2017 from diverse sources (Atlas data, Habitat mapping, Grid mapping, Vegetation relevées and private records). An established taxonomic reference was used list to standardize the taxonomy. Local frequency scaling (Hill, 2009) was used to correct for reporting bias. The final dataset comprises 45 Mio entries of occurrence probabilities of approx. 2500 species between 1960 and 2017 on the grid cell level.
On the basis of species, occurrence probabilities were summed across all grid cells for each species within the three timeslices of approx. 20 years, each. Temporal changes in the occurrence probabilities of species were estimated using a Bayesian model with temporal dependency. Likewise, changes in the mean occurrence patterns of species accumulated according to their floristic status were estimated. Spatio-temporal changes in the mean occurrence patterns of species categorized into their floristic status were carried out using a model allowing for spatiotemporal dependencies among grid cells.
Across all species, >73% showed a decline in their occurrence patterns across the last 6 decades. We find a systematic decrease in Archaeophytic species, whereas Neophytic species ended to increase in their occurrence patterns, especially in the last 20 years. Spatial maps of changes help to identify regions with the highest amounts of change according to the composition of the floristic status within communities on the grid cell level.

Session 1-O2 - Data for biodiversity change assessment

Cross-taxon biodiversity trends in central Europe

Eva Katharina Engelhardt[1], Matthias Biber[1], Christian Hof[1]

[1]Biodiversity & Global Change Lab, Terrestrial Ecology Research Group, Technical University of Munich, Freising, DE, e.k.engelhardt@tum.de

Changes in climate and land-use are considered to have considerable impacts on different levels of biodiversity, associated with rapid declines in many populations, range shifts, and changes in species communities. Most studies investigating such biodiversity trends are limited by a lack of reliable fine-scale, long-term field data, especially in highly heterogeneous regions. In central Europe, heterogeneous areas are affected by different human pressures acting at different scales and changing over short spatial distances, which increases the need for fine-scaled assessments of biodiversity trends. The state of Bavaria in southern Germany includes a diverse mixture of landscapes and habitats, ranging from lowland forests and floodplains to alpine environments. Therefore, Bavaria may serve as a model region for recent pressures on central European biodiversity.
Here, we present long-term trends in four ecologically and physiologically different animal taxa (birds, butterflies, dragonflies, grasshoppers), based on survey data over the course of more than 30 years. Specifically, we provide an assessment of the biases in the data used for our analyses, and explore, after accounting for these biases, population declines and range shifts of selected taxa as well as changes in species communities in Bavaria.
Our results emphasize the need for more systematic, reliable assessments of the effects of human pressures on different levels of biodiversity, especially in areas as greatly affected by human actions as central Europe. Understanding past influences of climate and land-use change on species is the first step towards the mitigation of increasing human pressures on biodiversity in the future.

Session 1-O3 - Data for biodiversity change assessment

Insect declines in Europe? Contrasting long-term trends among commonly assessed taxonomic groups

Roel van Klink[1], Diana Bowler[1], Jonathan Chase[1]

[1]German Centre for Integrative Biodiversity Research, Leipzig, DE

Recently, evidence has mounted that declines in total insect abundance are widespread in Central and Western Europe, but it remains unclear if all taxonomic groups show the same trends. We compiled all findable openly available long-term (10+ years) standardized monitoring data and resampling studies of various taxa, resulting in a database of 37 datasets with 268 individual sites, collected between 1959 and 2017.
Overall, our data showed that in Central and Western Europe, in both the terrestrial and freshwater systems, declines in insect abundances are widespread, but not ubiquitous. This contrasts the positive global trend for freshwater insect abundances, which we reported previously.
The different taxa of aquatic insects showed contrasting responses: Stoneflies and Caddisflies declined, but chironomid midges and aquatic beetles increased in numbers, and mayflies and dragonflies showed non-significant increases. This generally suggests increasing nutrient availability in freshwater systems, to the detriment of taxa that depend on nutrient poor conditions.
Also in the terrestrial realm there was a great deal of variation. Groups that mostly inhabit herbaceous vegetation such as butterflies and plant-and leafhoppers showed mostly negative trends, but moths showed increases. Ground beetles, spiders and terrestrial Diptera showed declines, but weevils, lady beetles and rove beetle numbers increased over time.
Overall, there thus were strong contrasts in both direction and magnitude of abundance changes in insect assemblages. This challenges the common perception of an overall insect Armageddon, and provides hypotheses regarding the drivers of changes in insect abundance.

Session 1-O4 - Data for biodiversity change assessment

Trends in ground beetle (Carabidae) abundance and species richness over 33 years in Southwest Germany

Carl Skarbek[1], Angelika Kobel-Lamparski[2], Carsten F. Dormann[1]

[1]University of Freiburg, Biometry and Environmental Systems Analysis, Freiburg im Breisgau, DE, carl.skarbek@gmail.com
[2]University of Freiburg, Institute for Biology I, Freiburg im Breisgau, DE

Insects play an oversized role in our ecosystems, and recently, a number of studies have pointed to a large scale insect decline across taxa. However, high resolution data from long term surveys are rare in ecological studies, and yet are required in order to make accurate predictions about populations. Here we look at the trends in abundance and species richness of ground beetles (Carabidae) sampled continuously at monthly intervals over a 33-year period (1979-2011). The data collected include true abundance counts at species level. The study site, an unmanaged grassland amidst intensively managed vineyards in South-West Germany, underwent reterracing for viticulture just before data collection began, which led the early community composition to be defined by the successional vegetation. We used a generalized additive modeling approach (GAM) to factor in the main drivers of the population trends in ground beetles, noticeably vegetation cover and climate. Both vegetation cover and climatic conditions only had a minimal effect on carabid abundance and richness over the study period. However, there was a notable decrease in both abundance and species richness of 55% (SE ~19%) and 27% (SE ~12%), respectively, since the end of the initial colonisation period (around 1990). Our results also indicate a stable core community with a relatively high turnover of less common species - yearly absolute species turnover averaged 18 species with a mean of 45 species found in any given year. We can only speculate about other effects that may potentially help explain the variance in the data. While there was little land-use change in the immediate vicinity during the study period, larger scale land-use changes or the use of pesticides in the surrounding areas, as well as other climatic variables may have contributed to this decline. These data do, however, highlight the importance of standardized long term data collection when considering questions of biodiversity.

Session 1-O5 - Data for biodiversity change assessment

Do we understand regional patterns of biodiversity changes using the German butterfly monitoring scheme?

Thomas Gottschalk[1]

[1]Hochschule für Forstwirtschaft Rottenburg, Rottenburg, DE, gottschalk@hs-rottenburg.de

In Germany, the nationwide butterfly monitoring (TMD) scheme started in 2005. Actually the number of transects has been increased to 460. The main goal of my study was to examine how representative are single transects of this scheme to identify regional diversity patterns of butterflies and to find out if they have the potential to identify regional diversity changes. Therefore, the results of two transects comprising a total length of one kilometre at the Spitzberg close to Tübingen were compared with results of an intensive survey of butterflies covering 650 km transects of the whole Spitzberg (624 ha). For each species, the total population size was estimated for both (1) the Spitzberg and (2) for the TMD transects. 92 % off all butterfly and burnet moth species recorded at the Spitzberg were also sampled by the two TMD transects. For 22 species the population size estimated on the two transects covered less than 10 % of the total population. This suggests that for some species the monitoring scheme might failed to detect potential changes. To identify the main drivers of biodiversity patterns and to better understand changes in insect populations at the Spitzberg, different environmental factors were analysed using a GLMM. Percent cover of forest, nutrient-poor grassland and protected areas as well as insolation were the most important drivers of butterfly diversity. These findings were confirmed by extensive analyses of historical and actual aerial photographs and historical species records at the Spitzberg. Because of habitat changes richness of butterfly and burnet moth species decreased by about 33 % in the last 100 years from 102 species recorded in former times to 69 species up to now. Percent cover of areas overgrown with trees and bushes has increased as well as forest free enclaves within the forest have almost disappeared in the last 70 years.

Session 1-O6 - Data for biodiversity change assessment

Adding years, adding certainty? Drivers of temporal change in bees and birds in agricultural landscapes

Mark Frenzel[1], Oliver Schweiger[1]

[1]Helmholtz Centre for Environmental Research UFZ, Halle, DE, mark.frenzel@ufz.de

Which elements of biodiversity and related environmental characteristics should be monitored? In this study conducted within the German TERENO project (Terrestrial Environmental Observatories) as part of the German LTER network we cover several aspects of bird and wild bee communities like population trends, traits, community composition and related environmental parameters. While there is a wealth of knowledge about trends in bird populations in Europe, wild bee communities are less accessible and thus it is more difficult to tell how they are affected by landscape characteristics and agricultural practice. Wild bees play an important role as pollinators and are expected to respond on small spatial scales, while birds perceive landscapes from the bird's eye view, responding on a much larger scale. We analyze the temporal impact of landscape quality and land use parameters on these groups in six agriculturally dominated sites of 4x4 km² in Central Germany. In the short term, bee communities are directly affected by abiotic parameters like weather. They show surprising patterns in terms of species richness and abundance in different landscapes, but temporal trends become just after more than six years of trapping apparent. In birds, species richness is not affected, but the number of territories as a measure for abundance declines in time especially in more diverse landscapes.

Session 1-O7 - Data for biodiversity change assessment

Moderately common plants suffer most from overall diversity loss

Florian Jansen[1]

[1]Universität Rostock, Rostock, DE, florian.jansen@uni-rostock.de

Nature conservation efforts are often focused on rare species. Common and moderately common species receive much less attention. However, an analysis of occupancy change of flora in two surveys between around 1980 and 2000 in Northeast Germany reveals significant losses for most of the 355 modelled plant species with highest losses for moderately common species. Those occurring in 20-40% of grid cells e.g. declined on average by 50% in 20 years. With regards to conservation status we found no correlation between decline and Red List category but habitat loss seems to be a main driver. Our approach uses the association of species to habitat types and species-area-relationships to overcome the problems with different sampling designs.

The talk will give an introductio into the methods, will show examplaratory results and will recap its applicability to other regions and datasets.

We suggest to rethink nature conservation indicators to include previously common species in monitoring and conservation management. Our approach can not replace proper data from urgently needed monitoring schemes for Germany.

Session 1-O8 - Data for biodiversity change assessment

120 years of change: using historical data to assess the effects of climate change on Arctic plant-pollinator interactions

Leana Zoller[1], Joanne Bennett[1,2], Tiffany Knight[1,2,3]

[1]Martin Luther University Halle-Wittenberg, Halle (Saale), DE, leana.zoller@idiv.de
[2]German Centre for Integrative Biodiversity Research (iDiv), Leipzig, DE
[3]Helmholtz Centre for Environmental Research – UFZ, Halle (Saale), DE

The majority of the world´s plants rely on animal pollinators for reproduction, making pollination a key ecosystem service for the maintenance of natural and cultivated plant communities. However, pollinators are experiencing a severe global decline. Amongst other anthropogenic drivers, climate change is considered responsible for this decline. In high latitude regions, climate change is projected to be especially pronounced and to act as one of the most important drivers of biodiversity change. However, data on plant-pollinator interactions from high latitude areas remain scarce. Furthermore, understanding the impacts of climate change on ecosystems and biodiversity is challenging, since the effects may take decades to transpire. We aim to overcome that challenge by using historical data collected in the late 19th century in Finnish Lapland, which provides us a valuable insight on high latitude plant-pollinator interaction networks from over a century ago. We are resampling these interaction networks and comparing the present-day data with the historical records in order to explore the changes that occurred during the last century in plant-pollinator networks in high northern latitudes.

Session 1-O9 - Data for biodiversity change assessment

Using permanent and quasi-permanent vegetation plot records to identify winners and losers of biodiversity change in Germany

Helge Bruelheide[1,2], Ute Jandt[1,2]

[1]Institute of Biology / Geobotany and Botanical Garden, Martin Luther University Halle-Wittenberg, Halle (Saale), DE, helge.bruelheide@botanik.uni-halle.de
[2]German Centre for Integrative Biodiversity Research (iDiv) Halle-Jena-Leipzig, Leipzig, DE, helge.bruelheide@botanik.uni-halle.de

While there is ample evidence for biodiversity change at the regional and global scale, trends at the fine scale of plant communities have been found to be inconsistent. While most studies have shown that changes in community species richness are not significantly different from zero, they often reveal a high species turnover. A key problem in analysing species turnover across different ecosystems is how to summarize changes in community composition. We here present an approach to calculate relative abundance and frequency changes at the species level, which allows to aggregate changes across all different habitat types. This approach allows combining spatially invariant records of permanent plot time series with resurveys of plots that have repeated observations in time, which however, vary in geographic exactness of the plot location (so called quasi-permanent plots).
We compiled a dataset of 6,742 (semi-)permanent vegetation plots from 59 different projects. Across all plots, we followed the change in cover and frequency for 2,274 species in time series ranging from 1927 to 2018. For every species we calculated the relative change in cover across all available intervals, resulting in 475,054 species by time x interval combinations. For 256 species with more than 100 time x interval observations, we encountered a significantly positive or negative trend (at $p<0.001$) across all observation intervals. There were more species that declined than those that increased in cover or frequency. The numbers of observation of losses and gains were distributed highly unevenly among species, with more evenly distributed losses than gains. Summarizing species-specific changes by decade shows that most losses occurred already in the 1970s, when also evenness became different between losses and gains. Furthermore, we show how gains and losses depend on species characteristics and on habitats. We discuss the results in the light of ongoing monitoring efforts to measure biodiversity change in Germany.

Session 1-O10 - Data for biodiversity change assessment

InInvitation to forest canopy ecology: global scale collaborations in a changing world

Akihiro Nakamura[1], Ekgachai Jeratthitikul[2], Alyssa Stewart[2], Luxiang Lin[1]

[1]Xishuangbanna Tropical Botanical Garden, Chinese Academy of Sciences, Yunnan Province, CN, a.nakamura@xtbg.ac.cn
[2]Mahidol University, Salaya, TH

The canopy is the defining components of any forest ecosystem and is known to harbour a large proportion of global biodiversity. The canopy community is vitally important for the essential roles in ecosystem functioning and services. Over the last several decades there have been significant advances in canopy science, and we now better understand the importance of forests and their canopies in promoting biodiversity and ecosystem functioning. There remain many challenges in understanding canopy systems in order to make predictions about the consequences of global-scale human disturbances, such as global warming, and their impacts on forest ecosystems. Canopy science is undergoing an exciting, radical change of approach from descriptive studies to experimental manipulation with the aid of new technologies such as DNA metabarcoding and remote sensing, and a new array of infrastructure such as global network of canopy cranes. Here we examine recent progress in canopy science, and invite you to join global canopy networks which can be incorporated into multilateral, collaborative efforts to further develop our understanding of canopy ecosystems in a changing world.

Session 1-P1 - Data for biodiversity change assessment

Flora Incognita – how artificial intelligence revolutionizes plant identification

Michael Rzanny[1], Jana Wäldchen[1], David Boho[2], Alice Deggelmann[1], Marco Seeland[2], Hans-Christian Wittich[2], Patrick Mäder[2]

[1]Max-Planck-Institute for Biogeochemistry, Jena, DE, mrzanny@bgc-jena.mpg.de
[2]Technische Universität Ilmenau, Ilmenau, DE

Monitoring presence or abundance of plant species is a key requirement of conservation, but depends on expert knowledge. Using the Flora Incognita smartphone app for automated species recognition, both enthusiasts and professionals can help mitigating the "taxonomic gap" and at the same time provide vast amounts of data on actual species distributions. Today, it already covers all native plant species in Germany, constantly expanding its services.
The recognition process is based on convolutional neuronal networks and allows even botanical laymen to reliably recognize plants species directly in the field. The species name, taken images and its location are uploaded to the Flora Incognita server and by this allow for monitoring and mapping the distribution of plants in Germany.
I will present an overview about the first phase of this project and report on experiences and collected species observations of the current vegetation season with about 2 million conducted Flora Incognita identifications during a single year.

Session 1-P2 - Data for biodiversity change assessment

The Flora Incognita Project – automated species identification 2.0

Jana Wäldchen[1], Michael Rzanny[1], David Boho[2], Alice Deggelmann[1], Marco Seeland[2], Hans-Christian Wittich[2], Patrick Mäder[2]

[1]Max-Planck-Institute for Biogeochemistry, Jena, DE, mrzanny@bgc-jena.mpg.de
[2]Technische Universität Ilmenau, Ilmenau, DE

Many activities, such as studying the biodiversity richness of a region, monitoring populations of endangered species, determining the impact of climate change on species distribution, and weed control actions depend on accurate species identification skills.
The research project Flora Incognita developed an efficient and reliable method for this. From expert to layperson, everyone with access to a smartphone and internet will thus be enabled to play a part in the preservation of ecosystems.
To harness collected knowledge from different approaches, three component apps have and will be developed. Together, they ensure the highest amount of identification accuracy.
(1) Flora Incognita – for (semi) automated plant identification. (2) Flora Capture - a citizen science tool to collect on-site observations, comprising of images and habitat information. (3) Flora Key – taking traditional plant characters into account.
Our poster presentation will provide insight into the current state of the Flora Incognita project, give some background on our machine learning approach and show how Flora Incognita can contribute to biodiversity monitoring.

Session 1-P3 - Data for biodiversity change assessment

Nationwide revisitation study reveals considerable local plant extinctions

Anne Kempel[1], Christophe N. Bornand[2], Andreas Gygax[2], Philippe Juillerat[2], Michael Jutzi[2], Lionel Sager[2], Beat Bäumler[2], Stefan Eggenberg[2], Markus Fischer[1]

[1]University of Bern, Bern, CH, kempel@ips.unibe.ch
[2]Info Flora, Berm, CH

Biodiversity is being lost rapidly, globally, regionally and locally. However, precise and quantitative information on local extinctions is scarce, and species trends are commonly assessed based on expert knowledge alone. This hampers generalisations about the patterns, habitats and characteristics of the species that decline. Particularly for threatened species, comprehensive data on recent trends are lacking. Here we present a nationwide revisitation study, where 8024 populations of all rare and endangered plant species of Switzerland (n=713) recorded between 1960 and 2001 were revisited by 420 volunteer field botanists from 2010–2016. 27% of the revisited populations had gone extinct. The likelihood of local extinction increased with increasing threat category: 40% of the revisited populations of species considered critically endangered had gone extinct compared with only 12% of species considered to be of least concern. Species from the two most threatened habitat types in Europe, ruderal and freshwater habitats, showed the highest rates of local extinctions. Our results provide compelling evidence that populations of many plant species in Switzerland are going extinct at a very rapid rate, and that the species considered most threatened declined most swiftly. Future population losses are likely to result in a drastic loss of plant diversity. Such quantitative assessments of species trends are laborious and challenging, but are an extremely valuable and relevant way of assessing human impact on nature. Our study thus presents clear evidence that current efforts to conserve threatened plant species are insufficient and must be urgently scaled up if we aim to protect today`s biodiversity.

Session 1-P4 - Data for biodiversity change assessment

"Länderübergreifender Biotopverbund" – An appropriate Indicator to improve species dispersal capabilities in Germany?

Cindy Baierl[1]

[1]Universität Kassel, FB 06, FG Landschafts- und Vegetationsökologie, Kassel, DE, cindy.baierl@uni-kassel.de
[2]Universität Kassel, FB 06, FG Landschafts- und Vegetationsökologie, Kassel, DE

Climate Change and its consequences for biodiversity as human livelihood used to be one of the main challenges at presence. This resulted in several monitoring systems for a systematical detection of changing environment worldwide, in Europe and as well in many countries. As part of an Indicator set to measure changes and to apply climate change adaptation measures in Germany we introduce the indicator "Länderübergreifender Biotopverbund" which focusses on the preservation and improvement of species dispersal capabilities by providing a coherent network of biotope structures in high quality. Therefor an indicator was developed and is now calculated in a time series from 2010-2017, to examine the location of new strictly protected areas inside or outside of suitable areas of woodlands, dry and wet habitats. In order to verify and calculate the overlap of these area types we used geoprocessing tools executed in the Geographic Information System ‚ArcGIS'. As the result we can show the percentage and absolute share of new strictly protected areas in suitable areas for biotope network.

SESSION 2

Urban ecosystems: challenges, potentials and solutions

Chairs:
Lena Neuenkamp, Roland Schröder, Leonie K Fischer, Valentin Klaus

In times of massively expanding cities and shrinking space for biodiversity in rural areas, urban habitats more and more serve as places that can—or need to—support biodiversity. Moreover, integrating ecosystem services and wildlife into cities is increasingly seen as one of the relevant strategies to enhance quality of life in future cities. In this regard, the multiple benefits of urban greenspace have been reported and their general value for biodiversity is emphasized. However, urban ecosystems differ strongly from natural ones due to their specific anthropogenic context. This highlights the necessity to develop specific approaches when dealing with wildlife in cities. The urban matrix is hereby a strong driver of urban biodiversity, including both environmental and socio-economic factors. Likewise, supporting biodiversity and ecosystem services in cities needs to account for the intensive use of urban green by the human city population, calling for an involvement of the urban population when designing urban habitats. This session aims to bring together current practical knowledge and innovative research that deals with the challenges and potentials of today's urban areas. We invite contributions that span from basic research and theoretical concepts of urban nature to applied and transdisciplinary work in the field of urban ecology.

Session 2-O1 - Urban ecosystems

Urban biodiversity in Munich as affected by the design of public squares

Sebastian T. Meyer[1], Maximilian Mühlbauer[1], Wolfgang W. Weisser[1]

[1]Technical University of Munich, Freising, DE, sebastian.t.meyer@tum.de

Rural land use is threatening biodiversity and cities have been suggested as an alternative habitat for wildlife with a potential for species conservation. However, urbanisation increases worldwide due to the migration of humans into cities. Resulting densification within cities and sprawl of cities into the surrounding landscapes contribute to the loss of wildlife habitat. Currently, it remains unclear which properties of urban spaces have the strongest effects on urban wildlife and how to integrate these properties into city planning.
We monitored the diversity of birds, bats, small mammals, arthropods, pollinators, and mosses on 100 public squares in the city of Munich, which span gradients in size, distance to the city centre, and greenness on and in the surrounding of the squares, to investigate effects on urban biodiversity. We found positive effects of an increasing greenness (proportion of grassy surface area, number of trees, shrub volume) on the abundance and diversity of various taxa. Interestingly, square properties of different spatial scales affected animals. Sampling locations within squares differed depending on local conditions. Properties of the squares as a whole (e.g., proportion of grass) and properties of the surrounding of a square (e.g., greenness in a buffer around the square) affected animals. Further, some taxa showed diverging effects of square properties. For example, the activity of hedgehogs and birds increased with distance from the city centre while the activity of rodents decreased.
Our study shows that public squares in cities can be wildlife habitat given they contain sufficient vegetation and point to the importance of heterogeneity both within and between squares. However, greenspaces in cities are under increasing pressure of being converted, and their function as wildlife habitat has to be considered explicitly in city planning if they are to contribute to the conservation of biodiversity in future.

Session 2-O2 - Urban ecosystems

Supporting regional biodiversity by native species introduction on extensive green roofs

Roland Schröder[1], Daniel Jeschke[1], Kathrin Kiehl[1]

[1]Osnabrück University of Applied Sciences, Osnabrück, DE, r.schroeder@hs-osnabrueck.de

In times of ongoing urbanization, the spatial extent of urban green infrastructure is declining. This often results in a loss of important ecosystem functions beneficial for the urban environment like water retention, temperature regulation and habitat function for biodiversity. It has been shown, that the greening of buildings can mitigate negative environmental effects of urban densification to some extent. Conventional green roofs, however, have mostly been developed by species-poor plant mixtures containing non-native plant species (incl. cultivated varieties of *Sedum* and *Phedimus* species). In contrast, the use of native plant species of regional origin could enhance the habitat function for regional native biodiversity not only for plants but also for insects. By combining a habitat template and a seed provenance approach, we studied the suitability of plant species from regionally occurring sandy dry grasslands (Koelerio-Corynophoretea) for extensive roof greening in North-Western Germany. Since 2015, we investigate the effects of species introduction on vegetation development by sowing seed mixtures with species from regional native seed production and by transfer of raked material from an ancient dry grassland including diaspores of vascular plants and cryptogams. In several ex-situ and in-situ experiments, we also tested engineered green roof substrates with and without arbuscular mycorrhiza inoculation, and different layering for their suitability to establish self-sustaining plant populations of native dry grassland species. In this talk, we will present key results of our past and ongoing experiments and give recommendations for successful roof greening intended to support regional native biodiversity.

Session 2-O3 - Urban ecosystems

Developing novel restoration substrates – re-use of waste bricks for land-fill coverage and urban tree planting

Markus Bauer[1], Johannes Kollmann[1,2]

[1]Technical University of Munich, Munich, DE, markus1.bauer@tum.de
[2]Norwegian Institute of Bioeconomy Research, As, NO

Selection of suitable restoration substrates depends on the specifics of the target vegetation. For some substrates, artificial material may be advantageous as long as they support plant growth and are not toxic. Brick waste is a major challenge for recycling schemes and future restoration, because of its abundance and the poorly know qualities for plant growth. So far, bricks are re-used as bulk material after demolition of buildings that does not exploit its potentially positive features. Future recycling processes may use bricks as substrate additive, e.g. for re-cultivation of landfills or for planting urban trees. The aim of this study is to test, whether or not brick granulate is growth-inducing due to its storage capacity and controlled release of water and nutrients. As a test system, we used sown oat grass communities.
In a greenhouse experiment, we tested substrates with 20 vs 40% brick ratio, 4–8 vs 8–16 mm granulate size, bricks treated with more and less acidic acid, and dry vs moist regime. Communities were sown in 40 trays that were divided into two subplots. A commercial mixture with regional seeds of Arrhenatherion species was used. We measured vegetation cover, biomass, and species composition over a period of 12 weeks. Furthermore, we calculated the mean Ellenberg indicator values (N, F, R), and community weighted means of specific leaf area and seed mass.
In all treatments, the sown species emerged successfully and a dense sward developed. Under moist conditions, significantly less biomass was produced on coarse brick substrate. Brick ratio and acidity influenced not aboveground biomass. A higher brick ratio increased community weighted mean of seed mass and slightly mean Ellenberg N and R. The results indicate that bricks are suitable soil additives. A strong acid treatment is not necessary, and the brick granulate should be <8 mm. Ongoing research tests the effects of increased pH of brick-based substrates and effects on germination.

Session 2-O4 - Urban ecosystems

Leaf litter decomposition and litter fauna in urban forests

Sandro Meyer[1], Hans-Peter Rusterholz[1], Jörg-Alfred Salamon[2], Bruno Baur[1]

[1]University of Basel, Basel, CH, sandro.meyer@unibas.ch
[2]University of Veterinary Medicine Hannover, Hannover, DE

Urbanisation is an important driver of environmental change and has the potential to alter the functioning of ecosystem processes. In urban forests, a key ecosystem process is litter decomposition, which is driven by the litter and soil community including Acari and Collembola. We examined whether the degree of urbanisation and forest size influences litter decomposition rates and their associated litter fauna in Basel, Switzerland. We exposed litterbags with three mesh sizes (100 µm, 2 mm, and 4 mm) filled with a mixture of *Acer pseudoplatanus*, *Fagus sylvatica*, and *Fraxinus excelsior* litter for a period of 9 months in 17 urban forests of different sizes. We recovered the litterbags after 3, 6, and 9 months, extracted the fauna and assessed the decomposition rates. We recorded that litter decomposition rates were negatively affected by the degree of urbanisation. We also found variable responses by Acari and Collembola to the degree of urbanisation and forest size. While Acari and in particular, the dominant oribatid mites were most frequent in forests in moderately urbanised areas, Collembola were most abundant in forests in highly urbanised areas. In addition, we examined whether morphological and lifestyle traits of Collembola were affected by urbanisation, forest size, and environmental variables. Although, the Collembola species composition did not shift with urbanisation, species with globular and stocky bodies were more abundant in forests in areas with a low degree of urbanisation, and species with a eudaphic life form were less abundant in small forests. We showed that urbanisation and forest size have the potential to impact litter fauna abundances and species with certain morphological and lifestyle traits.

Session 2-O5 - Urban ecosystems

Sustainable urban greenspaces: Do citizens' needs and biodiversity conservation meet?

Lena Neuenkamp[1,2], Leonie Fischer[3,4], Jussi Lampinen[5], Maria Tuomi[5], Valentin H. Klaus[6]

[1]Institute of Plant Sciences, University of Bern, Bern, CH, lena.neuenkamp@ut.ee
[2]Institute of Ecology and Earth Sciences, University of Tartu, Tartu, EE, lena.neuenkamp@ut.ee
[3]Department of Ecology, Ecosystem Science/Plant Ecology, Technische Universität Berlin, Berlin, DE
[4]Berlin-Brandenburg Institute of Advanced Biodiversity Research (BBIB), Berlin, DE
[5]University of Turku, Turku, FI
[6]ETH Zürich, Zürich, CH

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

Session 2-O6 - Urban ecosystems

"Nature to go": Wild vegetation along urban railway stations allows people everyday contact with nature

Leonie K Fischer[1], Nina Hartmann[1], Ingo Kowarik[1]

[1]Technische Universität Berlin, Berlin, DE, leonie.fischer@tu-berlin.de

In an increasingly urbanized world, the "extinction of nature experience" is feared to result in an indifference towards conservational objectives due to decreased motivation of residents to invest into the protection of the environment. Efforts to reconnect residents with nature rely on natural spaces nearby places where people live and work. Informal greenspaces like railway verges are omnipresent in many cities and might thus play an important role in complementing formal greenspaces.
Even though informal greenspaces gain an increasing attention in literature, limited information is available about their dimensions and potential for human-nature relationship. Our study focuses on informal greenspaces stretching along railway verges opposite to railway platforms of Berlin's rapid transport system (*S-Bahn*). We investigated what type of vegetation is visible to passengers waiting on the platforms, and if passengers prefer formal or informal vegetation types. We recorded the vegetation along all 166 railway stations across the city and interviewed waiting passengers at 32 stations about their preferences for urban railway vegetation.
In Berlin, 77% out of 166 railway stations allowed a view from the platform to green railway verges that were largely dominated by informal vegetation (71%), including a set of both native and non-native tree species. In all, the vast majority of respondents showed positive attitudes towards wild, woody vegetation. The findings demonstrate that a surprising amount of wild urban vegetation can be perceived by city dwellers in their everyday lives in Berlin and reveal that people largely appreciate informal vegetation along urban railway verges.
The results support strategies to preserve wild vegetation within the urban transportation system and point to unexploited opportunities in human-nature interactions in cities. Whether "nature to go" at railway stations also has a positive impact on people's commitment to nature conservation remains an important open question.

Session 2-O7 - Urban ecosystems

Learning from Mimi, Pelle & co: tracking domestic cats in a citizen science project

Anne-Kathrin Schneider[1], Michael W. Strohbach[1], Thomas Albrecht[2]

[1]Technische Universität Braunschweig, Braunschweig, DE, anne-kathrin.schneider@tu-braunschweig.de
[2]Gaußschule - Gymnasium am Löwenwall, Braunschweig, DE

Domestic cats are probably the most popular pets worldwide. Even if they may seem cuddly, they still carry many traits of a wild animal. Especially their foraging behaviour regarding birds is in the focus of conservationists and leads to heated debates. Aside from this controversy, domestic cats are great for involving citizens in urban ecosystem research. This year, we started a small citizen science project with a secondary school (Gymnasium) in Braunschweig, Germany, in order to uncover the secret paths of domestic cats (*Felis catus*). Our project aims at a better understanding of the movement behaviour of cats in our city and making cat owners aware of the true range of their pets. Most of all, we want to raise children's interest in urban- and movement ecology. We used the school network to find cat owners who were willing to participate with their cat. A small data logger attached to an H-style harness, instructions, a questionnaire, a cat diary, and a treat for the cat where handed out to the participants. After a week, the logger, questionnaire and cat diary were recollected. The data logger tracked GPS coordinates and tri-axial acceleration was to get information about the position of the cat and its behaviour. Cat tracks were analysed by the pupils with ArcGIS online. Together, we investigate home range sizes, spatial behaviour (i.e. do the cats have favourite spots they visit during their forays or do they randomly walk around), and a relationship between the cat's personality and their movement behaviour. In addition, a brief report with a map of the cat track was returned to the cat owners. In our presentation, we will present results from the 11 cats that where tracked between March and June 2019, and we will discuss the advantages and obstacles of such small, but wide-ranging citizen science project.

Session 2-O8 - Urban ecosystems

Local and landscape drivers of ecosystem services trade-offs and synergies in urban agroecosystems

Monika Egerer[1], Stacy Philpott[1], Heidi Liere[2], Brenda Lin[3], Peter Bichier[1], Shalene Jha[4]

[1]University of California, Santa Cruz, Santa Cruz, US, megerer@ucsc.edu
[2]Seattle University, Seattle, US
[3]Land and Water Flagship, CSIRO, Aspendale, AU
[4]University of Texas at Austin, Austin, US

Biodiversity and ecosystem functioning contribute to human well-being by providing ecosystem services. Local and landscape management are assumed to directly impact biodiversity and indirectly impact ecosystem services, but the specific relationship between habitat management, biodiversity, and service provision are rarely evaluated simultaneously for multiple taxa across landscape contexts, especially in the increasingly widespread urban agroecosystem. Few studies examine trade-offs or synergies between services given local and landscape management practices. This research asks: 1) How do local management factors and landscape characteristics affect biodiversity and ecosystem services in urban agroecosystems? 2) Are there trade-offs or synergies among factors that affect distinct services? 3) Do the impacts of local factors on ecosystem services depend on landscape context? We examine data collected over 5 years in 25 urban community gardens to ask how local features (ground cover, plant richness, floral abundance, garden size) and landscape features (natural cover) affect ecosystem service providers (e.g. natural enemies, pollinators) and services (e.g., pest control, climate mitigation). We show that relationships between putative service providers and services are often not strong, and local factors may better predict services. We also show that multiple trade-offs exist in local management for multiple services. Increasing local tree density and ground cover increases climate regulation services, but these two local factors negatively affect pest control and pollination. Finally, we show that nearly half of all services are best predicted by a local-landscape interaction. Here, the impacts of tree density on pollination depend on landscape habitat availability, likely because mobile service providers only colonize gardens given a minimum threshold of landscape-level habitat availability. The results provide practical insight into managing local and landscape abiotic and biotic factors to better support biodiversity and maximize service synergies.

Session 2-O9 - Urban ecosystems

Landscape typology of urban vegetation ecosystem services across European urban areas

Marlène Boura[1], Geoffrey Caruso[1,2]

[1]University of Luxembourg, Esch-sur-Alzette, LU, marlene.boura@uni.lu
[2]Luxembourg Institute of Socio-Economic Research, Esch-sur-Alzette, LU

Urban areas exhibit a large variety of patterns that may affect the negative externalities of human settlements on ecosystems. Ecosystem Services (ES) can help assessing the urban pressure on the environment and its impact on the well-being of inhabitants. Compactness or densities have often been associated to potential ES. Yet, the effects of the relative spatial arrangement of vegetation, forests and water bodies, with respect to the urban lands - which are source of anthropogenic CO_2emissions - on potential ES are still not systematically analysed.
In this work we propose a typology, for about 800 European urban areas (>50,000 inhabitants) based on the intra-urban structure of cities and the associated ES potentials. The GMES/Copernicus Urban Atlas 2012 database provides a comparable definition of urban area and land use categories, necessary to a systematic cross-European analysis. More particularly, we investigate the share of different land uses and the distance between human settlements, forests and the other vegetated lands as well as their relative spatial distribution within urban settlements. We then use spatial metrics as proxies for urban ES associated with urban forests – e.g., microclimate regulation (air-cooling, shade), air pollution removal (canopy), rainwater runoff (impervious lands). The typology is created using an unsupervised machine learning approach (clustering) with standardized spatial metrics as input data.
Different urban "forest cultures" across the continent are observable. Urban areas around the Mediterranean Sea - facing warmer temperatures - attribute significantly more space to herbaceous lands (10 to 70%), but generally less than 10% for forests. Transport networks and infrastructures are more present along the axe going from central UK, to Italy and on the east coast of Spain (5 to 9%). Similarly, Industrial built up lands are more present along this axis, including West Germany, Romania and the east coast of Spain (5 to 22%).

Session 2-O10 - Urban ecosystems

Assessing biotic homogenization in cities – A taxonomic and functional beta diversity approach

Marco Moretti[1], Joan Casanelles[1], David Frey[1]

[1]Swiss Federal Research Institute WSL, Birmensdorf, CH, marco.moretti@wsl.ch

Studies assessing the effects of urbanization on biodiversity reveal contrasting patterns. While some studies find evidence of *biotic homogenization,* i.e. higher similarity of species assemblages among cities compared to rural sites, others claim *biotic differentiation* and thus a high species richness and turnover among cities compared to rural sites. Besides heterogeneous sampling designs (e.g. spatial scales, taxonomic groups and urban green type studied), one cause of such contrasting patterns could be that different components of biodiversity (e.g. taxonomic and functional diversity) respond differently to urbanization. We tested this prediction by investigating the taxonomic and functional responses of alpha and beta diversity across eight taxa, urban green types, and cities in Switzerland. We compared both inter- and intraspecific trait variation within cities and between urban and adjacent rural habitats. We found two main patterns of community responses to urbanization: 1) high alpha and beta taxonomic diversity, mainly driven by true species turnover thus no loss of species richness except in highly densely urbanized area and 2) a gradual reduction of beta functional diversity among green areas due to loss of functional space, but mainly in very densely built urban areas. Taken together, our results are in line with the hypothesis that the high species richness observed frequently in urban areas is due to a high species turnover, which is probably driven by the high spatial and temporal heterogeneity of urban ecosystems. However, when urban densification increases beyond a given threshold, communities tend to be functionally homogenous. This threshold varies between taxa and degree of urbanization. We conclude that by accounting for different aspects of biodiversity of multiple taxa, the contrasting patterns shown in previous studies may be reconciled, thereby gaining a more mechanistic understanding of the effects of urbanization on biodiversity.

Session 2-O11 - Urban ecosystems

Cross-city analysis of mutual influences of urban trees and microclimate

Carola Helletsgruber[1], Angela Hof[1], Celina Stanley[1,2]

[1]Universität Salzburg - Fachbereich Geographie und Geologie, Salzburg, AT, Carola.helletsgruber@sbg.ac.at
[2]IÖR - Leibniz-Institut für ökologische Raumentwicklung, Dresden, DE

Measured by the proportion of the population living in them, cities are the most important living space of humans. The urban heat island effect (UHI) can significantly reduce the thermal comfort for humans. As the UHI effects increases as climate change progresses, the interest in climate-adapted urban development continues to grow. Opportunities to reduce the thermal load in cities include the expansion and adaptation of green infrastructure. Urban trees are particularly effective. However, not only urban trees influence the microclimate but also the urban climate has a significant effect on the urban trees.
We will present environmental monitoring, including phenological observations in spring and autumn and microclimate measuring campaigns, in a young citizen science project. The dynamics of urban tree phenology and microclimate regulation throughout the growing season is analysed in a cross-city approach, along intra- and inter-urban gradients and for a set of the most common urban tree species. We equipped urban trees in 5 European cities with beacons that connect via Bluetooth to a tailor-made app. The app is used for phenological monitoring, to display microclimate measurements and to send them to a database. Moreover, the app broadcast information on the trees' microclimate-regulating ecosystem services. The approach and setting are scalable to other citizen-engagement and volunteered geographic information projects. It fosters an understanding of how urban trees are in sync with urban climate, and deepens our understanding of systemic feedback, which is key for implementing urban tree management. Results show inter-species differences in the length of the growing season as measures of the delivery of regulatory ecosystem services and as responses to urban heat island intensity.

Session 2-O12 - Urban ecosystems

Cities promote diverse wild bee communities and specific functional groups

Anita Grossmann[1], Anika Gathof[1], Sascha Buchholz[1,2], Ingo Kowarik[1,2]

[1]Technical University Berlin, Department of Ecology, Chair of Ecosystem Science / Plant Ecology, Berlin, DE, anita.j.grossmann@campus.tu-berlin.de
[2]Berlin-Brandenburg Institute of Advanced Biodiversity Research, Berlin, DE

Urbanisation and decline of wild bees are accelerating and coinciding global trends, leading to the question about the role of cities as habitats of wild bee species. Therefore, research in urban pollinators has gained interest and previous studies demonstrated that cities could provide important habitats for bees. Still, effects of urbanisation on wild bee taxonomic and functional diversity are ambiguous and the question, which functional groups can thrive in urban environments, remains open. Thus, major knowledge gaps still exist regarding the functional level and it is still insufficiently investigated how various functional traits are affected by the urban matrix. We used a study system approach with the standardized ecosystem type dry grassland to investigate wild bee assemblages along an urbanisation and connectivity gradient. We investigated the effects at the scale of the urban matrix and local habitat on the species richness and abundance of wild bees and identified species-specific functional traits that pass the urban filter. In summer 2017, we collected 1463 bee individuals representing 108 bee species using the standard pan trap method on dry grassland sites in and around Berlin. 25 % of collected wild bee species were of conservation concern, in addition 16 species were specialized in their dietary behaviour (oligolectic). Surprisingly, wild bee species richness and abundance were not affected by urbanisation, connectivity and local habitat parameters, while connectivity significantly influenced wild bee assemblage. We detected significant relationships between environmental parameters and functional traits, whilst urbanisation had the greatest impact. Due to functional groups, some wild bee species can be promoted within the urban matrix. Our findings highlight the importance of cities as suitable habitats for diverse wild bee communities. In face of dramatic wild bee decline, cities can act as important refuges within an increasingly hostile environment.

Session 2-O13 - Urban ecosystems

Trait change in insect species in urban and rural habitats from 1900 to now

Silvia Keinath[1,2], Johannes Frisch[1], Johannes Müller[1,2], Frieder Mayer[1,2], Mark-Oliver Rödel[1,2]

[1]Museum für Naturkunde, Leibniz Institute for Evolution and Biodiversity Science, Berlin, DE
[2]Berlin-Brandenburg Institute of Advanced Biodiversity Research - BBIB, Berlin, DE

Increasing anthropogenic influence on environments leads to rapid transitions from near natural to novel ecosystems. Consequently, many native species disappear, whereas non-native species migrate into transformed ecosystems. However, there are also species that persist throughout environmental transitions. The consequences for these species, especially if rapid transitions trigger any changes in their phenotypes, remain often unclear. Neither has it been clarified which adaptations enable species to persist, whilst other species disappear. Unfortunately, due to the comparatively long time periods during which these changes occur, direct observations of changing ecological adaptations, behaviour or morphology of persisting species are usually not possible. However, some insights can be gained from preserved specimens in museum collections. Whereas behavioural and physiological changes cannot be directly assessed in museum vouchers, morphological traits may be used as a proxy for a species' ecological and physiological modifications during the transition of an ecosystem. These historical datasets can be completed with recent samples to cover spatio-temporal gradients across environmental transitions. In our study, we investigated morphological trait change in insect species of the Berlin (urban habitat) / Brandenburg (rural habitats) area over the last 100 years. Various species and sex depended trait changes have been detected and will be discussed.

Session 2-O14 - Urban ecosystems

The importance of plant resources at multiple spatial scales for a key pollinator

Hannah Reininghaus[1,2], Kristy Udy[2], Erin Treanore[3], Teja Tscharntke[2], Christoph Scherber[1]

[1]University of Münster, Münster, DE, Hannah.Reininghaus@uni-muenster.de
[2]University of Göttingen, Göttingen, DE, Hannah.Reininghaus@uni-muenster.de
[3]PennState University, Pennsylvania, US

Increasing urbanization may lead to declines in pollinator biodiversity and associated pollination services. We studied how floral resources at local and landscape scales affect bumblebee foraging and colony performance along a farmland-urban gradient. Bumblebee colonies were set up along a contrasting farmland to urban gradient in settlements of increasing size. We conducted a marking tracking experiment with fluorescent dye to determine how bumblebees forage in the local surroundings of their colonies and took pollen samples to investigate bumblebee long-range foraging behaviour. The weight gain of bumblebee colonies did not differ between the different sites. Proportion of bumblebee adult number, however, and brood cells increased along the urban to farmland gradient. Bumblebee workers visited more flowering plant species, when plant species richness was high. According to this result, bumblebee workers in village and city gardens collected a higher proportion of pollen than in farmland sites, exploiting the high local plant diversity. In conclusion, bumblebee colonies showed reactions on flowering plant species richness in the direct surrounding, whereas plant species richness on the landscape scale had no effect on bumblebee colony performance.

Phylogenetic conservation of functional diversity in plant communities declines with urbanization

Anne Hiller[1,2], Moritz von der Lippe[1,2], Sascha Buchholz[1,2], Ingo Kowarik[1,2]

[1]Department of Ecology, Technische Universität Berlin, Berlin, DE, anne.hiller@tu-berlin.de
[2]Berlin-Brandenburg Institute of Advanced Biodiversity Research (BBIB), Berlin, DE, anne.hiller@tu-berlin.de

Urban areas are often richer in plant species than rural areas, but species richness is not the only facet of biodiversity. Phylogenetic (PD) and functional diversity (FD) are more and more considered as important biodiversity aspects, because they are connected to ecosystem functioning and resilience. However, there is no consensus whether FD is phylogenetically conserved or develops independently from phylogeny through adaptive radiation, especially in the context of urbanization.
We therefore aimed to reveal the effect of urbanization on PD and FD and their interrelation. To achieve this, phylogenetic and functional plant diversity of dry grasslands in the metropolitan region of Berlin, Germany, are analysed along the urbanization gradient, defining the level of urbanization by different physical and socioeconomic parameters.
Despite a general significantly positive relationship between FD and PD, urbanization dissolves this interdependence, as the relationship becomes insignificant and no longer positive with increasing urbanization. Thus, the detected phylogenetic conservation of FD diminishes with urbanization, indicating that phylogeny is not the determining factor for FD in highly urbanized areas. Instead, adaptations to extreme environmental conditions and interactions, such as competition or facilitation, with other species may play a more important role. Furthermore, FD increases with urbanization, while PD tends to decrease, supporting the claim that FD and PD do not simply represent each other.
We conclude that PD cannot be used as simple proxy for FD, as both are not strictly positively related and respond differently to the complex processes of urbanization.

Session 2-O16 - Urban ecosystems

The function of a set-aside railway bridge in connecting urban habitats

Brigitte Braschler[1], Claudine Dolt[1], Bruno Baur[1]

[1]Section of Conservation Biology, Department of Environmental Sciences, University of Basel, Basel, CH, brigitte.braschler@unibas.ch

Railway embankments are important corridors in urban environments connecting otherwise isolated habitat fragments. They are interrupted when railways cross major roads. It is not known whether dispersing animals use railway bridges to cross roads. We examined the function of a set-aside iron-steel railway bridge crossing a 12-m wide road with high traffic density in Basel (Switzerland) for dispersing animals. We installed drift fences with traps on a single-track, 32-m long and 6-m wide railway bridge with a simple gravel bed, and daily collected animals for 9 months. We captured more than 1500 animals crossing the bridge: small mammals, reptiles and amphibians as well as numerous invertebrates including snails, woodlice, spiders, harvestmen, millipedes, carabids, rove beetles and ants. For some animals, it is likely that the gravel bed, at least temporarily, serves as a habitat. Many animals, however, were apparently dispersing, using the bridge to cross the busy road. We found season- and daytime-dependent differences in the frequency the bridge was used. Our findings indicate an important function of a set-aside railway bridge for connecting urban habitats. As most animal dispersal was recorded during night, railway bridges with no (or little traffic) during night may also contribute to animal dispersal.

Session 2-O17 - Urban ecosystems

Modelling biodiversity in urban areas: a first study in the city of Zurich

Joan Casanelles Abella[1,2], Marco Moretti[1], Martin K. Obrist[1], David Frey[1,2], Loïc Pellissier[1,2]

[1]Swiss Federal Research Institute WSL, Zürich, CH
[2]ETHZ, Zürich, CH

Urbanization increases worldwide posing threads but also offering opportunities for biodiversity conservation. Even though the number of urban ecology studies is increasing, knowledge on urban biodiversity is still hampered by the difficulty of extrapolating traditional biodiversity point measurements to a larger spatial scale (i.e. to predict biodiversity distribution in urban areas). Species distribution models (SDMs) have proved to be a key tool to solve this shortfall in biodiversity knowledge in several ecological studies. However, SDMs have rarely been used in the context of urban areas due to either the lack of sufficient species records or high-quality predictors (e.g. meaningful ecological maps). After years of urban ecology research, an extensive dataset of urban biodiversity composed of several taxonomic groups exists for the city of Zürich. Here, we have used the species records (including insects, isopods and snails) in Zürich collected during the last decade and modelled species distributions using a wide range of high-resolution predictors including climatic (e.g. temperature), pollution (e.g. particulate matter), habitat and remote-sensing data (e.g. LiDAR). Our aims were to find out (1) whether biodiversity can be modelled in urban areas using existing datasets and predictors that are becoming available for many cities; (2) which are the most relevant predictors to model and predict occurrences for different taxonomic group and; (3) what is the potential of the generated species distributions maps for improving biodiversity conservation in urban areas.

Session 2-P1 - Urban ecosystems

Examining community gardens as a source of ecological and social connectivity in cities

Monika Egerer[1], Elsa Anderson[2,5], Nakisha Fouch[3], Mysha Clarke[4]

[1]University of California, Santa Cruz, Santa Cruz, US, megerer@ucsc.edu
[2]University of Chicago, Illinois, Chicago, US
[3]Clemson University, Clemson, US
[4]Villanova University, Villanova, US
[5]Technische Universität Berlin, Berlin, DE

Connectivity of social-ecological systems across urban landscapes promotes the resilience of communities and ecosystems to change. Community gardens are social-ecological systems that support food production, social interactions, and biodiversity conservation. Despite their importance as hubs of socioecological processes and socioecological connectivity, these systems are often temporary in the landscape. We investigate how these hubs of ecosystem services facilitate socio-ecological connectivity and service flows across complex urban landscapes. In three US cities (Baltimore, Chicago, New York City), we use gardens as a model system to demonstrate how biophysical and social features of landscapes control the direction and magnitude of ecosystem service flows among these systems. We show that biophysical connectivity drives connectivity and service flows in some cities (Chicago). In others (New York City), social connectivity drives flows because gardens cluster within neighbourhoods promoting connectivity hotspots, but producing landscape-scale connectivity cold spots. The particular patterns illustrate how urban form and social amenities largely shape ecosystem service flows. These socio-ecological analyses can be applied to enhance and stabilize landscape connectance to improve life and resiliency in cities as they grow in population and building density. We highlight how researchers, urban planners, and policymakers can apply such landscape-scale analyses to enhance landscape connectivity over time and space.

Session 2-P2 - Urban ecosystems

Designed wildflower patches as urban green infrastructure and temporal habitat for pollinators

Simon Dietzel[1], Johannes Kollmann[1], Harald Albrecht[1], Christina Fischer[1]

[1]Chair of Restoration Ecology | TUM, Munich, DE, simon.dietzel@tum.de

Increasing urbanisation is challenging (semi-) natural landscapes, thus threatening biodiversity, and ecosystem services. Nonetheless, cities can provide suitable habitats and essential resources, for example for insect pollinators, while space is limited resulting in frequent land-use conflicts. Yet there are untapped opportunities to enhance biodiversity in urban areas, e.g. in brown fields, parks and along transport axes. In our project, we establish wildflower patches along major roads in Munich to achieve insights into opportunities to functionally enhance urban green. We investigate the effects as foraging or nesting sites on pollinator abundance, diversity and dispersal along a gradient of urbanization. Wild bees and hoverflies will be recorded from April to September using pan traps and trap nests. The urban landscape around the wildflower patches, described as the proportion of sealed ground, building density, urban green, forest and agricultural land will be analysed as key factor affecting occurrence of pollinating insects on a large scale. Small-scale habitat structures, in terms of flower and vegetation density or potential nesting sites are mapped as well to understand the effects on pollinator communities. We predict small-scale habitat structures and life-history traits of pollinators as main drivers of pollinator diversity and community composition, whereas the establishment of wildflower patches will enhance their abundance and diversity over time. The four-year project is supported by well-targeted PR activities including elements of citizen science. This will improve public knowledge on the significance of urban wildflower patches and their benefits for diversity and functions of urban pollinators.

Session 2-P3 - Urban ecosystems

Urban trees for a cooler future - Resilience of urban trees to a changing climate

Valentina Vitali[1,2], Christian Messier[2,3], Alain Paquette[2,3]

[1]Swiss Federal Institute for Forest, Snow and Landscape Research WSL, Birmensdorf, CH, valentina.vitali@wsl.ch
[2]Université du Québec à Montréal, UQAM, Montreal, CA, valentina.vitali@wsl.ch
[3]Institut des Sciences de la Foret Tempérée, Université du Québec en Outaouais., Ripon, CA

Urban trees provide important environmental services and are indispensable for the regulation of a city's climate, whilst growing in stressful conditions with low water and space availability. However, compared to their forest counterparts, little is known about urban trees capability to cope with climate change. Furthermore, due to the heat island effect, urban areas of Montreal have already been experiencing 1.4°C higher temperatures, which creates ever more challenging conditions for urban trees. Planting resilient trees is necessary maximize their capability to maintain their resistance against pests and, consequently, minimize the efforts needed to ensure their health and performance and ensure the provisioning of environmental services.
Through dendrochronological analyses, we have compared the growth rates of four common urban tree species Norway maple (*Acer platanoides*), silver maple (*Acer saccharinum*), lime (*Tilia cordata*), and common hackberry (*Celtis occidentalis*). Trees were sampled across an urban gradient, from trees growing in city centre on pavement pits, to residential areas, and in parks, in the metropolitan area of Montreal.
Contrary to expectations, street trees have been showing an increase in growth rates in the last decades, showing in the last years similar of higher growth than the one shown by park trees. Both *Acer* species have shown a significant increase in growth rates, overreaching the ones achieved by park trees. Climate correlations indicate a strong positive effect of autumn temperature, indicating an increase of the vegetative period in this area and therefore an increase in growth. In the case of Eastern Canada, climate projections indicate an increase in temperature as well as precipitation, which explains the consistent increase in growth in the last decades. These results are a first assessment necessary to understand the complex system of urban forestry, and stress the necessity for further research.

Session 2-P4 - Urban ecosystems

The 'GardenApp' - Communicating the ecological value of private gardens

Michael W. Strohbach[1], Anne-Kathrin Schneider[1], Boris Schröder-Esselbach[1]

[1]Technische Universität Braunschweig, Braunschweig, DE, m.strohbach@tu-braunschweig.de

Private gardens make up large parts of urban green. In contrast to public green spaces, planning and management usually occurs uncoordinated and independent of municipal planning and management strategies. Therefore, the potential of private gardens for providing ecosystem services and habitat, and for functioning as corridors for wildlife, is not fully utilized. While more public knowledge on gardens would be needed for planning and management strategies that include them, gardeners could probably be nudged into improving habitat quality or managing their gardens for improved provision of ecosystem services. In order to address both issues, we developed a GIS-based web application for the city of Braunschweig, Germany: the 'GardenApp.' We used remote sensing data to delineate vegetation heights at one-meter resolution, which are the basis for calculating ecosystem services like carbon storage and cooling, as well as the vegetation structure of the garden. Users of the app have to outline their garden on a web-map and fill in a questionnaire on biodiversity-relevant management practices we derived from the literature. They are also asked about observations of well recognizable species groups in their gardens. As an output, the gardeners are provided with an estimate of the ecosystem services their garden provides, and with a biodiversity estimation. To highlight the potential role of the garden as a wildlife corridor, the gardeners are also provided with results from connectivity modelling for Red Squirrels (*Sciurus vulgaris*) and the European hedgehogs (*Erinaceus europaeus*). In return, their observations are used to assess the quality of the connectivity models. We show results in terms of what we have learned from development and application of the GardenApp and give an outlook on the potential of web-applications for urban sustainability and conservation.

Session 2-P5 - Urban ecosystems

The role of urban vegetation in air quality improvement

Marta Alós Ortí[1], Anskje Van Mensel[2], Babette Muyshondt[2], Roeland Samson[2], Lauri Laanisto[1]

[1]Estonian University of Life Sciences, Tartu, EE, martaalosorti@gmail.com
[2]University of Antwerp, Antwerp, BE

Cities have experienced a rapid population growth in the last decades. Consequently, air pollution has increased mainly due to emissions from business activities, heating/cooling systems and traffic. As a result, city dwellers are facing health-related problems such as respiratory difficulties. However, urban trees have been shown to be an effective tool mitigating air pollution, an important ecosystem service (ES). The aim of this study was to assess and quantify air pollution, specifically particulate matter (PM) deposition on tree leaves occurring in green urban areas, like city parks. For this purpose, we sampled 36 urban green areas differing in size and isolation located in Antwerp (Belgium). In particular, i) we used quadrats method to measure structural traits (i.e. height of the plant and diameter at breast height) of trees. ii) We measured foliage surface of each studied tree and calculated, based on leaf saturation isothermal remnant magnetization (SIRM) data (i.e. a proxy for PM accumulation) how much air pollution it can potentially mitigate. iii) We also obtained the whole foliage surface of each urban green area and based on that iv) determined the potential of each urban green area to accumulate air pollution. Our results show that urban green infrastructure is capable of removing PM from the air through deposition on leaves, but the efficiency of air pollution mitigation depends on urban park size, its vegetation structure and species present. This study contributes to better understanding how urban green areas mitigate air pollution, and provides a cost-effective way to estimate how much PM trees are able to remove from the air as well as to determine the best species selection to maintain the air quality in cities. By linking plant traits and SIRM, our study offers a comprehensive assessment of ESs patterns in urban areas.

Session 2-P6 - Urban ecosystems

Urban pollinators - Solitary bees in Freising

Julie Weissmann[1], Hanno Schäfer[1]

[1]Technische Universität München, Freising, DE, Julie.Weissmann@tum.de

The project uses a holistic approach integrating pollinators, plants and people in a large town and aims to answer three main questions: 1) How important are urban habitats for applied bee conservation? 2) How relevant is bee diversity for urban fruit crop pollination? 3) How can urban citizens become involved in urban bee research?
The study was carried out in a large town in southern Germany. Occurrence data of target specialized bee species was collected on existing and newly established flower patches throughout the city. Flower visitors were recorded through systematic observations on rosaceous fruit crops flowering throughout the season. Students and citizen scientist were trained to perform pollination observations on fruit crops and search for selected target bee species.
Occurring and newly introduced food sources are used by some of the specialized and therefore particularly vulnerable bee species. The crop flower visitor community composition varied strongly throughout the season and between plant species. Participation by urban citizens in bee identification trainings was high; the contribution through observation reports was low.
We conclude that 1) cities can contribute to target species conservation for some specialized bee species; 2) an urban food security perspective highlights the importance of protecting diverse bee communities in urban environments; 3) participative approaches in urban bee research have an educational impact but taxonomic difficulties raise specific challenges for citizen scientists.

Session 2-P7 - Urban ecosystems

The Bee City of Braunschweig: Investigating the effects of local and landscape factors on bee diversity in a city-wide experiment.

Monika Weber[1], Benjamin Arlt[1], André Krahner[1], Henri Greil[1], Tobias Jütte[1], Anke C. Dietzsch[1], Jens Pistorius[1]

[1]Julius Kühn-Institute, Braunschweig, DE, monika.weber@julius-kuehn.de

Urban habitats are becoming increasingly important for supporting native biodiversity in Germany. However, although several studies on bee diversity in cities have been conducted in the recent past, there are still considerable knowledge gaps with regard to the factors driving bee diversity across the heterogeneous landscapes within urban settlements. Furthermore, there is only a weak database guiding specific actions that aim at promoting bee and other insect populations within cities. These data are urgently needed to assist urban planners in taking the optimal decisions for conserving native biodiversity.

In a large-scale and long-term project, in collaboration with the administrative authorities of the City of Braunschweig, the JKI Institute for Bee Protection investigates the local and landscape factors underlying the spatio-temporal pattern of bee diversity in the city. In 2019, bees were sampled at more than 50 sites, covering the whole city and spanning a gradient from urban to agricultural land use. Most sites were selected as replicates on the landscape scale relevant for bees, some sites being selected for future implementation of measures improving the habitat for bee populations. These measures will be evaluated later on, taking into account the local and landscape context.

Because the city of Braunschweig is, in several aspects, representative for many German cities, the insights gained in this study will help develop urban areas towards harbours for bee diversity across Germany and beyond. The study rationale and preliminary data from the first study year will be presented.

Session 2-P8 - Urban ecosystems

Effects of high frequency electromagnetic radiation on bee development and colony growth

Felix Fornoff[1], Alain Thill[1], Gita Benadi[2], Alexandra-Maria Klein[1]

[1]Nature Conservation and Landscape Ecology, University of Freiburg, Freiburg, DE, felix.fornoff@nature.uni-freiburg.de
[2]Biometry and Environmental System Analysis, University of Freiburg, Freiburg, DE

Insect populations including bees are declining, especially in industrialized countries. Factors like climate change, habitat loss and modern agricultural practice are discussed as the main drivers. Other anthropogenic sources and low-dose toxins are less well studied. One currently controversially discussed anthropogenic factor which could potentially affect bees is the radiation of high frequency electromagnetic fields (EFMs) arising from mobile phone and Wi-Fi technologies. EFMs might directly disturb bee physiology and have subtle effects on behaviour and orientation. Until now, scientific tests of bee responses under real-world conditions have been mostly correlative and of low sample size. Here, we present the results of a field experiment at eight cell phone tower locations using mason bees and three controlled experiments using Wi-Fi routers to test the effects of electromagnetic fields on honeybee and bumblebee colony growth and mason bee larval development. We show that cell phone tower radiation neither affected nesting activities of mason bees nor colony growth in honeybee and bumblebee hives. Moreover, larval development of mason bees was not affected by the intensity of Wi-Fi radiation. In summary, our tests of multiple experimental setups under real-world and laboratory conditions revealed no effect of EMFs on this group of insects. However, our experiments are not conclusive with respect to Hymenoptera population responses, life cycle or long-term effects. A large body of literature exists that shows multiple mechanisms of electromagnetic field-driven perturbations on insects, including bee behaviour and colony responses and malfunctioning of cellular membranes especially affecting the nervous system. This, in combination with the expected increasing levels of EMF radiation due to the introduction of 5G networks suggests an urgent need for future research and monitoring of insect populations in response to modern EMF technologies.

Session 2-P9 - Urban ecosystems

The origin of urban communities – From the regional pool to community structures and composition in city

Marco Moretti[1], David Frey[1], Bertrand Fournier[2]

[1]Swiss Federal Research Institute WSL, Birmensdorf, CH, marco.moretti@wsl.ch
[2]Concordia University, Montreal, CA

The ever-expanding urban environment is affecting biodiversity and ecological processes at a global scale. Understanding of the mechanisms underlying the assemblage of species from the regional pool into urban communities will provide evidence of the key drivers acting at different spatial scales.
Here we investigate the multi-scale filtering effect of urban ecosystems on the phylogenetic and functional structure of communities of wild bees and ground beetles in three Swiss cities. We first use constrained null models to assess the effect of urban ecosystems on the regional species pool, if any. We then test the hypothesis that urban habitat heterogeneity favours the coexistence of multiple species via niche partitioning, leading to high phylogenetic and functional diversity within a small area.
We found that while urban ecosystems filter phylogenetic and functional diversities from the regional species pool mainly by selecting for communities dominated by warm and dry tolerant species, habitat heterogeneity within cities mitigates biotic homogenization at the largest spatial scale.
For the first time, we show that urban community assembly results indeed from complex filtering and complementarity processes co-occurring at different spatial scales and that urban habitat heterogeneity plays a major role in diversifying phylogenetic and functional components of urban communities. Our results provide no evidence that species assembly from the regional pool lead to biotic homogenization in urban ecosystems, but rather suggest that an efficient planning and management of urban green habitats can increase biodiversity variation in cities.

SESSION 3

Macroecology and Biogeography: Understanding generalities that shape the phylogenetic, functional and taxonomic diversity on earth

Chairs: Stefan Pinkert, Manuel Jonas Steinbauer

Aiming to understand and predict biodiversity patterns across large spatial, temporal and taxonomic scales, macroecology has become a flourishing ecological discipline at the intersection of community ecology, biogeography, functional ecology and evolutionary ecology. Because large-scale approaches simplify ecological detail and exceptions, macroecology is predestined for discovering the laws and rules that govern the biodiversity on earth: the big picture. With our session we want to provide a forum for presenting novel developments in macroecology and large-scale biogeography and discuss classical patterns as well as processes that shape large-scale patterns of the phylogenetic, functional and taxonomic diversity. Examples for topics include global island biogeography, trait-based ecology, movement ecology, ecophysiology and global change biology at large spatial or temporal scales. Contributions may be empirical, theoretical or both. We specifically encourage studies that aim to draw synthesis across different taxa, regions or facets of biodiversity. We are convinced that such synthesis is needed to understand the fundamental evolutionary and ecological processes that generate and maintain the diversity of life on Earth, which ultimately helps to guide large-scale conservation priority setting.

Session 3-O1/2 - Synthesis of large-scale biodiversity patterns

Why islands are cool, and why "complexity" is other than a convenient excuse for ecologists

Michael Krabbe Borregaard[1]

[1]University of Copenhagen, Copenhagen, DK, mkborregaard@bio.ku.dk

About 1.5 million years ago, a single species of Lupinus made it to the high Paramó of the Andes. Today there are 81 co-occurring species, making this one of the fastest radiations recorded. Why? The location of this evolutionary fireworks is no accident - the regional dynamics of climatic oscillations, the dynamic geological processes, and the existence of unusual soils deriving from uplifted oceanic crust, together conspire to create an area of high evolutionary creativity. The central point here is that Earth's life is tied to Earth itself.
Certain areas have acted as foci of evolutionary novelty, primarily oceanic islands and high mountain ranges in the tropics. The key factors seem to be the tropical climate with freedom from resource-depleted periods during the year, a dynamic geology, and structural complexity. I'll give some examples on how ecology and evolution play out on geologically dynamic areas and how complexity plays a role in this, with a focus on island and mountaintop settings. Doing this I will touch upon how we try to bridge ecological scale, e.g. in leveraging abundance data and biotic interactions for larger-scale analyses.

Session 3-O3 - Synthesis of large-scale biodiversity patterns

Integrating within-island heterogeneity into theory of island biogeography

Manuel Steinbauer[1]

[1]University of Bayreuth, Bayreuth, DE, Manuel.Steinbauer@uni-bayreuth.de

Most established theories in island biogeography are neutral as all species are treated equally and each island is integrated as one unit. MacArthur & Wilson already acknowledged this unrealistic aspect of their theory in 1967. However, it is only now where trait availability and computational power allow implementing species pool concepts that account for species-specific differences. In addition, as potential colonisers vary in their adaptation to environmental conditions, different ecozones within islands should differ in establishment probabilities of focal species.

The objective of this talk is to outline the potential of a non-neutral theory of island biogeography. Using dispersal and plant growth strategy related trait patterns within islands I will show that ecozones within islands can be quantified as distinct units. The evolutionary dynamics within the island should be influenced by these differences. Analyses of the distribution pattern of endemic species within islands provide strong support for this expectation. Further highlighting the potential of within-island studies, I will show that the differences in environmental conditions within islands can be used to test fundamental questions in biogeography as I will exemplify using the convergent evolution of secondary woodiness. Integrating within-island heterogeneity into theories in island biogeography is thus a crucial step forward.

Session 3-O4 - Synthesis of large-scale biodiversity patterns

Inter- and intraspecific variation of arthropod thermal tolerances along elevational gradients in Pakistan

Christian Hof[1], Imran Khaliq[2]

[1]Biodiversity and Global Change Lab, Terrestrial Ecology Research Group, Technical University of Munich, Freising, DE, christian.hof@tum.de
[2]Department of Zoology, Ghazi University, Dera Ghazi Khan, PK

Explanations for the spatial variation of biodiversity as well as the distribution of species often rely on the abiotic factors. Among these abiotic factors, temperature is one of the most prominent ones, as suggested by numerous studies showing strong statistical correlations between the spatial variation of e.g. species richness and temperature variables. Thermal physiology may serve as a link between ambient temperatures and species' geographical distributions, as thermal traits determine the range of temperatures under which a species can survive and thus delimit the area of suitable climatic conditions. However, the question of how thermal tolerances vary inter- and intra-specifically over space and with elevation has rarely been addressed from a multi-species and cross-taxonomic perspective. Here, we use data from physiological experiments on more than 7000 individuals of about 100 species to analyze intra- and interspecific patterns of thermal tolerances of a range of arthropod taxa along elevational gradients in Pakistan. Preliminary results suggest that microclimatic conditions influence the elevational patterns of thermal tolerances in different mountain ranges. Furthermore, thermal tolerances show considerable intra-specific variation along elevational gradients. These findings may have implications on how we perceive impacts of temperature change on species, and call for a more profound consideration of intra-specific variation in trait-based analyses. More generally, we argue that the multi-disciplinary integration of data and methods from biogeography, physiology and ecology as well as across taxonomic and spatial scales is a promising, albeit challenging, avenue towards more realistic projections of potential distributions and diversity patterns under global change.

Session 3-O5 - Synthesis of large-scale biodiversity patterns

Drivers of species richness variation of phytophagous insects among plants in Germany

Martin Brändle[1], Martin M. Gossner[2]

[1]Animal Ecology, Department of Ecology, Faculty of Biology, Philipps-Universität Marburg, Marburg, DE, braendle@staff.uni-marburg.de
[2]Forest Entomology, Research Unit Forest Health and Biotic Interactions, Swiss Federal Research Institute WSL, Birmensdorf, CH

Richness of insect assemblages on plants varies strongly and a number of attempts have been made to understand the causes of this variation. Outcomes of previous studies are however restricted by small sample sizes, incomplete taxonomic coverage, small numbers of explanatory variables and methodological restrictions. This limits generalizations. Here we analyzed the richness of insect assemblages of the vascular plants of Germany using a plant-phytophagous insect interaction data base established from a literature survey. This data base considered the phytophagous species of the most species rich insect taxa in Germany (Hemiptera, Lepidoptera, Coleoptera, Diptera, Hymenoptera, Orthoptera; overall ~ 9600 insect species). As explanatory variables we considered plant morphological, physiological, evolutionary, ecological and biogeographic traits available from public data collections (LEDA, BIOLFLOR, FloraWeb). Analyses were performed on the plant species as well as the plant genus level. Preliminary results revealed that the richness of insect assemblages increased with increasing plant distribution, plant habitat niche breadth, plant canopy height, leaf dry matter content, plant life span and increasing competitiveness. Richness of insect assemblages partly decreased with increasing specific leave area and increasing phylogenetic isolation of plants. These variables accounted consistently for more than 50% of the variation in the richness of insect assemblages. We conclude that the richness of insect assemblages on the vascular plants of Germany is largely predictable and related to number of evolutionary, biogeographic and ecological factors. Since plant distribution and canopy height accounted for the largest part of the variation, biogeographic effects and niche availability seems to be in particularly important for the richness of insect assemblages.

Session 3-O6 - Synthesis of large-scale biodiversity patterns

Congruent patterns of functional diversity in saproxylic beetles and fungi across European beech forests

Jonas Hagge[1,3], Nerea Abrego[2], Claus Bässler[3,4], Christophe Bouget[5], Antoine Brin[6], Herve Brustel[6], Morten Christensen[7], Martin M. Gossner[8], Jacob Heilmann-Clausen[9], Jakub Horak[10], Axel Gruppe[1], Gunnar Isacsson[11], Frank Köhler[12], Thibault Lachat[8,13], Laurent Larrieu[14,15], Jiri Schlaghamersky[16], Simon Thorn[17], Livia Zapponi[18], Jörg Müller[3,17]

[1]Technical University of Munich Department of Animal Sciences Chair of Zoology – Entomology, Freising, DE, jonashagge@posteo.de
[2]Department of Agricultural Sciences, University of Helsinki, Helsinki, FI
[3]Bavarian Forest National Park, Grafenau, DE, jonashagge@posteo.de
[4]Chair of Terrestrial Ecology, Technical University of Munich, Freising, DE
[5]National Research Institute of Science and Technology for Environment and Agriculture (Irstea), Nogent-sur-Vernisson, FR
[6]Université de Toulouse, Ecole d'Ingénieurs de Purpan, Toulouse, FR
[7]-, Sorø, DK
[8]Forest Entomology, Swiss Federal Research Institute WSL, Birmensdorf, CH
[9]Center for Macroecology, Evolution and Climate, Biological Institute, University of Copenhagen, Copenhagen, DK
[10]Czech University of Life Sciences Prague, Faculty of Forestry and Wood Sciences, Prague, CZ
[11]Swedish Forest Agency, Hässleholm, SE
[12]-, Bornheim, DE
[13]Bern University of Applied Sciences, School of Agricultural, Forest and Food Sciences HAFL, Zollikofen, CH
[14]UMR 1201 DYNAFOR, INRA, INPT, INPT-EI Purpan, Université de Toulouse, Tolosane, FR
[15]CRPF-Occitanie, antenne de Tarbes, Tarbes, FR
[16]Masaryk University, Faculty of Science, Department of Botany and Zoology, Brno, CZ
[17]Field Station Fabrikschleichach, Department of Animal Ecology and Tropical Biology, Biocenter, University of Würzburg, Rauhenebrach, DE
[18]Centro Nazionale per lo Studio e la Conservazione della Biodiversità Forestale

"Bosco Fontana" Carabinieri, Marmirolo, IT

Beech forests comprise a globally unique temperate forest type in Europe. The dominance of beech in these forests developed during the ongoing post-glacial northward re-colonization, concurrently with intensified forest use by humans. We investigated how these two processes together with climate shaped the patterns of functional diversity of two major species groups involved in wood decomposition and whether functional diversity is determined on the local or regional species pool level. We analysed records of 532,496 saproxylic beetles of 788 species and 8,630 records of 234 saproxylic fungal species based on sets of traits similar to both groups. The response of local functional diversity of both saproxylic beetles and fungi followed a highly congruent pattern of decreasing functional diversity towards the north, with higher elevation and, accounted for overall geographical gradients, with higher temperature, while increasing with higher precipitation. Structural equation modelling revealed that local functional diversity is determined by community changes operating on the level of the regional species pool. Our findings suggest that the functional diversity patterns of saproxylic organisms in European beech forests are mainly determined on the regional scale and driven by both anthropogenic and biogeographical processes. To conserve the variation and hotspots of functional diversity in beech forests, a comprehensive network of protected areas representing the geographical and climate range of European beech forests is necessary, including the primeval forests in the east, as started by the UNESCO World Heritage selection of "Ancient and Primeval Beech Forests of the Carpathians and Other Regions of Europe".

Session 3-O7 - Synthesis of large-scale biodiversity patterns

The signature of Quaternary climate change in patterns of species richness and endemism across Africa and its consequences for conservation

Stefan Pinkert[1], Dirk Zeuss[1], Klaas-Douwe B. Dijkstra[4], Jens Kipping[3], Viola Clausnitzer[5], Stefan Brunzel[2], Roland Brandl[1]

[1]Philipps-Universität Marburg, Marburg, DE, StefanPinkert@posteo.de
[2]University of Applied Sciences Erfurt, Erfurt, DE
[3]University of Applied Sciences Anhalt, Köthen, DE
[4]Naturalis Biodiversity Center, Leiden, NL
[5]Senckenberg Museum of Natural History Görlitz, Görlitz, DE

Many taxa show remarkable similarities in their geographical diversity patterns and these similarities are commonly used to define large-scale conservation priorities. Here we investigated the relative importance of the contemporary climate and of climate change since the last glacial maximum for determining the species richness and endemism patterns of all mammal, bird, amphibian and dragonfly species of sub-Saharan Africa. We assessed the extent to which diversity patterns are congruent across taxa because of similar responses to these two drivers and we identify the hotspots of biogeographical history. Spatial simultaneous autoregressive error models were used to decompose diversity patterns based on their relationships with the contemporary climate and Quaternary climate change. For raw and decomposed diversity patterns, cross-taxon congruence and the coverage of diversity hotspots by established protected areas were determined. We show that the species richness and endemism of all taxa increased with increasing temperature and precipitation, but also with decreasing historical climatic change. Cross-taxon congruence was higher for predictions based on the contemporary climate than on Quaternary climate change. Protected areas covered only 17–37% of the biodiversity hotspots and even fewer hotspots of biogeographical history. Our results indicate that the diversity patterns of mammal, birds, amphibians and dragonflies across sub-Saharan Africa are jointly shaped by the contemporary climate and by Quaternary climate change. However, similar responses of taxa to the contemporary climate have resulted in high cross-taxon congruence in diversity patterns, despite differences in the underlying biogeographical histories of the taxa. While current conservation strategies emphasize regions with many species and high concentrations of endemic species, they less effectively protect hotspots of the biogeographical history. Moreover, coverage is biased towards mammals and birds. Therefore, our results highlight the potential of using diversity-climate relationships to identify conservation important areas and the need to improve the protection of biogeographically unique species.

Session 3-O8 - Synthesis of large-scale biodiversity patterns

Temperature shapes opposing latitudinal gradients of plant taxonomic and phylogenetic β diversity

Ian McFadden[1,2], Brody Sandel[3], Constantinos Tsirogiannis[4], Naia Morueta-Holme[5], Jens-Christian Svenning[4], Brian Enquist[6], Nathan Kraft[2]

[1]WSL Birmensdorf and ETH Zürich, Zürich, CH, ian.mcfadden@wsl.ch
[2]University of California, Los Angeles, Los Angeles, US, ian.mcfadden@wsl.ch
[3]Santa Clara University, Santa Clara, California, US
[4]Aarhus University, Aarhus, DK
[5]University of Copenhagen, Copenhagen, DK
[6]University of Arizona, Tucson, US

Latitudinal and elevational richness gradients have received much attention from ecologists but there is little consensus on underlying causes. One possible proximate cause is increased levels of species turnover, or β diversity, in the tropics compared to temperate regions. Here, we leverage a large botanical dataset to map taxonomic and phylogenetic β diversity, as mean turnover between neighboring 100 × 100 km cells, across the Americas and determine key climatic drivers. We find taxonomic and tip-weighted phylogenetic β diversity is higher in the tropics, but that basal-weighted phylogenetic β diversity is highest in temperate regions. Supporting Janzen's 'mountain passes' hypothesis, tropical mountainous regions had higher β diversity than temperate regions for taxonomic and tip-weighted metrics. The strongest climatic predictors of turnover were average temperature and temperature seasonality. Taken together, these results suggest β diversity is coupled to latitudinal richness gradients and that temperature is a major driver of plant community composition and change.

Session 3-O9 - Synthesis of large-scale biodiversity patterns

A global synthesis reveals general effects of ecosystem decay on multiple components of biodiversity in habitat remnants

Felix May[1], Shane Blowes[2], Tiffany Knight[2], Katharina Gerstner[2], Jonathan Chase[2]

[1]Leuphana University Lüneburg, Lüneburg, DE, felix.may@leuphana.de
[2]German Centre for Integrative Biodiversity Research (iDiv), Halle-Jena-Leipzig, DE

Although land use changes and the resulting habitat loss have been the predominant factors leading to biodiversity loss in the Anthropocene, exactly how this loss manifests remains a central debate in ecology and conservation biology. One hypothesis – random sampling – purports that species are lost in proportion to their abundance and distribution in undisturbed (semi)-natural habitats. The other hypothesis – ecosystem decay – assumes that there are significant changes of ecological demographic processes in smaller habitats, such that more biodiversity is lost than would have been expected simply by the loss of habitat area. Unfortunately, rigorous tests of these hypotheses and syntheses across studies are often confounded, because of heterogeneous sampling designs and spatial scales. Furthermore, most previous focus on species richness only, although this is highly sensitive to sampling effort and scale, and just constitutes one aspect of the multidimensional nature of biodiversity. Here, we analyzed an extensive database on more than 100 community-level abundance patterns of multiple taxa in fragmented landscapes. While random sampling certainly plays a role, our multidimensional analyses showed overriding support for the ecosystem decay hypothesis. This means that smaller habitat fragments contain fewer individuals, fewer species, and less even communities than would be expected from a random sample of larger fragments. Furthermore, we found that some proportion of the species in smaller habitats were not present in larger habitats, suggesting that species turnover (likely from habitat generalists) partially buffered this overall effect. We suggest that the incorporation of such disproportionate effects will improve projections for how habitat loss will lead to biodiversity loss, and provides a framework for habitat protection and restoration.

Session 3-O10 - Synthesis of large-scale biodiversity patterns

Worldwide and host-dependent variation in fungal endophyte diversity in twigs of eleven tree genera

Iva Franić[1,2,3], Simone Prospero[2], Kalev Adamson[4], Eric Allan[3], Fabio Attorre[5], Marie-Anne Auger-Rozenberg[6], Sylvie Augustin[6], Dimitrios Avtzis[7], Wim Baert[8], Marek Barta[9], Kenneth Bauters[8], Amani Bellahirech[10], Piotr Boroń[11], Helena Bragança[12], Tereza Brestovanská[13], May Bente Brurberg[14], Treena Burgess[15], Daiva Burokienė[16], Michelle Cleary[17], Juan Corley[18], David R Coyle[19], György Csóka[20], Karel Černý[13], Kateryna Davydenko[21], Maarten de Groot[22], Julio J Diez[23], Hatice Tuğba Doğmuş Lehtijärvi[24], Rein Drenkhan[4], Mohamed Elsafy[17], Csaba Béla Eötvös[20], Jianting Fan[25], Ágnes Fürjes-Mikó[20], Bartłomiej Grad[11], Martin Hartmann[26], Ludmila Havrdová[13], Markéta Hrabětová[13], Mathias Just Justesen[27], Magdalena Kacprzyk[11], Natalia Kirichenko[6,28,29], Volodymyr Kramarets[30], Nikola Lacković[31], Jelena Lazarević[32], Marianna Leskiv[30], Hongmei Li[33], Corrie Lynne Madsen[27], Chris Malumphy[34], Marta Matek[31], Dinka Matošević[31], Iryna Matsiakh[30], Johan Meffert[35], Duccio Migliorini[36], Christo Nikolov[37], Richard O Hanlon[38], Funda Oskay[39], Trudy Paap[40], Taras Parpan[41], Barbara Piškur[22], John Richard[42], Anne Ronse[8], Alain Roques[6], Karolis Sivickis[16], Venche Talgø[14], Maria A Tomoshevich[43], Anne Uimari[44], Michael Ulyshen[45], Anna Maria Vettraino[46], Caterina Villari[47], Yongjun Wang[25], Johanna Witzell[17], Milica Zlatković[48], René Eschen[1]

[1]CABI, Delémont, CH, i.franic@cabi.org
[2]Swiss Federal Institute for Forest, Snow and Landscape Research WSL, Birmensdorf, CH, i.franic@cabi.org
[3]Institute of Plant Sciences, University of Bern, Bern, CH, i.franic@cabi.org
[4]Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, Tartu, EE
[5]Department of Environmental Biology, Sapienza University of Rome, Rome, IT
[6]French National Institute for Agricultural Research (INRA), URZF, Orléans, FR
[7]Forest Research Institute, Hellenic Agricultural Organization – Demeter, Thessaloniki, GR
[8]Meise Botanic Garden, Meise, BE
[9]Slovak Academy of Sciences Arboretum Mlynany, Slepcany, SK
[10]National Research Institute of Rural Engineering, Water and Forests (INRGREF), Ariana, TN
[11]Institute of Forest Ecosystems Protection, University of Agriculture in Krakow, Krakow, PL
[12]Instituto Nacional de Investigação Agrária e Veterinária I. P. (INIAV I. P.), Oeiras, PT
[13]Silva Tarouca Research Institute for Landscape and Ornamental Gardening, Pruhonice, CZ
[14]NIBIO, Norwegian Institute of Bioeconomy Research, Ås, NO

[15]Murdoch University, Perth, AU
[16]Institute of Botany at the Nature Research Centre, Vilnius, LT
[17]Southern Swedish Forest Research Centre, Swedish University of Agricultural Sciences, Alnarp, SE
[18]Instituto Nacional de Tecnología Agropecuaria (INTA), Bariloche, AR
[19]Department of Forestry and Environmental Conservation, Clemson University, Clemson, US
[20]NARIC Forest Research Institute, Mátrafüred, HU
[21]Ukrainian Research Institute of Forestry and Forest Melioration, Kharkiv, UA
[22]Slovenian Forestry Institute, Ljubljana, SI
[23]Universidad de Valladolid, Palencia, ES
[24]Isparta Applied Science University, Isparta, TR
[25]Zhejiang A & F University, Linan, CN
[26]Institute of Agricultural Sciences, ETH Zürich, Zürich, CH
[27]Department of Geosciences and Natural Resource Management, University of Copenhagen, Copenhagen, DK
[28]Sukachev Institute of Forest, Russian Academy of Sciences, Siberian Branch, Krasnoyarsk, RU
[29]Siberian Federal University, Krasnoyarsk, RU
[30]Ukrainian National Forestry University, Lviv, UA
[31]Croatian Forest Research Institute, Jastrebarsko, HR
[32]Biotechnical Faculty, University of Montenegro, Podgorica,
[33]CABI, Beijing, CN
[34]Fera Science Ltd, National Agrifood Innovation Campus, York, UK
[35]National Plant Protection Organisation, Netherlands Food and Consumers Product Safety Authority, Ministry of Agriculture, Nature and Food Quality, Wageningen, NL
[36]Institute for Sustainable Plant Protection (IPSP), National Research Council C.N.R., Sesto Fiorentino, IT
[37]National Forest Centre, Forest Research Institute, Zvolen, SK
[38]The Agri-Food & Biosciences Institute (AFBI), Belfast, UK
[39]Faculty of Forestry, Çankırı Karatekin Üniversitesi, Cankiri, TR
[40]Forestry and Agricultural Biotechnology Institute (FABI), University of Pretoria, Pretoria, ZA
[41]Ukrainian Research Institute of Mountain Forestry, Ivano-Frankivsk, UA
[42]Tanzania Forestry Research Institute (TAFORI), Lushoto, TZ
[43]Central Siberian Botanical Garden, Russian Academy of Sciences, Siberian Branch, Novosibirsk, RU
[44]Natural Resources Institute Finland, Suonenjoki, FI
[45]USDA Forest Service, Southern Research Station, Athens, US
[46]DIBAF, University of Tuscia, Viterbo, IT
[47]D.B. Warnell School of Forestry & Natural Resources, University of Georgia,

Athens, US
[48]Institute of Lowland Forestry and Environment, University of Novi Sad, Novi Sad, RS

Arboreal fungal endophytes are a highly diverse group of organisms associated with asymptomatic tissues and some of them are latent pathogens. The knowledge of fungal endophytes is limited, because previous studies mainly focused on foliar fungal endophytes of a limited number of host species and locations. We assessed the fungal endophyte diversity in twigs of congeneric native and exotic tree species belonging to eleven angiosperm and gymnosperm genera in mostly temperate regions of 32 countries on six continents. We describe how host taxonomy and geographic location affect endophyte diversity and how diversity differs between native and exotic trees. More than 400 samples were collected on both hemispheres and fungal communities were assessed by high-throughput sequencing. Sampling was done in winter, because trees are mostly traded in winter, when deciduous trees lack foliage. We found around 15,000 fungal Exact Sequence Variants (ESVs) associated with the tree genera. ESV richness varied among sampled taxa, but did not differ between native and exotic hosts. ESV richness in most of the northern hemisphere tree genera peaked at 45-50 degrees of latitude, but the pattern for southern hemisphere genera was not clear. The endophyte communities of angiosperms and gymnosperms differed; around 30% of all ESVs were found in a single genus and less than 1% was found in all genera. Distinct geographic patterns among and within continents were found and the similarity of the endophyte communities decreased with distance between sampling locations in most genera. This study reveals fungal endophyte diversity on an unprecedented scale as a result of the wide geographic and taxonomic diversity of the samples. The geographic differences in ESVs in particular suggest that international live plant trade can facilitate the exchange of geographically isolated fungal communities, which could threaten tree-based resources in importing countries.

Session 3-P1 - Synthesis of large-scale biodiversity patterns

How well can space replace time for predicting the response of grassland plant communities to 10yrs of land use change?

Lena Neuenkamp[1], Hugo Saiz Bustamante[1], Caterina Penone[1], Daniel Prati[1], Eric Allen[1], Markus Fischer[1]

[1]University Bern, Bern, CH, lena.neuenkamp@ips.unibe.ch

A central question in global change research is how biodiversity is changing in the Anthropocene. Although it is agreed that biodiversity is declining at the global scale, recent syntheses of time series data have suggested that local biodiversity may not be declining consistently. These results are sparking a vigorous debate and are in stark contrast to studies using space-for-time substitutions, where e.g. a spatial gradient inland use intensity is used as a proxy of intensification effects over time. There are several reasons for the mismatch: time series approaches may underestimate declines if they are too short and missing a correct baseline, if they include a biased sample of sites or confounding factors. It has also been suggested that space-for-time approaches might better capture variation in aggregate community properties such as richness or biomass, than the abundance of individual species. Very few studies have compared space-for-time and time series approaches and the Biodiversity Exploratories present a unique opportunity to fill this gap of knowledge. They principally use space-for-time substitution to test for land use effects on diversity but they have also generated time series of plant and insect diversity and land use intensity on 300 plots. Using 10 years of Biodiversity Exploratories data we tested whether the magnitude of response of 150 grassland communities to changes in land use intensity is similar across time and space, and whether space-for-time substitutions predict temporal trends in aggregate properties like plant diversity, composition or biomass better than trends of individual species? Our preliminary results of comparing responses to spatial and temporal shifts in land use intensity show that temporal trends in land-use response of individual species and aggregated community properties exist, but that spatial trends are more pronounced than temporal trends. The final outcomes of this cross-correlation analysis will provide an important comment on a key current issue in global change research, namely the accuracy of predicting temporal trends in community change from spatial gradients and potential application of conversion factors to adjust for differences between temporal and spatial trends in predictions.

A decreasing plant species richness-altitude relationship in Tenerife: functional traits as tools to reveal underlying mechanisms

Amanda Ratier Backes[1,2], Christine Römermann[2,3], Tiffany M. Knight[1,2], Jake M. Alexander[4], Sylvia Haider[1,2]

[1]Martin Luther University Halle-Wittenberg, Halle (Saale), DE, amandaratier@gmail.com
[2]German Centre for Integrative Biodiversity Research (iDiv) Halle-Jena-Leipzig, Leipzig, DE, amandaratier@gmail.com
[3]Friedrich Schiller University Jena, Jena, DE
[4]Swiss Federal Institute of Technology (ETH Zurich), Zurich, CH

Species richness (SR) patterns along altitudinal gradients have been investigated since the 19th century by early naturalists. Yet, the mechanisms determining these patterns remain poorly understood. Here we propose a novel approach that uses plant functional traits as a tool to test different mechanisms by looking at changes of community weighted means (CWMs) and functional diversity over these gradients.
In this study we looked at SR of native and non-native plants along three altitudinal gradients in Tenerife in plots next to and 50 m away from roads. Since SR decreased with altitude, species-area relationships (SAR) and abiotic filtering (by temperature) were candidate theories to explain the observed pattern. We translated these theories into assumptions regarding CWMs and functional diversity (FD, measured as functional richness), and tested them using trait data collected in the field.
If the main mechanism shaping SR is climatic filtering through decreasing temperature with altitude, we expected with increasing environmental harshness negative relationships for CWMs of traits associated with acquisitive strategies, and positive relationships for CWMs of traits related to conservative strategies. On the other hand, we did not expect any trend for CWMs for SAR. For both mechanisms, we expected FD to be positively correlated with temperature and area, respectively.
We found an increase of FD with temperature and area, supporting both mechanisms. Looking at CWMs, we found that increasingly low temperatures at higher altitudes were related to communities with low SLA, low leaf Mg and high leaf C concentrations, confirming our expectations for climatic filtering. This points out that environmental filtering is an important mechanism for shaping the altitudinal SR pattern on Tenerife.
This trait-based approach proved to be a promising tool for testing different mechanisms generating an altitudinal SR pattern and can be further applied to other SR-altitude relationships.

Session 3-P3 - Synthesis of large-scale biodiversity patterns

Latitudinal pattern in predation, herbivore performance and herbivory in hostile and enemy free space

Katerina Sam[1], Sara Fernandez Garzon[1], Jan Kollross[1], Marketa Tahadlova[1], Martin Libra[1], Sam Finnie[1], Matthias Weiss[1], Legi Sam[1], Rachakonda Sreekar[1]

[1]Biology Centre CAS, Ceske Budejovice, CZ, katerina.sam.cz@gmial.com

It is well recognized that predators can enhance plant growth by reducing herbivore abundance. Yet the strength of such trophic cascades has been found to be quite variable both within and between communities. We hypothesise that birds, bats and ants are important predators of arthropods. However, their relative importance differs along large gradients. We also expect, that the importance of predators differs in forest canopies and understories, due to different productivity.
We conduct exclosure experiments at six sites in Japan, China, Malaysia, Papua New Guinea, and at two sites in Australia. We exclude ants, birds, bats separately and in combinations from saplings and forest canopies and complete experiment with work on control saplings. We protect saplings by nets (against birds and/or bats) and by tangle foot (against ants). We survey insect communities and herbivorous damage every four months. Further, we complete our experiments with surveys of focal predators. At several study sites, bats and ants do not seem to affect arthropod communities significantly. Birds seem to be the most important predators at many studied sites. We argue that the strength of the top down control can't be considered without the bottom up control (i.e. plant defences and species identity). We conclude that stable arthropod populations are maintained low by natural enemies of various importance along gradients. Disruption on communities of natural enemies has the potential to allow arthropods to reach high levels, resulting in extensive herbivorous damage.

SESSION 4

**Ecological stoichiometry -
a unifying theory across ecosystem compartments**

Chairs: Ute Hamer, Till Kleinebecker, David Ott

Ecological stoichiometry is a powerful tool to improve the mechanistic understanding of nutrient dynamics and related ecosystem functions across ecosystem compartments. The growth of organisms, the structure of food webs and the cycling of nutrients are regulated by the balance or imbalance of multiple chemical elements. The input of nutrients into terrestrial and aquatic ecosystems is increasing globally and this is projected to accelerate in the next decades. Thus, understanding the complex interactions between several co-occurring above- and belowground matter transformation processes towards changes in nutrient resources will enable us to predict the response of ecosystems towards global change phenomena. We welcome contributions from a broad range of ecological disciplines (e.g. plant ecology, animal ecology, soil ecology, marine ecology, ecohydrology).

Session 4-O1/2 - Ecological stoichiometry

Stoichiometric constraints on responses to global change: linking matter and energy flow

Helmut Hillebrand[1,2]

[1]University Oldenburg, Wilhelmshaven, DE, hillebrand@icbm.de
[2]Helmholtz Institute for Functional Marine Biodiversity, Oldenburg, DE, hillebrand@icbm.de

Ecological stoichiometry (ES) has become one of the most pervasive theoretical frameworks in environmental sciences and biology in the last two decades. ES allows predicting processes on all organizational levels from subcellular structures to ecosystems by relating the elemental composition and demand of organisms to the relative availability of resources. However, beyond this, ES also allows to understand (and to predict) responses to global change such as warming and altered biogeochemical cycles. Based on a range of experimental and observational studies, I will address how the effects of higher temperature differ in resource limited conditions from resource replete, as temperature alters resource demand and incorporation. Moreover, I will shed light on how resource incorporation varies between species and within species, making resource use efficiency (RUE) a master trait for understanding the functional link between biodiversity and ecosystem functions.

Session 4-O3 - Ecological stoichiometry

Stoichiometric constraints on phytoplankton resource use efficiency in monocultures and mixtures

Maren Striebel[1], Franziska Frank[1], Michael Danger[2], Helmut Hillebrand[1,3]

[1]Institute for Chemistry and Biology of the Marine Environment, Carl von Ossietzky University of Oldenburg, Wilhelmshaven, DE, maren.striebel@uni-oldenburg.de
[2]Université de Lorraine, CNRS, LIEC, Metz, FR
[3]Helmholtz-Institute for Functional Marine Biodiversity at the University of Oldenburg, Oldenburg, DE

A central concept for understanding the mechanisms linking diversity and primary production or more general, ecosystem functioning, is resource use efficiency (RUE). It quantifies the amount of biomass production over time relative to unit resource supplied, i.e. represents a quota of matter use efficiency. Given anthropogenic alterations of biogeochemical cycles, the consequent changes in supply rate and especially supply ratio of nutrients will change. Using four species of freshwater phytoplankton, and their mixture, we asked how the RUE for nitrogen and phosphorus depends on the stoichiometry of resource supply and how this differs between single species and their mixture. We conducted a factorial laboratory experiment spanning 25 different nutrient supply treatments with differing absolute and relative nitrogen (N) and phosphorus (P) concentrations. N and P supply increased biomass production and decreased C:nutrient ratios and RUE for the respective nutrient, but always significantly affected by the supply of the respective other nutrient. Biomass peaked at molar N:P supply ratios above the Redfield ratio. Species tended to respond similarly to the resource gradients. Consequently, mixtures outperformed the component species only during early growth responses, but not regarding maximum biomass and RUE. Bioassays performed at the end of the main experiment revealed predominance of N-limitation, but again strongly depending on the interaction between both nutrient gradients. Our study suggests that stoichiometric constraints of resource incorporation and RUE need to be accounted for when studying the response of phytoplankton to natural and anthropogenic variation in resource availability.

Session 4-O4 - Ecological stoichiometry

Stoichiometric relations in plankton communities along the West Antarctic Peninsula

Christoph Plum[1], Philipp Wenta[1], Dominik Bahlburg[1], Stefanie Moorthi[1]

[1]University of Oldenburg, Wilhelmshaven, DE, c.plum@uni-oldenburg.de
[2]Institute for Chemistry and Biology of the Marine Environment

Climate changes along the West Antarctic Peninsula (WAP) have resulted in shifts in krill and salp populations as well as phytoplankton composition. Krill and salps represent the most important macrozooplankton grazers at the WAP but differ profoundly in feeding biology, population dynamics, excretion rates and stoichiometric demands. Changes in dominance of these grazers may have strong potential to further alter phytoplankton composition and resource stoichiometry with subsequent consequences for the elemental composition of the phytoplankton community. Elemental composition of herbivores and phytoplankton represents an ecophysiological trait that has a strong potential to modify food web dynamics and biogeochemical cycling. However, our knowledge on stoichiometric relations in planktonic food webs of remote ecosystems such as the West Antarctic Peninsula is limited.
The aim of this study is to identify spatial differences in phytoplakton stoichiometry at the WAP ecosystem in relation to grazer abundance phytoplankton composition and distribution. To assess these relations, we sampled 10 stations around Elephant Island and the South Shetland Islands during a field survey aboard the RV Polarstern in austral summer 2018. Spatial differences in phytoplankton stoichiometry were observed and assigned to resource availability and spatial patterns of dominant macrograzers.
The outcome of this study will foster our knowledge of potential consequences of shifts in plankton community composition on food-web dynamics and stoichiometric interactions.

Session 4-O5 - Ecological stoichiometry

Nutrient deficiency induces a shift in the silicon to carbon balance in plant tissue

Vanessa Minden[1,3], Jörg Schaller[2], Harry olde Venterink[3]

[1]Landscape Ecology Group, Institute of Biology and Environmental Sciences, University of Oldenburg, Oldenburg, DE, vanessa.minden@uni-oldenburg.de
[2]Environmental Geochemistry, Bayreuth Center for Ecology and Environmental Research (BayCEER), University of Bayreuth, Bayreuth, DE
[3]Department of Biology, Ecology and Biodiversity, Vrije Universiteit Brussel, Brüssel, BE, vanessa.minden@uni-oldenburg.de

Various studies have shown a functional relationship between plant silicon (Si) and plant performance. Accumulation of Si in plant tissue alleviates physical stress, such as drought and UV radiation, as well as chemical stress like salt stress and metal toxicity. It also enhances the resistance of plants to diseases and suppresses pests such as phytophagous insects.
It has been suggested that Si-accumulating species (e.g. Poaceae species) evolved under low CO_2 levels, and substituting carbon (C) with Si gave those species a competitive advantage over species which lacked this competence. Indeed, studies have shown that when C acquisition is limited (i.e. under low CO_2 or low light conditions), Si is favored over carbon, as its uptake is energetically less expensive. It is less known if nutrient limitation also induces an increase of Si content in plant tissue. We investigated if plants take up more Si instead of C under nutrient limited conditions. In a greenhouse experiment, we exposed *Holcus lanatus* plants to nitrogen (N) and phosphorus (P) limited conditions, as well as balanced nutrient concentrations. We measured plant growth and concentrations of Si, C, N, P and their ratios in plant organs, as well as traits known to respond to nutrient availability, such as total root length and phosphatase activity. Under nutrient limited conditions, plants allocated significantly less C and more Si in leaf, stem and root tissue than under balanced nutrient conditions. Plant growth was lower under nutrient limited conditions than under balanced nutrient conditions, with lowest growth rate under P limitation. Our results indicate a significant role of Si in plant responses toward nutrient availability and suggest that the ability to use Si to substitute C may play an important role in plant performance under nutrient limitation. Hence, although Si is considered a non-essential element for plant growth, it may affect nutrient use efficiency and competition among plants.

Session 4-O6 - Ecological stoichiometry

Macronutrient ratio homeostasis of grassland plant species along a land-use intensity gradient

Verena Busch[1], Lukas Heiland[2], Till Kleinebecker[1]

[1] Justus-Liebig-Universität Gießen, Gießen, DE, verena.busch@umwelt.uni-giessen.de
[2] Universität Regensburg, Regensburg, DE

In Central European grasslands land-use intensification is causing overall species loss. Nutrient concentrations in foliar biomass of 3 vascular plant species predominantly occurring at low, medium and high land-use intensities, respectively, were recorded across 150 managed grassland plots in three regions in Germany. The variation of foliar nutrient ratios (N, P, C:N, C:P and N:P) was evaluated dependent on respective soil nutrient ratios along a land-use intensity gradient. Species declining in view of high land-use intensity displayed reduced homeostatic regulation on P, C:P and N:P ratios, indicating excess uptake of P and slow growth rates. Species profiting from high land-use intensity were significantly more homeostatic with regard to phosphorus ratios, indicating P limitation and increased growth rates. Results indicate that species reacting negatively to high land-use intensity may persist in grassland communities where phosphorus is limiting fast-growing plant species productivity.

Session 4-O7 - Ecological stoichiometry

Grasshoppers induced acceleration of C and N cycling in N-limited pasture system

Karin Potthast[1], Stefanie Meyer[2], Alexander Tischer[1], Gerd Gleixner[3], Anna C. Crecelius[4,5], Ulrich S. Schubert[4,5], Beate Michalzik[1]

[1]Friedrich-Schiller-Universität/Institut für Geographie/Bodenkunde, Jena, DE, karin.potthast@uni-jena.de
[2]Medical Center LMU Munich, München, DE
[3]MPI for Biogeochemistry, Research Group of Molecular Biogeochemistry, Jena, DE
[4]Friedrich-Schiller-Universität Jena/Laboratory of Organic and Macromolecular Chemistry (IOMC), Jena, DE
[5]Friedrich-Schiller-Universität/Jena Center for Soft Matter (JCSM), Jena, DE

Ecosystem disturbances like insect pests induce time and space limited process heterogeneity that allow to quantify changes in biogeochemical reaction rates. Insect pests are known to impact element and organic matter (OM) cycling in ecosystems by defoliation and deposition of fecal material. To study these effects on OM and nutrient cycling in a N-limited pasture system under herbivore attack, a laboratory mesocosm experiment with grass (*Dactylis glomerata)* and grasshoppers (*Chorthippus dorsatus)* was conducted. Focus was given to the short-term impact (5 days) of herbivory on the abundance of OM along a plant-herbivore-excretions-soil solution pathway. $^{13}CO_2$ pulse-labelling, together with labeled ^{15}N feces were used to trace the fate of C and N in above- and belowground biomass, feces, bulk soil, soil microbial biomass and soil solutions.
As a result of herbivory, aboveground grass biomass was reduced by about 34% within 5 days. Linear mixed effects model revealed that herbivory enhanced total dissolved N amounts in throughfall solutions by a factor of 5 to 8 ($p < 0.05$). In total, 76.1% of the initial feces-N was translocated from above- to the belowground system. Furthermore, a significant enrichment of ^{15}N in roots led to the assumption that feces-^{15}N was rapidly taken up by roots to compensate for frass-induced N losses in N-limited pastures. The total amount of soil microbial biomass was not influenced by herbivory, however, compared to the "label only" treatment a lower amount of freshly assimilated C (^{13}C) was found in their biomass. In the present study, herbivory slightly reduced C- and N translocations in soil solutions due to a rapid plant-N-uptake, confirming that grasshoppers function as ecosystem drivers. In conclusion, in N–limited pastures heavy insect herbivory could lead to greater impacts on belowground nutrient cycling processes with accelerated nutrient availability and stronger plant-microbe nutrient competitions in the short-term.

Session 4-O8 - Ecological stoichiometry

Nutrient recycling and the contribution of wood versus leaves to tree nutrient budgets

Martyna Kotowska[1]

[1]University of Göttingen, Göttingen, DE, mkotows@gwdg.de

While the role of nutrient recycling and translocation from senescent leaves has been long recognized, the contribution of other tissues such as wood to the whole-plant budget remains unclear. We hypothesize that in woody plants the translocation of nutrients from sapwood becoming heartwood will play an increasing role particularly in nutrient-poor habitats and with increasing tree size. Based on fieldwork and experimental data acquired from several subtropical and tropical tree species of South-Eastern Australia and Indonesia, we (i) investigate the contribution of leaves, bark, branch and stem wood to the annual tree budget by collecting data on leaf and branch turnover, stem growth, and nutrient contents of living and senescent tissues and (ii) attempt to estimate whether with increasing tree size wood nutrient requirement will overtake nutrient cost for leaf replacement combining functional trait data with modeling approaches. In addition, to understand the potential plasticity in wood anatomical traits related to nutrient availability, the tissue fractions of parenchyma in wood was studied in the field and in five selected species growing under controlled conditions. First results suggest that the contribution of wood to the whole-tree budget depends linearly on the tree height with average tree sizes where leaf replacement and wood construction are contributing in equal shares at around 8.0 m for nitrogen and 10.6 m for phosphorus. Thus, the availability and the actual cost of de-novo nutrient uptake might be constraining the potential tree height and consequentially shaping the vegetation type as a major influencing factor. Nonetheless, in our dataset soil nutrient status does not influence the relative contribution of wood to total budgets significantly as well as the nutrient requirements for replacing a certain leaf area when including leaf lifespan data. Further, neither axial nor total parenchyma fractions were strongly related to tissue and soil nutrient concentrations. By trying to generalize the framework of nutrient budgets in woody plants, we hope to better understand the trade-off between costs and benefits of adaptive strategies and to which extent these properties can be modified along geophysical gradients.

Session 4-O9 - Ecological stoichiometry

Effects of plant-derived dissolved organic matter on soil microbial C:N:P stoichiometry

Alexander Tischer[1], Karin Potthast[1], Ute Hamer[2]

[1]Friedrich-Schiller-Universität/Institut für Geographie/Bodenkunde, Jena, DE, alexander.tischer@uni-jena.de
[2]Westfälische-Wilhelms-Universität Münster/Institute für Landesschaftsökologie, Münster, DE

There is an ongoing debate on the flexibility of soil microbial C:N:P stoichiometry. Most studies claim that microbial stoichiometry appears to be relatively fixed with no or only minor alterations as resource stoichiometry changes. In contrast, only a small proportion of studies demonstrated significant flexibility in microbial stoichiometry and linked this with alterations in microbial physiology and microbial community composition. In the present account, we tested how soil microbial C:N:P ratios respond to the addition of plant-derived dissolved organic matter (pDOM) with presumably high C and nutrient availability. We incubated topsoil material from two different land-use conditions: 1) a fertile and biological active pasture and 2) a degraded and abandoned pasture; both differing in soil chemical conditions and microbial community composition. Plant-derived OM was obtained by extracting material from the leaves of the dominant grass species of the active pasture site (*Setaria sphacelata*, C4-plant) and the dominant species of the abandoned pasture (*Pteridium arachnoideum*, C3-plant). pDOM were added and soils were incubated for 28 days. The CO_2-amount as well as d^{13}C-signature of released CO_2 were monitored in order to quantify microbial activity and resource use. Before and at the end of incubation microbial C, N, and P were quantified (FUMEX-method) and microbial community structure was characterized (PLFA-method). The results indicate a significant increase in microbial P, a slight increase in C while N remained unaffected. Overall, these alterations led to shifts in microbial C:P and N:P and pointed to flexibility of microbial stoichiometry. These alterations were accompanied with the preferential use of plant-derived DOM over soil-derived OM and shifts in the abundance of specific PLFA-marker indicating either alterations in microbial community composition or microbial physiology in concert with variable microbial stoichiometry.

Session 4-P1 - Ecological stoichiometry

Importance of P limitation for the C:N:P ratio in *Robinia* plantations on marginal sites

Stella Gypser[1], Maik Veste[2]

[1]Brandenburg University of Technology Cottbus-Senftenberg, Chair of Soil Protection and Recultivation, Cottbus, DE, stella.gypser@b-tu.de
[2]Brandenburg University of Technology Cottbus-Senftenberg, Chair of Ecology, Cottbus, DE

Due to disturbances of soils after open-cast lignite mining activities in the Lusatian mining district, Northeast Germany, large areas covered with excavated and dumped material. These initial soils are characterized by a lack of nutrients and organic matter which is why *Robinia pseudoacacia* was established during reclamation of those marginal sites. As a pioneer species, *Robinia* is well suitable for the establishment on reclaimed forest ecosystems due to the N fixation capability and its ability to grow on a nutrient-poor sandy substrate with low water holding capacity. Since the N requirement of the *Robinia* can be covered by symbiotic nodule bacteria, P is important as a growth-limiting nutrient. Even though the total and available P in soils increased with the age of the plantings (planted between 1995 and 2007), the ratio of available to total P decreased relative to younger plantings. Despite the accumulation of organic matter and the decomposition of organic bound P, the bioavailability is affected by ad- and desorption processes, especially on Fe- and Al-hydroxides. It was hypothesized that the P demand of young trees, initially provided by a one-time fertilizer application, exceeds the P supply by mineralization over time. As a first step, kinetics of P desorption from synthetic Fe- and Al-hydroxides were characterized by using humic acid as a model organic compound, to detect fast and slow releasable P over time. At the *Robinia* sites, soil samples were examined at different depth with regard to their C, N and P concentrations. From the first results, we can conclude that the P availability and its limitation influences the growth performance of *Robinia* as well as the N-fixing symbiotic bacteria and, thus, the C:N:P ratio as a long-term effect on an ecosystem scale.

Session 4-P2 - Ecological stoichiometry

Carbon, nitrogen and phosphorus stocks in soil and aboveground biomass of forest areas of the Northeastern Atlantic Forest, state of Alagoas, Brazil

Silvia Rafaela Lins[1], Luiz Antonio Martinelli[2]

[1]Universidade Federal de Pernambuco - UFPE, Recife, BR, silviarafaela@gmail.com
[2]Universidade de Sao Paulo - USP, Piracicaba, BR

As the secondary forest areas increase worldwide, it also increases the recognition of these forests and all disturbed forests as carbon (C) reservoirs. One of the first steps to evaluate the role of forests as a reservoir is to conduct a forest inventory to determine forests C pools. In order to investigate soil C, nitrogen (N) and phosphorus (P) concentrations and stocks in soil and vegetation in the highly fragmented areas of the Brazilian Northeastern Atlantic Forest, plots were established in four 0.4-ha chronically disturbed forest areas, and one 0.4-ha restored area. In all areas, soil concentrations and stocks of the elements were determined at the depth intervals of 0-10, 10-20, 20-30 cm, in addition to trunks sampling from the bigger trees. Soil C stocks were similar to those found in other tropical forests of Brazil. The aboveground C stock was comparable with lowland physiognomy of the Brazilian Southeastern Atlantic Forest, and lower than submontane and montane physiognomies, which has a higher aboveground biomass. Above and belowground stocks of N were also similar to other Neotropical forests. The belowground soil stocks of available P_{resin} was comparable the Brazilian Southeastern Atlantic Forest, and aboveground P stocks were lower. The results from this study show that apparently chronic disturbances have not disrupted the organic matter input to the soil in the areas. Concluding that these forests hold large amount of C in the soil. In addition, the areas seems to be N-rich as other tropical forests. P results emphasize the importance of the P in these forests.

SESSION 5

Theoretical and empirical approaches to enhance our current niche concept

Chairs: Oliver Krüger, Jürgen Gadau

Over the last two decades, individualisation has emerged as a powerful concept in both behaviour and ecology. Whether indiviodual niche specialisation or even niche construction, such concepts have been regarded as important, critical and overlooked components of both evolutionary as well as ecological processes. These views are intensively and critically debated within the scientific community. In this symposium, we want to invite speakers who will present both theoretical and empirical aspects of recent modifications of a corner stone of ecological theory: the niche concept.

Session 5-O1 - Niche concept

An integrative conceptual framework across behaviour, ecology and evolution: individualised niches

Oliver Krüger[1]

[1]Department of Animal Behaviour, Bielefeld University, Bielefeld, DE, oliver.krueger@uni-bielefeld.de

Individuals differ. This seemingly trivial statement has nevertheless led to paradigm shifts, as three fields of organismal biology have seen a marked change in key concepts over the last years. In behaviour, it has been realised that there are profound differences between individuals in their behaviour and that these can be stable over time and across contexts, giving rise to the concept of animal personalities. In ecology, an increasing focus is likewise on the considerable variation in the ecological niche realised by species, populations, and even individuals, giving rise to the concept of niche specialisation or individual niche variation. In evolutionary biology, where individual variation has always been central, there is an increasing awareness of the complexity with which genotypes interact with the environment to produce unique phenotypes. Recent theoretical and empirical work has also highlighted that the fitness landscape is a rather complex one with multiple peaks and which local or global fitness peak is attenable by descendants of a certain genotype depends on the individuals with their genotypes, their specific environment and the interaction between both. Over the past 15 years or so, the need for more integrated conceptual frameworks transcending classic disciplines has been voiced ever more strongly. While in each of these fields, the concept of individualisation has contributed to major scientific knowledge increase, we currently lack sufficient cross-fertilisation. Beyond fields of research which, even in their name, combine two fields such as behavioural ecology and evolutionary ecology, a unification process is well under way. I propose a new level of conceptual unification: the individualised niche. By merging the niche concept with the fitness concept and consistent differences in behaviour between individuals, new explanatory power for both ecological and evolutionary processes emerges.

Session 5-O2 - Niche concept

Scaling the linkage between environmental niches and functional traits for improved spatial predictions of biological communities

Antoine Guisan[2], Heidi Mod[2], Daniel Scherrer[1,2], Tamara Münkemüller[3], Julien Pottier[4], Jake Alexander[2,5], Manuela DAmen[2,6]

[1]WSL Swiss Federal Research Institute, Birmensdorf, CH, daniel.scherrer@wsl.ch
[2]University of Lausanne, Lausanne, CH, daniel.scherrer@wsl.ch
[3]CNRS, Grenoble, FR
[4]INRA, Clermont-Ferrand, FR
[5]ETH Zürich, Zürich, CH
[6]ISPRA, Livorno, IT

Approaches to predicting species assemblages through stacking individual niche-based species distribution models (S-SDMs) need to account for community processes other than abiotic filtering. Such constraints have been introduced by implementing ecological assembly rules (EARs) into S-SDMs, and can be based on patterns of functional traits in communities. Despite being logically valid, this approach has led to a limited improvement in prediction, possibly because of mismatches between the scales of measurement of niche and trait data. S-SDM studies have often related single values of a species' traits to environmental niches that are captured by abiotic conditions measured at a much finer spatial scale, without accounting for intraspecific trait variation along environmental gradients. Many evidences show that omitting intraspecific trait variation can hinder the proper inference of EARs from trait patterns, and we further argue that it can therefore also affect our capacity to spatially predict functional properties of communities. In addition, estimates of environmental niches and trait envelopes could vary depending on the scale at which environmental and trait measurements are made. We suggest that to overcome these limitations, surveys sampling both niche and trait measurements should be conducted at fine scales along wide environmental gradients, and integrated at the same scale to test and improve a new generation of spatial community models and their functional properties.

Session 5-O3 - Niche concept

Models of ecological niches and biotic interactions to explain local coviability and joint species distributions across the geographic ranges of plants

Jörn Pagel[1], Frank M. Schurr[1]

[1]University of Hohenheim, Stuttgart, DE, jpagel@uni-hohenheim.de

Spatial patterns of biodiversity depend on the ability of species to coexist at different scales and across environmental gradients. Explaining the geographic distributions of species does thus not only require the quantification of species' ecological niches, but also an understanding of the context-dependent capability of species to grow in the presence of each other (coviability). Commonly applied static joint species distribution models (jSDMs) aim at disentangling ecological niches and biotic interactions by estimating environment-occurrence relationships simultaneously for multiple species and including a covariance structure that describes residual patterns of co-occurrence. However, covariance in species' occurrence can result from a range of different factors and estimated model parameters cannot be interpreted as interaction coefficients of joint population dynamics. Here, we instead analyse species co-occurrence data with an integrated statistical model of community dynamics. The model combines species-specific demographic responses to environmental variation (pre-interactive Hutchinsonian niches) with Lotka-Volterra-type population dynamics to predict stochastic equilibria of species abundances and population growth rates in different abiotic and biotic environments. We apply our approach to multi-scale biodiversity data for Proteacea shrubs in the South African Fynbos that comprise (i) ordinal abundance data for 55,000 Proteaceae communities, (ii) proxies of population growth for 1,500 species-community combinations and (iii) individual-level measurements of demographic rates in comprehensively mapped plant communities. Our model not only generates predictions of shifts in possible community compositions under environmental change, but enables us to test whether effects of biotic interactions on local population growth can explain range-wide co-occurrence patterns, thereby enhancing our predictive understanding of large-scale biodiversity dynamics.

Session 5-O4 - Niche concept

How does the establishment niche of European forest trees differ from the niche of ‘adult’ occurrence?

Lukas Heiland[1], Georges Kunstler[2], Florian Hartig[1], Lisa Hülsmann[1]

[1]Universität Regensburg, Regensburg, DE, lukas.heiland@ur.de
[2]Irstea EMGR, Grenoble, FR

In Ecology, the Hutchinson niche is a widely applied concept to comprehend the conditions under which species maintain their populations. As species’ traits undergo change during their life history, their fundamental niche will necessarily change, and so will most likely the only observable, the realized niche. Ecologists have called this phenomenon ontogenetic niche shift. Considering the ontogenetic changes of the niche may often be crucial to understand species presence or absence under particular environmental conditions.
In trees, a sensitive ontogenetic phase associated with strong environmental filtering is establishment. For temperate forest tree species, it has been shown that saplings often establish under different conditions than ‘adult’ trees survive. Nevertheless, few studies have made a systematic attempt to partition the niche into the contributions of the different life stages.
We explore how establishment and adult niches differ in European tree species, based on recruit and adult densities from national forest inventories across Europe. Using Bayesian inference with hierarchical and observation models, we integrate different national forest inventories to test whether the establishment niche along selected environmental gradients is narrower or broader than the respective adult niche. Acknowledging the differences between establishment and adult niche will allow ecologists to better predict range dynamics and will generally contribute towards a more dynamic understanding of tree species niches.

Session 5-O5 - Niche concept

Positive plant-soil feedbacks trigger tannin evolution by niche construction: a spatial stoichiometric model

Jean-François Arnoldi[2], Sylvain Coq[3], Sonia Kéfi[4], Sébastien Ibanez[1]

[1]Université Savoie Mont Blanc, Chambéry, FR, sebastien.ibanez@univ-smb.fr
[2]Trinity College, Dublin, IE
[3]Université de Montpellier, Montpellier, FR
[4]CNRS, Montpellier, FR

Among plant traits, plant secondary metabolites such as tannins mediate plant-herbivore interactions but also have after-life effects on litter decomposition and nutrient cycling. We propose that niche construction mechanisms based on positive plant-soil feedbacks (PSF) could influence the evolution of tannin production. By modeling the flow of nitrogen and carbon through plants and soil in a spatially explicit context, we explored the relative contribution of herbivory and positive PSF as drivers of tannin evolution. We assumed soil nitrogen to be composed of labile and recalcitrant compartments, the latter made of tannin-protein complexes accessible by plants via associations with mycorrhizal fungi. In infertile environments and for plants with low biomass turnover rates, we show that when tannins modify soil properties locally, positive PSF alone can drive their evolution. We further predict the existence of positive coevolutionary feedbacks between associations with mycorrhizae and tannins, possibly triggered by the evolution of the latter as protection against herbivores. In line with our theoretical results, empirical evidence suggest that tannins are mostly present in plants with low tissue turnover, associated with mycorrhizae able to decay organic matter and inhabiting infertile environments. Our model proposes that the evolution of tannin production can be triggered by positive PSF, provided that tannins locally increase the amount of recalcitrant nitrogen and that mycorrhizal fungi associated with plants are able to reabsorb nitrogen from tannin-protein complexes. In our model, tannin production evolves only in infertile ecosystems, in agreement with field observations. Our findings highlight that the strength of niche construction depends on the ecological context, i.e. that global ecological properties constrain local eco-evolutionary dynamics.

Session 5-O6 - Niche concept

What is a social niche and how does it change our view of social evolution?

Jürgen Gadau[1], Jürgen Gadau[1], Jürgen Gadau[1]

[1]WWU Münster

A social niche is, narrowly defined, a "*set of social environments in which the focal individual has nonzero inclusive fitness*". Social niche construction is therefore any behaviour that changes the social environment of an individual analogous to niche construction where traits of an organism determine the environment that it experiences. A similar logic applies to social niche choice where, for example, individuals vary in their preference for group size and probability to accept and cooperate with other individuals. The harvester ant *Pogonomyrmex calilfornicus*is an ideal system to study the genetic architecture of social niche choice and construction because it shows consistent intraspecific variation for both of these processes. We have studied several populations of the harvester ant *Pogonomyrmex californicus* in Arizona and California for the last 15 years and documented alternate social phenotypes of queens founding nests either alone (haplometrosis) or in groups of unrelated yet cooperative individuals (pleometrosis).

Session 5-O7 - Niche concept

A risky niche: among-individual differences in landscapes of fear

Melanie Dammhahn[1]

[1]University of Potsdam/Animal Ecology, Potsdam, DE, melanie.dammhahn@uni-potsdam.de

To eat or to feed - that is one of the most fundamental problems governing animal behaviour. Besides direct predation risk, the mere presence of predators might change prey foraging behaviour. This perceived predation risk varies in space and time creating a landscape of fear, but do all individuals have the same distribution of fear? Here, I test the hypothesis that among-individual differences in exploration and boldness predict the spatio-temporal distribution of perceived predation risk, i.e. individual specialisation in risk niches. In semi-natural enclosures and laboratory conditions I created landscapes varying in avian predation risk and quantified foraging and space use of behaviourally phenotyped bank voles (*Myodes glareolus*). I found that aspects of foraging and space use varied among individuals, were repeatable over time, and predicted by among-individual differences in boldness and exploration. These results suggest that individual variation along a risk-reward trade-off creates individualized landscapes of risk, which might have important consequences for predator-prey interactions.

Session 5-O8 - Niche concept

Coping with the climate: how cuticular hydrocarbons are linked to the climate niche of an insect

Florian Menzel[1], Philipp Sprenger[1], Barbara Feldmeyer[2]

[1]University of Mainz, Faculty of Biology, Mainz, DE
[2]Senckenberg Biodiversity and Climate Research Centre (BiK-F), Frankfurt, DE

Climate change will lead to overall higher temperatures, but also more climatic fluctuations. Hence, organisms will have to cope with such climate variation. Given their small bodysize, insects are especially vulnerable to desiccation. They waterproof their body surface with a layer of cuticular hydrocarbons (CHC). These CHCs consist of complex, and species-specific hydrocarbon mixtures. Waterproofing requirements, but also the waterproofing ability of a CHC layer change with climate. Hence, the CHC composition of an insect represents a functional trait that constrains its climatic niche. Furthermore, insects must continuously adjust their CHCs to current conditions in order to survive.
We investigated how four ant species respond to different climate regimes. We investigated CHC changes in response to constant and fluctuating regimes, and measured subsequent drought survival. Moreover, we studied how CHC differences between species are linked to their climatic niche in a global comparison. Despite strong CHC differences, the four ant species used similar strategies to acclimate to different temperatures. They showed parallel changes in chemical composition, which coincided with differential drought survival. In contrast, the responses to constant and fluctuating regimes differed, suggesting that the species differ in their ability to cope with temperature fluctuations. Across species, CHC composition was linked to the precipitation in the habitat, with more unsaturated hydrocarbons in hygrophilous species.
Our results suggest that an insect's CHC layer is a functional trait that is strongly linked to its climatic niche. Hence, habitat filters may constrain CHC composition in a community. Moreover, a species' ability to adjust it to climatic changes determines its ability to survive. The CHC diversity of an insect community may indicate its response diversity to climatic changes, such that a chemically diverse community may show a higher functional redundancy.

Session 5-O9 - Niche concept

The influence of niche parameters on the diversity of xylobiont beetles in the canopy of the Leipzig floodplain forest

Nora Haack[1,2], Martin Schlegel[1], Henrique Pereira[2,4], Detlef Bernhard[1], Christian Wirth[1,2], Klaus Henle[3]

[1]University of Leipzig, Leipzig, DE, nora.haack@idiv.de
[2]German Centre for Integrative Biodiversity Research (iDiv) Halle-Jena-Leipzig, Leipzig, DE, nora.haack@idiv.de
[3]Helmholtz-Zentrum für Umweltforschung, Leipzig, DE
[4]Martin-Luther-Universität Halle-Wittenberg, Halle, DE

Xylobiont beetles are excellent model organisms to study and understand the emergence of biodiversity, as they are a speciose, functionally diverse and well described group. Specifically, we aim to determine the impact of niche and neutral processes on diversity of communities and the rarity and abundance of single species. As a first crucial step we studied the influence of niche parameters on biodiversity at different scales. We found that niche parameters have a stronger influence on beta than on alpha diversity. Species richness of xylobiont beetles in the Leipzig floodplain forest is not significantly influenced by sampled tree species or vertical canopy stratum. Community composition on the other hand is shaped by both. Our results give an overview over the alpha and beta diversity of xylobiont beetles and provide the first opportunity to assess the influence of a set of niche parameters, including tree species and vertical stratification, on beetle biodiversity in the Leipzig floodplain forest.
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Session 5-P1 - Niche concept

Niche breadth estimates of beech (*Fagus*) species worldwide

Qiong Cai[1,2], Helge Bruelheide[2,3], Erik Welk[2], Zhiyao Tang[1], Chengjun Ji[1], Jiangling Zhu[1], Jingyun Fang[1]

[1]Peking University, Beijing, CN, caiqiong@pku.edu.cn
[2]Martin Luther University of Halle-Wittenberg, Halle (Saale), DE, caiqiong@pku.edu.cn
[3]German Centre for Integrative Biodiversity Research (iDiv) Halle-Jena-Leipzig, Leipzig, DE

The genus *Fagus* is one of the most representative broad-leaved deciduous trees in the Northern Hemisphere. While phylogenetic relationships of different *Fagus* species have been studied, much less attention has been given to their niche breadth. We hypothesized that the biotic niche breadth is much larger in species with a large geographic range size and broader climatic niche, such as in *F. sylvatica* and *F. grandifolia*, compared to species with confined geographic and climatic ranges, such as the Chinese beech species. We tested this hypothesis with a total of 108,013 vegetation plots with beech trees in East Asia, Europe and West Asia, and North America, compiled mainly from the sPlot database and a database in China based on field surveys. The biotic niche breadths of 10 *Fagus* species worldwide were estimated based on the species co-occurrence data and the climatic niche breadths by climate envelopes. Against expectation, the Chinese beeches *F. lucida* and *F. longipetiolata* had relatively larger biotic niche breadths compared to other beech species, while those of European and north American beeches had intermediate positions, and *F. multinervis* and *F. japonica* had the narrowest biotic niche breadths. Despite of some incongruences among different estimating methods, co-occurrence based niche breadths of the 10 *Fagus* species showed similar patterns to those based on climate envelopes. Our results suggest a recent evolution of biotic niche breadth, which is independent of the age of the clade, suggesting that the biotic niche breadth is not phylogenetically conserved.

Session 5-P2 - Niche concept

Evolutionary capacitance and the social cues mediating the downregulation of hsp90 in red flour beetles, *tribolium castaneum*

Reshma R[1], Lisa Johanna Tewes[2], Caroline Müller[2], Joachim Kurtz[1]

[1]Institute for Evolution and Biodiversity, University of Muenster, Muenster, DE, rr@uni-muenster.de
[2]Department of Chemical Ecology, Bielefeld University, Bielefeld, DE

Evolutionary capacitance could be an important process that helps to rapidly adapt to different niches. It means that populations 'store' genetic variants in the form of cryptic genetic variation and then release them under stressful environmental conditions. These hidden genetic variations could have been generated by adaptation to different niches in the past. In the model organism *Tribolium castaneum* (the red flour beetle), evolutionary capacitance is tightly linked to their individualized immunological experiences of parasites or parasite-related cues. It has been shown in a previous study that the introduction of wounded beetles into a group of naïve beetles resulted in the downregulation of the important evolutionary capacitor, HSP90 which could lead to the mobilization of genetic variation. Also, the release of cryptic genetic variation in offspring and their fitness advantages in a stressful environment have been confirmed by another study in these beetles using RNA interference and the chemical inhibition of this molecular chaperone. However, the chemical cues that might have led to the downregulation of HSP90 in the naïve conspecifics of wounded beetles are unknown and are addressed in the present study. Preliminary experiments involving gas chromatography-flame ionisation detection analysis of the insect surface wash revealed that the cuticular surface profiles differ between naïve and wounded (injected with buffer) or primed (injected with heat killed bacteria) beetles. Along with these results, we will present further plans for experiments that address the hypotheses that evolutionary capacitance of a group is modified by the experience of individuals, thus leading to individualized niches, and that evolutionary capacitance enhances evolvability.

Session 5-P3 - Niche concept

The impact of individual immune experience on niche construction in the red flour beetle, *Tribolium castaneum*

Lai Ka Lo[1], Lisa Johanna Tewes[2], Caroline Müller[2], Joachim Kurtz[1]

[1]Animal Evolutionary Ecology group, Institute for Evolution and Biodiversity, University of Münster, Münster, DE, lo@uni-muenster.de
[2]Department of Chemical Ecology, Bielefeld University, Bielefeld, DE

In the process of niche construction, organisms modify their ecological niches, e.g. via their metabolism or behaviour, and hence selection acts on themselves and their offspring. As experimental tests of the ecology and evolutionary consequences of niche construction are sparse, we employ *Tribolium castaneum* and its natural parasite *Bacillus thuringiensis tenebrionis (Btt)* as a host-parasite model system for niche construction.
Adult *T. castaneum* release secretions containing high levels of benzoquinones, which have been shown to inhibit the growth of bacteria, yeast and fungi commonly found in flour and the beetle's natural environments. As group-living animals that share the same niche, the secretions from adult beetles could in turn influence the level of pathogenic threat that their conspecifics or offspring are exposed to and thus modify the selective environment of both the niche constructors and recipients. Moreover, adults of *T. castaneum* show immune priming (i.e. increased immune response against previously encountered microbes) within and across generations. As the magnitude of niche construction likely varies with individual experience, i.e. exposure to environmental stressors, we hypothesise that individual immunological experiences in *T. castaneum* might lead to the construction of individualised niches.
In our study, individual beetles were either left naive, sham-exposed by injection of phosphate-buffered saline or primed via injection of heat-killed vegetative *Btt*. We found time-dependent differences in the chemical profiles, including quinone levels, in the secretions of adult beetles undergoing these immunological treatments. Here, we will present our preliminary work on the influence of individual immune experience on niche construction, and the fitness consequences of impaired niche construction by experimentally suppressing quinone secretion using RNAi.

SESSION 6

Water in Plants - mechanisms, fluxes and experiments from the leaf to the ecosystem

Chairs: Marco M. Lehmann, Bernhard Schuldt, Thorsten Grams

Water is a key factor determining the structure and function of plants and ecosystems. Questions regarding plant and ecosystem water relations, the impact of water availability on plant growth and ecosystem biogeochemistry as well as impacts of future climatic changes such as increases in frequency and intensity of severe drought and heat events on ecosystem functions remain largely unanswered. This session brings together researchers investigating plant water relations across scales from organs to whole plant, stand and ecosystem level. We invite contributions covering plant hydraulics and processes related to or affected by water uptake via roots and leaves, transport, transpiration as well as their control mechanisms, from both observational studies and experimental manipulations. Modeling studies scaling these processes and novel developments to trace water dynamics in the soil-plant-atmosphere continuum are also welcome. This session aims at elucidating structural, functional and physiological responses of plants to their environments spanning from eco-physiological to flux based approaches from different fields. We plan to assemble a group of scientists who are willing to step out of their disciplinary comfort zone and to discuss emergent topics from organ to ecosystem levels in the scope of climate change.

Session 6-O1 - Water in plants

Introduction to the session of water in plants

Marco M. Lehmann[1], Bernhard Schuldt[4], Thorsten Grams[3]

[1]Swiss Federal Institute for Forest, Snow and Landscape Research, Birmensdorf, CH
[3]Technical University of Munich, Munich, DE
[4]University of Würzburg, Würzburg, DE, bernhard.schuldt@uni-wuerzburg.de

Water is a key factor determining the structure and function of plants and ecosystems. Questions regarding plant and ecosystem water relations, the impact of water availability on plant growth and ecosystem biogeochemistry as well as impacts of future climatic changes such as increases in frequency and intensity of severe drought and heat events on ecosystem functions remain largely unanswered.
This session brings together researchers investigating plant water relations across scales from organs to whole plant, stand and ecosystem level, and aims at elucidating structural, functional and physiological responses of plants to their environments spanning from eco-physiological to flux based approaches from different fields. We will use the first 15 minutes for a general introduction, summarizing the covered topics by the oral and poster presentations, and for the overall aim of this session.

Session 6-O2/3 - Water in plants

Vulnerability of temperate forest to drought: Physiological insights form the 2003, 2015 and 2018 extreme events

Ansgar Kahmen[1], Matthias Arend[1], Allan Buras[3], Henrik Hartmann[4], Günter Hoch[1], Nadine Rühr[5], Bernhard Schuldt[2], Yann Vitasse[6], AK Ökosystemforschung[7]

[1]University of Basel, Basel, CH, ansgar.kahmen@unibas.ch
[2]University of Würzburg, Würzburg, DE
[3]Technical University of Munich, Munich, DE
[4]Max Planck Institute for Biogeochemistry, Jena, DE
[5]Karlsruhe Institute of Technology, Garmisch, DE
[6]WSL, Birmensdorf, CH
[7]GfÖ, Berlin, DE

Climate models project that precipitation patterns in Europe will change, with reduced precipitation in the summer months. In addition, it is projected that heat spells and drought events – as experienced in the summers of 2003, 2015 and 2018 - will occur more frequently in the future. There is now growing evidence that these climatic events critically impact the functioning of temperate forests and that wide-ranging tree mortality could be an ultimate consequence. Importantly, the physiological mechanisms that make temperate tree species vulnerable to drought events are often unclear. These uncertainties impair our ability to predict the fate of our temperate forests in a future climate. In my talk, I will synthesize the outcome of a recent workshop of the AK Ökosystemforschung that assessed the impacts of the 2003, 2015 and in particular the 2018 drought on temperate European forests. Specifically, I will report how mature trees from different temperate European tree species responded in their water and carbon relation to these extreme events and to what extent the trees approached what we believe are lethal thresholds for carbon starvation or hydraulic failure. The data I show will contribute to a better understanding the physiological performance of different temperate tree species to drought and can help to better assess the vulnerability of temperate forests to drought-induced tree mortality.

Session 6-O4 - Water in plants

Can continuous recordings of stem diameter variations be used to predict canopy water potential in mature trees during extreme drought events?

Rachel Patthey[1], Ansgar Kahmen[1], Matthias Arend[1]

[1]University of Basel, Basel, CH, rachel.patthey@unibas.ch

Twig water potential in the canopy of trees is an important physiological indicator of tree water status. Measuring twig water potential is, however, a challenge in the canopy of tall, mature trees. In a previous study it has been shown that species-specific relationships exist between water-dependent stem diameter variations at the base of a tree and canopy tree water potential; and from these relationships it has been concluded that stem diameter variations can be used to predict the canopy water potential (Dietrich et al. 2018). What remains unknown, is how robust these relationships are for applications at other sites and during conditions of extreme drought. We took advantage of the extreme summer drought 2018 to test, (i) if the relationships described previously by Dietrich et al. (2018) can also be applied at another forest site (the Swiss Canopy Crane II site in Hölstein, Switzerland) to predict canopy water potential from stem diameter variations for a given species, and (ii) if the relationships are still valid under extreme drought conditions, as experienced in the summer of 2018. With our study, we were able to confirm that stem diameter variations are a good predictor of canopy tree water potential, as we found a good agreement of models for a given species at different forest sites, even if the trees experienced extreme drought. However, we also observed a lag in the response of stem diameter variation to rain fall events, which may limit the predictive power of the obtained models at shorter time scales. Neither can the model predict water potential in dying trees.

Reference

Dietrich L, Zweifel R, Kahmen A (2018) Daily stem diameter variations can predict the canopy water status of mature temperate trees. Tree Physiol 38:941–952. doi: 10.1093/treephys/tpy023

Session 6-O5 - Water in plants

Hydraulic response of European beech, Norway spruce and Douglas fir during an exceptionally dry summer

Katja Schumann[3], Bernhard Schuldt[2], Miriam Fischer[3], Christoph Leuschner[3]

[2]Julius-von-Sachs-Institute of Biological Sciences, University of Würzburg, Würzburg, DE
[3]Department of Plant Ecology and Ecosystem Research, Albrecht von Haller Institute for Plant Sciences, University of Goettingen, Göttingen, DE, katja.steinhoff@stud.uni-goettingen.de

Central European forests are increasingly affected by severe drought events, highlighting the need for adaptive forest management strategies. Norway Spruce, the commercially most important but potentially drought-sensitive species, might widely be replaced by Douglas fir in future in production forests. To confirm the species' higher drought-stress resistance, branch hydraulic and foliar characteristics of mature trees of the two conifers were related to stomatal regulation patterns, leaf water potential and sap flux density during the extreme summer drought of 2018, and compared to European beech. Although the three species differed in branch specific hydraulic conductivity, no species differences in embolism resistance and turgor loss point were observed. Douglas fir had the smallest hydraulic safety margin. Unexpectedly, sap flow in Douglas fir reached zero flux already in early August, while flux continuously declined in beech and spruce until mid of September. In beech, this was accompanied by a steady leaf water potential decline, indicating an anisohydric stomatal control strategy, while potentials remained constant at either high (spruce) or low (Douglas fir) level in the conifers. Stomatal conductance was sensitively regulated in response to air humidity in beech and spruce, but not in Douglas fir, which showed signs of an isohydric behaviour. This raises questions about the drought tolerance of this species.

Session 6-O6 - Water in plants

Water uptake and allocation upon re-watering after 5 years of repeated summer drought in mature Beech and Spruce

Benjamin D. Hesse[1], Timo Gebhardt[1], Kyohsuke Hikino[1], Karl-Heinz Häberle[1], Thorsten E. E. Grams[1]

[1]Technical University of Munich, Freising, DE, benjamin.hesse@tum.de

After every drought event eventually plants will have access to water again. This phase of re-watering might be as challenging as the struggle for survival during drought. We investigated the recovery of a mixed mature forest stand upon drought stress released by re-watering. After 5 years of experimentally induced, repeated summer drought the Kranzberg Forest roof experiment (k.roof) reached its second phase, focusing on re-watering with deuterium labeled water (D_2O) of a mature stand of European beech (*Fagus sylvatica* L.) and Norway spruce (*Picea abies* (L.) H.Karst). We hypothesized that anisohydric beech will recover its water household faster and stronger than isohydric spruce. As a more isohydric species, spruce is expected to have a relatively high level of ABA in leaves, controlling stomatal closure, while stomatal aperture of anisohydric beech is expected to be under direct hydraulic control. We labeled 3 control and 3 drought plots of the k.roof-experiment with deuterium enriched water, i.e. δ^2H of 1200 and 400 ‰, respectively. We then traced the deuterium signal from the soil to stems and leaves. We assessed deuterium distribution in the soil by frequent soil cores to 1 m soil depth. In the stem, we installed online isotope probes to continuously measure the water isotopic signal of xylem water at DBH. Additionally, we took leaf samples at several time points and extracted the water. We calculated the probable depth of water uptake and turnover time of water pools in different tree organs. Furthermore, we measured leaf water potential and pressure-volume-curves to estimate drought stress release and related changes in osmotic potential. Combining all data allows for estimating the drought resilience of a mature forest stand after repeated summer drought and subsequent re-watering.

Session 6-O7 - Water in plants

Hygroscopic aerosols cause 'hydraulic activation of stomata' and decrease stomatal control

Jürgen Burkhardt[1], Daniel Zinsmeister[1], David A. Grantz[2], Mark A. Sutton[3], Sonja Vidic[4], Mauricio Hunsche[1], Shyam Pariyar[1]

[1]University of Bonn, Bonn, DE, j.burkhardt@uni-bonn.de
[2]University of California at Riverside, Parlier, US
[3]Centre of Ecology and Hydrology, Edinburgh, UK
[4]Meteorological and Hydrological Service, Zagreb, HR

Stomata, the tiny pores on the surfaces of leaves, are critical to the survival in an unsaturated atmosphere by enabling CO_2 uptake while simultaneously safeguarding sufficient hydration. Theory and models of stomatal behavior are based on the assumption of clean leaf surfaces. Real leaf surfaces are not clean. The ubiquitous dry deposition of atmospheric aerosols causes accumulating contamination on leaves throughout their lifetime. Many deposited aerosols on leaves are hygroscopic and act as "dew condensation nuclei", in analogy to their role as cloud condensation nuclei in the atmosphere. On leaf surfaces, the sources of the condensing water vapor are both ambient humidity and the transpiration stream. Thin films of highly concentrated solutions with specific physicochemical properties are formed. Reduced surface tension enables their expansion into the stomata. By joining with water coming from the roots, this 'Hydraulic Activation of Stomata' (HAS) expands the plants hydraulic system and reduces stomatal control.

Experiments were conducted with both amendment and exclusion of particles. By spraying with 50 mM solutions, the minimum epidermal conductance (g_{min}) of Scots pine needles increased between 18% ($NaNO_3$) and 45% (KI); the increase by NaCl was 34%, but was 96% for NaCl + surfactant. By filtering out 99% of aerosols from the greenhouse air, g_{min} was reduced to 81% (silver fir), 78% (common oak), and 77% (Scots pine). Similarly, the sap flow of anisohydric beeches and sunflowers was correlated with particle concentration. The sap flow of isohydric Scots pine seedlings was unaffected by particles, but photosynthesis tended to decrease.

Atmospheric aerosols and HAS may have served important ecological functions by enabling stomatal exchange of liquid water and nutrients. High anthropogenic aerosol concentrations can have a direct impact on plant water relations and particulate air pollution may have consequences for the drought tolerance of trees.

Session 6-O8 - Water in plants

Differential deuterium enrichment occurring during the synthesis of organic compounds under different metabolisms affects hydrological signal of *n*-alkanes and a-cellulose

Marc-Andre Cormier[1,2], Roland A. Werner[1], Ansgar Kahmen[2]

[1]ETH Zürich, Zürich, CH
[2]University of Basel, Basel, CH, cormier@erdw.ethz.ch

When hydrogen (H) isotopes of plant organic compounds (e.g. those of *n*-alkanes and a-cellulose) are used in ecological studies, their (δ^2H) values are generally interpreted as being indicative of the plants source water. Recent observations made on heterotrophic plants, however, suggest that variations in hydrogen isotope fractionation that occur during the biosynthesis of plant compounds (^{2}H-ε_{bio}) imprint valuable metabolic information into the hydrogen isotope composition of plant organic compounds.
In this presentation, we show a consistent ^{2}H-enrichment of compounds in heterotrophically growing plants across a series of autotrophic/heterotrophic plant pairs. Supported by previous experiments in which we forced autotrophic plants into a heterotrophic metabolism, we suggest that this ^{2}H-enrichment is due to a higher recycling of compounds in the Calvin and tricarboxylic acid cycles in heterotrophic plants that is associated with a more complete exchange of C-bound H with the surrounding ^{2}H-enriched foliar water.
Our analyses also found that ^{2}H-enrichment in heterotrophic plants was larger for carbohydrates than for lipids. We suggest that this systematically larger ^{2}H-enrichment for carbohydrates than for lipids might be due to the potential uptake of lipids by heterotrophic plants. This work aims to extend the mechanistic understanding of the biochemical principles that couple the carbohydrate dynamics of plants to their δ^2H values and hope to promote metabolic applications of H isotopes in plant sciences.

Session 6-O9 - Water in plants

Growth rates of tropical trees depend on size and canopy position but not on hydraulic potential and wood density

Roman Mathias Link[4], Henrik Hartmann[3], Dagoberto Arias Aguilar[2], Juan Carlos Valverde Otarola[2], Marvin Castillo Ugalde[2], Bernhard Schuldt[4]

[2]Instituto Tecnológico de Costa Rica, Cartago, CR
[3]Max Planck Institute for Biogeochemistry, Jena, DE
[4]University of Würzburg, Julius-von-Sachs-Institute for Biological Sciences, Chair of Ecophysiology and Vegetation Ecology, Würzburg, DE, roman.link@uni-wuerzburg.de

- The drivers of tree growth and their relationship to hydraulic potential and climate are a central issue in plant ecology.
- Based on a dataset of 201 trees belonging to 40 tropical tree species from 5 sites situated along a rainfall gradient in western Costa Rica, we analyzed the relationship between climate, tree properties and drought affiliation.
- We used a piecewise structural equation model to assess how mean annual precipitation (MAP) drives differences in tree size, wood density (WD) and wood anatomical traits, and how these in turn affect sapwood nonstructural carbohydrate (NSC) concentrations, aboveground biomass increment (AGBI) and water deficit affiliation (WDA).
- In our model, MAP had a strong positive effect on tree height, which fully mediated the precipitation effects on all variables except for WDA via its effect on tree position relative to the canopy (CP). Potential hydraulic conductivity (Kp) was independent of CP and did not respond to any variable besides tree diameter. Total NSC stocks were significantly larger for trees with higher WD that were closer to the canopy, but were unrelated to Kp. Trees belonging to species associated with wetter habitats (higher WDA) had higher NSC concentrations, but did not differ in CP, WD and Kp. After accounting for size effects, AGBI increased strongly with CP, but was unrelated to WD and Kp. Notably, after accounting for the effects of the other predictors, no correlation remained between WDA and AGBI. Most variables in the model showed pronounced species differences, with random species effects explaining between 4 and 83% of the variance in the submodels.
- Our data show growth to strongly depend on size and light availability, but imply a much lower effect of wood density than previously anticipated. In addition, wood anatomical traits were largely unrelated to growth, NSC storage and drought affiliation, putting into question their use as key predictors of plant growth and drought response.

Session 6-O10 - Water in plants

Xylem vulnerability to embolism in natural and transformed tropical systems in Sumatra, Indonesia

Pierre-André Waite[1], Christoph Leuschner[1], Kyra Zembold[1], Sylvain Delzon[2], Triadiati Triadiati[3], Bernhard Schuldt[4]

[1]Department of Plant Ecology and Ecosystem Research, Albrecht von Haller Institute for Plant Sciences, University of Goettingen, Göttingen, DE, pwaite@gwdg.de
[2]BIOGECO, INRA, University of Bordeaux, Bordeaux, FR
[3]Department of Biology, Faculty of Mathematics and Natural Sciences, Bogor Agricultural University, Darmaga Campus, Bogor, ID
[4]Chair of Ecophysiology and Vegetation Ecology, Julius-von-Sachs-Institute of Biological Sciences, University of Würzburg, Würzburg, DE

In investigations of plant sensitivity to drought, functional traits related to water transport such as the water potential at 50% loss of conductivity (P_{50}) are commonly used. While relationships between P_{50} and other plant traits are well documented for non-tropical trees, much less is known for tropical trees and palms. The present study examines several wood structural and anatomical, and hydraulic traits of oil palm (*Elaeis guineensis*) and rubber (*Hevea brasiliensis*) in monocultures, and of ten rainforest tree species in Sumatra, Indonesia. Branch embolism resistance (P_{50}) of the forest species ranged from -4.43 to -1.86 MPa, and was significantly negatively related to tree height, but not to wood density (WD). In rubber and oil palm, average P_{50} was -2.45 and -1.86 MPa, respectively. The plasticity in the hydraulic system in response to water availability was particularly large in oil palm. The observed diversity in tree hydraulic strategies in the rainforest trees may increase the resistance and resilience of the natural forest to climatic changes. In contrast, oil palm, which widely replaces the forest, is more vulnerable to embolism. The high plasticity in the hydraulic system of oil palm may, however, reduces its vulnerability.

Session 6-P1 - Water in plants

A novel dendroecological method finds a non-linear relationship between elevation and seasonal growth continuity on an island with trade wind-influenced water availability

Robert Weigel[1,2], Severin D. H. Irl[3,4], Kerstin Treydte[5], Carl Beierkuhnlein[3], Johanna Berels[2], Richard Field[6], José Carlos Miranda[5], Alana Steinbauer[2], Manuel Steinbauer[7], Anke Jentsch[2]

[1]Plant Ecology, Albrecht von Haller Institute for Plant Sciences, University of Goettingen, Goettingen, DE, robert.weigel@uni-goettingen.de
[2]Disturbance Ecology, University of Bayreuth, Bayreuth, DE, robert.weigel@uni-goettingen.de
[3]Biogeography, University of Bayreuth, Bayreuth, DE
[4]Biogeography and Biodiversity Lab, Institute of Physical Geography, Johann-Wolfgang Goethe-University, Frankfurt, DE
[5]Forest Dynamcis, Swiss Federal Research Institute WSL, Birmensdorf, CH
[6]School of Geography, University of Nottingham, Nottingham, UK
[7]GeoZentrum Nordbayern, Department of Geography and Geosciences, Friedrich-Alexander University, Erlangen-Nuremberg, DE

It is poorly understood how different aspects of seasonality (especially regarding temperature and precipitation) affect growth continuity of trees in climates with low seasonality because seasonality is often only crudely measured. On islands, exceptionally wide elevational species distribution ranges allow the use of dendroecology to identify how growth continuity and climate–growth relationships change with elevation. We present a novel dendroecological method to measure stem growth continuity based on annual density fluctuations (ADFs) in tree rings of *Pinus canariensis* to indicate low climatic seasonality. We measured three decades of tree-ring data of 100 individuals distributed over 10 sites along the island's elevational range. The successfully implemented ADF approach revealed in a remarkably clear pattern that stem growth continuity (percentage of ADFs) showed a hump-shaped relationship with elevation reaching a maximum at around 1000 m a.s.l.. Low- to mid-elevation tree growth was positively correlated with the Palmer Drought Severity Index (indicating aridity) and sea surface temperature (indicating trade wind-influenced moderation of water supply), while high-elevation tree growth was positively correlated with winter temperature (indicating a cold-induced dormancy period). We conclude that ADFs are a useful method to measure stem growth continuity in low-seasonality climates. Growth of *P. canariensis* on the Canary Islands is more frequently interrupted by winter cold at high elevations and by summer drought at low elevations than in the trade wind-influenced mid elevations, where growth sometimes continues throughout the year. Climate change-associated alterations in trade wind cloud formation might cause non-analogue growth limitations for many unique island species.

Session 6-P2 - Water in plants

Challenges in measuring stomata anatomical traits – a case study on stomatal density in Norway spruce seedlings (Picea abies (L.) KARST.)

Anna Lehr[1], Melanie Schueler[1], Katrin Heer[1], Karl-Heinz Rexer[1], Birgit Ziegenhagen[1]

[1]University of Marburg, Marburg, DE

Stomata traits are listed in the PLANT TRAIT DATABASE (TRY) and are thought to be appropriate response variables while analyzing effects of varying environmental conditions like water availability, solar and temperature regime or CO_2 concentration. Here, stomatal conductance is a functional trait of choice though not easy to handle. It is hard to measure in the field and in addition may largely vary even during short phases of measurement. In contrast, stomata anatomical traits are stable over times of assessment. Thus e.g., stomatal density (SD) has frequently been used as surrogate for stomatal conductance while comparably responsive. However, contradictory results have been reported on direction and strength of SD variation which made us critically re-visiting measurements of SD in needles of Norway spruce seedlings (*Picea abies* (L.) KARST.). The present stepwise study is based on seedlings, which were grown in the green-house and originated from a low vs. high altitude Norway spruce stand in the Bavarian Forest National Park. We found that SD differed between seedlings from different altitudes, but was also depending on the position of the investigated needle at the twig. Distally inserted needles had a higher SD. This effect was more pronounced in seedlings from higher altitude. We assumed that different year´s shoot and needle growth rhythms shaped by SD variation could play a role in local adaptation processes. To check for more intra-individual variation which could render a bias to SD studies, we differentiated between stomatal density from ad- vs. abaxial faces of the needles. Preliminary results revealed that the adaxial stomatal density was much more responsive. Our studies are ongoing also including needle length and width and results will be presented. They will contribute to a more robust assessment of stomatal traits in ecological studies, particularly with conifer species.

Session 6-P3 - Water in plants

Assessing soil moisture on different temporal and spatial scales by linking Cosmic Ray Neutron Probes with remotely sensed data

Veronika Döpper[1], Tobias Gränzig[1], Birgit Kleinschmit[1], Michael Förster[1]

[1]TU Berlin - FG Geoinformation and Environmental Planning, Berlin, DE, v.doepper@tu-berlin.de

Soil moisture content (SMC) is a key variable of ecological processes driving water availability for plants, vegetation composition, structure and condition as well as thermal states of the soil. Common soil moisture measurements range from local point measurements to global remote sensing based SMC datasets. Nevertheless, they always must compromise between temporal and spatial resolution. Thus, it is still challenging to quantify spatially and temporally distributed SMC at regional scale which is extremely relevant for hydrological modeling or agricultural management. The innovative technology Cosmic-Ray Neutron Sensing (CRNS) shows significant potential to fill this gap by quantifying the present hydrogen pools within footprints larger than 0.1 ha.
We will link CRNS measurements with high resolution UAV data of hyperspectral (using plant traits and condition as soil moisture indicators), LiDAR (representing the effect of vegetation structure on soil moisture), and thermal data acquired with varying temporal resolution on a grassland site at the Bavarian foothills of the Alps. We are aiming to understand the process-based relationships between the integral spatial recording of soil moisture by CRNS and the predominantly surface-based prediction with remote sensing detectors to detect SMC patterns in the point and field scale. For upscaling the results to a whole catchment area, also satellite data, mainly from Copernicus missions, will be included.
The project is part of the DFG-funded joint project *Cosmic Sense* consisting of ten subprojects in which a wide variety of disciplines will address the question of large-scale soil moisture determination with high spatial and temporal resolution in small catchment areas.

SESSION 7

Conservation and restoration

Chairs: Anna Bucharova, Nina Farwig, Johannes Kollmann

According to the recent IPBES report, human-caused habitat degradation is the main driver of biodiversity loss. Scientist urge to take actions that will halt or even reverse this negative trend. This is necessary not only to protect biodiversity for its intrinsic value but especially for the ecosystem services that nature provides to humanity. The actions supporting biodiversity range from traditional nature conservation that protects species, habitats, and their functionality, to ecological restoration that actively re-creates functional ecosystems. This session aims to provide a stage for researchers working along the complex conservation-restoration gradient, with the goal to illustrate current topics, emerging challenges, and novel solutions in current conservation and/or restoration of biodiversity in Europe and beyond.

Session 7-O1 - Conservation & restoration

Multiple forest attributes underpin the supply of multiple ecosystem services

María Felipe-Lucia[1,2,3], Eric Allan[3]

[1]UFZ – Helmholtz Centre for Environmental Research, Leipzig, DE, maria.felipe-lucia@idiv.de
[2]German Centre for Integrative Biodiversity Research (iDiv), Leipzig, DE, maria.felipe-lucia@idiv.de
[3]University of Bern, Bern, CH, maria.felipe-lucia@idiv.de

Trade-offs and synergies in the supply of forest ecosystem services are common but the drivers of these relationships are poorly understood. To guide management that seeks to promote multiple services, we investigated the relationships between 12 stand-level forest attributes, including structure, composition, heterogeneity and plant diversity, plus 4 environmental factors, and proxies for 14 ecosystem services in 150 temperate forest plots. Our results show that forest attributes are the best predictors of most ecosystem services and also good predictors of several synergies and trade-offs between services. Environmental factors also play an important role, mostly in combination with forest attributes. Our study suggests that managing forests to increase structural heterogeneity, maintain large trees, and canopy gaps would promote the supply of multiple ecosystem services. These results highlight the potential for forest management to encourage multifunctional forests and suggest that a coordinated landscape-scale strategy could help to mitigate trade-offs in human-dominated landscapes.

Session 7-O2 - Conservation & restoration

Is the success of deadwood restoration diminished by isolation and small size of forests?

Inken Doerfler[1]

[1]Institute of Biology and Environmental science, Vegetation science & Nature conservation, Carl von Ossietzky University of Oldenburg, Oldenburg, DE, inken.doerfler@uni-oldenburg.de

The human influence on European temperate forests left the recent forests strongly changed in structure with negative effects on biodiversity. Especially species living in deadwood and related microhabitats are threatened since production forests contain only small amounts of deadwood and old trees. Restoration programs in production forests aim therefore to increase these habitats and especially deadwood enrichment is successful in promoting biodiversity. These results, however, originate mainly from restoration actions in large and publicly managed forests, whereas more than 50 % of the managed forest in Europe is privately owned with many small and isolated areas, surrounded by an agricultural landscape and managed by non-professionals. Due to the large total area of privately-owned forests, these should be considered in conservation actions since they are necessary to establish a continuous habitat connectivity. The size and isolation of the areas, however, raises the question whether focal species might reach restored habitats and whether private owners are willing to implement restoration actions. To see whether (1) a cooperation with private forest owners is possible, and (2) how deadwood enrichment influences biodiversity in small and isolated forest areas, we conducted a trial study. This included the determination of biodiversity with flight interception traps in three small and isolated forests areas with recent deadwood enrichment. One trap was placed close by the deadwood and one > 200 m away as a reference. We found the forest owners to be very cooperative in supporting restoration and research. The response of biodiversity towards deadwood enrichment was positive but with the exceptions of one forest area, especially for beetles. These results show the necessity to implement a large-scale experiment and enable a discussion on how such an experiment should be set up.

Session 7-O3 - Conservation & restoration

Small-scale disturbance regimes alter small mammal communities in a tropical West African forest

Eric Adjei Lawer[1], Alexandra-Maria Klein[1], Anne-Christine Mupepele[1]

[1]Nature Conservation and Landscape Ecology, University of Freiburg, Freiburg, DE, ladjei@uds.edu.gh

Small-scale logging and mining for subsistence are among the common uses of forests by people in tropical developing countries. These activities, often illegal, occur pervasively in protected forest areas. Although the effects of small-scale disturbance on biodiversity, such as selective logging have been widely investigated, that of chainsaw milling (CSM) and artisanal/shallow pit mining (ASM) remain unclear especially, in afromontane forests. In this study, we compared diversity measures of terrestrial small mammals between CSM, ASM and undisturbed forest areas (UFA) and assessed whether communities varied under these disturbance regimes. Relationships between diversity or communities and environmental variables were assessed using non-metric multidimensional scaling and generalized additive models. We found that diversity measures did not differ among disturbance regimes, though ASM consistently recorded lower measures. There was however a significant relationship between species richness and the environmental variables measured (e.g. elevation, canopy cover and disturbance type). Our analysis showed that composition of small mammal communities varied significantly between disturbed and undisturbed forest areas, suggesting differential species response to environmental factors. Complementary tests revealed that ASM altered the occurrence and frequency distribution of species compared to CSM and UFA. This may be due to the digging of pits coupled with the creation of small gaps in the canopy, hence a depletion in food and space resources. In conclusion, our results highlight the importance of understanding the effects of different small-scale disturbance regimes before developing conservation and management interventions to mitigate their effects.

Session 7-O4 - Conservation & restoration

The Belgian Gagea (*Gagea spathacea*) in Germany: How to safeguard a species of national conservation responsibility within the context of global change and sustainable forest management

Bettina Ohse[1], Andreas Fichtner[1], Werner Härdtle[1]

[1]Leuphana University Lueneburg, Lüneburg, DE, bettina.ohse@uni-lueneburg.de

To implement the Convention on Biological Diversity, many countries have developed National Biodiversity Strategies and Action Plans (NBSAP). These NBSAPs often list species for which a country has a special conservation responsibility from a global perspective. The development of appropriate conservation measures for species of national conservation responsibility, however, requires a sound autecological knowledge of the target species. This also applies to *Gagea spathacea* (Liliaceae), a 'vulnerable' woodland spring geophyte with a distribution largely restricted to the lowlands of Central Europe. The species mainly occurs in (ancient) moist mixed-deciduous forests of Northern Germany and reproduces almost exclusively by developing subterraneous daughter bulbs (bulbils). Yet, key ecological knowledge necessary to effectively safeguard this species in the long term is missing so far.
Within a 6-year project, we addressed the following questions, using both observational and experimental approaches: (1) What are the habitat requirements of *G. spathacea*, i.e. which abiotic conditions mainly determine the species' vitality? (2) Why is this species largely restricted to nutrient-rich sites? (3) How does *G. spathacea* respond to global change, especially N deposition and drought? (4) Is assisted migration an appropriate conservation strategy to ensure the survival of *G. spathacea* populations, potentially even at restored forest sites?
Main results indicate that maintaining forest continuity and natural site conditions is crucial for sustaining populations of *G. spathacea*. Strict protection or low-impact forest management of '*G. spathacea*-forests' is therefore necessary to protect this rare woodland species, which in turn would also benefit the biodiversity typical of temperate moist deciduous forest ecosystems.

Session 7-O5 - Conservation & restoration

A global Red List of orchids stresses the reliability of automated conservation assessment based on species occurrence records from public databases

Alexander Zizka[1], Pati Vitt[2], Tiffany Knight[1,3,4]

[1]German Center for Integrative Biodiversity Research (iDiv), Halle - Jena - Leipzig, DE, alexander.zizka@idiv.de
[2]Northwestern University, Plant Biology and Conservation, Evanston, US
[3]Institute of Biology, Martin Luther University Halle-Wittenberg, Halle, DE
[4]Department of Community Ecology, Helmholtz Centre for Environmental Research- UFZ, Halle, DE

The Red List of the International Union for the Conservation of Nature (IUCN) is a widely used tool to prioritize global conservation needs, but IUCN assessments are resource-intensive and therefore only available for a fraction of global species richness. Automated conservation assessments based on publicly available geographic occurrence records are a rapid alternative, but it is unclear how accurate and biased these are. Here, we present the results of case studies from the orchid (Orchidaceae) family applying novel bioinformatics tools for automated data cleaning and conservation assessment. The results suggest that 70% of the all orchid species might be threatened with extinction and point to Ecuador, Madagascar, and Southeast Asia as conservation hotspots. Furthermore, the results show that automated conservation assessments, together with automated data cleaning procedures can identify possibly threatened species with an accuracy of around 80% compared to full IUCN assessments and can eliminate bias present in IUCN assessments. Hence, automated assessments are a critical tool to reach the goal of a global extinction risk assessment for all known species and improve the prioritization of conservation effort.

Session 7-O6 - Conservation & restoration

Conservation planning for riparian plant species under changing climate

Sabine Fink[1], Christoph Scheidegger[1]

[1]Swiss Federal Institute for Forest, Snow and Landscape Research, WSL, Birmensdorf, CH, sabine.fink@wsl.ch

Riparian habitat decreased significantly over the last decade, mainly due to human impact. Protected areas such as floodplains of national importance can be refugia for specialized riparian species. Conservation efforts targeting riparian plants have to consider changes in habitat availability due to changing climate while identifying the most suitable sites for future river restoration.
We investigated the potential future distribution of species of the *Salicion albae* (softwood floodplain forest) and of the *Fraxinion* (hardwood floodplain forest) plant communities. In this study, we model the habitat suitability for these target species for river restoration based on abiotic environmental predictors (geology, topology, climate) and simulate their spread along rivers by implementing information on life history traits and dispersal as well as barriers to dispersal along rivers.
Our results show that areas of future suitable habitat changed dramatically when taking into account two climate change scenarios. Predicted distributions for both plant communities do not show any future sites suitable for all species of a community. Additionally, for most of the plant species, approximately half the cells within floodplains of national importance were suitable habitat for the species in the future, while for two species (*Populus nigra* and *Salix alba*) only <10% of the protected areas were predicted to be suitable in the future. Simulations for the dispersal of species showed that the presence of current major barriers to dispersal (e.g. river dams) have a significant effect on the future distribution of softwood and hardwood floodplain species. Modelled species occurrences are not persistent over time, which stresses the importance of functional connectivity of riparian habitat for plants. Our results suggest that conservation management should focus on suitable future areas for plant species distributions, as current protected floodplains do not provide sufficient refugia for softwood and hardwood floodplain forest species.

Session 7-O7 - Conservation & restoration

Abiotic conditions and bottlenecks for *Luronium natans* populations in Atlantic Germany

Ludo Smits[1], Eva Remke[1], Emiel Brouwer[1], Jan Roelofs[1]

[1]B-WARE, Nijmegen, NL, ludosmits@live.nl

As a part of the vegetation of soft water lakes (Littorellion), the amphibic plant *Luronium natans* prefers moors that are low in nutrients and dissolved inorganic carbon. Perturbations to any of these factors causes the species to eventually be shaded and outcompeted in the water layer which marginalises the population to the littoral zone where water levels fluctuate. A decline of Littorellion species is observed in Atlantic German. This study aims to shed light on and better understand the key factors that are determinant for the endangered *L. natans* in Atlantic Germany.
In the field ten different lakes were studied to determine quality of sites and dominant problems. Thereafter, several short experiments were conducted in the lab to support mechanisms underlying these problems. During this talk the effects of acidification and alkalisation, nitrate/ammonium ratios on nutrient availability will be covered. These are key biogeochemical processes which need to be guarded during the restoration of soft water lakes in the Atlantic region.

Session 7-O8 - Conservation & restoration

Impact of recreational fisheries on aquatic and riparian biodiversity in artificial lake ecosystems

Robert Nikolaus[1], Malwina Schafft[1], Sven Matern[1], Christian Wolter[1], Robert Arlinghaus[1,2]

[1]Department of Biology and Ecology of Fishes, Leibniz-Institute of Freshwater Ecology and Inland Fisheries, Berlin, DE, nikolaus@igb-berlin.de
[2]Division for Integrative Fisheries Management, Albrecht Daniel Thaer-Institute of Agriculture and Horticulture, Faculty of Life Science, Humbolt-Universität zu Berlin, Berlin, DE

There is general consensus about global declining biodiversity, and freshwater-associated biodiversity is in particular steep decline. Novel ecosystems created through human use of littoral resources (e.g., sand, gravel) can provide substitute habitats of large importance to conservation of freshwater biodiversity. However, we can expect these lakes, which are often managed for and by recreational fisheries, to also exhibit high recreational use intensity, which may negatively impact aquatic biodiversity. Our objective was to evaluate the species inventory and conservation value of a range of water-based aquatic taxa (plants, amphibians, waterfowl, dragonflies, damselflies, song birds) in and at artificially created lake ecosystems managed by recreational fisheries (N = 16) and compare the biodiversity inventory present at similar lake ecosystems lacking recreational-fisheries management (N = 10). Managed and unmanaged gravel pit lakes were similar in regards to morphological and productivity-related variables, while differing in littoral and riparian habitat structure and recreational use intensity by both anglers and other recreationists. Despite these differences, the average species richness and conservation value of the species detected at both lake types was largely similar. In fact, managed lakes hosted a significantly larger diversity and conservation value of submerged macrophytes, despite the presence of large-bodied cyprinids favoured by regular stocking. To conclude, the presence of anglers and recreational-fisheries management is not per se a constraint to aquatic biodiversity and thus selectively excluding one user group – recreational anglers – from newly created lake ecosystems or in nature conservation area seem unsupported from a conservation perspective that values multiple taxa jointly.

Session 7-O9 - Conservation & restoration

Catastrophe of Chaohu Lake Ecosystem and Wetland Restoration and Cyanobacteria Removal in Wetland

Kaining Chen[1], Kaining Chen[1]

[1]Nanjing Institute of Geography and Limnology□Chinese Academy of Sciences, Nanjing, CN

Chaohu Lake is a large shallow lake in eastern China. It covers an area of 760 square kilometers and has an average water depth of 3.1 meters. The eutrophication of its water body is serious. When the area of cyanobacteria blooms is the largest, it is close to half of the lake area. Firstly, the catastrophic process of Chaohu Lake ecosystem is introduced. Due to the construction of sluice gates in 1962, the rise and fluctuation of water level in Chaohu Lake became gently, resulting in the loss of wetland and the disappearance of submerged vegetation, and the increasing eutrophication of water bodies. Cyanobacteria grew in large numbers during 1975-1985, resulting in the decline of biodiversity and cyanobacteria blooms broke out. In addition to reducing the load of external pollution, the main measures for lake ecological restoration are the restoration of lakeside wetlands and the prevention and control of cyanobacteria inside the restored lakeside wetlands. The method of wetland restoration is mainly based on the change of water level in the past five years, building the gentle slope of lakeside zone to adapt to water level, and then planting emergent aquatic plants artificially. The results show that the species diversity index of the restored wetland plants reaches 2.31, and five kinds of water birds are observed. But there are a lot of cyanobacterial blooms in lakeside wetlands. Therefore, we have invented a device for removing cyanobacterial blooms in wetlands. Experiments showed that the device can effectively remove cyanobacterial blooms and prevent cyanobacteria from decaying and smelling in wetlands. In addition, estuarine wetlands were restored to reduce nutrient loads of polluted rivers into lakes.

Session 7-O10 - Conservation & restoration

Should I graze or should I go? Vigilance behaviour of wild ungulates when foraging together with livestock in an east African savannah

Anna Treydte[1,2], Angelamercy Baltazary[1]

[1]Nelson Mandela African Institution of Science and Technology (NM-AIST), Arusha, TZ, anna@treydte.com
[2]University of Hohenheim, Stuttgart, DE, anna@treydte.com

In many savannahs around the world, mammalian herbivore species often graze together to reduce predation risk and facilitate their foraging success. On the other hand, herbivore species feeding on overlapping foraging sites might also compete for the same plant resources. Little is known about the role livestock plays when foraging together with wild herbivore species and whether they compete for resources or promote foraging activities. We tested vigilance behaviour, i.e., watching out for predators, on wild herbivore species in an UNESCO world heritage site, the Ngorongoro Conservation Area (NCA), Tanzania, where both wildlife and livestock have been grazing together for centuries. During driving transects in the dry and the wet season of 2018 we recorded 158 groups of wild herbivore species including plains Zebra (*Equus burchelli*), Thomson's gazelle (*Gazella thomsonii)*, Grant's gazelle (*G. granti)* and Wildebeest (*Connochaetes taurinus*), grazing either with or without livestock species, i.e., cattle (*Bos taurus)*, goats (*Capra aegagrus hircus)* and sheep (*Ovis aries*). On average over the dry and the wet season, 48 herds were without and 31 herds were mixed with livestock. Mean herd size of wild herbivores mixed with livestock was 33 while livestock groups alone had 51 individuals on average. The mean vigilance time was twice as high and by about 25% higher when wild herbivores grazed together with livestock compared to those without livestock during wet and the dry season, respectively. Foraging was the most dominant activity during both the wet and dry season when the wild herbivores were not associated with livestock. However, this dominant activity was replaced by vigilance when wildlife was associated with livestock. We conclude that, in contrast to foraging facilitation theory, the presence of livestock is not beneficial for wild herbivores and that wildlife protection zones excluding livestock are essential refuges in NCA to promote long-term conservation.

Session 7-O11 - Conservation & restoration

Restoration of plant and habitat diversity by small-scale ploughing of abandoned grasslands

Martina Fabšičová[1], Jan Šipoš[1,2], Tomáš Vymyslický[3], Martin Jiroušek[4,5]

[1]Institute of Botany, Czech Academy of Sciences, Department of Vegetation Ecology, Brno, CZ, martina.fabsicova@ibot.cas.cz
[2]Mendel University in Brno, Department of Zoology, Fisheries, Hydrobiology and Apiculture, Brno, CZ
[3]Agricultural Research, Ltd., Troubsko, CZ
[4]Mendel University in Brno, Department of Plant Biology, Brno, CZ
[5]Masaryk University, Department of Botany and Zoology, Brno, CZ

The biodiversity of intensively managed agricultural landscape has rapidly decreased across Europe during the past decades. In the Czech Republic, it was also connected with the abandonment of traditional management practices in the borderland regions after the World War II. Former fields were often converted into non-managed grasslands, extensive pastures or were completely abandoned. Such habitats were also present in the territory of the Podyjí National Park. To increase biodiversity in the protected area and its buffer zone and to support ecosystem services, small-scale ploughing as a restoration management was used. Plant species composition was monitored on permanent plots for three years under following treatments: (A) annual ploughing, (B) after initial ploughing left as a fallow, and (C) non-ploughed part left as a control. Due to very heterogeneous localities, both in terms of environmental conditions and previous land-use in the past, we obtained various results for species diversity as well as for plant community changes. Several plant species which disappeared many years ago were discovered again. Common weed species of arable land prevailed in the first year, while some rare or endangered species occurred mainly on fallows. Significant decrease in species numbers was found in annually ploughed treatment during the following years, where short-lived species were continuously selected. During the three-year-long succession after single ploughing, the vegetation continually developed towards the herb-rich initial successional state of grassland. We suppose that application of small-scale ploughing management could serve as a suitable tool for nature conservation, leading to increase of both, species and habitat diversity. Based on the previous results, we recommend the rotation of ploughed plots within one locality in three-year cycles to prevent increasing populations of invasive species.

Session 7-O12 - Conservation & restoration

Restoration of a serpentine sites of endemic species *Minuartia smejkalii*

Hana Pánková[1], Karel Kříž[2], Iveta Husáková[1,1], Zuzana Münzbergová[1,3]

[1]Institute of Botany of the Czech Academy of Sciences, Průhonice, CZ, Hana.Pankova@ibot.cas.cz
[2]Czech Union for Nature Conservation, Vlašim, CZ
[3]Department of Botany, Faculty of Science, Charles University, Prague, CZ

Minuartia smejkalii is Czech endemic species occurring on serpentine bedrock. Its distribution is limited on two sites appr. 30 km apart. Total population size was only 339 individuals in Želivka SCI (6 populations) and 183 individuals in Hadce u Hrnčíř SCI in in 2015, when the project LIFE for Minuartia (LIFE15 NAT/CZ/000818), aimed on the rescue of this species, started. Both sites were degraded by high shading, accumulation of humus layer and high vegetation cover. Occurrence of *M. smejkalii* was thus limited only to small parts of open rocks.
Rescue of the species was based on: 1) Restoration of the serpentine habitat and 2) Enhancement of its population size by sowing and transplantation of juvenile plants. On the basis of genetic analysis and hybridization experiments, we used native seeds for the enhancement (for details see poster).I will present only results from Želivka SCI, where the restoration was done by removal of humus layer and developed ruderal vegetation to uncover serpentine bedrock and some trees were cut.
To measure effectiveness of the actions, we established permanent plots, recorded phytosociological relevés and evaluated changes in abundance of target and non-target species and abiotic conditions. We also individually marked all individuals of *M. smejkalii* and followed their fate and establishment of new individuals.
The results showed that the revitalisation of sites let to spread of target species (e.g. *Potentilla cranzii*, *Knautia serpentinicola*, *Thymus praecox*, *Festuca ovina*) on the renewed patches. Germination of sown Minuartia seeds was only 0.2%. Transplanted plants had survival rate more than 70%, plants were flowering and producing seeds. Second year after transplantation we observed new seedlings distributed over the whole site. This suggests that population of *M. smejkalii* is recovering. The evaluation of habitat quality as well as fitness of *M. smejkalii* will continue in the following years.

Session 7-O13 - Conservation & restoration

Impact of small-scale conservation managements on spider communities (Araneae) in xeric grasslands

Tomáš Hamřík[1], Ondřej Košulič[1]

[1]Department of Forest Protection and Wildlife Management, Faculty of Forestry and Wood Technology, Mendel University in Brno, Brno, CZ

Until the second half of the 20th century, the Czech landscape was traditionally maintained by traditional farming and grazing that produced a heterogeneous mosaic of microhabitats. However, the abandonment of traditional farming caused the areas with early stages of succession to overgrow and become homogeneous, resulting in the serious loss of arthropod biodiversity. This traditional farming therefore needs to be replaced by an active conservation management method. This research studies the effect of conservation management on spiders of the steppe biotopes Pláně Nature Monument. Specifically, the influence of mowing, prescribed burning, soil disturbance and non-intervention on abundance, species richness, functional diversity and conservation indicators was investigated. Spider sampling was carried out using pitfall traps and sweeping during the season in 2017 and 2018. The treatments were applied on the patches (4 x 5 m) and replicated at three sites. A total of 154 species with 11,634 specimens including many rare and endangered species were captured. Management had no significant effect on the species richness. Spiders had a higher abundance in unmanaged and burned patches. Burned patches also had a high abundance of rare and endangered species of spiders. Intensive soil disturbance had the lowest values of conservation indicators and had rather a negative effect on the overall arachnofauna. Prescribed burning had positive results for most of the studied indicators. The results show that interventions performed on a small area can significantly support the biodiversity of steppe habitats. To support habitat heterogeneity and the diversity of organisms that depend on it, the interventions should be combined and performed in such a scale that would avoid extensive habitat disturbance.

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Session 7-O14 - Conservation & restoration

Environmental heterogeneity is a major driver of community assembly – Lessons from the restoration of landscape scars

Orsolya Valkó[1], Béla Tóthmérész[2], Tamás Miglécz[3], Katalin Lukács[3], Réka Kiss[3], András Kelemen[1], Laura Godó[3], Balázs Deák[2]

[1]MTA-DE Lendület Seed Ecology Research Group, Debrecen, HU, valkoorsi@gmail.com
[2]MTA-DE Biodiversity and Ecosystem Services Research Group, Debrecen, HU
[3]University of Debrecen, Department of Ecology, Debrecen, HU

We studied the vegetation development after the restoration of two types of landscape scars in alkaline steppes, East-Hungary. We explored the drivers of grassland recovery after soil-filling 27 drainage channels and studied post-restoration vegetation development in a former military training area. After the removal of approximately 40,000 unexploded ordnances the bomb-craters have been soil-filled, leaving large unvegetated surfaces on 4000 hectares. These research settings provided a unique opportunity to study the effects of environmental heterogeneity on community assembly in a study system, where soil salt content and micro-topography are the major drivers of vegetation patterns. Due to the mixing of soil layers, there were patches with extremely high salt content on the recovering surfaces and several halophyte species established from the seed bank already in the first year. We found that the diversity of plant species and CSR strategy types was the largest in the first years. Micro-topographic heterogeneity had no effect on the vegetation in the early successional stages. Conversely, in later years, higher micro-topographic heterogeneity resulted in higher diversity, and lower cover of the dominant grass *Festuca pseudovina*. Our results show that the even a few centimeters difference in micro-topography can be a major driver of restoration success.

Session 7-O15 - Conservation & restoration

Kurgans as refuges for grassland species: large-scale multi-taxon study on Eurasian burial mounds

Balázs Deák[1], Orsolya Valkó[2], Dávid Nagy D.[1], Péter Török[3], Attila Torma[4], Gábor Lőrinczi[4], András Kelemen[5], Szabolcs Mizser[1], Antal Nagy[6], Ádám Bede[7], András István Csathó[8], Béla Tóthmérész[1,5]

[1]MTA-DE Biodiversity and Ecosystem Services Research Group, Debrecen, HU, debalazs@gmail.com
[2]MTA-DE Lendület Seed Ecology Research Group, Debrecen, HU
[3]MTA-DE Lendület Functional and Restoration Ecology Research Group, Debrecen, HU
[4]University of Szeged, Department of Ecology, Szeged, HU
[5]University of Debrecen, Department of Ecology, Debrecen, HU
[6]University of Debrecen, Faculty of Agricultural and Food Sciences and Environmental Management, Debrecen, HU
[7]University of Szeged, Department of Geology and Paleontology, Szeged, HU
[8]Körös-Maros National Park Directorate, Szarvas, HU

In transformed landscapes, many populations of grassland specialist plant and animal species live outside the few protected areas, and are often preserved on small natural features (SNFs) such as road verges, field margins and rocky outcrops. In the Eurasian steppe and forest steppe zones the ancient burial mounds (kurgans) are widespread SNFs providing refuge for grassland species. Based on a large-scale botanical and zoological survey of 138 kurgans in Hungary, we compared the management regimes, threatening factors and conservation potential of kurgans embedded in non-protected transformed landscapes and in protected areas. We found that kurgans extend the borders of protected areas by maintaining the populations of grassland specialist plants and arthropods (ants, orthopterans, true bugs, rove beetles) even in transformed landscapes. Improper management, anthropogenic disturbances and the encroachment of woody species are major threats for the long-term maintenance of biodiversity on kurgans outside the protected areas. For their effective conservation a new approach is needed in order to integrate them into the network of other SNFs on a landscape-level. As the ecological importance of kurgans is disproportionate to their size, this approach offers a greater rate of return on the conservation efforts than can be expected in larger continuous sites.

Session 7-O16 - Conservation & restoration

Restoration supports biodiversity on golf courses: From dense swards to biodiverse roughs

Johannes Kollmann[1,2]

[1]Technical University of Munich, Freising, DE, jkollmann@wzw.tum.de
[2]Norwegian Institute of Bioeconomy Research, Oslo, NO, jkollmann@wzw.tum.de

Golf courses have considerable potential to support biodiversity and ecological functions both at the site and at the landscape level. Appropriate planning and management are key to realise this potential of reduced maintenance costs, improved biodiversity and enhanced ecosystem services, while maintaining high-quality playing conditions. The support of pollinators is one such critical ecosystem service that requires more attention and where golf courses actually could make a difference, since conflicts with agricultural management are less pronounced. If golf courses could provide resources for pollinators (like pollen, nectar, nesting and wintering sites), they would contribute to larger and more robust insect population. For golfers this may well be a win-win situation as less dense and less grass-dominated roughs with more flowering herbs will also increase the aesthetic value of the course, and will make it easier to find the balls after poor strokes. Furthermore, the conversion of some of the semi-roughs or even fairway areas into flowering grasslands can also reduce maintenance costs. An ongoing project addresses the challenge of reducing soil fertility and the resulting competitive grass vegetation on roughs by adding saw dust, sowing a hemiparasite and testing various management methods in a factorial experiment that was set up in Norway, Sweden and Germany in 2017. Current trends in biomass production, biodiversity of plants and pollinators will be reported as a basis for restoration of biodiversity and ecological functions.

Session 7-O17 - Conservation & restoration

A Case Study on the Selection of Genetic Conservation Areas for German Species-Rich Grasslands

Ellen Pagel[1], Theresa Anna Lehmair[1], Cornelia Straubinger[2], Christoph Reisch[1], Peter Poschlod[1]

[1]University of Regensburg, Regensburg, DE, ellen.pagel@ur.de
[2]Nationalpark Bayerischer Wald, Grafenau, DE

Semi-natural, species-rich grasslands and the intra- and interspecific diversity of their species are declining across Europe. As a measure to protect genetic resources of agriculturally used plant species, the concept of genetic conservation areas has been established for crop wild relatives (CWR). The aim of our study was to extend this concept from CWR species to wild species in grasslands. In a model study, we characterized the species diversity and genetic diversity and differentiation of common plant species on semi-natural, species-rich grasslands in Southwest Germany to determine the minimal setting for genetic conservation areas for grasslands within the study area.
We studied three different grassland habitats (calcareous grasslands, oat-grass meadows and litter meadows) and within each ecosystem we analysed the genetic diversity and differentiation of three plant species, commonly occurring at the sites. In total we included over 2500 individuals of nine different species from 60 individual grasslands in our data set.
Genetic diversity in all analysed species lay within the range expected for species with their respective traits, while genetic differentiation among populations was generally low, indicating moderate to high gene flow among the studied grasslands.
Based on the observed genetic variation within and among populations for each species, we statistically determined how many and which of the studied grasslands could be included in a network of genetic conservation areas. Our results show that relatively few grasslands (2-9) are needed to incorporate the genetic diversity of a given species in our study region. Thus we conclude, that the protection of genetic diversity in grasslands could be accomplished with relatively few protection areas.

Session 7-O18 - Conservation & restoration

Rapid evolution in plants cultivated for ecosystem restoration

Malte Conrady[1], Walter Durka[2], Oliver Bossdorf[3], Christian Lampei[1], Norbert Hölzel[1], Anna Bucharova[1]

[1]Institut für Landschaftsökologie, Universität Münster, DE, malte.conrady@uni-muenster.de
[2]Department Community Ecology Helmholtz Centre for Environmental Research - UFZ, Halle, DE
[3]Plant Evolutionary Ecology Institute of Evolution & Ecology University of Tübingen, Tübingen, DE

In the face of global change, the need for restoration following ecosystem degradation is increasing. Growing number of restoration projects require large amounts of seeds. As wild harvest cannot cover the demand, wild plants are propagated on fields as crops. Specialized companies collect seeds of native species in multiple wild populations with proven natural origin, mix them to ensure high genetic diversity and establish monocultures for seed production. Parts of the seeds harvested from these farms are then sold, while another part is used for establishing the next generation for seed production. During the on-farm propagation, the plants face a novel environment with new selection pressures, and it is possible they adapt to the cultivation. In an experiment with 22 species, we grew seeds from several consecutive generations in cultivation in a common garden and tested for genetic differentiation in traits. We can see that many of the species changed during the time in monoculture. The novel environment of the propagation site lead to increased biomass, higher rates of germination and a more synchronised phenology. In one species, the proportion of genotypes that do not shed their seeds increased across generations in cultivation, a typical pattern observed within domestication syndrome in crops. In summary, fitness relevant plant traits change during cultivation in seed propagation sites due to unintended selection.

A comparison of the effects of stress and inbreeding on plants from an ex-situ cultivated population and its source population

Tobias Sandner[1], Diethart Matthies[1], Andreas Ensslin[1]

[1]Plant Ecology, Faculty of Biology, Philipps-Universität Marburg, Marburg, DE, tobias.sandner@biologie.uni-marburg.de
[2]Botanical Garden of the University of Bern, Bern, CH

During cultivation in botanic gardens plants are often kept in relatively small populations, which may lead to the loss of genetic diversity through genetic drift and result in inbreeding. This genetic erosion may not cause a reduction in fitness, because cultivation can select for inbred lines which are well adapted to the prevailing local conditions and recessive deleterious alleles may have been exposed and removed by selection, a process called purging. However, the apparent high fitness of plants from populations cultivated ex-situ may drastically change under novel or more complex conditions, e.g. when plants are reintroduced into natural habitats. This could be a consequence of adaptation to the botanic garden conditions, but also a consequence of inbreeding depression (ID), which is often assumed to be higher under more stressful conditions and may threaten the survival of ex-situ lines in the natural habitat. To test these hypotheses, we raised self and cross pollinated offspring from both a population of *Digitalis purpurea* grown for 30 years in a botanic garden and from the original source population under benign and stressful conditions. In particular, we mimicked stresses regularly occurring in natural populations of the species but not in botanic gardens, including nutrient deficiency, drought, herbivory, competition and their combinations. After one year of growth, the magnitude of ID was influenced by environmental stress, and these effects differed between plants from the natural population and the botanic garden. In garden plants, ID was highest under nutrient poor conditions, whereas in plants from the natural population ID was higher under the most stressful conditions combining several stress types. There was thus no support for the specific hypothesis that stresses typically occurring in the natural habitat increase inbreeding depression particularly in plants with a history of cultivation under artificial botanic garden conditions.

Session 7-O20 - Conservation & restoration

Restoration of species-rich grassland at high elevation using adapted seed mixtures

Manuel Schneider[1,3], Kirsten Edelkraut[2,3], Daniel Suter[1]

[1]Agroscope, Zürich, CH, manuel.schneider@agroscope.admin.ch
[2]ZHAW School of Life Sciences and Facility Management, Wädenswil, CH
[3]WG for high-altitude restoration, Swiss Association for Biological Engineering, Rapperswil, CH, manuel.schneider@agroscope.admin.ch

The restoration of grassland vegetation in high elevations is challenging due to harsh climate, a short vegetation period and shallow, nutrient-poor soils. Moreover, environmental conditions differ largely between sites and require site-adapted restoration measures. Seed mixtures allow for a flexible addition of adapted plant species at appropriate dates during the short vegetation period, alone or in combination with transplanted pieces of turf or pre-established seedlings. First, we reviewed the literature about seed mixtures proposed for the subalpine and alpine zones of the Alps and complemented them by mixtures of commercial seed companies and mixtures specifically designed for selected restoration projects. The species composition of the 24 identified seed mixtures was analysed using non-metric multidimensional scaling. It showed that the mixtures were often built around a common set of plant species complemented by a large diversity of additional species. The mixtures contained 26 species on average and 188 species in total. Second, a subset of eight mixtures was tested in an ongoing randomised experiment with three repetitions at a high-elevation site in Eastern Switzerland (1850 m asl., 1365 mm mean precipitation, cambisol on serpentinite). Despite considerable overlap in the core composition of the mixtures, we found large differences in the initial establishment and the composition of the sward. For example, two months after sowing, soil cover ranged from 82 to 100 % and the cover of grasses ranged from 6 to 48 %. This highlights the need to test more seed mixtures for high-elevation restoration in the field in order to improve scientific understanding as well as guidance and extension documents for practitioners.

Session 7-P1 - Conservation & restoration

Southeast Asia Plant Biodiversity Information Infrastructure(SEADiv)

Bo Liu[1], Keping Ma[1], Zheping Xu[1], Maofang Luo[1], Jinlong Zhang[1]

[1]Institute of Botany, Chinese Academy of Sciences, Beijing, CN, boliu@ibcas.ac.cn

Botanical inventory of Southeast Asia is very fragmented and incomplete, we aim at using current flora literatures and specimen records to make a preliminary inventory and build an information infrastructure to facilitate all levels of scientific researchers and amateurs. So as to enhance and provide supports for future analysis, and for a better understanding of plant diversity and conservation. The Southeast Asia Plant Biodiversity Information Infrastructure (SEADiv) aims at integrating plant biodiversity information in 11 Southeast Asia countries. Currently SEADiv has two major achievements. First, over 2 million specimen records, 1 million records of species checklists, over 0.1 million records of multimedia data, 52 000 literatures were collected and digitalized. In addition to data from online resources, 859 national/regional floras and published checklists were used to create the database. Useful references for SEADiv included 462 floras, of which 114 were prioritized as key resources. SEADiv currently contains 153,146 digitized records covering 44,289 species (after deleting 31,219 unmatched records, 4,785 unsolved records, and 76,660 duplicated accepted records synonymized based on www.theplantlist.org), belonging to 4,063 genera and 331 families. The literature collection criteria and database development will be described. Secondly, the online platform (http://www.seadiv.org) has been online since fall 2016. In the future, SEADiv will publish regional species checklist of some target plant groups with the cooperation of more national, regional and international experts, institutes and projects.

Session 7-P2 - Conservation & restoration

Nature 4.0 - Biodiversity monitoring through networked sensors as a basis for conservation strategies

Kim Lindner[1], Nina Farwig[1], Team Natur 4.0[1]

[1]Philipps-Universität Marburg, Marburg, DE, kim.lindner@biologie.uni-marburg.de

Efficient conservation strategies require detailed information on ecosystems and the species that live therein. Conventional data sampling often has to compromise between the level of detail, spatial coverage and temporal resolution of the desired data. The project Nature 4.0 which started in 2019 connects novel approaches from ecology, geography, computer science and mathematics to bridge the gap between basic and applied research and to provide an innovative instrument for biodiversity monitoring. Using networked environmental sensors, powerful data integration and data analysis tools, we develop a modular environmental monitoring system for the high-resolution observation of conservation-relevant species, habitats and processes. Classic in-situ field surveys are used to validate the information obtained from the sensor network, generating large high-resolution datasets on different functional groups. The data obtained is used to model complex interaction networks and assess consequences of changes in species composition and ecosystem processes. Results can then be transferred to the landscape level and be used for the development of early warning indicators required for conservation planning and policy making. We will provide preliminary results on classical bird censuses combined with experimental approaches on predation interactions and UAV assessments of habitat structures. We will further trace fine-scale phenological changes in important structural variables and assess their effect on species composition and interaction networks. We expect that data obtained by UAV can be used to model habitat quality and therefore serves as a proxy for bird community composition and interactions.

On the dominance of rare event recruitment in our landscapes: A demographic perspective on nature conservation in the Anthropocene

Andreas Schweiger[1,2]

[1]Plant Ecology, University of Bayreuth, Bayreuth, DE, andreas.schweiger@uni-bayreuth.de
[2]Bayreuth Center of Ecology and Environmental Research, BayCEER, Bayreuth, DE, andreas.schweiger@uni-bayreuth.de

Landscapes are characterized by geomorphological structures like mountain ranges, valleys or floodplains. However, plants with striking visual appearance and high ecological, economic and cultural importance can also be defining elements characterizing whole landscapes. Iconic species like the baobab or the welwitschia in Africa, the saguaro cactus or Joshua tree in North America, the broad-leaf mahogany in tropical South America, or the Patagonian cypress in South-Central Chile strongly influence our perception of whole landscapes across the world. All of the mentioned species share a common set of characteristics – they are very conspicuous in their appearance from the surrounding flora and generally long-lived, but have infrequent regeneration linked to temporally sporadic environmental conditions. Although perceived to be permanent, everlasting landscape features due to their longevity and striking appearance, we argue that these species are actually exceptional ecosystem components due to sporadic regeneration and recruitment resulting in strong temporal lags in the demographic structure of their populations. These demographic peculiarities have to be actively acknowledged in strategic adaptive management schemes for species and landscape conservation and restoration to counteract sustained losses of biodiversity under accelerating environmental changes with non-equilibrial conditions which increasingly characterize our ecosystems. The framework we developed not only describes these demographic peculiarities of sporadic recruiters but is generally applicable to account for lagged demographic responses to changing environmental conditions – certainly one of the key challenges for nature conservation and resource management in the Anthropocene.

Session 7-P4 - Conservation & restoration

Relocation success of ground-nesting bees and wasps

Anne-Christine Mupepele[1,2], Felix Fornoff[1]

[1]University of Freiburg, Freiburg, DE, anne-christine.mupepele@biom.uni-freiburg.de
[2]Senckenberg Biodiversity and Climate Research Centre, Frankfurt, DE, anne-christine.mupepele@biom.uni-freiburg.de

In Germany, construction work often affects protected biotopes and the law requires compensation measures to create new equally valuable biotopes. In Freiburg, the construction of a new football stadium leads to the loss of a nutrient-poor grassland, a habitat for rare and threatened invertebrates among them grasshoppers, wasps and bees. For compensation, the upper soil layers of the construction area were transferred to a new place during the winter months. The focal purpose of this measure was to relocate soil and plant propagules. We now investigate whether the soil transfer also successfully relocates nesting and hibernating invertebrates with a particular focus on bees and wasps. For this purpose emergence traps were placed on the transferred soil in March 2019. The bee and wasp community emerging from the soil was sampled during the whole vegetation period and compared to undestroyed parts of the initial habitat. Here we present and discuss the results.

Session 7-P5 - Conservation & restoration

Impact of active conservation management on biodiversity of spiders in protected lowland oak forest

Ondřej Košulič[1], Pavla Vymazalová[1], Jan Šipoš[2], Radim Hédl[3]

[1]Department of Forest Protection and Wildlife Management, Faculty of Forestry and Wood Technology, Mendel University in Brno, , , ondra.kosulic@seznam.cz
[2]Department of Zoology, Fisheries, Hydrobiology and Apiculture, Faculty of Agri-Sciences, Mendel University in Brno, Brno, CZ
[3]Department of Vegetation Ecology, Institute of Botany, The Czech Academy of Sciences, Brno, CZ

The objective of the present study was to investigate the impact of active logging interventions on spiders in formerly coppiced oak-hornbeam forests in the Děvín National Nature Reserve, which were conserved for overall 80 years without any active management. We studied the effect of canopy thinning on species richness, abundance, functional diversity, conservation value, degree of rareness and community composition of spiders. Sampling was based on 15 plots distributed equally among three thinning intensities: strong thinning, moderate thinning and control (no management).
Altogether, we collected 3,683 adult spiders representing 21 families, 70 genera, and 116 species. The records contained a total of 23 species (20%) listed in the Red List of Threatened Species. The species richness and conservation indicators increased with canopy openness. The abundance of spiders had the highest values in the moderate thinning. Functional diversity was significantly higher in open habitats with strong canopy thinning, however, the functional traits (spider hunting strategies and body size) were equally dispersed in all canopy thinning variants.
The presented research showed that return to active management can be an appropriate strategy for biodiversity conservation in oak woodlands. However, the logging activities should not be applied by large scale clearings. The strong community changes of spiders highlight the importance of complexity of lowland forests maintained by active interventions.
The study was financially supported by the Specific University Research Fund of the Faculty of Forestry and Wood Technology, Mendel University in Brno (LDF_PSV_2017004) and by the Grant Agency of the Czech Republic, project 17-09283S.

Session 7-P6 - Conservation & restoration

Spatial structure of natural boxwood and box tree moth in Europe can promote long-term coexistence

Léo Ledru[1,2], Jimmy Garnier[1,3], Christiane Gallet[1,2], Sébastien Ibanez[1,2]

[1]Université Savoie Mont Blanc, Le Bourget-du-Lac Cedex, FR, leo.ledru@univ-smb.fr
[2]Laboratoire Ecologie Alpine (LECA), Le Bourget-du-Lac Cedex, FR, leo.ledru@univ-smb.fr
[3]Laboratoire de Mathématiques (LAMA), Le Bourget-du-Lac Cedex, FR

The Asian native box tree moth (Cydalima perspectalis) is present in many European countries since its arrival in Germany in 2006. Moth larvae trigger complete defoliation often entirely defoliate boxwood (Buxus sp.) and cause serious socio-ecological concerns due to the wide use of boxwood as ornamental shrub and the potential extinction of indigenous boxwood stands.
Using a spatially explicit mathematical model, the coexistence of the boxwood and the moth was questioned in the long term and at different spatial scales. The model was calibrated using data from literature, field measurements and a mesocosm experimentation.
At the local scale of a few hectares of boxwood, the moth is irremediably heading towards its own extinction following defoliation of the host plant, while the boxwood can regenerate after the extinction of the moth. In contrast, at a larger spatial scale both species can coexist: local extinction of the moth is counterbalanced by the colonization of intact boxwood stands; meanwhile the boxwood regenerates where the moth has locally disappeared. However, coexistence has a major impact on boxwood since it reaches only 20% of its carrying capacity and 15% of the stands disappeared. We also show that about 10 years periodic dynamics occur in most coexistence regimes, where the moth is present in 30% of the boxwood stands during highs, and only 5% during lows. Years of low moth prevalence should therefore not be confused with imminent moth extinction. Nevertheless, identifying these periods of low abundance to carry out intensive control efforts targeted in areas where the moth persists can be an effective conservation strategy. Finally, long-distance dispersal that ensures desynchronization of local dynamics appears necessary for coexistence. Management practices should limit anthropogenic long-distance dispersal such as boxwood trade, to allow synchronization of local population dynamics and favor the extinction of the moth.

Session 7-P7 - Conservation & restoration

Conservation of meadow orchards: The role of genetic fingerprinting of old fruit varieties

Julius Bette[1], Christina Mengel[1], Sascha Liepelt[1], Birgit Ziegenhagen[1]

[1]University of Marburg, Marburg, DE

Meadow orchards play an important role for conserving biodiversity in our old-grown cultural landscape with up to 5000 different associated taxa. Moreover, the large number of traditional fruit varieties represent a substantial genetic resource as well as new market opportunities. So far, laborious cultivation and only small commercial profit have led to a severe decline of this diverse landscape element. Apple is the most common fruit species in meadow orchards. More than 3000 mostly old cultivars have been recorded in Central Europe with many of them being at risk of getting lost. Identification is fundamental for conservation. The availability of genetic markers constitutes a significant contribution to the pomological expertise. The outcome will range from the detection of synonyms and misnaming to reconstructing domestication and breeding lines. In the present study we introduce a genetic identification procedure which is based on eight nuclear microsatellite markers chosen from various apple genotype databases. Criteria were pomological references, overlapping marker loci while the final number of markers should be large enough for unambiguous identification and small enough for minimizing costs and lab work. Against these demands, the chosen marker set is currently being validated across the available genotype databases. Next, we will invite regional owners of old apple varieties to provide test material for genetic re-identification as a kind of blind testing. Given an overall high power of identification we will standardize the markers for use throughout different labs and sequencing devices. A final step will be the creation of a questionnaire. Questions will address features of meadow orchards, awareness of the owners and the willingness to pay (WTP) for safe identification or for products from certified old varieties. Our prediction is that with increasing knowledge, the motivation for conservation and cultivation of this cultural treasure will increase.

Session 7-P8 - Conservation & restoration

Population differentiation of plants at restored and ancient meadows – a joint plant trait and genetics approach

Theresa Klein-Raufhake[1], Johannes Höfner[1], Walter Durka[2], Christian Lampei[1], Ondřej Mudrák[3], Anna Lampei-Bucharova[1]

[1]Westfälische Wilhelms-Universität, Münster, DE
[2]Helmholtz Centre for Environmental Research, Halle, DE
[3]Institute of Botany of the ASCR, Průhonice, CZ

Land-use change is the main driver for biodiversity loss on a global level. As biodiversity is linked to ecosystem stability and a large proportion of natural ecosystems is considered threatened, restoration is a central mean in preserving global ecosystem services. Among the major challenges are the restoration of abiotic and biotic factors and establishment of target species. To address these challenges, we need to understand the processes that drive restoration success. Here we focus on limits of plant population performance. We compare plants of the same species growing at restored and ancient meadows in the White Carpathians, a low mountain range along the border between Czech Republic and Slovakia. The restoration was done 15 years ago using a regional seed mixture. We selected three plant species and will compare their populations on five pairs of restored and adjacent ancient meadows. First, we focused on phenotypes in the field. We measured plant functional traits and will relate them to abiotic conditions (soil and biomass) in order to estimate what limits plant performance. Preliminary results indicate that plants at restored sites are smaller and more infested by herbivores. The soil and biomass analysis is still ongoing. Second, we will use DNA analysis (genotyping by sequencing) to estimate the genetic relatedness of the plants among restored and ancient meadows and assess the effect of seed source, gene flow and possible selection on the genetic architecture of the restored meadows.

Session 7-P9 - Conservation & restoration

Native seed addition as an effective tool for post-invasive restoration

Anna Bucharova[1], František Krahulec[2]

[1]University of Münster, Münster, DE, anna.lampei-bucharova@uni-muenster.de
[2]Institut of Botany CAS, Pruhonice, CZ

Invasive plants reduce biodiversity, alter ecosystem services and cause economic losses. Invasive plant control is therefore in high demand by land managers and policymakers. However, invasive plant control frequently fails, partly because management often focuses only on eradication of the invader, but not on revegetation with native species that would occupy the emptied space and prevent re-invasion. In this study, we focused on *Rumex alpinus*, an invader that is effectively removed by herbicide but leaves behind a persistent seeds bank. Without further treatment, the species rapidly regenerates and re-invades the area. We show that native seed addition after herbicide treatment can effectively suppress regeneration of the invader from the seed bank, reduce its biomass and consequently, prevent massive re-invasion, establish target vegetation and restore ecosystem services. The success was conditioned by detailed knowledge of the biology of both invasive and native species, as well as restoration of abiotic conditions to remove environmental drivers that initiated the invasion.

Session 7-P10 - Conservation & restoration

Strengthening of population size of endemic species *Minuartia smejkalii*

Hana Pánková[1], Mária Šurinová[1,2], Vojtěch Zeisek[1,2], Bojana Stojanova[1,3], Zuzana Münzbergová[1,2]

[1]Institute of Botany of the Czech Academy of Sciences, Průhonice, CZ, Hana.Pankova@ibot.cas.cz
[2]Department of Botany, Faculty of Science, Charles University, Prague, CZ
[3]Department of Biology and Ecology, Faculty of Science, University of Ostrava, Ostrava, CZ

Conservation of endangered species should be problematic since the populations should be too small to be able to reproduce. In such case restoration of habitat is not sufficient for the species rescue and population size must be enhanced by humans. Such action should ensure that the population will not suffer from loss of fitness due to outbreeding depression.
We present the results of a genetic analysis and hybridization experiment aimed to provide background information for enhancement of *Minuartia smejkali* population, a critically endangered endemic species occurring only on two isolated regions with 7 populations in total. Since the species is restricted to serpentine, the target site was prior population enhancement revitalized (see talk). Both actions were done within project LIFE for *Minuartia* (LIFE15 NAT/CZ/000818).
We performed genetic analysis and a hybridization experiment to understand the between population differentiation and thus to select appropriate source of seeds for population enhancement. Genetic variability was analysed by nextRad sequencing using 20 individuals per population. Hybridization experiment was done by hand pollination of plants with pollen from the same plant, same population or other population. The developed capsules were collected, number and germination of ripe seeds evaluated. The results showed that populations from the two regions are genetically differentiated. On the other hand, populations within each region are not genetically different. Plants pollinated by pollen from other population within the same region produced the highest amount of seeds only in the smallest population. Self-pollination reduced seed set. The germination of all seeds was high and the hybrids grew well. This suggests that the source of seeds for population enhancement of the smallest population should combine individuals from different populations within each region. In contrary, for other population we should use native seeds.

Session 7-P11 - Conservation & restoration

How to establish floral resources for the promotion of insects in fen grasslands - an experimental approach for a landscape lab.

Julian Ahlborn[1], Thomas Kaiser[2], Phillipp Scharschmidt[1], Juergen Pickert[1], Axel Behrendt[3], Frank Eulenstein[1]

[1]ZALF Sustainable Grassland Systems, Paulinenaue, DE, julian.ahlborn@zalf.de
[2]ZALF Sustainable Grassland Systems, Muencheberg, DE
[3]ZALF Experimental Infrastructure Platform, Paulinenaue, DE

Grassland-dominated agricultural systems have been intensified within last 50 years to increase forage quality for livestock and more recently for biogas production. Nesting habitats and food resources for insects have been largely neglected in these production systems so far, contributing to the global decline of insect diversity. A major challenge for the conservation of grassland biodiversity in general and insect diversity in particular is the (re-)establishment of resources and habitats for insects, as well as the development of practicable management schemes. However, the successful transfers of these management schemes into practice depends on the extent to which they can be integrated into economic agricultural production systems. The BML-funded FInAL-project seeks to explore insect-friendly agricultural practices with a focus on renewable energies. Effects of changes in the agricultural landscape on insect biodiversity will be monitored on various scales in three 3 x 3 km landscape laboratories.
The grassland-dominated landscape laboratory “Havelländisches Luch” in north-eastern Germany is mostly under extensive use. Drastic transformations of these fen grasslands during the last 50 years resulted in species-poor plant communities and a lack of suitable conditions for insects. A first challenge in increasing insect diversity will be the establishment of suitable forbs into the existing swards over organic soils. We designed experiments with legume-grass mixtures and wildflower seeds under different soil moisture conditions and soil disturbance treatments to establish species- and flower-rich grassland communities. We will study the long-term establishment success of the mixtures, quantify the benefit for insects and upscale the most promising swards into the landscape lab. In this session, we present the start of our experiments on the establishment of diverse grassland communities and discuss future management options for the promotion of insect diversity.

Session 7-P12 - Conservation & restoration

Species Enrichment in Agricultural Grassland

Sabine Heinz[1], Martina Hofmann[2], Verena Reindl[2], Fabian Numberger[2], Jörg Feder[2], Sophie Hauswald[2]

[1]Bayerische Landesanstalt für Landwirtschaft, Institut für Agrarökologie, Freising, DE, Sabine.Heinz@LfL.Bayern.de
[2]Hochschule Weihenstephan-Triesdorf, Fakultät Nachhaltige Agrar- und Energiesysteme Grünland, Futterbau und Biologie, Freising, DE

Grassland can be very species-rich and plays a key role in the conservation of biodiversity in the cultural landscape. However, species-rich grasslands have become rare and even if intensive use is abandoned, grassland species often do not re-establish. This leads to extensive but species-poor grassland with low yields. While restoration by hay transfer or sowing are common and effective practice in nature conservation, species enrichment in agricultural grassland by farmers could expand the range addressed largely. The aim of the "Transfer" project was to test species enrichment in agricultural grassland by means of hay transfer (five sites) or the sowing of local seeds (two sites). Deviating from restoration in a nature conservation context, the target lies not on restoring rare species or complete plant communities, but to bring typical grassland herbs back to sites managed in low intensity. The practical implementation by farmers, for whom a guide on species enrichment is being developed, is of particular importance to address a wide range of agricultural grassland.
To measure the seed potential of the transfer material hay samples were incubated in the greenhouse parallel to the hay transfer on site. In the greenhouse samples between 35 and 52 different species could be detected. And a seed potential of 2722.9 seeds/m² to 13122.8 seeds/m² on the hay transfer sites was calculated. The sown seed mixtures had only 2154 to 3028 seeds/m². Even though the proportion of herbs was higher in the seed mixtures than in the transferred hay.
The number of species increased at all project sites. In the second year after hay transfer, between 14 and 26 species, transferred from the donor area and not initially present, were detected at the recipient site. At sites re-seeded using local seeds almost all species established.
The whole workflow of enrichment was successfully organized and carried out with typical farm machinery by the farmers who owned the project sites.

Session 7-P13 - Conservation & restoration

Relevance of inbreeding and outbreeding effects for selection of donor populations in restoration ecology of *Arnica montana* L. (Asteraceae)

Isabella Aberle[1], Ilona Leyer[2], Verena Hollmann[2], Sascha Liepelt[1]

[1]Philipps-Universität Marburg, Marburg, DE, aberle@students.uni-marburg.de
[2]Hochschule Geisenheim University, Geisenheim, DE

The global change in ecosystems leads to an increasing number of endangered species. In Germany there are over 70 vascular plants in need of effective protection and restoration measures. For these, the use of local over nonlocal seeds is often seen as a gold standard, led by a precautionary principle to prevent outbreeding depression and therefore negative consequences on the species. This approach is questioned by results showing advantages of the introduction of non-local genotypes when it comes to small, isolated populations with a suspected small gene pool. There is a need for more knowledge on population genetics of the endangered species.
Arnica montana L. is an endangered Asteraceae species native to central Europe, showing a rapid decline in its lowland populations. We investigated in- and outbreeding depression by crossing plants from Hassia (Germany) in 5 categories ranging from selfing to crosses within and among populations to populations far apart. To estimate fitness of the F1-generation, seed set, seedling biomass, growth and survival were monitored in a common garden design. The trial was accompanied by genotyping of the parental and F1-generation using microsatellites.
First results indicate a connection between crossing category and fitness with a biomass increasing by grade of outcrossing, with exception of the most distant crossing. Further results will be discussed.

SESSION 8

Naturschutzpraxis trifft Wissenschaft - Erhaltung und Renaturierung von Offenlandlebensraeumen, Auen und Mooren

Chairs:
Kathrin Kiehl, Norbert Hölzel, Ilona Leyer, Gert Rosenthal, Nils Stanik

Artenreiche Offenlandlebensräume wie Mager- und Trockenrasen sowie Auen und Moore sind aufgrund von Landnutzungsänderungen selten geworden und außerhalb von Schutzgebieten weitgehend verschwunden. Die noch vorhandenen Reliktflächen weisen oft einen schlechten Erhaltungszustand auf. Es ist dringend notwendig, geeignete Naturschutz- und Renaturierungsstrategien für diese Ökosysteme zu identifizieren und umzusetzen, was auch die kritische Überprüfung etablierter Methoden vor dem Hintergrund globaler Umweltveränderungen mit einschließt. Dabei ist ein enger Austausch zwischen Wissenschaft und Praxis unerlässlich. Mit dieser deutschsprachigen Session wollen wir Kolleginnen und Kollegen aus Naturschutzpraxis und Wissenschaft zusammenbringen, um Ergebnisse aus Naturschutz- und Renaturierungsprojekten vorzustellen und zu diskutieren. Diese sollen auf wissenschaftlichen Monitoring- und Begleituntersuchungen zur Erfolgskontrolle beruhen und eine evidenzbasierte Diskussion ermöglichen. Themen umfassen Konzepte, Verfahren und Maßnahmen u.a. zur Wiederansiedlung naturraumtypischer Offenlandökosyteme und –arten, zur Offenhaltung der Landschaft und der Renaturierung von Feuchtgebieten. Für Teilnehmer/innen, die ausschließlich für diesen Tag anreisen, wird eine ermäßigte Tagungsgebühr erhoben. Der thematische Rahmen der Session ist bewusst breit gehalten. Je nach thematischem Schwerpunkt der eingereichten Beiträge wird diese Session ggf. in Sub-Sessions unterteilt.

Session 8-O1 - Naturschutzpraxis trifft Wissenschaft

Naturschutzfachliche Aufwertung von Grünland durch Artenanreicherung – Stand des Wissens, Möglichkeiten und Fallstricke

Norbert Hölzel[1]

[1]University of Münster, Münster, DE, nhoelzel@uni-muenster.de

Selbst innerhalb von Schutzgebieten befinden sich Grünlandbestände aus naturschutzfachlicher Sicht oft in einem beklagenswert schlechten Erhaltungszustand. In besonderem Maße gilt dies auch für naturschutzfachliche Renaturierungs-, Ersatz- und Ausgleichsmaßnahmen, die auf eine Wiederherstellung von artenreichen Grünlandes abzielen, aber häufig nicht zum gewünschten Erfolg führen. Eine Hauptursache hierfür ist die zunehmende Ausbreitungslimitierung zahlreicher Zielarten des Grünlands infolge der Verkleinerung, Fragmentierung und räumlichen Isolation von Quellpopulation sowie dem Wegfall von traditionellen Ausbreitungsvektoren. Auch bei erfolgreicher Senkung der Produktivität und Extensivierung der Nutzung stellen sich die Zielgemeinschaften oft auch langfristig nicht oder nur unvollständig ein. Eine gezielte Artenanreicherung von Grünlandbeständen hat dadurch in den vergangenen beiden Jahrzehnten zunehmend an Bedeutung gewonnen. Die dabei angewandten Methoden reichen von der Ausbringung von lokal gewonnenem Mahd- und Druschgut bis zur Verwendung von zertifiziertem Regio-Saatgut. Obwohl sich der der Kenntnisstand zur erfolgreichen Durchführung von Artenanreicherungsmaßnahmen enorm erweitert hat, werden bei der Durchführung immer noch vermeidbare Fehler begangen. Darüber hinaus bestehen auch von Seiten des Naturschutzes nach wie vor starke Vorbehalte gegenüber einer gezielten Artenanreicherung, der oft pauschal eine Falsifikation lokal gewachsener genetischer Integrität unterstellt wird. Unerwartete Probleme entstehenden vielerorts auch durch eine fachlich kaum nachvollziehbar restriktive Definition von Grünland seitens der Agrarverwaltungen, wodurch Landbesitzer und Nutzer oft fürchten bei Extensivierung und Artenanreicherung ihre EU-Flächenprämie zu verlieren. Der Vortrag gibt einen Überblick zum aktuellen Stand des Wissens und zeichnet Konfliktlinien und Lösungsansätze im Spannungsfeld zwischen Renaturierung, Naturschutz und Landwirtschaft nach.

Session 8-O2 - Naturschutzpraxis trifft Wissenschaft

Wildpflanzensaatgut - wertvoller Baustein zur Förderung der Artenvielfalt

Ann Kareen Mainz[1], Markus Wieden[1]

[1]VWW - Verband deutscher Wildsamen- und Wildpflanzenproduzenten e.V., Langgöns, DE, info@natur-im-vww.de

Der Verlust an Lebensraum in unserer Agrarlandschaft ist eine der Hauptursachen des Artenschwunds unter den Insekten. Zwar verbessern blühende Ansaaten mit Kulturpflanzen das Nahrungsangebot für viele Bestäuber, doch sind sie kein echter Ersatz für verlorengegangenes, extensiv genutztes Grünland.
Gebietseigenes Wildpflanzensaatgut ist ein wertvolles Mittel, naturnahe Habitate herzustellen, wo Spenderflächen für Mahdgutübertragung oder Wiesendrusch fehlen. Doch bereits jetzt führt die gestiegene Nachfrage zu Lieferengpässen, die sich mit Inkrafttreten der Genehmigungspflicht für die Ausbringung gebietsfremder Arten ab 2020 verschärfen dürften.
Trotz intensiver Bemühungen der Produzenten gelingt es nur langsam, das Angebot an Wildpflanzensaatgut zu steigern. Die zaghafte Unterstützung des behördlichen Naturschutzes mag hierbei eine Rolle spielen. Fest steht: Wildpflanzensaatgut ist ein knappes Gut. Gesetzliche Vorgaben, schwierige Kultivierung und arbeitsintensive Ernteverfahren bedingen hohe Preise für einzelne Arten.
Diese Marktsituation setzt Anreize, fremde Ware einzuschleusen oder in Deutschland gesammeltes Ausgangsaatgut im Ausland zu vermehren. Lückenlose Kontrollen sind wichtig, denn die für Deutschland anerkannten Zertifikate für Wildpflanzensaatgut (VWW-Regiosaaten®, RegioZert®) sichern die Herkunft nur bis zum ersten Inverkehrbringen ab. Es bleibt in der Verantwortung ausschreibender Stellen, Lieferdokumente zu prüfen und Ansaaten zu begleiten. Flächennachweise und der Besuch der Anbaubetriebe geben Sicherheit zur Saatgutherkunft. Nachträglich kann eine Isotopenuntersuchung die Angaben zur Saatgutherkunft bestätigen.
Damit die Schaffung wertvollen (Ersatz-)Lebensraums sicher gelingt, sollten die Mischungen für Wildpflanzenansaaten optimal auf Standort und Maßnahmenziel abgestimmt und die Etablierung der Pflanzen durch gute Bodenvorbereitung und Ansaattechnik unterstützt werden.

Session 8-O3 - Naturschutzpraxis trifft Wissenschaft

Regiosaatgut zur Wiederherstellung von Pflanzengemeinschaften

Anna Bucharova[1]

[1]University of Münster, Münster, DE, anna.lampei-bucharova@uni-muenster.de

Die Wiederherstellung von Pflanzengemeinschaften erfordert eine große Menge an Saatgut einheimischer Pflanzen. Im Idealfall sollte dieses Saatgut sowohl lokal angepasst sein, um eine gute Leistung unter den gegebenen Bedingungen zu ermöglichen, als auch genetisch vielfältig sein, um die Anpassung, die im Zuge des Klimawandels nötig werden, zu ermöglichen. In Deutschland gibt es ein entwickeltes System, das Saatgut für die (hauptsächlich) Grünlandrestaurierung bereitstellt. Saatgut wird aus mehreren Populationen innerhalb einer Region (Saatgut-Transferzone) gesammelt und anschließend gemischt, um genetische Variabilität zu erreichen. Mit diesen Samen wird nun eine Monokultur angelegt um Saatgut für Renaturierung zu gewinnen. Wir haben eine Reihe von Gartenexperimenten und molekularen Methoden verwendet, um die Eigenschaften des kommerziell erhältlichen regionalen Saatguts zu untersuchen. Das Saatgut bietet im Vergleich zu einzelnen natürlichen Populationen eine erhöhte genetische Vielfalt und damit ein verbessertes Anpassungspotenzial. Obwohl der Anbau zu einer unbeabsichtigten Selektion führt, die auf phänotypischer und molekularer Ebene sichtbar ist, haben wir festgestellt, dass regionale Pflanzen im Durchschnitt besser sind als Pflanzen aus anderen Regionen. Darüber hinaus beeinflusst der pflanzliche Ursprung interagierende Organismen auf zwei trophischen Ebenen. Zusammenfassend lässt sich sagen, dass das kommerziell erhältliche Saatgut ein wirksames Instrument zur Wiederherstellung von Grünlandgemeinschaften ist.

Session 8-O4 - Naturschutzpraxis trifft Wissenschaft

Renaturierung urbaner Lebensräume durch Ansaat gebietseigener Wildpflanzen – Ergebnisse, Erfahrungen und Herausforderungen

Kathrin Kiehl[1], Daniel Jeschke[1], Roland Schröder[1]

[1]Osnabrück University of Applied Sciences, Osnabrück, DE, k.kiehl@hs-osnabrueck.de

Die Renaturierung städtischer Freiflächen umfasst nicht nur das Zulassen der Entwicklung von Spontanvegetation auf Brachflächen, sondern auch die Extensivierung vormals intensiv gepflegter Rasenflächen und die Wiederansiedlung gebietseigener Wildpflanzen zur Förderung der regionaltypischen Biodiversität. Nach der Gründung des Osnabrücker Bienenbündnis im Jahr 2013 wurden in der Stadt Osnabrück im Rahmen verschiedener Forschungs- und Praxisprojekte zahlreiche arten- und blütenreiche Wiesen und Säume durch Ansaat mit naturraumtypischen Wildpflanzen angelegt. Auf einem ehemaligen Kasernengelände wurden nach Gebäuderückbau in einem wissenschaftlichen Blockversuch verschiedene Saatmischungen getestet. In Bereichen mit höheren pH-Werten und Humusgehalten entwickelten sich attraktive Blühaspekte, die im Vergleich zu den Kontrollflächen ohne Ansaat eine deutliche ästhetische Aufwertung bewirkten. Durch die eingebrachten Kräuter konnte die Vorherrschaft konkurrenzkräftiger Gräser reduziert werden. Auf humus- und nährstoffarmen Sanden mit niedrigen pH-Werten wurden statt der angesäten Arten vor allem „Spontanetablierer“ gefunden, darunter auch mehrere Rote-Liste-Arten naturraumtypischer Sandmagerrasen und Pionierfluren. Insgesamt gesehen fördert also die Beibehaltung heterogener Bodeneigenschaften die Arten- und Strukturvielfalt städtischer Freiflächen. Weitere Ansaaten mit der für das Osnabrücker Bienenbündnis entwickelten „Osnabrücker Mischung“ aus mehr als 40 gebietseigenen Wildpflanzenarten zeigen, dass für eine erfolgreiche Wiederherstellung arten- und blütenreicher Wiesen und Säume eine sehr gute Bodenbearbeitung sowie eine standortangepasste Entwicklungs- und Folgepflege essenziell sind. Dafür werden fachkundige „Kümmerer“ vor Ort benötigt.

Session 8-O5 - Naturschutzpraxis trifft Wissenschaft

Förderung von Bienen in Apfelplantagen durch naturnahe Vegetationsstrukturen

Vivien von Königslöw[1], Alexandra-Maria Klein[1]

[1]Albert-Ludwigs-Universität Freiburg, Freiburg, DE, vivien.von.koenigsloew@nature.uni-freiburg.de

Apfelplantagen scheinen wegen des geringen Blütenangebots nach der Apfelblüte nur begrenzt Lebensraum für Bienen bereitzustellen. Mit steigendem Bewusstsein für ökologische Belange, legen Landwirte vermehrt Blühstreifen zur Förderung von Bienen an. Jedoch könnten andere naturnahe Strukturen, z.B. Hecken, besser geeignet sein, weil sie über einen längeren Zeitraum Blüten bereitstellen. Für die Attraktivität von Hecken spielt aber die Qualität eine wichtige Rolle und es ist fraglich, ob Hecken, die typischerweise entlang von Apfelplantagen zu finden sind, der zugeschriebenen Habitatqualität entsprechen. Aufwertungsmaßnahmen könnten die Qualität entscheidend steigern. Das Ziel unserer Untersuchung ist, herauszufinden, wie sich die Anwesenheit verschiedener Vegetationsstrukturen auf Bienenpopulationen in Apfelplantagen auswirkt und welche Strukturen Bienen am effektivsten fördern. Dafür wurden im Bodenseegebiet Plantagen mit unterschiedlicher Vegetationsausstattung verglichen, und zwar Plantagen mit Blühstreifen beziehungsweise mit Hecken. Zusätzlich wurden an einigen Hecken Blühsäume angelegt. Wir untersuchten die Effekte der Vegetationsstrukturen mithilfe von Blütenbeobachtungen innerhalb der Apfelplantagen sowie in den Vegetationsstrukturen. Wir haben festgestellt, dass die Hecken von signifikant weniger Bienenindividuen und –arten besucht wurden als die Blühstreifen, die während ihrer Blütezeit sehr beliebt bei Bienen waren. Betrachtet man jedoch die gesamte Plantage, war die Anzahl der Bienen in Plantagen mit Hecken höher. Der angelegte Heckensaum kam im ersten Jahr der Untersuchung kaum zur Blüte, war dennoch besonders für solitäre Bienen attraktiv. Eine Aufwertung der Hecken durch Blühsäume scheint also eine geeignete Maßnahme zur Förderung von Bienen zu sein, besonders wenn in den kommenden Jahren mehr Pflanzen zur Blüte kommen.

Wiederansiedlung von Offenlandlebensräumen im Hotspot-Projekt „Wege zur Vielfalt“ und im Projekt „Hotspot goes LEADER“

Annika Brinkert[1], Sarah Bülter[2], Hartmut Storch[1]

[1]Biologische Station Kreis Steinfurt e. V., Tecklenburg, DE, annika.brinkert@biologische-station-steinfurt.de
[2]Kreisverwaltung Steinfurt, Steinfurt, DE

Vor dem Hintergrund intensiver landwirtschaftlicher Nutzung und hohen Flächendrucks ist die Erhaltung der biologischen Vielfalt eine wesentliche Herausforderung im Nordwestdeutschen Tiefland. Allein in den häufig isoliert liegenden Naturschutzgebieten mit hohen negativen Randeffekten wird der Schutz von Pflanzen, Tieren und ihren Lebensräumen jedoch langfristig nicht ausreichen, um die Arten in unserer Kulturlandschaft zu erhalten.
Ziel der Projekte „Wege zur Vielfalt – Lebensadern auf Sand“ sowie „Hotspot goes LEADER – blühende Säume im Tecklenburger Land“ ist es daher u. a., in der intensiv genutzten Agrarlandschaft, aber auch in Städten und Dörfern auf öffentlichen Flächen artenreiche Säume durch Aussaat von Regiosaatgut anzulegen und bestehende Säume und Wiesen durch Anreicherung mit Regiosaatgut zu optimieren. So werden artenreiche Strukturen geschaffen, miteinander vernetzt, Pflanzen nährstoffarmer Standorte gefördert und Nahrungs- und Fortpflanzungshabitate geschaffen.
Aufgrund der häufig geringen Breite der Säume und der zum Teil schwierigen Aufnahme des Mahdgutes ist eine Nutzung als Tierfutter oder zur Energiegewinnung in der Regel nicht wirtschaftlich und der Aufwuchs muss entsorgt werden. Dies hat dazu geführt, dass Kommunen aus finanziellen und organisatorischen Gründen meist auf Mulchmahd zurückgreifen, was wiederum zu Nährstoffanreicherung und Artenverarmung von Säumen führt. Auch der notwendige späte Schnittzeitpunkt auf artenreichen Säumen und Wiesen erschwert eine wirtschaftliche Verwertung des Aufwuchses als Tierfutter. Hier sind eine intensive Öffentlichkeitsarbeit und Beratung aber auch finanzielle Anreize über Vertragsnaturschutz, Kompensationsmaßnahmen etc. notwendig.

Session 8-O7 - Naturschutzpraxis trifft Wissenschaft

Ansiedlung und Vermehrung von Bulttorfmoosen in der Hochmoorrenaturierung

Peter Raabe[1], Till Kleinebecker[2], Klaus-Holger Knorr[1], Norbert Hölzel[1]

[1]Institute of Landscape Ecology, Münster, DE, p.raabe@uni-muenster.de
[2]Institute of Landscape Ecology and Resource Management, Gießen, DE

Seit den 1980er Jahren werden in Nordwestdeutschland industriell abgetorfte Hochmoorflächen als Folgenutzung für die Renaturierung hergerichtet und wiedervernässt. Die Mehrzahl dieser Renaturierungsflächen haben das Ziel einer möglichst vollständigen Hochmoor-Regeneration jedoch bei Weitem noch nicht erreicht. Als wesentliche Ursache hierfür ist, neben instabilen hydrologischen Bedingungen und teilweise unpassendem Nährstoffniveau, vor allem eine Ausbreitungslimitierung von Bulttorfmoosen auf der lokalen und regionalen Landschaftsebene infolge anthropogener Habitatfragmentierung sowie einer generell geringen Bedeutung der generativen Vermehrung bei Bulttorfmoosen zu nennen.
Wie Untersuchungen zum Etablierungserfolg zeigen, konnte 18 Monate nach gezielter Einbringung von vegetativ vermehrten Bulttorfmoosen lokaler Herkunft in 7% - 69% der Fälle von in Sodenform transplantierten Varianten ein Etablierungserfolg festgestellt werden. Die Ergebnisse variierten vor allem in Abhängigkeit der hydrologischen Standortbedingungen, der Moosvariante sowie der zugrunde gelegten Messmethode zur Bestimmung des Etablierungserfolgs. Wenngleich sich die über längere Zeiträume ablaufenden Interaktionen mit der bereits etablierten Vegetation nur bedingt abschätzen lassen, sprechen die Ergebnisse dafür, dass aktive Wiederansiedlungsmaßnahmen von Bulttorfmoosen bei Erfüllung wesentlicher Etablierungsvoraussetzungen (Auswahl geeigneter Diasporen, günstige Standortbedingungen) einen wichtigen Beitrag zur Optimierung der derzeitigen Renaturierungspraxis leisten können. In diesem Zusammenhang werden am Beispiel einer erfolgreich erprobten Anlage zur Torfmoosvermehrung Potenziale von Bulttorfmoosen in der Vermehrung in Mono- und Mischkultur unter besonderer Berücksichtigung von Arteigenschaften, Artenzusammensetzung und verschiedenen Bewässerungstechniken vorgestellt.

Session 8-O8 - Naturschutzpraxis trifft Wissenschaft

Erfolg einer Wiederansiedlung von Europäischen Laubfröschen (*Hyla arborea)* in der Steinhuder Meer-Niederung, Niedersachsen

Thomas Brandt[1]

[1]Ökologische Schutzstation Steinhuder Meer, Rehburg-Loccum, DE

Nachdem der Europäische Laubfrosch *Hyla arborea* Ende der 1970er Jahre am niedersächsischen Steinhuder Meer ausgestorben war, konnte die Art nach umfangreichen Naturschutzmaßnahmen wieder erfolgreich angesiedelt werden. Da eine natürliche Wiederbesiedlung nicht möglich war, wurden von 2005 bis 2008 circa. 8500 Kaulquappen in 15 Gewässern innerhalb der westlich an den See angrenzenden Naturschutzgebietskulisse freigelassen. Die Entwicklung der rasch anwachsenden Population wurde jährlich. 2016 konnten etwa 3600 rufende Männchen in über 100 Gewässern nachgewiesen werden, 2018 bereits über 6.000 Rufer. Rund ein Fünftel der Rufgewässer lag außerhalb der Naturschutzgebietskulisse. Ein besonders geeignetes Umfeld und begleitende, die speziellen Ansprüche der Art berücksichtigende Naturschutzmaßnahmen förderten das Populationswachstum dieser für den Amphibienschutz wichtigen Leitart. Mittelfristig soll sich die Population mit weiteren, wieder angesiedelten Lokalpopulationen mit ähnlich positiven Bestandsentwicklungen zu einer Metapopulation entwickeln, deren besiedelter Raum sich auf über 100 km^2 erstreckt.

Session 8-O9 - Naturschutzpraxis trifft Wissenschaft

WIPs-De II - Wildpflanzenschutz-Deutschland

Peter Borgmann[1], Daniela Listl[2], Peter Poschlod[2], Sabine Zachgo[1]

[1]Botanischer Garten der Universität Osnabrück, Osnabrück, DE
[2]Botanischer Garten der Universität Regensburg, Regensburg, DE

Das Bundesamt für Naturschutz (BfN) hat 92 Wildpflanzenarten benannt, für deren Schutz und Erhalt Deutschland global eine besondere Verantwortung hat. In dem WIPs-De II Projekt werden unterschiedliche Maßnahmen des botanischen Artenschutzes kombiniert, um dem Verlust dieser Verantwortungsarten entgegenzuwirken. Hierzu werden in einem Verbund bestehend aus den fünf Botanischen Gärten Berlin, Mainz, Osnabrück, Potsdam und Regensburg unterschiedliche Projektziele bis 2023 realisiert. Bundesweit werden genetische Ressourcen in Form von Saatgut und Sporen von einer Vielzahl gefährdeter Verantwortungsarten in vier Projektregionen koordiniert gesammelt und in regionalen Saatgutgenbanken für weitere wissenschaftliche Untersuchungen und Naturschutzmaßnahmen gesichert und bereitgestellt. Aus den Samen werden in Botanischen Gärten Jungpflanzen zum Aufbau von Erhaltungskulturen herangezogen. Von ausgewählten Arten werden Jungpflanzen und Samen am natürlichen Wuchsort ausgebracht und die Ergebnisse dieser Maßnahmen über mehrere Jahre evaluiert. Die fünf Verbundpartner kooperieren regional mit dem behördlichen Naturschutz und weiteren Fachleuten verschiedener Naturschutzinstitutionen. Zum besseren Verständnis der Ökologie dieser meist seltenen Pflanzen werden Gegebenheiten und Veränderungen am Standort erfasst. Sowohl die Qualität, Langlebigkeit und Keimungsökologie des Saatgutes als auch die Bedingungen für die Anzucht von Pflanzen für Erhaltungs- und Vermehrungskulturen werden ermittelt. Ziel der Bildungsarbeit ist, die im Projekt angewandten Artenschutzmaßnahmen für unterschiedliche Zielgruppen begreifbar zu machen und die Bedeutung der biologischen Vielfalt und des botanischen Artenschutzes hervorzuheben. WIPs-De II wird im Rahmen der Nationalen Strategie zur biologischen Vielfalt durch das BfN mit Mitteln des Bundesministeriums für Umwelt, Naturschutz und nukleare Sicherheit gefördert.
www.wildpflanzenschutz.de

Session 8-O12 - Naturschutzpraxis trifft Wissenschaft

Erfolgskontrolle von langjährig abgeschlossenen Vorhaben zur Auenrenaturierung

Dominique Remy[1]

[1]Universität Osnabrück, Osnabrück, DE, dremy@uos.de

Ungestörte Auen waren aufgrund ihrer Dynamik und der resultierenden Strukturvielfalt, Zentren der Biodiversität. Heute wird versucht diese zwischenzeitlich stark strukturell und funktionell verarmten Auen aufwendig zu renaturieren. Während für Fließgewässer viele Erfahrungen mit Erfolgskontrollen und entsprechende „Instrumente“ zur Bewertung vorliegen, sind derartige Erfolgskontrollen bei Projekten zur Auenrenaturierung noch relativ selten. Dieses Projekt versucht die längerfristigen Erfolge solcher Maßnahmen bezogen auf die ganze betroffene Aue zu erfassen und vergleichend zu bewerten. Es wurde Teilabschnitten von vier Flussauen untersucht, bei denen die Renaturierung bereits vor mindestens zehn Jahren abgeschlossen wurde. Es wurde erwartet, dass sich in diesem Zeitraum ein auetypisches, dynamisches Gleichgewicht eingestellt hat. Außerdem sollten sich die Folgen der damaligen Baumaßnahmen sowie der späteren Managementmaßnahmen in den Projektgebieten vollständig ausgeprägt haben. Drei der Renaturierungsgebiete, nämlich an Berkel (NRW), Hase (Niedersachsen) und Oster (Saarland), haben in sich geschlossene Projektgebiete, deren Quererstreckung sich weitgehend am natürlichen Talrand orientiert. Hier konnten in Teilen der Aue eine natürliche Dynamik zugelassen werden. Die Ergebnisse der Untersuchungen zeichnen teilweise ein sehr uneinheitliches Bild. Generell wurden die Maßnahmen seinerzeit wie geplant umgesetzt. Bezogen auf die untersuchten biotischen und abiotischen Parameter, bzw. bezogen auf ausgewählte Indikatorgruppen, gibt es sowohl positive, wie auch negative oder auch keine Entwicklungen, wobei generell positive Entwicklungen überwiegen. Problematisch wird eine Bewertung der Entwicklung dann, wenn die betrachteten Parameter auch außerhalb der Projektgebiete starken Veränderungen unterliegen. So kann beispielsweise der Zustand der Avifauna der betroffenen Gebiete nicht ohne Berücksichtigung der Entwicklung im größeren Umfeld bewertet werden.

Session 8-O13 - Naturschutzpraxis trifft Wissenschaft

Der Einfluss des Pflegeregimes auf die Vegetation und den Nährstoffhaushalt von Feuchtwiesen im Münsterland – Ergebnisse eines 30-jährigen Freilandexperiments

Frederike Velbert[1], Lina Birkner[1], Peter Schwartze[2], Norbert Hölzel[1]

[1]Universität Münster, Münster, DE, frederike.velbert@uni-muenster.de
[2]Biologische Station Kreis Steinfurt, Tecklenburg, DE
[3]Universität Gießen, Gießen, DE

Entwicklung und Erhalt von Feuchtgrünland erfordert eine regelmäßige Mahd oder Beweidung, um das Aufkommen von Hochstauden oder Gehölzen zu verhindern. Um die Eignung verschiedener Pflegeregime für den floristischen Grünlandschutz zu testen, wurden 1987 im Rahmen des Feuchtwiesenschutzprogrammes NRW neun Versuchsflächen angelegt und bis 2017 mindestens alle zwei Jahre vegetationskundlich aufgenommen. Die allesamt ungedüngten Pflegevarianten umfassten: Mahd im Juni, September oder an beiden Terminen, sowie eine Brache mit regelmäßiger Gehölzentfernung. Zum Abschluss des Experimentes wurden von allen Varianten die Aufwuchsmenge und Elementkonzentration in der Biomasse bestimmt.
Die verschiedenen Pflegevarianten bewirkten eine starke Differenzierung der Vegetation, mit artenarmen, hochwüchsigen Brachen und kürzeren, artenreichen gemähten Beständen. Zwei- und einschürig gemähten Varianten unterschieden sich in ihrer Vegetationszusammensetzung, nicht aber in ihrem Artenreichtum. Vegetationsunterschiede zwischen den juni- und septembergemähten Varianten waren gering, in einigen Versuchsflächen jedoch gut sichtbar. Eine späte Mahd entzog den Flächen weniger Nährstoffe als eine häufigere oder frühere Mahd. Kaliummangel war in allen gemähten Pflegevarianten häufig, während Stickstoff und Phosphor je nach Standort das Pflanzenwachstum limitieren konnten. Veränderungen in der Vegetation waren zu Beginn des Experimentes am stärksten. Die Brache erlebte dabei einen starken Artenverlust, der sich erst nach mehreren Jahrzehnten durch Neueinwanderung wieder ausglich. Bei allen Pflegevarianten zeigte sich zudem eine Tendenz zur Versauerung.
Eine einzige Mahd mit Abräumen kann artenreiche Bestände in den untersuchten Grünlandtypen erhalten. Unsere Ergebnisse demonstrieren die Relevanz von Langzeitexperimenten für die Naturschutzpraxis, da viele Ökosystemprozesse erst verzögert auf Umweltveränderungen reagieren. Ein vollständiges Blockdesign ist dabei nötig, um flächenspezifische Effekte herauszufiltern.

Session 8-O14 - Naturschutzpraxis trifft Wissenschaft

Keine Grenzen für den dunklen Ameisenbläuling!

Irma Wynhoff[1], Eva Remke[2], Lars Delling[3], Jac Mulders[4], Miriam Scherpenisse[5], Jürgen Schieren[6], Cristina Sevilleja[1], Alexander Terstegge[7], Peter Verbeek[5], Jan Boeren[8]

[1]De Vlinderstichting (Dutch Butterfly Conservation), Wageningen, , irma.wynhoff@vlinderstichting.nl
[2]Onderzoekcentrum B-ware, Nijmegen, NL
[3]Amt für Umwelt und Verkehrsplanung des Kreises Heinsberg, Abt. untere Naturschutzbehörde, Heinsberg, DE
[4]Natuurrijk Limburg, Boeren voor Natuur, Vlodrop, NL
[5]Ecologisch Adviesburo Natuurbalans-Limes Divergens, Nijmegen, NL
[6]WasserVerband Eifel-Rur, Düren, DE
[7]Naturschutzstation Haus Wildenrath, Wegberg, DE
[8]Provincie Limburg, Cluster Natuur en Water, Maastricht, NL

Der Dunkle Ameisenbläuling (*Maculinea nausithous*) war bis in die sechziger Jahre des letzten Jahrhunderts nicht selten im Deutsch-Niederländischen Rurtal. Der Falter ist in seiner Lebensweise sowohl auf die Wirtspflanze Großer Wiesenknopf (*Sanguisorba officinalis*) zur Eiablage als auch auf die Rote Knotenameise (*Myrmica rubra*) angewiesen. Im Nest der Ameisen ernähren sich die Raupen von der Ameisenbrut. Rund 1970 verschwand der Bläuling aus den Niederlanden, im Deutschen Teil der Rurauen konnten einige kleine Populationen sich halten, die 2001 eine Straßenböschung bei Posterholt (NL) kolonisierten. Der Große Wiesenknopf ist im Rurtal in einigen sehr unterschiedlichen Vegetationstypen zu finden, wovon das artenreiche mesotrophe Grünland (Feuchte Glatthaferwiesen), das durch traditionelle Landwirtschaft entstand, am wichtigsten ist. Leider ist dieser Typ stark zurückgedrungen auf Straßenränder, Bachufer und Reststücke. Die Rote Knotenameise wird oft in verwilderten Saumbereichen angetroffen.
Der Dunkle Ameisenbläuling ist eine wichtige Zielart des Naturschutzes in Europa, er ist in den Anhängen 2 und 4 der FFH-Richtlinie aufgeführt. Um den langfristigen Schutz der Art zu sichern, ist eine große, grenzüberschreitende Meta-Population nötig. Hierzu müssen die letzten deutschen, atlantischen Populationen und die niederländische Population miteinander verknüpft werden. Durch ein niederländisch-deutsches INTERREG Projekt ist die grenzüberschreitende Zusammenarbeit der Wasserverbände, Kreise, Gemeinden, Provinz, Bauern und Naturschutzorganisationen verbessert. Nachdem die Nährstoffversorgung des Bodens bestimmt wurde, kann anschließend pro potentiell zu entwickelnde Fläche ein Plan aufgestellt werden, wie wieder ein geeignetes Mosaik von Habitattypen entwickelt werden kann. Im Vortrag wird das zukünftige Biotopverbundnetzwerk, die geplanten Ersteinrichtungsmaßnahmen und die Zusammenarbeit verschiedener Akteure vorgestellt.

Session 8-O15 - Naturschutzpraxis trifft Wissenschaft

Lassen sich Kalkmagerrasen durch Beweidung mit Schafen und Damhirschen erhalten?
Ergebnisse aus einem 8-jährigen Dauerexperiment im Teutoburger Wald

Denise Rupprecht[1], Norbert Hölzel[1], Birgit Jedrzejek[1]

[1]Münster University, Institute of Landscape Ecology, Münster, DE, denise.rupprecht@uni-muenster.de

Im Teutoburger Wald bei Lengerich gibt es im Bereich ehemaliger Steinbrüche wertvolle Kalkmagerrasen, die unter anderem reich an Orchideen sind. Die Flächen werden zur Erhaltung und Pflege jährlich mit Schafen in Hütehaltung beweidet. Aber auch eine große lokale Population an Damhirschen übt in dem Gebiet starken Weidedruck aus. Würde die Beweidung ausreichen, um die Flächen dauerhaft offenzuhalten? Oder ist die Beweidung insgesamt zu intensiv, sodass seltene Zielarten in ihrem Bestand gefährdet werden? Um dies zu untersuchen, läuft seit 2011 ein Projekt der IG Teuto mit der Uni Münster, bei dem auf markierten Dauerflächen regelmäßig vegetationsökologische Untersuchungen durchgeführt werden. Hierzu wurden durch verschiedene Zäunungen entweder dauerhaft alle großen Weidetiere oder nur gezielt die Schafe ausgeschlossen. Acht Jahre nach der Einrichtung zeichnet sich ein klares Bild ab: Durch fehlende Störung und fehlende Biomasseentnahme nimmt in den dauerhaft eingezäunten Plots stetig die Menge an toter Streu zu. Es kommt zu einer Verfilzung und nach und nach zu einer Zunahme hochwüchsiger, vornehmlich holziger Arten, die einen Strukturwandel und damit einen Verlust an typischen Kalkmagerrasenarten nach sich ziehen. Auch die von Damhirschen beweideten, nur temporär gegen Schafe eingezäunten Bereiche erlitten in den vergangenen Jahren einen Qualitätsverlust, während die von beiden Spezies beweideten Kontrollflächen noch immer etwa gleichwertige Bedingungen und Artenzahlen wie zu Beginn aufweisen. Offenbar spielt also auch die Beweidung durch Damhirsche eine Rolle - sie ist aber alleine nicht ausreichend, um Struktur- und Artenvielfalt der Kalkmagerrasen dauerhaft zu sichern.

Session 8-O16 - Naturschutzpraxis trifft Wissenschaft

Ganzjahresbeweidung orchideenreicher Kalktrockenrasen – Ergebnisse aus 10 Jahren naturschutzfachlicher Erfolgskontrolle im NSG Tote Täler

Martina Köhler[1], Georg Hiller[1], Sabine Tischew[1]

[1]Hochschule Anhalt, Bernburg, DE, martina.koehler@hs-anhalt.de

Ganzjahresbeweidung als Management orchideenreicher Kalktrockenrasen wird bisher selten angewendet. Einerseits befürchten Fachleute eine ungleichmäßige Nutzung der Weidefläche, die teilweise zu Verbrachung und Verbuschung mit nachfolgender Reduzierung der günstigen Lichtbedingungen auf dem Boden führt, teilweise aber auch zu Übernutzung mit negativen Effekten wie Latrinenbildung, homogene Weiderasen oder Beeinträchtigung charakteristischer Pflanzenarten. Insbesondere Orchideenpopulationen gelten als stark beweidungssensibel. Andererseits ist die Beweidung mit großen Weidetieren ein ökonomisch profitables und zukunftsweisendes Instrument, um der Verbrachung wertvoller Lebensräume und damit dem Biodiversitätsverlust entgegenzuwirken. Von 2009 bis 2018 wurden unterschiedliche Habitatparameter und die Raumnutzung der Weidetiere (Koniks) auf 464 Plots á 0,25 ha auf einer insgesamt 90 ha großen Ganzjahresweide untersucht. Die Abundanz der Orchideenart *Ophrys apifera* wurde 2013 und 2018 flächendeckend erfasst. Zusätzlich lieferten Vegetationsaufnahmen Informationen über Veränderungen von Arten und -mächtigkeiten. Die Ergebnisse zeigten eine mosaikartige und strukturreiche Vegetationsentwicklung, die einer starken Dynamik durch den Beweidungseinfluss unterlag. Die Population von *O. apifera* erhöhte sich signifikant, andere seltene Orchideenarten wanderten neu in die Weide ein. Die floristische Artenzahl, insbesondere der Kalktrockenrasenarten, nahm kontinuierlich um ein Drittel zu. Eine extensive ganzjährige Beweidung mit Pferden eignet sich daher, um +/- ebene und großflächige orchideenreiche Kalktrockenrasen in einen günstigen Erhaltungszustand zu überführen.

Session 8-O17 - Naturschutzpraxis trifft Wissenschaft

Wildlebende Rothirsche im Offenland: Eine Chance für das Naturschutzmanagement

Friederike Riesch[1,2], Christoph Raab[1,2], Laura Richter[1,2], Bettina Tonn[1,2], Hans Georg Stroh[1], Marcus Meißner[5], Horst Reinecke[3], Nina Rohwer[3,5], Johannes Signer[3], Sven Herzog[4], Niko Balkenhol[3], Johannes Isselstein[1,2]

[1]Graslandwissenschaft, Department für Nutzpflanzenwissenschaften, Georg-August-Universität Göttingen, Göttingen, DE, friederike.riesch@agr.uni-goettingen.de
[2]Zentrum für Biodiversität und Nachhaltige Landnutzung, Georg-August-Universität Göttingen, Göttingen, DE, friederike.riesch@agr.uni-goettingen.de
[3]Wildtierwissenschaften, Fakultät für Forstwissenschaften und Waldökologie, Georg-August-Universität Göttingen, Göttingen, DE
[4]Dozentur für Wildökologie und Jagdwirtschaft, Technische Universität Dresden, Dresden, DE
[5]Institut für Wildbiologie Göttingen & Dresden e.V., Göttingen, DE

Naturnahe Offenlandlebensräume und ihre charakteristischen Artengemeinschaften sind bedroht, da immer weniger Flächen mit traditionellen landwirtschaftlichen Methoden extensiv bewirtschaftet werden. Insbesondere in großen oder unzugänglichen Gebieten ist die zunehmende Verbuschung eine Herausforderung für den Naturschutz. Es konnte bereits gezeigt werden, dass Lebensraumtypen wie Magere Flachlandmähwiesen und Trockene Europäische Heiden von einer Beweidung durch wildlebende Rothirsche (*Cervus elaphus*) profitieren. Eine offene Frage ist, inwieweit Rothirsche auch dazu beitragen können, die Gehölzsukzession im Offenland zu begrenzen. Der Truppenübungsplatz Grafenwöhr in Bayern ist durch einen großen Bestand wildlebender Rothirsche gekennzeichnet, welche das Offenland zur Nahrungssuche nutzen. In diesem Gebiet wurde zunächst ausgedehnte Gebüschvegetation, vorwiegend Schlehe (*Prunus spinosa*) und Weißdorn (*Crataegus* spp.), mechanisch entfernt und dann untersucht, wie sich der Wiederaufwuchs mit und ohne Einfluss wildlebender Rothirsche entwickelt. Dazu wurden 17 Flächenpaare aus einer offenen, frei zugänglichen Probefläche und einer ausgezäunten Kontrollfläche eingerichtet. Die Höhe und Deckung der Vegetation in Gehölz und Krautschicht wurde direkt nach dem Auf-den-Stock-Setzen sowie ein und zwei Jahre danach erfasst. Der experimentelle Ausschluss der Rothirsche führte zu einer deutlich höheren und dichteren Gehölzvegetation in den Kontrollflächen im Vergleich zu den offenen Probeflächen. Auch die Vegetation der Krautschicht war in den ausgezäunten Kontrollflächen höher und bestand zu einem höheren Anteil aus abgestorbener Biomasse als in den für Rothirsche frei zugänglichen Probeflächen. Rothirsche scheinen also in der Lage zu sein, den Wiederaufwuchs von Gehölzen effektiv zu verlangsamen. Ein angepasstes Wildtiermanagement, das Rothirschen die Nahrungssuche im Offenland ermöglicht, könnte daher den Pflegeaufwand zum Erhalt geschützter Offenlandlebensraumtypen verringern.

Session 8-O18 - Naturschutzpraxis trifft Wissenschaft

Renaturierung und Management von Sandrasen- und Heideökosystemen durch ganzjährig extensive Rinder- und Pferdebeweidung

Katrin Henning[1], Sabine Tischew[1]

[1]Anhalt University of Applied Sciences, Bernburg, DE, katrin.henning@hs-anhalt.de

Die Ausbreitung konkurrenzstarker Gräser sowie Veränderungen in der Habitatstruktur und Artenzusammensetzung sind direkte Folgen der Nutzungsaufgabe von Offenlandökosystemen wie Sandmagerrasen und Heiden. Für die Renaturierung und den Erhalt halboffener Lebensräume gewinnen ganzjährig extensive Beweidungsverfahren mit großen Pflanzenfressern verstärkt an Bedeutung. Jedoch ist noch immer unklar, ob diese Managementvariante die Ausbreitung von konkurrenzstarken Gräsern, wie *Calamagrostis epigejos*, verhindern und gleichzeitig die lebensraumtypische Habitatstruktur verbessern sowie charakteristische Vogel- und Pflanzenarten erhalten oder gar steigern kann.
Aufgrund dessen werden seit 2008 die Auswirkungen einer extensiven Ganzjahresbeweidung mit Rindern und Pferden auf die Entwicklung von *Calamagrostis*, die Habitatstruktur sowie auf den Artenreichtum von Gefäßpflanzen und das Vorkommen lebensraumtypischer Vogelarten innerhalb einer 800 ha großen Heidelandschaft untersucht.
Infolge des Managements konnten die lebensraumtypischen Habitatstrukturen wiederhergestellt und *Calamagrostis* erfolgreich reduziert werden. Ehemalige *Calamagrostis*-Bestände entwickelten sich zu artenreichen Sandmagerrasen. Darüber hinaus stieg die Anzahl an floristischen Zielarten und Magerkeitszeigern signifikant an. Auch die Brutpaarzahlen (BP) charakteristischer Vogelarten erhöhten sich infolge der Beweidung: Versiebenfachung des Ziegenmelkers (von 15 auf 103 BP), Verdreifachung der Heidelerche (von 32 auf 93 BP), Neuansiedlung des Wiedehopfes.
Die Untersuchungen zeigen, dass eine extensive Ganzjahresbeweidung mit Rindern und Pferden geeignet ist, langjährig brachgefallene Sandrasen- und Heideökosysteme erfolgreich zu renaturieren und langfristig in einem guten Zustand zu erhalten.

Session 8-P1 - Naturschutzpraxis trifft Wissenschaft

Eignet sich die Gewässerstrukturkartierung zur Bewertung von Auenlebensräumen an Alpenflüssen?

Romy Wöllner[1], Kilian Dorbath[1], Manuel Neukirchen[1], Johannes Kollmann[1,2], Thomas C. Wagner[1]

[1]Technical University Munich, Freising, DE, romy.woellner@tum.de
[2]Norwegian Institute of Bioeconomy Research, Ås, NO

Flüsse und ihre Auen wurden im Zuge flussbaulicher Maßnahmen für Hochwasserschutz, Land- und Energiegewinnung in ihrer Form und ökologischen Funktionalität stark beeinträchtigt. Um den negativen Folgen für die Ökosystemfunktionen sowie dem Verlust ihrer Biodiversität entgegenzuwirken, wird in der EU Wasserrahmenrichtlinie ein guter ökologischer Zustand der Gewässer gefordert. In Deutschland wurde unter anderem die Gewässerstrukturkartierung (GSK) etabliert, um den Fließgewässerzustand zu bewerten. Im Mittelpunkt der erhobenen Strukturparameter stehen dabei die aquatischen Lebensräume und es ist bisher unklar, inwieweit diese Kartierung sich auch für die Bewertung der Ufer- und Auenhabitate eignet. Inwiefern eine "gute Gewässerstruktur" mit dem Vorkommen typischer und heute oft gefährdeter Pflanzenarten einhergeht, ist beispielsweise wenig untersucht.
In unserer Studie vergleichen wir das Vorkommen typischer Pionierpflanzenarten der Aue entlang ausgewählter bayerischer Alpenflüsse mit der jeweiligen Zustandsbewertung der bayerischen GSK. Dabei wird der Gesamtbewertung, sowie der Bewertung der Einzelparameter an mehr als 260 100-m-Abschnitten die Häufigkeit der Zielarten entgegengestellt und mögliche Korrelationen mit generalisierten linearen Modellen getestet.
Die Ergebnisse zeigen positive Zusammenhänge der naturnahen Gesamtbewertung, naturnaher Laufkrümmung, Anlandungen und Strukturvielfalt mit dem Vorkommen charakteristischer Auenarten. Große Unterschiede zwischen den Flüssen erschweren es, eindeutige, allgemeine Zusammenhänge zwischen Artvorkommen und einzelnen Strukturparametern zu erkennen. Auch das Hinzuziehen eines eigens aufgestellten Auenindex verbesserte die Erklärungsstärke der Modelle nicht. Es sollte daher untersucht werden, ob zusätzliche und einfach zu erhebende Parameter im Rahmen der GSK eine Präzisierung der Fließgewässerbewertung erlauben, sodass bei der Planung von Renaturierungen zukünftig auch Auenhabitate verstärkt profitieren können.

Revitalisierung des Jävenitzer Moores (Altmark, Sachsen-Anhalt) im Rahmen von Kompensationsmaßnahmen

Holger Lieneweg[1]

[1]RANA - Büro für Ökologie und Naturschutz Frank Meyer, Halle (Saale), DE, holger.lieneweg@rana-halle.de

Das Jävenitzer Moor bei Gardelegen wurde seit dem Ende des 18. Jh. durch Entwässerungsmaßnahmen größtenteils zerstört und aufgeforstet/bewaldet. In einem kleinen Randbereich jedoch, welcher 1938 unter Naturschutz gestellt wurde, konnten sich im Umfeld kleiner Torfstichgewässer Relikte einer Zwischenmoorvegetation erhalten, die das Gebiet bis heute zu einem der bedeutendsten Tieflandsmoore Mitteldeutschlands machen.
Nach längerer Planungsphase wurde das Moor 2017–2019 umfangreich revitalisiert. Auf einer Fläche degradierten Torfkörpers von rund 160 ha wurde der Gebietswasserhaushalt durch Inaktivierung der Gräben wiederhergestellt. Zusätzlich wurden mehrere unbewaldete Flächen im Gebiet als Kerne einer wiederherzustellenden Offenmoorvegetation erweitert. Artenarme Degradationsvegetation aus *Molinia caerulea* und ein Teil des stark zersetzten oberen Torfes wurden großflächig abgetragen und somit grundwassernahe bis leicht überstaute Torfrohböden geschaffen. Im Umfeld der offenen Maßnahmeflächen wurden Waldbestände stark aufgelichtet, um eine Moorwaldentwicklung zu initiieren; Teilbestände nicht standortheimischer Arten (*Picea abies*, *Pinus strobus*) wurden vollständig entnommen.
Das Ziel der Maßnahme ist eine Wiederanregung des Moorwachstums, Zielvegetation ist ein Komplex aus Offenmooren, Feuchtheiden und Moorwäldern. In der Erwartung, dass eine Wiederetablierung von Pflanzenarten der Zwischenmoore auf den Maßnahmeflächen spontan aus dem lokalen Potential (z. B. *Sphagnum* spp., evtl. *Drosera* spp.) oder aber durch Wiedereinwanderung aus dem Naturschutzgebiet erfolgen kann, wurde auf eine gezielte Wiederansiedelung von Arten vorerst verzichtet.
Zur Erfassung der jetzt einsetzenden Gebietsentwicklung wurde ein auf 10 Jahre angelegtes hydrologisches und vegetationskundliches Monitoring angesetzt.
Die Umsetzung des Vorhabens erfolgte als Maßnahmen- und Flächenpool zur Kompensation von Eingriffen durch den Autobahnbau; Träger ist die Landesstraßenbaubehörde Sachsen-Anhalt.

Session 8-P3 - Naturschutzpraxis trifft Wissenschaft

Förderung von gefährdeten Ackerwildkrautarten durch Wiederansiedlung auf extensiv bewirtschafteten Ackerflächen

Marion Lang[1,2], Johannes Kollmann[1], Dominik Himmler[2], Harald Albrecht[1]

[1]Lehrstuhl für Renaturierungsökologie, Technische Universität München, Freising, DE, marion.lang@tum.de
[2]Bayerische Kulturlandstiftung, München, DE, marion.lang@tum.de

Ackerwildkräuter sind seit Jahrtausenden ein wichtiger Bestandteil der Agrarökosysteme in Europa. Durch Intensivierung der Landwirtschaft und Aufgabe von Grenzertragsstandorten ist die einst vielfältige Ackerwildkrautflora stark verarmt. Eine ökologische Aufwertung der Agrarlandschaft erfordert neben dem Erhalt bestehender Populationen die Wiederansiedlung gefährdeter Ackerwildkrautarten und die Integration in angepasste Bewirtschaftungsformen.

Im Projekt „Ackerwildkräuter für Bayerns Kulturlandschaft – Produktionsintegrierte Förderung seltener und gefährdeter Ackerwildkrautarten“ (2016–2019) werden regional gefährdete Rote Liste Arten in fünf bayerischen Naturräumen gesammelt, regional vermehrt und auf standörtlich geeigneten Ackerflächen ausgebracht. Für 34 Arten wurde der Etablierungserfolg auf extensiv bewirtschafteten Ackerflächen (Pestizid- und Düngeverzicht, Wintergetreide in reduzierter Aussaatstärke) untersucht. Die Aussaat erfolgte im Herbst 2017 auf ein bis 16 Ackerflächen pro Art mit einer Saatstärke von 100 Samen m^{-2} auf 25 m² Plots am Feldrand. Im Sommer 2018 und 2019 wurden die Individuenzahlen pro m² erfasst.

Die mittleren Etablierungsraten der Ackerwildkräuter lagen im ersten Jahr nach der Aussaat je nach Art zwischen 0 und 25%. Die höchsten Werte (>10%) konnten für *Scleranthus annuus, Teesdalia nudicaulis, Myosotis stricta, Cyanus segetum* und *Arnoseris minima* erzielt werden. Für *Adonis aestivalis* und acht weitere Arten lag die Etablierungsrate im ersten Jahr zunächst bei <1%, war jedoch im zweiten Jahr stark erhöht.

Die ersten Projektergebnisse zeigen, dass viele gefährdete Ackerwildkrautarten erfolgreich auf extensiv bewirtschafteten Ackerflächen etabliert werden können. Die Wiederansiedlung mit regionalem Saatgut kann zusammen mit Landwirten über freiwillige Maßnahmen oder im Rahmen der produktionsintegrierten Kompensation umgesetzt werden.

Session 8-P4 - Naturschutzpraxis trifft Wissenschaft

Wildlebende Rothirsche im Offenland: Vegetationsnutzung und Steuerungsmöglichkeiten.

Laura Richter[1,2], Christoph Raab[1,3], Friederike Riesch[2,3], Johannes Signer[1], Horst Reinecke[1], Marcus Meißner[4], Nina Rohwer[1,4], Hans-Georg Stroh[3], Bettina Tonn[2,3], Sven Herzog[4,5], Johannes Isselstein[2,3], Niko Balkenhol[1]

[1]Wildtierwissenschaften, Georg-August-Universität, Göttingen, DE, laurarichter@posteo.de
[2]Zentrum für Biodiversität und Nachhaltige Landnutzung (CBL), Georg-August-Universität, Göttingen, DE, laurarichter@posteo.de
[3]Graslandwissenschaft, Georg-August-Universität, Göttingen, DE
[4]Institut für Wildbiologie Göttingen und Dresden e.V., Göttingen, DE
[5]Dozentur für Wildökologie und Jagdwirtschaft, TU, Dresden, DE

Naturnahe Offenlandlebensräume sind für ihren Erhalt auf Biomasseentzug angewiesen. Dieser wird in der Regel durch Beweidung mit Nutztieren oder mechanische Pflege erreicht. In großen oder unzugänglichen Gebieten sind diese üblichen Methoden der Offenlandpflege jedoch häufig nicht wirtschaftlich oder nicht umsetzbar. Neuere Studien haben gezeigt, dass Beweidung mit Rothirschen (*Cervus elaphus*) eine effektive und praktikable Managementoption für verschiedene Offenlandlebensraumtypen sein kann. Anhand von GPS-Telemetriedaten von 24 weiblichen Rothirschen auf dem Truppenübungsplatz Grafenwöhr (Bayern) aus den Jahren 2015 bis 2019 zeigen wir Tagesdynamik, Vegetationsnutzung und Steuerungsmöglichkeiten von Rothirschen im Offenland.

Session 8-P5 - Naturschutzpraxis trifft Wissenschaft

Can arbuscular mycorrhizal fungi improve plant performance and drought resistance of native dry grassland species in shallow green roof substrates?

Daniel Jeschke[1], Milena Mohri[2], Jie Si Ma[1], Kathrin Kiehl[1], Schröder Roland[1]

[1]Osnabrueck University of Applied Sciences, Osnabrueck, DE, d.jeschke@hs-osnabrueck.de
[2]University of Göttingen, Göttingen, DE

The active introduction of native plant species of local provenance is an appropriate measure to enhance regional biodiversity in urban ecosystems. For standard extensive roof greening, however, plant selection is mostly restricted to non-native and/or cultivated succulents like *Sedum* species up to now. Most extensive green roofs have been built only with shallow growth substrates limiting their potential as habitat for non-succulent plant species such as dry grassland species. In addition, artificial standard growth substrates for green roofs are lacking beneficial soil organisms like arbuscular mycorrhizal fungi (AMF), which might improve the drought resistance of introduced species. Therefore, we started a pot experiment in March 2018 to investigate whether AMF inoculation into standard green roof substrate can enhance the habitat function for native plant species of sandy dry grasslands in northwestern Germany.
The results of a pot experiment with 11 plant species growing with (AMF plants) and without AMF inoculation (non-AMF plants) showed differences in fitness-relevant plant traits. After 88 days of moderate drought, AMF plants produced 2.5 times more above-ground biomass than non-AMF plants. Furthermore, the number of inflorescences on AMF plants was significantly higher in five out of seven flowering species. Under experimental severe drought stress created by stop of watering, however, AMF plants wilted on average 2.38 days earlier than non-AMF plants. Despite reduced drought resistance of AMF plants, their generative reproduction may be faster and higher. This may result in a successful establishment of a soil seed bank, which is necessary for self-sustaining plant populations in extensive green roofs.

Session 8-P6 - Naturschutzpraxis trifft Wissenschaft

Ökologische Funktionen und Dienstleistungen biologischer Bodenkrusten in Offenlandschaften - Fluch oder Segen?

Maik Veste[1], Stella Gypser[1]

[1]Brandenburgische Technische Universität Cottbus-Senftenberg, Cottbus, DE, maik.veste@icloud.com

Initiale und nährstoffarme Ökosysteme wie Grasländer und Offenlandschaften haben aus Sicht des Naturschutzes einen hohen Wert für die Landschaft und sind in der intensiv genutzten Kulturlandschaft Mitteleuropas selten geworden. Gerade Bergbaufolgelandschaften, aber auch gestörte Binnendünen, bieten Potenzial für die Entwicklung von initialen Lebensräumen und Landschaften. Die obersten Millimeter der Bodenoberfläche dieser Ökosysteme werden durch Biokrusten besiedelt. Gebildet werden diese komplexen Lebensgemeinschaften aus einer Vielzahl von Cyanobakterien, Grünalgen, Moosen, Pilzen, Bakterien und Flechten. Diese Organismen „verkleben" die Bodenoberfläche und beeinflussen als „Ökosystem en miniature" maßgeblich die ökosystemaren Prozesse und die weitere Vegetationsentwicklung. Der Eintrag von C und N sowie die Akkumulation von organischem Material fördert die Bodenentwicklung in der initialen Phase. Während der Sukzession der Biokrusten entwickeln sich die komplexen biotischen Prozesse des N-Kreislaufes mit Rückkopplungen auf die Nährstoffversorgung. Ausgeschiedene Exopolysaccharide, die eine Verbindung mit den Bodenpartikeln eingehen, verkleinern nach Regen den Porenraum der Bodenoberfläche und vermindern die Infiltration. Besonders Moos- und Flechten-Krusten unterbinden bei geringen Niederschlagsintensitäten die Infiltration in tiefere Bodenschichten. Konkurrenz und die großflächige Versiegelung der Bodenoberfläche haben zudem negative Auswirkungen auf die Keimung und Etablierung von höheren Pflanzen. Diese biotischen Interaktionen führen bei gesteuerten Sukzessionen auf Renaturierungsflächen zu Änderungen der Vegetationsentwicklung. Somit wird die Bedeutung der Biokrusten für die Renaturierungsökologie z.T. kontrovers diskutiert. Klein- und großräumige Störungen hingegen sind als integraler Bestandteil der Ökosystementwicklung einzuschließen.

Session 8-P7 - Naturschutzpraxis trifft Wissenschaft

Ansiedlungen gefährdeter Wildpflanzenarten

Okka Tschöpe[1], Michael Burkart[2], Daniel Lauterbach[2], Justus Meißner[3], Marie-Sophie Rohner[4], Anna Heinken-Šmídová[1], Albert-Dieter Stevens[1], Elke Zippel[1]

[1]Botanischer Garten und Botanisches Museum Berlin-Dahlem, Berlin, DE
[2]Botanischer Garten der Universität Potsdam, Potsdam, DE
[3]Stiftung Naturschutz Berlin, Berlin, DE
[4]Botanischer Verein Berlin Brandenburg, Berlin, DE

Ergänzend zum stets prioritären Schutz von Lebensräumen gewinnen Ansiedlungen gefährdeter Wildpflanzenarten zunehmend an Bedeutung. Da viele Arten nur noch in kleinen und zunehmend verinselten Reliktbeständen vorkommen, die sich aus eigener Kraft nicht mehr verjüngen oder gar ausbreiten können, können mit gezielten Ansiedlungen Restpopulationen gestärkt oder neue Vorkommen gegründet werden. Wichtige Voraussetzung für solche In-situ-Maßnahmen ist die langfristige Gewährleistung einer auf die jeweilige Zielart abgestimmte Nutzung bzw. Pflege der Fläche, die der Art zukünftig eine erfolgreich Reproduktion am Standort ermöglicht.
Am Botanischen Garten Berlin (BGBM) werden seit den 1990er Jahren erfolgreich Wiederansiedlungsmaßnahmen in Berlin durchgeführt, zum Beispiel für Trockenrasenarten wie *Pulsatilla pratensis* und *Silene chlorantha*. In den letzten Jahren wurden diese Aktivitäten verstärkt, in Zusammenarbeit mit dem Botanischen Garten Potsdam und im Rahmen des Projektes „Wildpflanzenschutz in Deutschland“ (WIPs-De II) intensiviert und auf die Bundesländer Brandenburg und Mecklenburg-Vorpommern ausgedehnt. Im Fokus unserer mit den Behörden abgestimmten Artenschutzmaßnahmen stehen gefährdete Arten, die ihren Verbreitungsschwerpunkt in Mitteleuropa haben, wie unter anderem *Arnica montana*, *Dactylorhiza majalis*, *Dianthus gratianopolitanus* und *Scabiosa canescens*. Ansiedlungen weiterer Arten sind in Planung.
Der Erfolg der Wiederansiedlungs-Maßnahmen wird nach einem praxisorientierten Monitoringkonzept überprüft. Eine Ansiedlung ist erfolgreich, wenn sich die gestützte oder neu gegründete Population am Standort etabliert hat und verjüngen kann, wie bei unseren Ansiedlungen von *S. canescens*, *P. pratensis* und *S. chlorantha*. *D. gratianopolitanus* und *A. montana* konnten sich zum Teil auf den Flächen sehr gut etablieren, zeigen aber bisher wenig oder keine Verjüngung.

SESSION 9

Urban Air Pollution

Chairs: Prof. Dr Andreas Held, Prof. Dr. Otto Klemm, Dr. Bastian Paas

Open, peer-reviewed scientific session on Urban Air Pollution. We invite scientists and practitioners in the fields of environmental meteorology and air pollution control that focus on topics such as atmospheric chemistry, biometeorology, pollutant dispersion, and health effects within urban landscapes. We foster high quality research results derived from both observations and model simulations. We wish for a broad overview on the topic with state-of-the-art contributions reflecting the multi-methodological approaches to assess urban air pollution dynamics on various spatial and temporal scales.

Session 9-O1 - Urban air pollution

The contribution of oxidized and reduced Nitrogen to particulate matter in the urban atmosphere

Laura Ehrnsperger[1], Otto Klemm[1]

[1]Climatology Research Group, University of Münster, Münster, DE

Emissions of both particulate and gaseous air pollutants often exceed those of emission inventories. There is a large lack of understanding concerning urban street traffic statistics, emission patterns of individual vehicles, and thus on the contribution of traffic on urban air pollution on the micro-scale. Besides street traffic, agricultural emissions contribute to reduced Nitrogen (NH_3, NH_4^+) concentrations in urban air.
The project LUFTHY combines high-resolution vehicle fleet data, as obtained with traffic cameras, with fast-response measurements of NO_x, O_3, CO_2, particulate matter (PM), and NH_3, in order to improve our understanding of real-world urban air pollution patterns. The campaign took place in an urban street-canyon site in the city center of Münster, NW Germany (51°57'48.5"N, 7°37'52.9"E), for two months from September to November 2018.
Besides the often discussed traffic-related air pollutants NO_x, the NH_3 concentrations were also measured to determine the role of SCR-systems of diesel vehicles as a local source of ammonia in urban air. Likely, significant amounts of NH_3 are emitted from diesel-powered traffic due to poorly adjusted exhaust gas treatment.
Chemical analysis of size-resolved PM samples was conducted to investigate the contribution of NH_3 to the formation of particles in the urban atmosphere. The highest concentrations of nitrate and ammonium were found for particles with a mean diameter of 0.71 µm.
On the long run, the results of this project should contribute to an improved understanding of NH_3 dynamics, secondary PM formation, and eventually to help mitigate urban air pollution.

Session 9-O2 - Urban air pollution

Unwanted side effects in the exhaust gas cleaning of combustion engines inferred from mobile air quality measurements.

Umar Javed[1], Robert Wegener[1], René Dubus[1], Franz Rohrer[1], Andreas Wahner[1], Dieter Klemp[1]

[1]Forschungszentrum Jülich GmbH / Institut für Energie- und Klimaforschung - Troposphäre (IEK-8), 52428 Jülich, DE

Nitrogen oxides (NO_x) are amongst the primary air pollutants and can cause adverse respiratory effects. In German cities, the main fraction (up to 80 %) of NO_x from transportation is mainly produced by Diesel vehicles. Therefore, it has been a priority over the years to reduce these NO_x emissions by applying different NO_x reduction methods (DeNOx technique). In modern Diesel vehicles, the selective catalytic reduction (SCR) technique is commonly used for the NO_x reduction. In this method, a urea solution is injected into the hot exhaust line where it is thermally decomposed to produce ammonia (NH_3) which acts as a reductant for NO_x.
The SCR method is highly efficient (up to 95 %) for the reduction of NO_x, but it has some drawbacks. Under urban driving conditions, when the engine load changes quickly, it can lead to slippage of NH_3, the formation of nitrous oxide (N_2O) and highly toxic isocyanic acid (HNCO). These unwanted emissions of NH_3, N_2O, and HNCO can affect the local air quality.
Mobile measurements are an important means to study the impact of these emissions on air quality. Instruments for mobile measurements of N_2O and NH_3 are commercially available while mobile measurements of HNCO haven't been conducted yet. The foci of this presentation will be on the results of campaigns with the mobile laboratory MOBILAB in the urban region of Stuttgart and the development of an HNCO instrument based on absorption spectroscopy. The measurements were performed as a part of the project "Stadtklima im Wandel (BMBF-Projekt: O1LP1602F)".

Session 9-O3 - Urban air pollution

Understanding the spatial variability of air pollutants in urban areas through microscale urban air quality research

Honey Dawn Alas[1], Sascha Pfeifer[1], Thomas Mueller[1], Kay Weinhold[1], Alfred Wiedensohler[1]

[1]Leibniz Institute for Tropospheric Research, Leipig, DE

Harmful air pollutants, which are highly variable in space and hence may not be captured by regular air monitoring stations, are highly relevant for understanding the exposure of pedestrians to air pollution, especially in urban areas. In recent years, microscale urban air pollution research has been done to determine the spatial variability of air pollutants on a fine scale with the use of mobile measurements. Here we present the results of experiments performed in urban areas of different sizes using a backpack equipped with portable instruments that measure black carbon and particle mass to determine how pedestrian exposure scenarios vary and what factors influence them. In 2015, as a pilot study, we did an intensive mobile measurement campaign in the megacity of Metro Manila, Philippines, a highly urbanized area with more than 10 million people. In 2016, we conducted a yearlong experiment in the city of Leipzig, Germany, home to more than 500,000 people and with a low emission zone in place, to determine how the spatial distribution of pollutants vary in different seasons. Based on these two experiments, we developed a method that assures the quality of mobile measurement data. In 2017, we tested this method in Rome, Italy, a highly touristic city of approximately 3 million people. The results of this study give insights on how the black carbon and particle mass vary in space in urban areas as well as the factors that drive the exposure of pedestrians to these pollutants.

Session 9-O4 - Urban air pollution

Determination of the spatial and temporal distribution of black carbon and particulate matter with mobile backpack measurements

Jens Voigtländer[1], Thomas Müller[1], Liina Tönisson[1], Denise Assmann[1], Ralf Käthner[1], Sarah Grawe[1], Bernd Heinold[1], Oswald Knoth[1], Andreas Macke[1]

[1]Leibniz Institute for Tropospheric Research (TROPOS), Leipzig, DE, jensv@tropos.de

Especially in economically developing megacities Black Carbon (BC) particle number and mass concentration remain still higher than what is considered to be save. Furthermore, the sources are often strongly varying with respect to space and time, which makes the determination of a representative BC concentration problematic. Therefore, measurements with high spatial and temporal resolution are required. Mobile measurements can fill the gap, and further can be used to create pollution maps and to investigate the deposition dose of individuals.

Based on its experiences with mobile particle mass (PM) and BC mass sensors in cities of varying size TROPOS is currently building a new infrastructure for mobile PM and BC mass concentration measurements for scientists, authorities and citizens. The further developed measurement packages are very lightweight and easy to use, but still meet scientific standards. Aim is to provide an, in terms of number of devices, easily scalable system for highly mobile PM and BC measurements. Measured data are displayed on a smartphone and transferred to a webserver at TROPOS in real time. The measurements are accomplished by an urban air quality forecasting system, which has been developed at TROPOS. The model results, in turn, may help interpret the small-scale BC measurements in a more regional context.
The system is now successfully applied for the first time in a joint research project with citizen participation called WTimpact. Within this project three field phases with about 90 volunteers are carried out in the city of Leipzig. WTimpact establishes the basis for future Citizen Science activities at TROPOS on local air pollution observations. Furthermore, the long-term objective of the study is that more reliable exposure rates will be obtained by means of measurement and model data and statistical data on the daily patterns of movement and residence of the population.

Session 9-O5 - Urban air pollution

Spatial and temporal ozone variability in northern Bavaria with a focus on Bayreuth

Seyed Omid Nabavi[1], Lisa Mahr[1], Anke Nölscher[2], Cyrus Samimi[2], Andreas Held[3]

[1]Faculty of Biology, Chemistry and Earth Sciences, Research Group of Climatology, University of Bayreuth, Bayreuth, DE, seyed.omid.nabavi@uni-bayreuth.de
[2]Faculty of Biology, Chemistry and Earth Sciences, Atmospheric Chemistry, University of Bayreuth, Bayreuth, DE
[3]Institute of Environmental Science & Technology, Technische Universität Berlin, Berlin, DE

The MiSKOR research project aims to study extreme temperatures and high surface ozone (O_3) concentrations in northern Bavaria (regional scale) and the city of Bayreuth (city scale). In one part of the project MiSKOR spatio-temporal patterns of O_3 are analyzed to give a basis for appropriate strategies to mitigate its impacts on urban life. This research is a part of the Bavarian joint project Climate Change and Health and funded by the Bavarian State Ministries of the Environment and Consumer Protection and Health and Care.
In order to identify the most influential features for O_3 model, we have applied partial dependencies and random forest statistical analysis on different types of predictors. In addition, HYSPLIT trajectory model and bivariate polar plots were respectively used to analyze the mid-range and local transportation of O_3/O_3 precursors to the study area. We found NOx concentration, temperature, and wind direction as the most crucial factors for O_3 estimation.
At the time of writing this abstract, the analysis of model outputs in both spatial scales continues. However, the preliminary results indicate a better performance of gradient boosting (GB) than other methods. With regard to city-scale modelling, as expected, the inclusion of spatial information such as land cover and distance to heavy traffic roads caused a significant improvement.
The trend of O_3 in northern Bavaria, unlike in other parts of Germany, has been upward in its all levels of intensities from 1985 to present. Additionally, there is a shift of O_3 peaks from the end of June to the beginning of it. The positive trend and the shift of O_3 concentrations may be caused by reducing NOx, increasing temperature, and a seasonal shift of higher temperatures in northern Bavaria.

Session 9-O6 - Urban air pollution

Modelling the urban air quality in Hamburg with the new city-scale chemistry transport model EPISODE-CityChem

Matthias Karl[1]

[1]Helmholtz-Zentrum Geesthacht, Geesthacht, DE, matthias.karl@hzg.de

Urban air quality modelling plays an important role by providing guidelines for efficient air pollution abatement measures. Episodes with elevated ozone (O_3) during summer are of specific interest, since these are associated with exceedances of the World Health Organization (WHO) guideline concentration limits for O_3 and of the regulatory limits for nitrogen dioxide (NO_2). High concentrations of O_3 occurring at urban stations in summer are attributable to photochemical formation that occurs at times in large urban areas during episodes of high solar radiation and temperature. The new EPISODE-CityChem model has the capability of simulating photochemistry and dispersion of multiple reactive pollutants within urban areas. It treats the complex photochemistry in cities using detailed photochemistry on the Eulerian 3-D grid, while using a compact chemistry scheme on a much higher resolution grid (receptor grid), i.e. close to industrial point sources and traffic sources. For the study of the air quality in Hamburg, EPISODE-CityChem was set-up with a main grid of 30x30 grid cells of 1x1 km^2 each and a receptor grid of 300x300 grid cells of 100x100 m^2. Simulations for the year 2012 show that the model reproduces well the temporal and spatial variation of pollutant concentrations monitored by the Hamburg air quality network. Emissions of volatile organic compounds (VOCs) in urban areas are not well quantified as they may originate from various sources, including solvent usage, industry, combustion plants and vehicular traffic. Model tests were performed with CityChem to study the ozone formation rate with variation of emissions of nitrogen oxides (by 20 %) and VOCs (by 100%) from road traffic. The sensitivity of ozone concentrations towards emission changes in different parts of the urban area is analyzed for the summer months. Photochemical ozone production mainly takes place in the outflow to the southeast of the city and in the urban background southwest of the city.

Session 9-P1 - Urban air pollution

Spatially resolved measurement of nitrogen dioxide in Berlin with diffusive samplers in a citizen science project

Annelie Höhne[1], Wolfgang Frenzel[1], Andreas Held[1]

[1]Technische Universität Berlin, Chair of Environmental Chemistry and Air Research, Berlin, DE

Nitrogen dioxide is a major air pollutant with adverse health effects. The main sources of urban NO_2 are combustion processes in road traffic, resulting in a large number and complex spatial pattern of local emission sources in an urban area such as Berlin. Hence it is of particular importance to understand the spatial variability of NO_2 concentrations. Therefore, diffusive samplers are used to determine NO_2 concentrations in Berlin in a dense network with diverse measuring sites involving citizen scientists for a spatially comprehensive data set. Besides obtaining a unique data set, raising the awareness of air pollution control is a major goal of the citizen science approach in our study.
For passive sampling we use modified Palmes tubes [1] for collection periods of two weeks. Afterwards NO_2 is determined as nitrite by spectrophotometry using a variation of the Saltzman reagent.
NO_2 concentrations determined in a first campaign in March 2019 vary between 10 µg/m³ in a back street in suburban Berlin-Friedrichsfelde and 27 µg/m³ in inner-city Schöneberg. An additional measurement in a backyard in Schöneberg gives lower NO_2 concentrations of 10 µg/m³. A campaign from May 2019 in the north-eastern outskirts of Berlin yields much lower NO_2 concentrations between 2 and 8 µg/m³. While the order of magnitude is in good agreement with the Berlin air pollution network BLUME, the small-scale variability observed in the citizen science data set will allow for an improved identification of NO_2 hot spots, sources and sinks in Berlin.
[1] Palmes, E.D., Gunnison, A.F., DiMattio, J., Tomczyk, C., Personal sampler for nitrogen dioxide, Am. Ind. Hyg. Assoc. J., 1976, 37, 570

Session 9-P2 - Urban air pollution

Performance evaluation of Random Forest and multi linear regression models for the calibration of low-cost air pollution sensors

Sebastian Schmid[1], Sean Carlos Conrad[1], Dr. Wolfgang Frenzel[1]

[1]Technische Universität Berlin, Chair of Environmental Chemistry and Air Research, 10623 Berlin, DE, s.schmid@campus.tu-berlin.de

Due to their portability, commercially available low-cost gas sensors are suitable for measurements of environmentally relevant pollutants, such as NO_2 in high spatial resolution. However, calibration, cross-sensitivities, high variability and poor reproducibility of these sensors are challenges which have to be addressed. This study develops a strategy to calibrate amperometric gas sensors manufactured by Alphasense (Great Notley, Essex, UK) that are going to be used inside a mobile nitrogen dioxide sensor at Technische Universität Berlin. Several different multiple linear regression models (MLR) and a Random Forest regression model (RF) were tested against the calibration provided by the manufacturer. Additionally, individual variances of identical and different designs of NO_2 sensors were investigated.
It was found that the Random Forest model shows a better performance on the training dataset with smaller deviations from the reference values. Nevertheless, under more realistic alternating environmental conditions, the MLR models containing O_3 electrodes showed better results with a RMSE of 2.69 ppb and R^2 of 0.92 compared to RF with a RMSE of 3.08 and R^2 of 0.84. MLR models including O_3 and NO electrode information yielded more acurate NO_2 estimates. Concerning long term stability the RF model showed better performance. Individual differences between sensors of identical design suggest that each sensor needs to be calibrated separately. For the NO_2 sensors a limit of quantification of 16 ppb with a RMSE of 2.69 ppb was found. The limit of quantification and RMSE determined in this study suggest that these sensors may be used for monitoring exceedances of the NO_2 limit values in the European Union, i.e. the annual limit value of 40 µg m^{-3} and the hourly limit value of 200 µg m^{-3}. However, wether data quality criteria as required by the 39. BImschV can be met remains to be validated.

Session 9-P3 - Urban air pollution

Measurement of nitrogen dioxide with high spatial resolution in a traffic burdened in-town area of the city of Berlin

Thu-Trang Huynh[1], Annelie Höhne[1], Andreas Held[1], Wolfgang Frenzel[1]

[1]TU Berlin, Berlin, DE

The recent discussions about problems related to nitrogen dioxide (NO_2) pollution and human health has raised old and new questions about the justification of existing NO_2 limit values, the proper positioning of measuring sites for NO_2 monitoring by local authorities, the concentrations of NO_2 at places where no measurement data are available, and the number of people affected by exceedingly high NO_2 concentrations.
There is no doubt that in-town NO_2 pollution and exceedances of limit values set by the European Union are typically associated with high local traffic. Measurements in air pollution control networks as well as modelling of air pollution show significant NO_2 concentration gradients between main roads and other city areas. This has also been confirmed by several campaigns run within scientific research programmes as well as measurements organized by non-governmental organisations. However, surprisingly little information exists about the spatial variability of NO_2 concentrations along main roads and the influence of crossings, width of the road, vertical gradients and existing or missing roadside structures.
In our study we have used passive sampling with modified Palmes tubes to evaluate NO_2 concentrations with very high spatial resolution in an about 0.5 km x 0.5 km area of a district in Berlin along a main road and in its close vicinity. The campaign was continuously run with two weeks sampling time over a period of more than nine months. For reasons of quality control some of the passive sampling sites were close to two measurement sites of the Berlin air pollution control network (BLUME) located in the investigated area.
The poster will present the results of the campaign and compare the data obtained with those from modelling the NO_2 pollution in the selected city area.

SESSION 10

Das deutsche Insektenschutz-Aktionsprogramm – was kann es bewirken, wo muss die Wissenschaft helfen?

Chairs: Carsten Neßhöver, Ilka Dege

Das Thema Insektenschutz ist durch die Diskussionen um ein Bienensterben durch Pflanzenschutzmittel, die „Krefelder-Studie“ zum Verlust der Insekten-Biomasse in deutschen Schutzgebieten, und zuletzt durch das Volksbegehren Artenvielfalt in Bayern hoch im öffentlichen Bewusstsein und auf der politischen Agenda. Das Bundesumweltministerium wird hierzu im Sommer 2019 ein Aktionsprogramm vorlegen, das bereits im Entwurfsstadium zu intensiven Diskussionen zwischen verschiedenen Interessen geführt hat. Im Kern geht es dabei um Maßnahmen, die vor allem in der Landwirtschaft ansetzen und in denen aus der ökologischen Forschung seit langem bekannte Defizite der Agrarlandschaft (Verlust von Strukturelementen wie Hecken und Säumen) und landwirtschaftlichen Praxis (Einsatz von Nährstoffen und Pflanzenschutzmitteln) aufgegriffen werden. Die Session hat das Ziel, das im September voraussichtlich vorliegende Aktionsprogramm kritisch anzuschauen, und aus verschiedenen Blickwinkeln zu analysieren:

- Sind die geplanten Maßnahmen zielgerichtet und flächenwirksam?
- Werden die richtigen Anreize gesetzt und die richtigen Akteure adressiert?
- Gibt es substanzielles Monitoringkonzept, dass eine Zielerreichung nachprüfbar macht?
- Welche Bedarfe lassen sich über die Beteiligung am Monitoring hinaus für die Wissenschaft ableiten?

Hierzu wird zunächst das Aktionsprogramm kurz vorgestellt, anschließen sollen verschiedene Sprecherinnen und Sprecher die oben genannten Fragen reflektieren. In einer folgenden Podiumsdiskussion soll vor allem der Bedarf für die Rolle der ökologischen Forschung gemeinsam mit dem Publikum diskutiert werden.

Session 10-O1 - Insektenschutzprogramm Deutschland

Das Aktionsprogramm Insektenschutz

Sprecher des BMU[1]

[1]Sprecher des Bundesministeriums für Umwelt, Naturschutz und nukleare Sicherheit

Session 10-O2 - Insektenschutzprogramm Deutschland

Für einen flächenwirksamen Insektenschutz – Stellungnahme von SRU und WBB-GR

Manfred Niekisch[1]

[1]Sachverständigenrat für Umweltfragen, Berlin, DE, manfred.niekisch@mail.de

Die starken Rückgänge bei Insektenpopulationen und -arten sind aufgrund der vielfältigen Funktionen dieser Tierklasse in Ökosystemen mit großer Sorge zu betrachten. Diese Verluste sind das Ergebnis komplexer und häufig kumulativ wirkender Einflussfaktoren, die hauptsächlich aus anthropogener Landnutzung resultieren. In deren Folge kommt es zu einer zunehmenden Degradation von Ökosystemen und ökologischen Verarmung von Landschaften. Dabei spielt die Landwirtschaft durch ihre Stoffeinträge in Böden, Wasser und Luft, sowie wegen ihrer Flächenwirksamkeit eine entscheidende Rolle. Um die Abnahme der Bestände von Insekten zu stoppen, sind weitreichende, systemische und flächenwirksame Maßnahmen notwendig. Die Mitwirkung von Land- und Forstwirtschaft sowie weiterer Akteure ist hierbei essenziell. Der Sachverständigenrat für Umweltfragen (SRU) und der Wissenschaftliche Beirat für Biodiversität und Genetische Ressourcen (WBBGR) haben mit ihrer Stellungnahme „Für einen flächendeckenden Insektenschutz“ entsprechende Handlungsempfehlungen an Bund und Länder ausgesprochen. Zentral ist eine insektenfreundlichere Gestaltung der Landnutzung. Dies beinhaltet im Wesentlichen die deutliche Reduzierung der Einträge von Pflanzenschutzmitteln und Nährstoffen, die Anreicherung monotoner Landschaften mit Kleinstrukturen, wie Hecken, Blüh- und Randstreifen und die nachhaltige Nutzung extensiven Grünlands. Auch im Siedlungsbereich ist schnelles Handeln erforderlich, insbesondere hinsichtlich der Verringerung von Pflanzenschutzmitteln bei der Bewirtschaftung öffentlicher Grünflächen und Privatgärten. Zudem muss die Lichtverschmutzung reduziert werden und das Bewusstsein der Bevölkerung für die vielfältigen ökologischen Funktionen von Insekten verbessert werden. Die Etablierung eines deutschlandweiten Monitoringsystems für Insekten sollte zügig vonstattengehen und sowohl die verschiedenen Insektenordnungen als auch all deren Entwicklungsstadien in unterschiedlichen Landschaftstypen abbilden.

Session 10-O3 - Insektenschutzprogramm Deutschland

Klotzen statt kleckern: Wirksamer Insektenschutz muss systemischen Probleme angehen

Ilka Dege[1]

[1]Deutscher Naturschutzring, Berlin, DE, Ilka.Dege@dnr.de

Wir werden das Insektensterben umfassend bekämpfen. Mit einem „Aktionsprogramm Insektenschutz“ wollen wir die Lebensbedingungen für Insekten verbessern.
Mit diesen Aussagen im Koalitionsvertrag ist die Bundesregierung eine deutliche Verpflichtung eingegangen. Im Sommer 2019 soll das Programm im Kabinett verabschiedet werden. Jetzt gilt es zu bewerten: Reichen die beschlossenen Maßnahmen aus, um den Verlust von Insekten und ihren Lebensräumen zu stoppen? Ist der gemeinsame Wille aller Ressorts erkennbar, das Programm zu einem Erfolg zu machen? Sind die Hauttreiber ausreichend adressiert bzw. wo muss Politik über das Aktionsprogramm hinaus ansetzen?
In einem gemeinsamen Papier haben die Umwelt- und Naturschutzverbände ihre Forderungen an Programm und Politik formuliert. Das Resümee: Eine Trendwende beim Insektensterben ist ohne eine echte Trendwende in der Bewirtschaftung unserer land- und forstwirtschaftlich genutzten Flächen, die ca. 50 Prozent der Gesamtfläche Deutschlands ausmachen, nicht zu schaffen. Trotz bestehender offener Fragen gilt auch: Wir haben kein Erkenntnis-, sondern ein Handlungsdefizit. Die Die Politik ist gefordert, rasch, zielführend und konsequent zu handeln. Die Wissenschaft, die Zielerreichung und Wirksamkeit der Maßnahmen zu überprüfen und zu begleiten. Und alle an der Wertschöpfungskette Beteiligten – Landwirte, Verarbeiter, Handel, Verbraucher und damit alle Bürgerinnen und Bürger – vor Ort, wirksam und engagiert zum Schutz unsere Insekten und ihrer Lebensräume beizutragen.

Session 10-O4 - Insektenschutzprogramm Deutschland

Das Aktionsprogramm Insektenschutz aus Sicht der agrarökologischen Forschung

Jens Dauber[1,2], Petra Dieker[1], Fabian Nürnberger[1]

[1]Thünen-Institut für Biodiversität, Braunschweig, DE, jens.dauber@thuenen.de
[2]Technische Universität Braunschweig, Braunschweig, DE, jens.dauber@thuenen.de

Ein Schwerpunkt im Aktionsprogramm Insektenschutz ist Insektenlebensräume und Strukturvielfalt in der Agrarlandschaft zu fördern. Da mehr als die Hälfte der Fläche Deutschlands landwirtschaftlich genutzt wird, hat das Aktionsprogramm die besondere Rolle von Agrarlandschaften bei der Bereitstellung von Lebensräumen für Insekten identifiziert. Ziel soll es sein, die Strukturvielfalt in der Agrarlandschaft zu erhöhen und Insektenlebensräume in ausreichender Qualität und Quantität zu erhalten, auszuweiten bzw. wiederherzustellen sowie insektengerecht zu pflegen.
Agrarlandschaften sind aber nicht nur Räume, in denen idealerweise eine Vielzahl an Organismen leben, sondern auch Orte, die in erster Linie für landwirtschaftliche Produktion genutzt werden. Diese Agrarproduktion interagiert auf vielfältige Weise mit den von Insekten und anderen Arthropoden erbrachten Ökosystemfunktionen und -leistungen auf und um Produktionsflächen. Aus Sicht der agrarökologischen Forschung wäre daher eine Ausdifferenzierung der Zielstellung und der zur Zielerreichung geplanten Maßnahmen wünschenswert. Diese sollten besonders Insekten und andere Arthropoden in ihren Rollen als Nützlinge sowie als Schädlinge in Agrarökosystemen berücksichtigen. Angesichts der Herausforderungen, vor der die landwirtschaftliche Produktion steht (z. B. Reduzierung des Einsatzes von Pflanzenschutzmitteln, Anpassung an den Klimawandel, Anbaudiversifizierung), wäre es sinnvoll, wenn das Aktionsprogramm Insektenschutz nicht an der Grenze zu den Produktionsflächen halt machen würde.
Die Herausforderung für agrarökologische Forschung besteht darin Agrarsystem-spezifische Maßnahmen(kombinationen) zu entwickeln, die sowohl dem Schutz von Arten als auch der Nutzung von Ökosystemleistungen gerecht werden (im Sinne eines sozio-ökologischen Systemansatzes). Darüber hinaus gilt es Monitoringansätze zu konzipieren, die eine Überprüfung der Erreichung solch differenzierter Zielstellungen ermöglichen.

Session 10-O5 - Insektenschutzprogramm Deutschland

Deutschland summt! Summen Sie mit?

Corinna Hölzer[1]

[1]Stiftung für Mensch und Umwelt, Berlin, DE, hoelzer@stiftung-mensch-umwelt.de

Seit September 2010 befördert die in Berlin ansässige, bundesweit tätige, Stiftung eine sinnstiftende, lebenserhaltende und verantwortungsvolle Mensch-Umwelt-Beziehung. Inhaltliche Schwerpunkte sind die „Erhaltung der Biologischen Vielfalt“ und die „Vernetzung von Akteuren“. Der Stiftung sind dabei neue Allianzen der Zusammenarbeit sowie eine offene und lösungsorientierte Kommunikation wichtig. Neben der Umweltbildung für Kinder steht besonders die Schärfung des Umweltbewusstseins von Entscheidern sowie das fachliche Begleiten entsprechender Maßnahmen im Fokus.
Mit der eher ungewöhnlichen Kommunikationsstrategie der Initiative „Deutschland summt! Wir tun was für Bienen“ (www.deutschland-summt.de) gelang es, die (Massen)Medien für das Thema „Bienenschutz“ zu interessieren. Es ist inzwischen offensichtlich, dass die breite Bevölkerung, Politik und Wirtschaft das Insektensterben als wichtig einstufen, Handlungen fordern und selbst aktiv werden.
Der Aufruf „World Scientists’ Warning to Humanity“ von über 15.000 Wissenschaftlern im Jahr 2017, verbunden mit der Forderung, 50% des Planeten unter Schutz zu setzen, von „The Alliance of World Scientists, AWS“ ins Leben gerufen. Die Stiftung für Mensch und Umwelt schließt sich der Argumentation von AWS an, allerdings glaubt sie – genau wie die Gruppierung „Conservation optimism“ – fest daran, dass „der Naturschutz“ unbedingt aufzeigen muss, was er zu leisten imstande ist. Menschen sind nur durch Hoffnung bereit, sich zu ändern. Im Kurzvortrag werden Erfahrungen mit Entscheidern, Medien und breiter Bevölkerung als Basis genommen, um den im September 2019 vorliegenden Insektenschutzplan der Bundesregierung wohlwollend kritisch einzuschätzen.

Urwaldreliktarten als Zeigerarten für die Qualität unserer Wälder als Lebensraum für Insekten

Nora Haack[1,2], Lisa Hahn[1], Martin Schlegel[1], Henrique Pereira[2,4], Christian Wirth[1,2], Klaus Henle[3], Detlef Bernhard[1]

[1]University of Leipzig, Leipzig, DE, nora.haack@idiv.de
[2]German Centre for Integrative Biodiversity Research (iDiv) Halle-Jena-Leipzig, Leipzig, DE, nora.haack@idiv.de
[3]Helmholtz-Zentrum für Umweltforschung, Leipzig, DE
[4]Martin-Luther-Universität Halle-Wittenberg, Halle, DE

Im Entwurf zum Aktionsprogramm Insektenschutz wird „Insektenschutz im Wald“ als ein wichtiger Unterpunkt aufgeführt. Dies ist besonders hervorzuheben, da unter den gefährdeten Insekten Deutschlands besonders viele xylobionte (= holzbewohnende) Arten sind. Unter den xylobionten Insekten sind Urwaldreliktarten sind besonders eng an naturnahe Waldgebiete mit hohem Totholzanteil gebunden. Anhand der xylobionten Käfer im Leipziger Auwald werden Urwaldreliktarten systematisch erfasst und quantifiziert. Unsere Untersuchungen ergaben, dass der Leipziger Auwald eine der höchsten Zahlen von Urwaldreliktarten im Land Sachsen aufweist. Im Vergleich mit anderen Erfassungen soll verdeutlicht werden, wie dieses Ergebnis mit Umweltparametern im Wald sowie dessen Bewirtschaftung korreliert. Des Weiteren soll der Einfluss des Vorhandenseins von Totholz und der Diversität des Baumbestandes auf den Artenreichtum xylobionter Käfer bestimmt werden. So konnten wir feststellen, dass nicht das Vorhandensein einzelner Baumarten, sondern die Diversität des Baumbestandes entscheidend ist. Diese Ergebnisse über den Einfluss der Menge und Diversität von Totholz und Lebendbewuchs auf die Diversität von Waldinsekten sind insbesondere im Hinblick auf das Festlegen konkreter Schutzmaßnahmen für holzbewohnende Waldinsekten von großer Bedeutung.
Wir danken dem Deutschen Zentrum für Integrative Biodiversitätsforschung (iDiv) Halle-Leipzig-Jena, gefördert von der Deutschen Forschungsgemeinschaft (FZT 118), für die Förderung unserer Forschungsarbeit.

SESSION 11

Umsetzung von NATURA 2000 in der Praxis: Schutz der Arten und Lebensräume der FFH- Richtlinie in der Europäischen Union mit Hilfe des Förderinstruments „LIFE Natur“

Chairs: Dr. Sebastian Schmidt, Dr. Martina Raffel, Thomas Kutter

Das Symposium soll zum einen aktuelle Herausforderungen bei der Umsetzung von Natura 2000 in Deutschland thematisieren und zum anderen praktische Beispiele aus der Umsetzung von Maßnahmen durch das EU-Förderinstrument „LIFE“ zeigen. Der Förderbereich “LIFE Natur und Biodiversität” dient dem Schutz von Arten und Lebensräumen gemeinschaftlicher Bedeutung. Das Programm unterstützt dabei vor allem die Errichtung und das Management des europäischen Schutzgebietsnetzes Natura 2000. Für den ersten Teil des Symposiums sind als Vortragende behördliche Vertreter aus Bundes- und Länderebene vorgesehen, um aktuelle Entwicklungen sowie Chancen und Herausforderungen bei der Umsetzung von Natura 2000 in einem übergeordneten Kontext zu beleuchten. Für den zweiten Teil sind Vertreter ausgewählter LIFE-Projekte vorgesehen, die aus der Praxis der Umsetzung berichten. Ein besonderes Augenmerk soll auf das Integrierte LIFE-Projekt „Atlantische Sandlandschaften“ gelegt werden, das erste integrierte LIFE-Projekt im Förderbereich Natur in Deutschland. Das Projekt zielt darauf ab, die Erhaltungszustände der FFH-Lebensräume und -arten in der atlantischen biogeographischen Region in Nordrhein-Westfalen und Niedersachsen zu verbessern. Neben dem konzeptionellen Ansatz zur Abstimmung und Verbesserung der Umsetzung von NATURA 2000 in allen Bundesländern der atlantischen Region werden unter Einbeziehung unterschiedlichster Akteure konkrete Maßnahmen zur Verbesserung der Erhaltungszustände ausgewählter Lebensraumtypen und Arten umgesetzt. Es wird so ein Schulterschluss zwischen behördlichem und praktischem Naturschutz angestrebt, um mögliche Naturschutzerfolge auch auf nationaler beziehungsweise biogeographischer Ebene sichtbar zu machen. Darüber hinaus sollen auch traditionelle LIFE-Projekte, die den Schutz einer bestimmten Region, typischer Lebensraumtypen oder einzelner Pflanzen- und Tierarten oder -gruppen zum Ziel haben, vorgestellt werden. In den Vorträgen sollen Beispiele aus der praktischen Umsetzung der Maßnahmen präsentiert und diskutiert werden. Dabei werden konzeptionelle, bürokratisch-formale und praxisbezogene Aspekte sowie Probleme bei der Umsetzung der Projekte gemäß einer Best-Practice-Analyse betrachtet. Die Session sollte nach Möglichkeit am deutschsprachigen „Practitioner Day“ stattfinden, um den Austausch unter Praktikern zu ermöglichen.

Session 11-O1/2 - Naturschutzpraxis im Rahmen von „LIFE Natur“

Das Integrierte LIFE-Projekt „Atlantische Sandlandschaften“

Sebastian Schmidt[1], Tom Kutter[2]

[1]Bezirksregierung Münster, Münster, DE, sebastian.schmidt@brms.nrw.de
[2]Niedersächsischer Landesbetrieb für Wasserwirtschaft, Küsten- und Naturschutz, Hannover, DE

Das LIFE-Programm dient seit 1992 auf europäischer Ebene als Förderinstrument für Maßnahmen im Bereich Umwelt, Naturschutz und Klimapolitik. Das LIFE-Projekt „Atlantische Sandlandschaften“ ist das erste Integrierte LIFE-Projekt (IP-LIFE) im Bereich „Natur“ in Deutschland. Die Länder Nordrhein-Westfalen und Niedersachsen zielen mit dem länderübergreifenden Projekt darauf ab, zur Trendwende beim Verlust der Artenvielfalt und wertvoller Naturräume beizutragen.
Erster Baustein des Projektes ist die Erarbeitung einer Gesamtkonzeption für die atlantische Region in Deutschland zur Verbesserung des Erhaltungszustandes aller nichtmaritimen Arten und Lebensraumtypen. Der zweite Baustein ist die Umsetzung konkreter Maßnahmen zur Verbesserung der Erhaltungszustände von zehn ausgewählten Arten und 15 Lebensraumtypen der Sandlandschaften. Hierbei werden unterschiedlichste Akteure in den Regionen einbezogen. Es wird so ein Schulterschluss zwischen behördlichem und praktischem Naturschutz angestrebt.
Die Gesamtverantwortung für das Vorhaben liegt in Nordrhein-Westfalen beim Ministerium für Umwelt, Landwirtschaft, Natur- und Verbraucherschutz und in Niedersachsen beim Ministerium für Umwelt, Energie, Bauen und Klimaschutz. Die Gesamtkoordination des Projektes wurde an die Bezirksregierung Münster übertragen, in Niedersachsen ist der Niedersächsische Landesbetrieb für Wasserwirtschaft, Küsten- und Naturschutz (NLWKN) zuständig.
Fachliche Unterstützung, insbesondere für die konzeptionelle Arbeit, wird von der jeweiligen Fachbehörde der Länder geleistet – dem Landesamt für Natur, Umwelt und Verbraucherschutz NRW sowie NLWKN in Niedersachsen.
Das IP-LIFE hat ein Gesamtbudget von 16.875 Millionen Euro, 60 % werden von der Europäischen Union gefördert. Das Projekt ist im Oktober 2016 gestartet und hat eine Laufzeit von 10 Jahren. In der Präsentation wird ein Überblick über die Projektziele und-strukturen gegeben sowie ausgewählte Umsetzungsmaßnahmen vorgestellt.

Session 11-O3 - Naturschutzpraxis im Rahmen von „LIFE Natur“

Aktuelle Herausforderungen bei der Umsetzung von Natura 2000 in Deutschland

Christina Müller[1]

[1]Bundesamt für Naturschutz, Bonn, DE, Christina.Mueller@BfN.de

Die neuen Berichtsergebnisse des FFH-Berichts 2019 zeigen, dass seit dem Bericht 2013 keine grundlegende Verbesserung der Erhaltungszustände der FFH-Schutzgüter stattfand und somit die 2020-Ziele der EU-Biodiversitäts-Strategie nicht erreicht werden können. Dies spiegelt sich auch im Vertragsverletzungsverfahren zur Schutzgebietsausweisung und Festlegung von Erhaltungsmaßnahmen sowie dem Pilotverfahren zu den Mähwiesen wider.
Die aktuellen und genaueren Daten des FFH-Berichts 2019 ermöglichen Analysen der einzelnen Parameter und Trends, um Hauptfaktoren für einen schlechten Erhaltungszustand zu bestimmen und herauszufinden, wie und wo eine Verbesserung des Zustandes der Arten und Lebensraumtypen notwendig und möglich ist. Nach der Schutzgebietsausweisung und der ersten Fassung der Managementpläne müssen nun wirksame Maßnahmen flächendeckend umgesetzt werden. Dabei sind v.a. die Mittel- und Ressourcenknappheit sowie der Handlungsbedarf, der weit über den Naturschutz hinausgeht, wie z.B. Beeinträchtigungen und Gefährdungen aus Landwirtschaft, Forstwirtschaft, Fischerei etc., eine große Herausforderung. Aufgrund von Verschlechterungen seit Erstmeldung der Gebiete geht es nicht mehr allein um das Halten des aktuellen Zustands, sondern auch um Wiederherstellung und Neuentwicklung. In der Kostenschätzung 2016 ergab sich ein Finanzbedarf für die Umsetzung der EU-Naturschutzrichtlinien von 1,416 Mrd. €/Jahr, aktuell steht nur ein geringer Teil dieser Summe zur Verfügung. Für eine tiefgreifende Verbesserung der Erhaltungszustände müsste außerdem ein Umdenken in anderen Ressorts, z.B. im Agrarsektor, stattfinden.

Session 11-O4 - Naturschutzpraxis im Rahmen von „LIFE Natur“

Das LIFE-Programm der EU – ein Beitrag zur Umsetzung des Natura 2000-Netzwerks auch in Deutschland

Ruth Brauner[1]

[1]LIFE-Beratungsstelle, Zukunft - Umwelt - Gesellschaft gGmbH, Bonn, DE, ruth.brauner@z-u-g.org

Seit 1992 unterstützt die EU mit dem LIFE-Programm die Umsetzung und die Weiterentwicklung der EU-Umweltpolitik. Gefördert werden insbesondere praxisorientierte Umweltprojekte in einer Vielzahl von Bereichen wie Luftqualität, Wasser, Abfall, Kreislaufwirtschaft, Chemikalien, Lärm, Klimaschutz und -anpassung – und nicht zuletzt Naturschutz. Im Schwerpunktbereich ‚Natur und Biodiversität‘ dienen die LIFE-Natur-Projekte seit 27 Jahren der Umsetzung der Vogelschutz- und der Fauna-Flora-Habitat-Richtlinie und unterstützen damit die Einrichtung und Ausgestaltung des Natura 2000-Netzwerks.

Über 130 Projekt der ‚Thematischen Priorität für Natur‘ wurden oder werden mittlerweile in Deutschland umgesetzt – von den Höhen des Schwarzwaldes bis zu den Flusstalmooren Mecklenburg-Vorpommerns und vom Wattenmeer bis zu Steppenrasen Thüringens. LIFE hat viele Wirkungsbereiche, macht auch vor Truppenübungsplätzen nicht Halt und hat bereits positive Effekte für den Denkmalschutz gehabt. LIFE-Natur-Projekte werden in der Regel in der Landschaft deutlich sichtbar und sie sollen und können sich auch sehen lassen.

Inzwischen gibt es in Deutschland nicht nur traditionelle LIFE-Natur-Projekte, sondern auch ein verstärkt strategisch ausgerichtetes, großräumiger angelegtes Integriertes LIFE-Projekt mit Naturschutzschwerpunkt sowie LIFE-Projekte des ‚Schwerpunktbereichs Verwaltungspraxis und Information‘ mit Bezug zu den Naturschutzrichtlinien der EU.

Im Rahmen des Vortrags gibt die im Aufbau befindliche LIFE-Beratungsstelle bei der Zukunft – Umwelt – Gesellschaft gGmbH einen kurzen Überblick über die Zielsetzung und die Möglichkeiten des EU-LIFE-Förderprogramms und über die Vielfalt insbesondere der LIFE-Natur-Projekte in Deutschland.

Session 11-O5 - Naturschutzpraxis im Rahmen von „LIFE Natur“

Länderübergreifendes Konzept zur Umsetzung von Natura 2000 - Beispielhaftes Vorgehen im IP-Life „Atlantische Sandlandschaften“

Ralf Schlüter[1]

[1]Landesamt für Natur, Umwelt und Verbraucherschutz NRW, Recklinghausen, DE, ralf.schlueter@lanuv.nrw.de

Aus dem FFH-Bericht Deutschlands ergeben sich deutliche Notwendigkeiten zur Verbesserung der Erhaltungszustände von Lebensraumtypen und Arten der atlantischen biogeographischen Region. Ein wesentliches strategisches Instrument um die FFH-Richtlinie in diesem Punkt umzusetzen sind die Prioritären Aktionsrahmen (Prioritised Action Framework = PAF) auf Ebene der EU-Mitgliedsstaaten. In einigen der EU-Staaten wurden bereits methodische Vorgehen entwickelt, um den PAF zu konkretisieren. Dabei geht es darum die Verbesserungsbedarfe aus den FFH-Berichtsdaten abzuleiten und die FFH-Schutzgüter entsprechend ihrer Priorität bei der Umsetzung von Maßnahmen einzuteilen. Im Integrierten LIFE-Projekt „Atlantische Sandlandschaften“ werden Methoden entwickelt, um diese Konkretisierung von Schwellenwerten und die Priorisierung von Schutzgütern auf Ebene der atlantischen biogeographischen Region voran zu treiben. Nordrhein-Westfalen und Niedersachsen arbeiten als direkte Projektpartner gemeinsam an der Konzeptentwicklung. Diese beiden Bundesländer nehmen den größten Flächenanteil (ca. 80 %) der atlantischen Region in Deutschland ein. Darüber hinaus werden Treffen auf übergeordneter Ebene organisiert (Bund-Länder-Plattform), in denen sich auch die anderen Bundesländer der atlantischen Region sowie Vertreter der Bundesbehörden einbringen. Durch den stetigen Austausch innerhalb des Projektkonsortiums soll die Entwicklung des Konzeptes als offener Prozess gestaltet werden. Während der Konzeptentwicklung sollen bereits konkrete prioritäre Maßnahmen abgeleitet werden, deren Umsetzung einen möglichst sichtbaren Erfolg des IP-LIFE gewährleisten. Auf diese Weise greifen Praxis und Konzept im späteren Verlauf des Projektes direkt ineinander. In Nordrhein-Westfalen fand ein ganz ähnlicher Prozess bereits im Vorfeld durch das Aufstellen von Verantwortlichkeitsprofilen auf Kreisebene und die Kommunikation in sogenannten Kreisgesprächen statt.

Session 11-O6 - Naturschutzpraxis im Rahmen von „LIFE Natur“

Setting priorities for the conservation of habitat types in Lower Saxony

Ines Bruchmann[1]

[1]Niedersächsischer Landesbetrieb für Wasserwirtschaft Küsten- und Naturschutz, Hannover, DE, ines.bruchmann@web.de

The LIFE Integrated Project “Atlantic Region DE” aims to improve the conservation status of specific habitat types such as inland dune habitat types. In order to steer the conservation measures in Lower Saxony as efficiently as possible, we have determined which occurrences of these habitat types in Lower Saxony’s biogeographic atlantic region are of the greatest relevance for the achievement of the project goals. To decide which of the numerous occurrences should benefit from the project, mapping data was analyzed and grouped according to a set of criteria. In-house developed GIS tools supported the identification of sites of high priority for the project.
Das Integrierte LIFE Projekts „Atlantische Sandlandschaften“ hat zum Ziel, den Erhaltungszustand bestimmter FFH-Lebensraumtypen in der atlantischen Region der BRD zu verbessern. Im Zuge der zehnjährigen Projektlaufzeit sollen hierfür u.a. konkrete Maßnahmen gemeinsam mit lokalen Partnern (Stakeholder) geplant und umgesetzt werden. Um die Wirksamkeit dieser Maßnahmen, im Sinne der übergeordneten Projektziele möglichst zielgerichtet und wirkeffizient zu gestalten, wurden in Niedersachsen alle bekannten Vorkommen der Ziel-Lebensraumtypen identifiziert, aus landesweiter Sicht anhand von naturschutzfachlichen Kriterien kategorisiert und für die Projektbelange priorisiert. Die Priorisierung bedeutsamer Vorkommensbereiche der Ziel-Lebensraumtypen erweist sich als wichtige Grundlage zur Lenkung von Projektressourcen in Niedersachsen sowie in der Kommunikation mit den Stakeholdern.

Session 11-O7 - Naturschutzpraxis im Rahmen von „LIFE Natur“

Die Rolle der Biologischen Stationen bei der Umsetzung von NATURA 2000 und LIFE in Nordrhein-Westfalen

Birgit Beckers[1]

[1]Dachverband Biologischer Stationen NRW, Solingen, DE, b.beckers@abu-naturschutz.de

Seit den 1980er Jahren bildete sich in Nordrhein-Westfalen ein Netzwerk von Biologischen Stationen. Heute arbeiten rund 40 Biologische Stationen als gemeinnützig anerkannte Vereine nahezu im ganzen Bundesland.
Die Trägervereine der Biologischen Stationen erhalten für ihre Arbeit vom Land NRW sowie den jeweiligen Kreisen Fördermittel. Hauptarbeitsfelder sind die Betreuung von Schutzgebieten, die Durchführung des FFH-Monitorings, Artenschutzmaßnahmen, Einwerbung von Vertragsnaturschutz sowie umfangreiche Öffentlichkeitsarbeit. Sie unterstützen das Ehrenamt vor Ort. Die FFH-Maßnahmenkonzepte im Offenland werden überwiegend von Biologischen Stationen erstellt, bei den FFH-Maßnahmenkonzepten im Wald übernehmen sie die Erhebung und Bereitstellung vegetationskundlicher und faunistischer Daten und machen Maßnahmenvorschläge. Bei der Erstellung der Vogelschutzmaßnahmenpläne wirken sie unterstützend mit.
Biologische Stationen setzen zudem eine Vielzahl verschiedener weiterer Naturschutzprojekte unterschiedlichster Fördergeber um. Bei LIFE-Projekten waren und sind die Biologischen Stationen Vorreiter in NRW. Von den mittlerweile 33 LIFE-Projekten in NRW sind bzw. waren 22 in der Trägerschaft von Biologischen Stationen. Aktuell sind allein 16 Biologische Stationen bei der Umsetzung des Integrierten LIFE-Projektes „Atlantische Sandlandschaften“ eingebunden.
2005 haben sich die Stationen im Dachverband Biologischer Stationen NRW e.V. zusammengeschlossen, der sich auf Landesebene für die Interessen der Stationen einsetzt.
Weitere Informationen finden sich auf der Internetseite des Dachverbandes Biologischer Stationen NRW e.V.: www.biostationen-nrw.com

Session 11-O8 - Naturschutzpraxis im Rahmen von „LIFE Natur“

Maßnahmen im Kreis Steinfurt zur Verbesserung des Erhaltungszustands von LRT 3130, Moorfrosch und Froschkraut

Dr. Peter Schwartze[1], Hartmut Storch[1]

[1]Biologische Station Kreis Steinfurt e.V., Tecklenburg, DE, peter.schwartze@biologische-station-steinfurt.de

Das Ergebnis des FFH-Berichtes 2013 zeigte, dass die Erhaltungszustände von Lebensraumtypen und Arten in der biogeographischen Region „Atlantische Sandlandschaften“ überwiegend ungünstig sind. Mit einem länderübergreifenden LIFE-Projekt versuchen Nordrhein-Westfalen und Niedersachsen eine Trendwende einzuleiten, um die Erhaltungszustände in der atlantischen Region zu verbessern.
In beiden Bundesländern werden vorhandene Heidelandschaften, artenreiche Sandtrockenrasen und nährstoffarme Stillgewässer optimiert bzw. wiederhergestellt.
Im Kreis Steinfurt wurden an drei Heideweihern aufgrund von Planungen der Biologischen Station Kreis Steinfurt im Rahmen des IP LIFE-Projektes „Atlantische Sandlandschaften“ Optimierungsmaßnahmen an nährstoffarmen Stillgewässern mit Strandlings- und Zwergbinsengesellschaften (FFH-LRT 3130) sowie in Feuchtheiden umgesetzt.
So wurden im FFH-Gebiet „Hanfteich“ der Heideweiher und ein Kleingewässer von Gehölzen freigestellt. Anschließend wurden die eutrophierten Uferbereiche und das Zentrum des Weihers entschlammt. So soll eine großflächige Heideweiherentwicklung erreicht werden, bei der u.a. *Luronium natans* im Bestand gestützt werden soll.
Im Gebiet „Heide an der Hohen Haar“ wurden ebenfalls die Ufer eines Heideweihers und eines Stillgewässers von Gehölzen komplett freigestellt und danach entschlammt. Der Zielbiotop ist hier die Entwicklung eines oligotrophen Gewässers mit dem LRT 3130 und die Vergrößerung des *Luronium natans*-Bestandes.
Ebenso wurden im FFH-Gebiet „Heideweiher an der Flötte“ aufkommende Gehölze an Gewässern und aus einer Feuchtheide entfernt. Die Entschlammung und das teilweise Abplaggen der Feuchtheide sollen die Entwicklung des LRT 3130 fördern.
Im FFH-Gebiet „Harskamp“ wurden vier Hektar Feuchtheide- und Schnabelriedfläche von aufkommenden Gehölzen befreit. Zahlreiche gefährdete Pflanzenarten werden damit gefördert.
Aktuelle Ergebnisse über die Wirkung der Optimierungsarbeiten werden vorgestellt.

Session 11-O9 - Naturschutzpraxis im Rahmen von „LIFE Natur“

Schutz und Wiederansiedlung der Knoblauchkröte (*Pelobates fuscus*) im Rahmen von LIFE

Christian Göcking, Norbert Menke[1]

[1]NABU Naturschutzstation Münsterland e.V., Münster, DE, c.goecking@nabu-station.de

Die Knoblauchkröte (*Pelobates fuscus*) ist eine in NW Deutschland extrem seltene Amphibienart (RL NRW 1) und im Anhang IV der FFH-Richtlinie aufgeführt. Sie ist ost- und mitteleuropäisch verbreitet und erreicht in Deutschland ihre westliche Verbreitungsgrenze.
Um den massiven Rückgängen von Vorkommen und Individuen und damit einem drohenden Aussterben insgesamt entgegen zu treten, wurde von 2012 – 2016 das Artenschutz-Projekt LIFE11 NAT / DE / 348 „Schutz der Knoblauchkröte in Teilen des Münsterlandes“ mit zahlreichen Kooperationspartnern (LANUV NRW, Kreis Warendorf, Kreis Borken) umgesetzt. Hierbei wurden Laichgewässer und Landlebensräume neu geschaffen und optimiert. Außerdem fanden Rettungszuchten und der Aufbau von Spiegelpopulationen statt, um das Überleben im Münsterland, zumindest in Teilbereichen, zu sichern.
Aufgrund der guten Erfahrungen wurde der Knoblauchkrötenschutz in Nordrhein-Westfalen im Rahmen des Projektes LIFE15 IPE DE 007 „Atlantische Sandlandschaften“ ab 2017 weiter betrieben und räumlich ausgedehnt.
Die Umsetzung der Maßnahmen und Wieder-Ansiedlungen in den verschiedensten Gebieten verliefen sehr erfolgreich und bereits im Laufe des Projektes konnten erste Reproduktionen der Art nachgewiesen werden.
Im Rahmen des Vortrages werden Maßnahmen, die Durchführung der Rettungszuchten und aktuelle Ergebnisse des Monitorings vorgestellt.

Session 11-O10 - Naturschutzpraxis im Rahmen von „LIFE Natur“

LIFE BOVAR - Management der Gelbbauchunke (*Bombina variegata*) und anderer Amphibien dynamischer Lebensräume

Christian Höppner[1], Bruno Scheel[1], Holger Buschmann[1]

[1]NABU Niedersachsen, Hannover, DE, christian.hoeppner@nabu-niedersachsen.de

Der NABU Niedersachsen widmet sich gemeinsam mit seinen Projekt- und Kooperationspartnern in dem internationalen Projekt LIFE BOVAR (LIFE16 NAT/DE/000660) dem Management der Gelbbauchunke (*Bombina variegata*) und anderer gefährdeter Amphibienarten sowie der gezielten Entwicklung dynamischer Lebensräume für den Artenschutz.
Wichtigste Ziele des Projektes sind die Umsetzung von praktischen Artenschutzmaßnahmen zur Wiederherstellung günstiger Lebensraumbedingungen für gefährdete Amphibienarten, die Stärkung des Biotopverbundes durch Trittsteine und die Wiederansiedlung. Dabei sollen die Zielarten Gelbbauchunke, Geburtshelferkröte (*Alytes obstetricans*), Kreuzkröte (*Epidalea calamita*) und Kammmolch (*Triturus cristatus*) profitieren. Außerdem soll die Etablierung extensiver Beweidungssysteme zum Erhalt der Dynamik und offener Uferstrukturen an Laichgewässern in den Projektgebieten beitragen. Insgesamt soll ein Beitrag zur Wiederherstellung des ursprünglichen Verbreitungsgebietes der Arten geleistet werden.
Zur Erreichung der Projektziele werden in den Projektgebieten über 260 Klein- und 3.000 Kleinstgewässer als Laichgewässer für die Zielarten neuangelegt und saniert. Darüber hinaus sollen genetische Grundlagen für den Aufbau eines Zuchtstammes der Geburtshelferkröte zur Bestandsstützung und Wiederansiedlung erarbeitet werden.
LIFE BOVAR wird gemeinsam mit sechs Projektpartnern über einen Zeitraum von acht Jahren in vier Projektregionen im niedersächsischen Bergland, Aachen, Soest (Nordrhein-Westfalen) und Limburg (Niederlande) durchgeführt. Der Vortrag stellt den Stand des Projektes mit einem Schwerpunkt auf der Umsetzung der praktischen Habitat- und Vernetzungsmaßnahmen dar.
Weitere Informationen zum Projekt LIFE BOVAR finden Sie unter: www.life-bovar.com.

Session 11-O11 - Naturschutzpraxis im Rahmen von „LIFE Natur“

Erfahrungen des NaturSchutzFonds Brandenburg aus zehn Jahren LIFE-Umsetzung

Holger Rößling[1], Janine Ruffer[1], Michael Zauft[1], Stefanie Luka[1], Inga Willecke[1]

[1]NaturSchutzFonds Brandenburg, Potsdam, DE, holger.roessling@naturschutz-fonds.de

Der NaturSchutzFonds Brandenburg ist die öffentlich-rechtliche Naturschutzstiftung des Landes Brandenburg. Sie setzt seit 2010 selbstständig Naturschutzprojekte mit Unterstützung des Finanzierunginstruments LIFE der Europäischen Union in Brandenburg um.

Mit den Projekten LIFE Kalkmoore (2010-2015), LIFE Sandrasen (2013-2019), LIFE Feuchtwälder (2014-2022) und LIFE Trockenrasen (2019-2026) werden mehr als 20 Mio. Euro in den Erhalt des Europäischen Schutzgebietsnetzes Natura 2000 in Brandenburg investiert.

In den Projekten wurden und werden Maßnahmen zur Wiederherstellung insbesondere folgender Lebensraumtypen durchgeführt:

- Offene Grasflächen auf Dünen (2330),
- Trockene europäische Heiden (4030),
- Trockene, kalkreiche Sandrasen (*6120),
- Subpannonische Steppen-Trockenrasen (*6240)
- Kalkreiche Niedermoore (7230),
- Moorwälder (*91D0),
- Auen-Wälder mit *Alnus glutinosa* und *Fraxinus excelsior* (*91E0),
- Mitteleuropäische Flechten-Kiefernwälder (91T0).

Schwerpunkte der Maßnahmenumsetzung waren und sind dabei vor allem

- die Wiederherstellung naturnaher Grundwasserverhältnisse in Niedermooren,
- die Wiederherstellung nährstoffarmer Standortverhältnisse in Mooren durch Flachabtorfungen,
- die Wiederherstellung von offenen Sandlebensräumen durch den Abtrag von Humus- und Streuauflagen,
- die Stabilisierung der Populationen von typischen und wertgebenden Pflanzenarten der Lebensräume durch aktive Wiederansiedlung,
- die Etablierung und Stabilisierung angepasster Nutzungssysteme (Beweidung) zum Erhalt nutzungsabhängiger Offenlandlebensräume.

Im Rahmen des Vortrags werden Beispiele aus allen LIFE-Projekten des NaturSchutzFonds Brandenburg vorgestellt. Insbesondere soll auf praktische Erfahrungen aus der Maßnahmenumsetzung, auf die Strategien in der Kooperation mit den Landnutzern und regionalen Akteuren sowie auf die Kooperation mit Wissenschaftseinrichtungen (z.B. BfN-Projekt WIPS-DE) eingegangen werden.

SESSION 12

Physiological plant ecology in a complex and changing world

Chairs: Arthur Gessler, Ansgar Kahmen, Charlotte Grossiord

Complex ecological patterns as well as the complex molecular regulation of plant functioning can be described by ever more sophisticated computational and analytical methods. However, these disciplinary advancements have tended to make ecology and plant physiology diverge rather than converge in scope and focus (large-scale and generality vs. small-scale and accuracy). While ecological studies are often confined to the description of patterns and processes, most physiological and mechanistic molecular studies are restricted to isolated processes in model organisms. Physiological plant ecology attempts to fill existing gaps between ecology and plant physiology, bridging differences in methods and scales, in order to arrive at a deeper functional understanding of the physiological mechanisms responsible for observed ecosystem patterns and processes. This session is planned as a broad forum linking physiological and ecological research centered around plants across scales. Contributions from all disciplines of plant ecology, from ecosystem ecology via plant ecophysiology to molecular physiology, are therefore encouraged. We especially welcome studies combining experiments with field observations, studies using isotope signals, multi-species studies, and studies on global-change effects on plant functioning.

Session 12-O1 - Physiological plant ecology

Population differentiation in metabolic cold stress responses of an endemic high mountain tree: implications for forest retractions and conservation under global change

Karin Schrieber[1,2,3], Yolanda Caceres[3,4], Alicia Engelmann[2], Isabell Hensen[3,4], Caroline Müller[2]

[1]Kiel University, Institute for Ecosystem Research, Geobotany, Kiel, DE, kschrieber@ecology.uni-kiel.de
[2]Bilefeld University, Faculty of Biology, Department Chemical Ecology, Bielefeld, DE, kschrieber@ecology.uni-kiel.de
[3]Martin-Luther-University Halle-Wittenberg, Halle (Saale), DE, kschrieber@ecology.uni-kiel.de
[4]German Centre for Integrative Biodiversity Research (iDiv), Leipzig, DE

The decline of mountain forests under global change is alarming and conservation is challenged by the need to future-proof populations to deal with the predicted environmental shifts. Assessing intra-specific differentiation in stress susceptibility and molecular stress responses of trees species along altitudinal gradients is crucial to estimate their vulnerability and identify adequate genetic sources for forest restoration. In this context, the increased risk of exposure to frost in the absence of protective snow layers for juvenile evergreen trees has been largely ignored. Here, we exposed saplings of the highly endangered, evergreen mountain tree *Polylepis australis* from low and high altitudinal origins to four different frost treatments with increasing stress intensity to assess plant performance and metabolic stress responses. Leaf damage and sapling mortality increased significantly with frost intensity. Leaves responded to frost with enhanced concentrations of sugars, organic acids, amines and specialized metabolites, which partly have freezing point depressing, cryo-protective and anti-oxidative properties. These responses were more pronounced in populations from high than low altitudinal origins indicating local adaptation to a higher frequency and intensity of frost events in the former. We discuss implications for forest restoration and the power of metabolomics in unravelling intra-specific differentiation across small geographic scales.

Session 12-O2 - Physiological plant ecology

Maximum carboxylation capacity, electron transport rates and leaf nutrients in five calcareous grassland species across Europe

Solveig Franziska Bucher[1], Christina Grün-Wenzel[1], Steven I. Higgins[2], Christine Römermann[1,3]

[1]Institute of Ecology and Evolution with Herbarium Haussknecht and Botanical Garden, Department of Plant Biodiversity, Friedrich Schiller University Jena, Jena, DE, solveig.franziska.bucher@uni-jena.de
[2]Chair of Plant Ecology, University of Bayreuth, Bayreuth, DE
[3]German Centre for Integrative Biodiversity Research (iDiv) Halle-Jena-Leipzig, Leipzig, DE

Photosynthesis is one of the main drivers for plant performance. Its rates are species specific but also influenced by site specific abiotic conditions. To see whether photosynthesis rates vary on an inter- and intraspecific scale, we measured A/C_i-Curves on five selected plant species, namely *Campanula glomerata* L., *Centaurea jacea* L., *Plantago media* L., *Salvia pratensis* L. and *Trifolium montanum* L. on 18 calcareous dry grassland sites in 15 European countries. To see how photosynthesis rates are linked to plant functional traits associated with plant performance such as leaf nitrogen and carbon status, specific leaf area or water-use efficiency (assessed via $\Delta^{13}C$) as well as the stable nitrogen isotope ^{15}N and stomatal parameters, we recorded these parameters in parallel. We found strong species specific and regional differences but a general trade-off in between photosynthesis rates and nitrogen content as well as ^{15}N on the one hand and water-use efficiency and stomatal parameters on the other hand. Area based leaf carbon content and SLA where independent from this axis in a PCA. This research helps to understand relationships between abiotic parameters, photosynthesis rates and leaf functional traits related to plant performance.

Session 12-O3 - Physiological plant ecology

Hotspot biocrusts: Combining chlorophyll fluorescence and NDVI to analyze spatial and temporal variations of photosynthesis

Stella Gypser[1], Maik Veste[2]

[1]Brandenburg University of Technology Cottbus-Senftenberg, Chair of Soil Protection and Recultivation, Cottbus, DE, stella.gypser@b-tu.de
[2]Brandenburg University of Technology Cottbus-Senftenberg, Chair of Ecology, Cottbus, DE

Biological soil crusts (biocrusts) play an important role as pioneering organisms on initial soils and in open landscapes after natural and human disturbances. Even though they only cover the topsoil, biocrusts are key drivers for biogeochemical and ecological processes and influencing ecosystem development. Microclimatic conditions, texture, water holding capacity, and chemical soil properties lead to the formation of spatial patterns. Sandy nutrient-poor soils in pine forests in the open-cast lignite mining district in Brandenburg are covered by biocrust, dominated by different functional types and species (e.g. algae, mosses, lichens). The photosynthetic activity of these poikilohydric organisms, strongly depending on moisture, affects biocrust function and their impact on soil C pools and dynamics. Therefore, the evaluation of photosynthesis in relation to the spatial distribution pattern variation is fundamental. For this purpose, we combined different remote sensing techniques, spectral reflectance sensors, and chlorophyll fluorescence imaging to analyze the photosynthetic dynamics in relation to biocrust species composition and wetness. Desiccation of the biocrusts was detected with a miniature moisture sensor and related to their activity. A low-cost consumer grade camera was used to determine NDVI and to map the distribution and heterogeneity of chlorophyll for a comprehensive characterization of spatial photosynthetic activity pattern. Basic as well as maximum fluorescence, the maximum photochemical efficiency, and NDVI decreased during desiccation of the biocrusts, whereby moss and moss/lichen biocrusts showed higher water holding capacities relative to green algae biocrusts. The combination of different sensor technologies is a powerful tool for monitoring long-term biocrust development and their implication for soil C dynamics.

Drought response traits in tropical deciduous woody species: opposite relation of turgor loss point to rainfall than expected

Eunyoung Jung[1], Marcelo Tabarelli[2], Inara Leal[2], Rainer Wirth[3], Bettina Engelbrecht[1,4]

[1]University of Bayreuth, Bayreuth, DE, eun-young.jung@uni-bayreuth.de
[2]Federal University of Pernambuco, Recife, BR
[3]University of Kaiserslautern, Kaiserslautern, DE
[4]Smithsonian Tropical Research Institute, Balboa, PA

To improve projections how global change will affect vegetation, and which species will win or lose under conditions of changing climate and land-use, we urgently need to improve our understanding of the mechanisms underlying plant responses to drought and identify traits that allow to predict them. The problem is especially acute in the Caatinga, an extensive seasonally dry tropical forest biome in northeastern Brazil, which is threatened by desertification through decreasing rainfall and through anthropogenic disturbance.
Turgor loss point (TLP), the water potential at which leaves lose turgor, has been suggested to be a key trait of drought resistance in woody species, with species with a lower TLP being more drought resistant. In this study, we addressed if TLP is also related to drought resistance in deciduous tropical dry forest species.
We quantified for 21 deciduous woody species occurring in the Caatinga the turgor loss point, as well as the minimum leaf conductance (g_{min}) and bark conductance (g_{bark}) to water vapor. We then analyzed how the community-weighted mean (CWM) of these traits changes across a pronounced rainfall gradient. We hypothesized that the CWM of all three traits increases with rainfall.
While we found the expected pattern for g_{min} and g_{bark}, the CWM of TLP decreased with rainfall, i.e., the relation was opposite to the one expected from previous studies. These results are consistent with a strategy of minimizing water loss through early stomatal closure, which is associated with high TLP, and an effective cuticle and bark. They indicate that avoiding desiccation is an important mechanism for deciduous woody plants in this system.
More importantly, these results highlight the need to assess the relation of functional traits to drought resistance in different plant life forms and systems, before using traits to predict plant drought responses.

Session 12-O5 - Physiological plant ecology

The hydrogen isotope composition of cellulose is related to the carbon status of leaves

Meisha Holloway-Phillips[1], Günter Hoch[1], Leonie Schönbeck[2], Ansgar Kahmen[1]

[1]University of Basel, Basel, CH, m.holloway-phillips@unibas.ch
[2]Swiss Federal Research Institute WSL, Birmensdorf, CH

The hydrogen isotope composition of plant organic compounds, including cellulose, reflects both the isotope composition of source and leaf water, as well as metabolism-dependent fractionation processes. Variation in the isotope composition of these components is driven by climatic conditions, the plant's response to the environment, and primary metabolism (e.g. C_3/C_4/CAM). Whilst semi-mechanistic models exist to predict the hydrogen isotope composition of cellulose, their application has been limited due to uncertainties in model parameters, especially those associated with carbon metabolism. This is due to a paucity of information as to the extent plant metabolism influences the hydrogen isotope composition of plant organic compounds. Here, we take an empirical approach and explore the relations between the carbon status of leaves (assessed as non-structural carbohydrates; NSC) in saplings and mature trees grown under field manipulations and in natural stands. We show that as NSC levels decrease as a result of shading or declining growth rates under natural settings, the hydrogen isotope composition of leaf cellulose increases. These results offer a promising way to track the carbon status of plants and retrospectively assess the response of plants to environmental change, particularly with respect to drought events and associated tree mortality.

Session 12-O6 - Physiological plant ecology

High frequency stable isotope signals as proxy for physiological responses to climate - Dual isotope approach at a European scale.

Valentina Vitali[1], R. Weigt[1], S. Klesse[1], K. Treydte[1], R. Siegwolf[1], M. Saurer[1]

[1]Swiss Federal Institute for Forest, Snow and Landscape Research WSL, Birmensdorf, CH, valentina.vitali@wsl.ch

Climatic effects on *Picea abies* and *Fagus sylvatica*, two of the most important tree species in Europe, have been extensively investigated. However, their physiology at temperate sites is not yet fully understood. For each species we sampled five sites along a climate gradient in Central Europe. Tree-ring width and stable isotope ratios (C and O) were measured and evaluated as indicators of physiological performance under different environmental conditions. After high-pass filtering of the chronologies, we analyzed the year-to-year variability of the isotopes time series for the last 100 years in relation to tree-ring width, spatial distribution and seasonal climate.
Climate sensitivity of radial growth of both species was rather variable and site-dependent, and was strongest at the driest sites. On the contrary, variability in the isotope ratios consistently responded to summer climate, particularly to vapor pressure deficit. On one hand, the high correlation of short-term $\delta^{18}O$ within sites, between sites, and compared to the other species highlights the strength of the environmental signal in $\delta^{18}O$ chronologies of both species. On the other hand, $\delta^{13}C$ shows lower correlations within and between sites, and between species, showing a stronger individual and site-dependent pattern. The generally positive correlation between the year-to-year variability in $\delta^{13}C$ and $\delta^{18}O$ at most sites demonstrates the strong role of stomatal conductance in controlling leaf gas exchange for these species, and its dependency on atmospheric moisture demand and soil water availability.
Understanding the underlying physiological mechanisms controlling the short-term variation in tree-ring records will help evaluating the performance of these ecologically and economically important tree species under future climate conditions.

Session 12-O7 - Physiological plant ecology

Hydraulic Redistribution – Relevance and mechanisms among Central European tree species

Benjamin D Hafner[1], Benjamin D Hesse[1], Taryn L Bauerle[2], Thorsten EE Grams[1]

[1]Technical University of Munich, Freising, DE, benjamin.hafner@tum.de
[2]Cornell University, Ithaca, US

Hydraulic redistribution (HR) is the passive flux of water through plants along a water-potential (ψ) gradient in the soil. Its influence on the water balance of plants and ecosystems depends on both soil processes and plant physiology. This contribution combines field observations and growth chamber experiments to trace, quantify and identify driving factors of HR among multiple Central European tree species under drought.
In a split-root growth chamber study, important driving factors of HR by diffuse porous (*Acer pseudoplatanus*, *Fagus sylvatica*), ring porous (*Castanea sativa*, *Quercus robur*) and conifer species (*Picea abies*, *Pseudotsuga menziesii*) were identified. Trees were planted with one individual (split-root plant) having its roots split between two pots with a reference tree each. A range of ψ gradients was established between the pots and HR was observed by stable isotope labeling. Over one night, species redistributed 0.39 ± 0.14 ml water. Higher ψ gradients and larger conduit diameters significantly increased HR. Especially trees with high xylem hydraulic conductivity had high HR capacitance, predestinating them as valuable 'silvicultural tools' to improve plant water-status.
In a mixed *F. sylvatica* - *P. abies* stand in southern Germany (Kranzberg forest, kroof.wzw.tum.de) HR by 70-year old *F. sylvatica* trees was studied on six throughfall exclusion plots. Via plastic tubes labeled water was applied to deep (30-50 cm) soil layers and HR was traced by sampling of soil and plant tissue. 2% of the applied water was redistributed to roots in the dry topsoil and also reached the rhizosphere where it was potentially available to neighboring *P. abies* trees. Concomitant sap flow measurements in coarse roots confirmed HR by *F. sylvatica* trees.
With anticipated precipitation shifts in the future, HR could play a crucial role in the water balance of Central European trees facing increasing drought periods and thus greater ψ gradients.

Session 12-O8 - Physiological plant ecology

Grazing response strategies of winter annuals: Linking traits to species' responses in the field

Susanne Kurze[1], Mark C. Bilton[2,3], Katja Tielbörger[3], Leonor Álvarez-Cansino[1], Bettina Engelbrecht[1,4]

[1]University of Bayreuth, Functional and Tropical Plant Ecology, Bayreuth Center of Ecology and Environmental Research (BayCEER), Bayreuth, DE, Susanne.Kurze@uni-bayreuth.de
[2]Namibia University of Science and Technology (NUST), Department of Agriculture and Natural Resources Sciences, Windhoek, NA
[3]University of Tübingen, Plant Ecology, Institute of Evolution and Ecology, Tübingen, DE
[4]Smithsonian Tropical Research Institute, Panama, PA

Grazing influences plant fitness with consequences on species' abundance and distribution. Plants have evolved three main grazing response strategies to cope with grazing. These strategies are well-known in perennials, which either *tolerate* grazing through a high re-growth ability, or *avoid* grazing through an inconspicuous stature and well-defended tissue. A third strategy, namely grazing *escape*, characterised by a short life cycle and seed dormancy, has been commonly attributed to annuals. However, the grazing response strategies of annuals are almost unexplored. Therefore, we investigated how traits, characterising the grazing escape, tolerance or avoidance strategy, are coordinated in winter annuals, and if these trait coordinations explain species' responses to grazing.
We directly linked 16 traits of 23 annual species from the Eastern Mediterranean Basin to species' fitness response to simulated grazing (clipping) in the greenhouse, and to species' abundance responses to grazing in an exclosure experiment in Jordan.
Traits were coordinated along two orthogonal axes characterized by either tolerance traits (large, nutrient-rich leaves, high growth rates) or escape traits (early flowering time, high seed dormancy, low growth rate). Both coordinations implied a high compensation ability. Avoidance traits in contrast were not coordinated. Species' positions along both axes (tolerance and escape) explained species' fitness responses to simulated grazing, but only the escape axis was associated with abundance responses to grazing in dry habitats. Abundance responses to grazing in wet habitats though were unrelated to both trait coordinations.
Our study showed for the first time that annual species exhibit two main grazing response strategies and established a direct link between these strategies and species' abundance responses in the field, reinforcing a foundation stone of trait-based ecology.

Session 12-O9 - Physiological plant ecology

Which leaf functional traits predict plant response to climate best? A case study along the latitudinal gradient in central Northern Eurasia

Larissa Ivanova[1,2], Dina Ronzhina[1,2], Polina Yudina[1], Svetlana Migalina[1,2], Christian Lampei[3], Klaus-Holger Knorr[3], Leonid Ivanov[1,2], Norbert Hölzel[3]

[1]Botanic Garten UB RAS, Ekaterinburg, RU, Ivanova.Larissa@list.ru
[2]Tyumen State University, Tyumen, RU
[3]Institute of Landscape Ecology, University of Münster, Münster, DE

Plant functional traits are commonly used in ecophysiological studies aiming to establish the plant-environment relationships. Since the range of functional traits is virtually infinite we need to know which functional traits are the most promising to predict plant response to environmental change. We studied over 30 leaf traits from whole-leaf to subcellular level in more than 400 plant samples of 160 species from 22 plots evenly distributed along the latitudinal gradient east of the Ural Mountains in Western Siberia (tundra, taiga, steppe plots) and Kazakhstan (steppe and desert). Indeed, we did find significant differences in the relevance of leaf traits for the indication of plant response to climate: surprisingly, the clearest relations of mean trait values per site to climate along the latitudinal gradient was found for mesophyll parameters such as mesophyll cell size and mesophyll cell surface and chloroplast surface per leaf area. Whereas, the classical whole-leaf traits, leaf area, leaf thickness and leaf mass per area (LMA) were only slightly related to climatic factors such as mean annual temperature and precipitation. Moreover, tundra and steppe plants did not differ in whole-leaf traits despite contrasting climate. The same was true for total pigment content while ratios chlorophylls:carotenoids and chlorophyll a:b were clearly related to climate along the gradient. Foliar $\delta^{13}C$ and $\delta^{15}N$ showed divergent response to climate in steppe and taiga. Our results suggest that functional anatomical parameters of photosynthetic tissues (mesophyll traits) are much better predictors of plant response to climate than whole-leaf traits.

Session 12-O10 - Physiological plant ecology

The dynamic of autumn phenology and winter dormancy in European tree species

Ilka Beil[1], Andrey Malyshev[1], Jürgen Kreyling[1]

[1]Experimental Plant Ecology, Greifswald University, Greifswald, DE, ilka.beil@uni-greifswald.de

Leaf phenology largely determines plants' growing season and hereby impacts NPP and carbon uptake. Despite improved phenology models the response to changing climate is not fully understood. Advance of bud burst in response to warmer spring temperatures is not linear and is slowing down. One potential explanation for this could be so far unexplored responses to autumn and winter warming. In order to establish a more mechanistic understanding we need experiments to test phenological responses to warming at different times of the year and beyond historic temperature variation. To track the influence of environmental conditions at a particular time the assessment of the dormancy state provides an important tool.
We investigated induction and release of bud dormancy of 5 common European tree species. Dormancy depth (endo-dormancy) was assed as the time it takes for the buds to leave out under artificially favorable conditions. In addition we examined the influence of temperature and photoperiod on autumn phenology, dormancy development and final leave out in a series of monthly climate manipulation experiments from August till April.
We found different patterns of bud dormancy development between the species. In *Betula pendula* and *Alnus glutinosa* dormancy depth of buds increased fast in September; in October and November they were highly dormant, meaning that even under warm and light conditions for several weeks they were hardly able to leave out. Accordingly the release of dormancy was fast in this species and was completed in February. *Fagus sylvatica* and *Quercus robur* in contrast showed a slower dormancy development.
Autumn leave colouration was not influenced by warming in August, but clearly delayed in all species by warming in October. Influence of warming and photoperiod manipulation at different times on bud dormancy and following spring phenology will be shown for the individual species.

Session 12-P1 - Physiological plant ecology

Systemic effects of rhizobia on leaf metabolites of Fabaceae species

Rabea Schweiger[1], Carla Maya Hunting[1], Anna-Maria Heise[1], Caroline Müller[1]

[1]Department of Chemical Ecology, Bielefeld University, Bielefeld, DE, rabea.schweiger@uni-bielefeld.de

Several important crop plant species belong to the Fabaceae. Members of this taxon interact with specific bacteria (rhizobia), which colonize the plant roots in so-called nodules. The host plant delivers dicarboxylic acids to the rhizobia, whereas the bacteria fix atmospheric nitrogen and provide their host plant with nitrogen-containing nutrients. Although the rhizobia are restricted to the plant roots, they probably have diverse systemic effects on aboveground plant tissues due to improved plant nutrition, their carbon sink activity and effects on phytohormones. Positive effects of rhizobia on soil properties, for example in intercropping or crop rotation systems, and on plant shoot biomass are well documented. However, little is known about potential systemic effects of rhizobia on the leaf metabolites of their host plants. In this study, several Fabaceae species, including the forage crop alfalfa (*Medicago sativa*), were inoculated with a strain of *Sinorhizobium meliloti*. Aboveground biomass, leaf carbon and nitrogen concentrations as well as the composition of leaf metabolites were compared between control (non-nitrogen-supplemented or nitrogen-supplemented) and rhizobia-inoculated (i. e., nodulated) plants. In general, enhancing effects of rhizobia on aboveground biomass and leaf nitrogen concentrations were found. Furthermore, there were profound metabolic changes in leaves in response to rhizobia, with some of them being plant species-specific. Moreover, besides nitrogen-mediated effects, we found many nitrogen-independent effects of rhizobia on the leaf metabolome of *M. sativa*. Both the positive effects of rhizobia on plant biomass and the effects on plant chemistry are of ecological and agricultural relevance. The aboveground metabolic composition can influence the interaction of plants with antagonists (e. g., agricultural pests) but at the same time also determines the nutritional value of the crop plants for humans or livestock.

Session 12-P2 - Physiological plant ecology

Influence of starch deficiency on photosynthetic and post-photosynthetic carbon isotope fractionations

Marco M. Lehmann[1], Shiva Ghiasi[2], Gavin George[3], Marc-André Cormier[4], Arthur Gessler[1], Matthias Saurer[1], Roland A. Werner[2]

[1]Forest Dynamics, WSL Birmensdorf, Birmensdorf, Zürich, CH, marco.lehmann@wsl.ch
[2]IAS, D-USYS, ETH Zurich, Zurich, CH
[3]IMPB, D-BIOL, ETH Zurich, Zurich, CH
[4]Geological Institute, D-ERDW, ETH Zurich, Zurich, CH

Carbon isotope (^{13}C) fractionations occurring during and after CO_2 fixation shape the carbon isotopic composition ($\delta^{13}C$) of plant material and respired CO_2, which are important indicators for plant physiological responses to environmental changes, plant water use efficiency, and changes in metabolic pathways. The underlying processes causing post-photosynthetic ^{13}C fractionations during diel variation in the leaf starch metabolism are assumed to be relevant, but not fully understood. Here we measured the diel variation in $\delta^{13}C$ of organic matter ($\delta^{13}C_{OM}$), $\delta^{13}C$ of dark-respired CO_2 ($\delta^{13}C_R$), concentrations and $\delta^{13}C$ of potential respiratory substrates, and gas-exchange in leaves of starch-deficient plastidial phosphoglucomutase (*pgm*) mutants and wild type plants of four species (*Arabidopsis thaliana, Mesembryanthemum crystallinum, Nicotiana sylvestris*, and *Pisum sativum*). The strongest $\delta^{13}C$ response to the *pgm*-induced starch deficiency was observed for *N. sylvestris*, with more negative $\delta^{13}C_{OM}$, $\delta^{13}C_R$, and $\delta^{13}C$ values for assimilates (i.e. sugars, starch) and organic acids (i.e. malate, citrate) in *pgm* mutants than in wild type plants during a diel cycle. The PGM-knockout effect on post-photosynthetic ^{13}C fractionations in the starch metabolism (e.g. via the plastidic fructose-1,6-bisphosphate aldolase reaction) or during respiration was small. In contrast, the differences in $\delta^{13}C$ values between the genotypes could be largely explained by differences in the leaf gas-exchange. The latter were potentially caused by increased sugar concentrations in the mutants compared to wild type plants. We conclude that the observed $\delta^{13}C$ responses caused by the *pgm*-induced starch deficiency are primarily driven by photosynthetic ^{13}C fractionations and reveal that interactions between plant metabolism and physiology are only barely understood. Our results stress the importance of mutants as a tool to study isotope fractionations in plants.

Session 12-P3 - Physiological plant ecology

Long term recordings of CO_2 response curves in irrigated and drought-stressed Scots pine

Leonie Schönbeck[1], Arthur Gessler[1,2], Petra d Odorico[1,3], Marcus Schaub[1]

[1]Swiss Federal Institute for Forest, Snow and Landscape Research WSL, Birmensdorf, CH, leonie.schoenbeck@wsl.ch
[2]ETH Zürich, Zürich, CH
[3]University of Toronto, Mississauga, CA

Long-term datasets on plant photosynthetic responses to environmental changes are scarce and indispensable for model calibration and validation. Photosynthetic CO_2 responses (A/C_i curves, where C_i is intercellular [CO_2]) are used to understand how photosynthesis responds to changing environmental conditions and to predict the responses of plant carbon uptake to future climatic conditions.
A long□term (15 yr) irrigation experiment was conducted in a natural *Pinus sylvestris*□dominated forest located at the dry margin of the species in southern Switzerland. After 10 years, irrigation was discontinued in part of the irrigated forest patches, resulting in an experimental setup with naturally dry, irrigated and 'irrigation-stop' plots. We expected that long-term adjustments to changing environment would result in comparable A/C_i responses across plots, but that drought stressed trees would react stronger to short term precipitation changes, visible in higher variance in the J_{max}/V_{cmax} ratios. We measured CO_2 response curves in the spring, summer and autumn season between the years 2013 and 2019. Complementary measurements of chlorophyll fluorescence and photosynthetic capacity were performed in the year 2019, to further investigate the partitioning of energy between photosynthesis and non-photosynthetic quenching. We show that trees in irrigated plots are generally characterized by slightly higher photosynthetic activity. Trees experiencing long- (control) or short-term (irrigation-stop) drought stress, however, react very fast on short-term environmental changes and capitalize on beneficial situations to open their stomata and assimilate C. We discuss the implications, challenges and possibilities of gas exchange and fluorescence measurements in long-term water manipulation experiments.

Session 12-P4 - Physiological plant ecology

EXPLOTREE - Exploring the upper hidden half of trees

Cedric Zahnd[1], Matthias Arend[1], Ansgar Kahmen[1], Günter Hoch[1]

[1]University of Basel, Basel, CH, cedric.zahnd@unibas.ch

Forest canopies show heterogenous microclimatic conditions, with strong vertical gradients. Many biological processes in tree crowns are driven by these environmental conditions. The project EXPLOTREE aims at describing the seasonal dynamics of key biological processes within the three-dimensional forest canopy, their interrelations and dependence on the microclimate. Within this project, phenology, growth and traits related to carbon- and water relations are measured at different heights in the crowns of trees from nine common temperate tree species at the newly established Swiss Canopy Crane II facility. Additionally, radiation, temperature and humidity are continuously recorded at different heights of the crowns. The high-density simultaneous measurements of these processes along the microclimatic gradients within the canopy will offer important insights into their functional interrelations and dependence on microclimate, which is key to understanding tree responses to environmental stresses.
Results from the first field season, focusing on phenology and growth, will be presented. Throughout the season, leaf phenology and secondary growth of twigs and branches were measured on permanently marked branches along the height of each tree crown, and stem growth was recorded. In all species, spring phenology tended to start earlier at the lowest part of the crowns, with considerable variation between and within species due to microclimatic differences. Across species, no uniform relation between leaf phenology and the onset of secondary growth was found, with patterns ranging from Oak where stem growth started before budbreak, to Hornbeam where stem growth only began about two months after budbreak. Stem growth onset generally preceded secondary growth in branches and twigs.
Growth and phenology are fundamental processes of trees and the results presented here provide important information for future studies on other processes in tree crowns.

SESSION 13

Carbon allocation and storage in plants and ecosystems: new insights from experiments and field observations

Chairs: Henrik Hartmann, Günter Hoch, Michael Bahn

Climate change potentially alters carbon (C) relations of plants and ecosystems. On the one hand, the ongoing increase of atmospheric CO2 changes plant and ecosystem stoichiometry with consequences for their functioning. On the other hand, increasing temperatures and drought might decrease net-C-uptake on the plant and ecosystem level, which, in extremis, can lead to declines in plant/ecosystem functioning and increasing mortality. Against this background, C allocation and reserve formation in plants and ecosystems have gained increasing attention over the last decade in plant ecology. However, although transport and allocation of photoassimilates to C sinks (e.g., respiration, structural growth, defense compounds, symbiotic interactions), the formation of C reserves and the re-allocation of stored C are essential processes in plants, our current understanding of the controlling mechanisms and the ecological significance of these processes, at the whole-plant level and beyond, is still surprisingly patchy. Moreover, the effect of environmental change, like drought or increasing temperatures, on the whole-plant C-balance and on C-allocation patterns, as well as the significance of C-reserves for stress resistance and resilience of plants are currently not well understood and a matter of ongoing debates. As a consequence of this lack of knowledge, we can neither properly predict the carbon balance of terrestrial ecosystems nor do we understand the factors that may drive plant mortality or survival under increasing environmental change. Within this session, we aim to bring together researchers working on different aspects of C allocation and storage in an ecophysiological context. In particular, we encourage contributions on quantitative analyses of phloem C-transport in plants, C-allocation at the whole-plant and ecosystem level and studies on the ecological significance of C-reserves for stress tolerance.

Session 13-O1/2 - Carbon allocation in plants and ecosystems

Belowground processes drive carbon allocation in trees under drought

Arthur Gessler[1,2], Jobin Joseph[1], Leonie Schönbeck[1], Jörg Lister[1], Rahel Mösch[1], Maihe Li[1], Martina Peter[1], Corinne Bloch[3], Günter Hoch[3], Marcus Schaub[1], Gao Decai[1], Frank Hagedorn[1]

[1]Swiss Federal Research Institute WSL, Birmensdorf, CH, arthur.gessler@wsl.ch
[2]ETH, Zurich, CH, arthur.gessler@wsl.ch
[3]University of Basel, Basel, CH

Plant carbon (C) allocation is a major determinant of plant responses to external environmental stresses such as drought. C distribution within plants results from several processes, which are thought to depend on the balance between how much C is available through photosynthesis (i.e. source activity) vs. how much C is needed to support plant functions (i.e. sink activity). Here we show the results of two 13C labelling experiments that indicate that the activity of the rhizosphere (roots and associated microorganisms) is key for determining the transport and allocation of newly assimilated C within trees.
Pulse labelling of 100-year-old Scots pine growing under dry conditions indicated that under soil drought the majority of 13C remained in aboveground (storage) tissues or was respired by leaves and stems while the supply of roots, mycorrhiza and soil microbes was inhibited. Only a slight increase in soil moisture, however, that also lead to increased soil microbial activity flipped the system within only a few days leading to a strongly increased 13C supply of the rhizosphere.
13C labelling of 3-year old Scots pine seedlings revealed reduced allocation of C to the roots with increasing drought intensity. When, however, additional nutrients were added to the system, belowground C allocation was increased (compared to well-watered controls) at least under moderate water restriction.
These results indicate (1) that only slight changes in soil water availability can strongly alter the metabolic and thus sink activity of the rhizosphere system affecting the distribution of newly assimilated carbon within the tree and the ecosystem. Such soil moisture tipping points might be decisive in determining if new assimilates are used to provide C and energy for soil resource uptake. We show (2) that additional nutrient supply can sustain root functioning under drought indicating that soil moisture tipping points are not necessarily constant but can be modified by other factors. We assume that an increased nutrient supply under drought improves rhizosphere metabolic functioning and cell structural integrity thus compensating for drought induced loss of root functioning

Session 13-O3 - Carbon allocation in plants and ecosystems

Fine root exudation of *Fagus sylvatica* in top- and subsoil on six sites differing in soil chemical properties

Eva Messinger[1], Dietrich Hertel[1], Christoph Leuschner[1]

[1]Plant Ecology and Ecosystems Research, Albrecht von Haller Institute for Plant Sciences, Georg-August-University, Goettingen, DE, messinger@gwdg.de

Forest soils are an important carbon sink and this importance may increase due to increasing temperatures in future. Therefore it is important to gain knowledge about the rhizodeposition of mature forest trees as an important process contributing to the soils' carbon cycle. The few studies available so far showed that root exudation increases with increasing temperature and decreasing nutrient availability but information about root exudation in the subsoil, may differ from that in the topsoil, are missing so far. We examined root exudation, in mature beech forests, up to two meter depth on six different sites, differing in their soil properties. Root exudation were investigated *in situ* with a cuvette-based method in summer 2017, summer 2018 and spring 2019. Results show that root exudation decreases with increasing soil depth. We relate root morphology and root chemistry (root length, SRA, SRL, number of root tips, C/N ratio, etc.) with root exudation, to determine if changes in the root ecomorphology and chemistry can explain the decrease of root exudation. Results show differing root exudation on various soils depending on soil chemical properties. Furthermore we relate root exudation to climate parameters as precipitation, photosynthetically active radiation and to sap flow and N uptake of small diameter roots.

Session 13-O4 - Carbon allocation in plants and ecosystems

Modelling of carbon allocation and dynamics of an agroforestry system using a novel tree-community model

Thorsten Stefan[1], Manfred Küppers[1], Dieter Schmitt[1], Magnus Wachendorf[1], Maik Veste[1,3]

[1]University of Hohenheim, Stuttgart, DE, thorsten.stefan@uni-hohenheim.de
[2]University of Hohenheim, Stuttgart, DE
[3]Brandenburg University of Technology Cottbus-Senftenberg, Cottbus, DE

Agroforestry systems can contribute to carbon sequestration and enhance soil quality in agricultural fields. For a better understanding of the carbon dynamic and biomass production, models based on ecophysiological processes are required. Integrating a model that calculates annual carbon gain at the leaf level, based on leaf gas exchange, into a novel multi-species tree-community model allows us to quantify carbon allocation and biomass production at the individual and the stand level of an agroforestry system.
The leaf net photosynthesis model is driven by light and modulated by temperature and air humidity, allowing for a prediction of the seasonal variation of CO2 uptake and release, and an estimation of the annual carbon fluxes of sun and shade leaves. This information is in turn used by our novel tree-community model, allowing for a scale-up from the leaf level to whole plant and stand carbon balances. The tree-community model is a functional-structural, stochastic, object-oriented model, written in the Python programming language, that defines the morphology of each tree species of the community using structural modules, which represent stem, branches, nodes, buds and leaves. Grouping of all variables determining tree morphology into explanatory (e.g. angle to vertical of branch, position of bud on branch) and response variables (e.g. length and angle of new twig), and defining the relationships between any two variables of these two groups allows for an enormous level of detail in fine-tuning the tree morphology, as many explanatory variables can influence any single response variable, which is in addition subject to an inherent stochastic variation. Interception of radiation is modelled by dividing the three-dimensional space that encompasses the tree community into "voxel" (i.e. 3D-pixel) boxes, which form the units that determine light flux, and therefore photosynthesis, taking into account shading by leaves of the same or other trees of the community.

Session 13-O5 - Carbon allocation in plants and ecosystems

Above- and belowground tree biomass allometry and partitioning for beech, in a primeval forest in the central Carpathian Mountains

Victor Mihaila[1], Gheorghe Stefan[1], Ion Catalin Petritan[2], Cosmin Braga[1], Vlad Crisan[1], Constantin Dumitru-Dobre[1], Any Mary Petritan[1]

[1]National Institute for Research and Development in Forestry "Marin Dracea", Brasov, RO, mvictor14bv@gmail.com
[2]"Transilvania" University from Brasov, Faculty of Silviculture and Forest Engineering, Brasov, RO

Tree biomass is one of the key elements of monitoring carbon storage in an ecosystem. In this regard, allometric equations are the most commonly used to estimate it. However, because beech presents a large variability across Europe when it comes to carbon allocation, the need for specific local equations rises. We aim to develop a set of allometric equations which can estimate biomass for all major tree components (e.g. stem, branches etc.) over a long gradient of diameters at breast height (DBH), from 0.3 to 74 cm, and compare them with European generic functions developed for beech. We also better estimated biomass using the volume and density of one meter pieces of the stem. Using a destructive approach, 18 beech trees have been harvested and we quantified each components biomass. Given the fact that each component biomass varied with the increase in three dimensions, we found that with the increase in DBH, stem biomass allocation increased from 40% to 70%, branches biomass allocation fluctuated freely, whereas foliage and roots biomass allocation decreased with DBH (from 14% to 1% and respectively from 36% to 11%). We developed models using a wide variety of biometrical parameters for all components, which led to performant models. Generic equations are estimating biomass very well for branches and leaves (8 kg difference at a DBH of 74), they underestimate stem biomass with the increase in DBH, while they overestimates root biomass starting from a DBH of 30. With stem density and volume we calculated the biomass indirectly for each tree and found out that at big dimensions stem biomass is overestimated (600 kg difference for a 60 cm DBH, with the allometric approach – less than 100 kg). With the two approaches we established a precise methodology that we can use to expand biomass to the entire virgin forest. Comparing the local models with the European generic ones gave us an insight of how carbon is sequestered at a large scale.

Session 13-O6 - Carbon allocation in plants and ecosystems

Post-stress recovery in Scots pine: Carbon allocation and turnover times differ in response to heat versus heat-drought stress

Romy Rehschuh[1], Andreas Gast[1], Andrea-Livia Jakab[1], Marielle Gattmann[1], Marco Lehmann[2], Matthias Saurer[2], Arthur Gessler[2], Nadine Ruehr[1]

[1]Karlsruhe Institute of Technology KIT, Institute of Meteorology and Climate Research, Garmisch-Partenkirchen, DE, romy.rehschuh@kit.edu
[2]Swiss Federal Research Institute WSL, Birmensdorf, CH

Plant physiological processes are closely coupled to climate, especially by the cycling of carbon (C) and water between plant, soil and atmosphere. Extreme droughts and heat waves are expected to alter carbon allocation and storage, which could result in impaired tree functioning lasting beyond the extreme event. The aim of this study was to investigate hydraulic properties, C cycling and storage of Scots pine saplings in response to heat-drought scenarios and subsequent recovery. For this, we used single tree cuvettes (n=18) allowing us to continuously measure above- and belowground gas exchange, $^{13}CO_2$ effluxes and stem increment in response to gradually intensifying heat or heat-drought stress (min. leaf water potential of - 2.8 MPa) and compare the results to a control treatment. Two days after stress release, we applied a 45% $^{13}CO_2$ pulse-label to trace the newly assimilated C during a 3-week recovery phase. We continuously sampled plant tissues to determine turnover times of recently assimilated C in the different organs and compounds. Whereas net photosynthesis (A_{net}) declined to ~60% of control values in heat stressed trees, it was almost suppressed in heat-drought treated trees. After stress release, A_{net} recovered quickly, reaching 115% and 90% of control values, respectively. The ^{13}C-label was detected first in root respiration of previously heat stressed trees (~5h after the start of labeling), then in control trees (~5-6h) and at last in previously heat-drought stressed trees (~11h), indicating generally slower C translocation in the latter. This was supported by a longer retention time of ^{13}C in needles of the heat-drought stressed trees throughout the 3-weeks recovery period. The slower turnover of C in this treatment indicates ongoing repair processes, whereas heat stress alone (max. 40°C needle temperature) apparently did not result in a persistent damage of trees, but rather in a compensation of stress-induced reductions in C uptake and stem growth.

Session 13-O7 - Carbon allocation in plants and ecosystems

Fertilization stimulates carbon allocation to belowground sinks during drought

Leonie Schönbeck[1,2], Arthur Gessler[1,3], Marcus Schaub[1], Andreas Rigling[1,3], Günter Hoch[2], Ansgar Kahmen[2], Mai-He Li[1]

[1]Swiss Federal Institute for Forest, Snow and Landscape Research WSL, Birmensdorf, CH, leonie.schoenbeck@wsl.ch
[2]University of Basel, Basel, CH, leonie.schoenbeck@wsl.ch
[3]ETH Zürich, Zürich, CH

Carbon (C) and nutrient uptake and allocation are altered or impaired under drought conditions, dependent on the stress level. Elevated soil nutrient availability might mitigate negative effects of drought by stimulating carbon and nutrient uptake and allocation. We hypothesize that an increase in nutrient availability improves the functioning of the root system and stimulates carbon allocation to belowground sinks under drought conditions compared to well-watered conditions.
We studied three year-old *Pinus sylvestris* saplings in open top chambers and exposed them to drought during two subsequent years, using three different water supply regimes (no drought, intermediate, and extreme drought). Trees were exposed to two soil nutrient regimes. During the peak of the first drought year, we applied ^{15}N labelled fertilizer to the soil by needle injection, and ^{13}C labelled CO_2 by fumigation. We assessed the tracer allocation by measuring the abundance of Nitrogen (N) and C isotopes in root, stem and needle organic matter during the following year.
C uptake was slightly lower in intermediate drought stressed trees and extreme drought inhibited largely N uptake and allocation compared to the control. C allocation to belowground tissues was decreased under drought on the whole tree level, but not in combination with fertilization. C was invested in higher root biomass, as the root biomass fraction (root biomass / total biomass) increased with drought intensity in the fertilized plots.
Our results indicate a potential positive feedback loop, where fertilization improved the water uptake of the roots, stimulating the source activity and hence C allocation to belowground tissues and thus root growth and foraging for water. We conclude that the negative effects of low intensity drought stress on C uptake and allocation could be compensated by increased nutrient availability.

Session 13-O8 - Carbon allocation in plants and ecosystems

The effects of drought and nutrition on the interplay between carbon and nitrogen relations in trees

Shengnan Ouyang[1], Arthur Gessler[1], Matthias Saurer[1], Maihe Li[1], Marcus Schaub[1]

[1]Swiss federal institute for forest, snow and landscape research, Zurich, CH, shengnan.ouyang@wsl.ch
[2]University of Chinese Academy of Sciences, Beijing, CN

Tree mortality across many forest biomes has profound effects on the structure and function of ecosystems and carbon balance. Nutrients are major limiting factors for plant and forest and have a similar role with drought in influencing plants growing and resistance ability. Focusing attention on the physiological basis of drought-induced tree mortality through combining carbon-nitrogen- water interactions in the physiological processes can provide a comprehensive understanding of the mechanism of plant survival or mortality under drought. To investigate the nutrients role in plant response to drought, as well as water and nutrients interactions on plant carbon and nitrogen allocation and re-distribution, a manipulative experiment in the greenhouse was conducted. Three-year-old species (*Acer pseudoplatanus*, *Quercus petraea*, *Abies alba*, *Pinus sylvestris*, *Picea abies*) were subjected to three soil nutrient levels for one growing season and exposed to the drought in the following growing season until plants die. 13C and 15N labeling conducted before and during drought to trace carbon and nitrogen translocation among tissues responding to drought. Gas exchange, tissues water potential, the ratio of shoot to root, non-structural carbohydrates concentration, carbon and nitrogen pool of tissues will be monitored. Meanwhile, anatomical indexes will also be analyzed to test the morphology changes in plants react to drought, nutrients enrichment and the interactions of both. We hypothesized that 1) High soil nutrient availability most likely pre-disposes plants to be more vulnerable to drought and died faster than low soil nutrients 2) Drought will stimulate more carbon and nitrogen to store in the root and less amount re-allocate to aboveground 3) Broad-leaf species will show different trade-off patterns of carbon-nitrogen-water among tissues compared to needle-leaf species.

Session 13-O9 - Carbon allocation in plants and ecosystems

Acclimation of Beech and Spruce during 5 years of repeated summer drought

Kyohsuke Hikino[1], Michael Goisser[1,2], Timo Gebhardt[1], Vjosa Dervishi[1], Thorsten Grams[1]

[1]Technical University of Munich, Department of Ecology and Ecosystem Management - Chair for Ecophysiology of Plants, Freising, DE, kyohsuke.hikino@tum.de
[2]Ecomatik, Dachau/Munich, DE

This contribution presents results from a 5-year throughfall-exclusion experiment on adult European beech (*Fagus sylvatica*) and Norway spruce (*Picea abies*) in southern Germany. Experimental summer drought started in 2014 and was repeated throughout 2018. To this end, precipitation throughfall was completely excluded from spring to late fall (i.e. March to November). Impact by repeated summer drought was assessed on c. 100 trees assigned to a total of 12 plots (Kranzberg forest roof experiment), resulting in significant drought effects on both tree species. For example, pre-dawn twig water potentials reached values as low as -2.5 MPa and were associated with significant reductions in annual shoot growth by up to 65% in beech and spruce. Accessibility of trees by canopy crane allowed for detailed assessments of leaf physiological processes. In the first two years, both species significantly reduced stomatal conductance and photosynthesis under drought, in particular in spruce with reduction by up to 85%. However, this decrease was diminished 2-3 years after the start of rainfall exclusion. Especially, stomatal conductance of beech that was reduced by c. 45% in the second year of drought, showed much smaller reductions relative to controls in the fifth year of throughfall exclusion (c. 20%). Observed long-term acclimation to summer drought in both species is discussed on both canopy and whole-tree level taking total leaf area and sap-flow data into account.

Session 13-O10 - Carbon allocation in plants and ecosystems

High carbon storage in trees at long-term carbon limitation

Günter Hoch[1], Raphael Weber[1], Arthur Gessler[2], Henrik Hartmann[3], Simon Landhäusser[4], Andrea Schwendener[1], Erin Wiley[4,5]

[1]Department of Environmental Sciencies - Botany, University of Basel, Basel, CH, guenter.hoch@unibas.ch
[2]Swiss Federal Research Institute for Forest, Snow and Landscape Research WSL, Birmensdorf, CH
[3]Max Planck Institute for Biogeochemistry, Jena, DE
[4]Faculty of Agricultural, Life and Environmental Sciences, University of Alberta, Edmonton, CA
[5]Department of Biology, University of Central Arkansas, Conway, AR, US

Tissue concentrations of non-structural carbohydrates (NSC, i.e. starch and sugars) are generally used as indicators for the carbon (C) balance of trees, assuming lower concentrations at C-limitation. However, there are still many open questions related to the control of C storage and C allocation strategies at C limitation in trees. Over the last years, a number of studies aimed to approach these questions with manipulative experiments that exposed tree seedlings to controlled C limitation by shading or darkening. In this presentation we will synthesize the main findings of recent experiments that investigated NSC responses of temperate tree species to long-term, non-lethal C limitation by shading, and to short-term, lethal C starvation by darkening. In combination, these experiments revealed important information for the interpretation of the C supply status of trees via NSC analyses. The main concluding findings from our experiments are: 1) C limitation by shading induced a massive and sustained growth restriction, but only a temporary reduction of NSC concentrations. All investigated species showed NSC concentrations similar to unshaded control trees after three growing seasons. Thus, the absence of reduced NSC concentrations does not necessarily reflect the absence of C shortage, but likely indicates preferential C allocation to storage under long-term C limitation. 2) C starvation that leads to tree mortality was indicated by a depletion of NSC concentrations in all tissues. C starvation should thus only be diagnosed, if starch and sugar concentrations are close to zero. 3) NSC pools in all tree organs, including older sapwood, reacted surprisingly fast do changes in C supply, indicating a very dynamic regulation of C reserves and high turn-over rates of seemingly steady NSC pools in trees.
The findings from our experiments on young trees will be finally put in context with recent observational data form mature forest trees under climatic stress.

Session 13-P1 - Carbon allocation in plants and ecosystems

Flux Puppy – An open-source software application and portable system design for low-cost manual measurements of CO_2 and H_2O fluxes

Mariah S. Carbone[1], Bijan Seyednasrollah[1], Tim T. Rademacher[1,2], David Basler[2], James M. Le Moine[1], Samuel Beals[1], James Beasley[1], Andrew Greene[1], Joseph Kelroy[1], Andrew D. Richardson[1]

[1]Northern Arizona University, Flagstaff AZ, US
[2]Harvard University, Cambridge MA, US

Manual chamber-based measurements of CO_2 (and H_2O) fluxes are important for understanding ecosystem carbon metabolism. Small opaque chambers can be used to measure leaf, stem and soil respiration. Larger transparent chambers can be used to measure net ecosystem exchange of CO_2, and small jars often serve this purpose for laboratory incubations of soil and plant material. We developed an Android application (app), called Flux Puppy, to facilitate chamber-based flux measurements in the field and laboratory. The app is designed to run on an inexpensive handheld Android device, such as a tablet or phone, and it has a graphical user interface that communicates with an LI-COR LI-820 and LI-830 (CO2) or LI-840 and LI-850 (CO2/H2O) infrared gas analyzer. The app logs concentrations of CO_2 and H_2O, cell temperature and pressure at 1 Hz, displays the output graphically and calculates the linear regression slope, R-squared, and standard error of the CO_2 time series. A metadata screen allows users to enter operator, site, and plot information, as well as take a photograph using the Android device's built-in camera, and log measurement location using the device GPS. Additionally, there is a notes field, which can be revised after the measurements are taken. Data files (the 1 s raw data, photograph, and metadata including statistics calculated from the raw data) are then transmitted off the device through file sharing options (Gmail, Outlook, Google Drive, Dropbox, etc.). Because Flux Puppy code is open-source (available on GitHub) and the flux measurement system we describe is relatively inexpensive and straightforward to assemble, it should be of broad interest to the carbon cycling community.

Session 13-P2 - Carbon allocation in plants and ecosystems

Coupled CO_2 and O_2 measurements indicate xylem transport of CO_2 in tree stems

Juliane Helm[1], Henrik Hartmann[1], Jan Muhr[1]

[1]Max Planck Institute for Biogeochemistry, Jena, DE, jhelm@bgc-jena.mpg.de

Between the respiratory release of CO_2 by mitochondria and the emission of CO_2 into the atmosphere via the bark a lot can happen in tree stems. CO_2 can be dissolved and transported away with the xylem sap or become re-fixed via cortical photosynthesis or phosphoenolpyruvatcarboxylase (PEPC). Because of this, CO_2 efflux has been criticized as an unreliable proxy for stem respiration, causing underestimations of up to 41%. By contrast, the uptake of O_2 is much less affected by the aforementioned post-respiratory processes, and hence O_2 measurements are considered a more reliable proxy for respiration. However, technical difficulties in measuring small changes of O_2 against the enormous atmospheric background concentration of almost 21% have so far hampered the use of O_2 measurements.
We have designed automated stem chambers that allow high-frequency simultaneous measurements of CO_2 release and O_2 uptake. During a field experiment on 12 mature poplar trees that was carried out from May through September 2018 we measured (among other parameters) stem gas exchange and xylem sap flux. Results obtained from our new chambers show that O_2 uptake was always higher than CO_2 release over the whole growing season. Concurrent sap flow measurements indicated a rapid decrease from ~600 g hr^{-1} in early June to ~200 g hr^{-1} at the end of July. Greatest differences between O_2 uptake and CO_2 release occurred in June (~35 vs. 23 mmol C h^{-1} m^{-2}) when sap flow rate was highest, suggesting that CO_2 is transported away with the xylem sap and not emitted at the site of measurement. We are currently investigating non-photosynthetic CO_2 refixation and will hopefully be able to show first results during the presentation.

Session 13-P3 - Carbon allocation in plants and ecosystems

Modelling photosynthesis and carbon fluxes of moss- and lichen- dominated biological soil crusts in temperate dry acid grasslands in Brandenburg

Miriam Diez[1], Manfred Küppers[1], Magnus Wachendorf[1], Thorsten Stefan[1], Maik Veste[1,2], Stella Gypser[2]

[1]University of Hohenheim, Stuttgart, DE
[2]Brandenburg University of Technology Cottbus-Senftenberg, Cottbus, DE

Top soils in temperate climates are regularly covered by cryptogames. Depending on the climatic and environmental conditions and their development stage, these biocrusts are built up by different species of cyanobacteria, bacteria, green algae, mosses, liverworts, lichens and fungi, which crosslink the uppermost soil particles. Biocrusts create a thin surface layer of high biotic activity, with high C and nutrient pools and fluxes to deeper soil layers, where the soil tends to be biotically and biogeochemically less active. Changes in soil structure, e.g. due to the accumulation of organic material and the ability of biological nitrogen fixation, result in significant feedback and control of biogeochemical processes. We analysed the response of photosynthesis and respiration to changing temperature and light in two moss-and lichen-dominated soil crusts from a dry acid grassland in the vicinity of a pine forest in Brandenburg, Germany. For the estimation of carbon fluxes, we combined lab-based CO_2 gas exchange measurements and continuous determination of biocrust drying and rewetting cycles under field conditions. These experiments facilitated the development of an empirical photosynthesis model that allows for an estimation of the carbon dynamics of biological soil crusts based on their ecophysiological performance.

SESSION 14

Bridging the gap between peatland ecology, hydrology, and biogeochemistry

Chairs: Klaus-Holger Knorr, Paul JH Mathijssen

Peatlands are the world's most important terrestrial carbon store, having accumulated approximately 600 GtC since the Last Glacial Maximum. Although under pristine conditions acting as net greenhouse gas sink, peatlands emit the strong greenhouse gas methane. Currently, peatlands' role as a sink of atmospheric carbon is threatened by climate change, land use and pollution. Therefore, it is vital that we understand how these ecosystems respond to these pressures, and what can be done to preserve peatlands' carbon stocks and other ecosystem functions. Peatlands combine features of terrestrial and aquatic ecosystems, and as such contain unique hydrological and biogeochemical conditions, and harbor unique microbial and plant communities. The topics of peatland hydrology, below ground biogeochemistry, gas exchange with the atmosphere, microbial and vegetation ecology are highly interactive, but they are usually studied by scientists from different disciplines. Although it is widely recognized that we need to integrate the findings of all disciplines to come to a more comprehensive understanding of peatlands functioning, this is made difficult because the various aspects are studied using different techniques and at different spatial and temporal scales and resources of individual studies are often limited. This session therefore aims to stimulate the integration of different disciplines. We particularly invite submissions that attempt to build bridges between sub-disciplines of peatland science, addressing questions such as: "what are the results of peatland restoration on both greenhouse gas fluxes and biodiversity?", "can we scale up biogeochemical processes using knowledge of vegetation composition and hydrology?", or "are long term effects of hydrological changes on biogeochemistry mediated by vegetation change?". Submissions from individual disciplines are encouraged as well to stimulate a broad discussion.

Session 14-O1/2 - An interdisciplinary view on peatlands

WETSCAPES –from understanding to sustainable use of peatlands

Juergen Kreyling[1], Hans Joosten[1], Tim Urich[1], Martin Wilmking[1], John Couwenberg[1], Bernd Lennartz[2], Peter Leinweber[2], Gerald Jurasinski[2], Ralf Bill[2], Nicole Wrage Mönnig[2], Franziska Schmacka[2]

[1]University of Greifswald, Greifswald, DE, juergen.kreyling@uni-greifswald.de
[2]University of Rostock, Rostock, DE

Peatlands and coastal wetlands are characteristic elements of the landscape and, thus, of land use in Mecklenburg-Western Pomerania. Depending on water and land management, their possible contribution to climate and water protection is much higher per unit area than that of other ecosystems. Within WETSCAPES, an interdisciplinary joint project of the Universities of Greifswald and Rostock, we develop scientific principles for sustainable land use on formerly degraded and now rewetted peatlands. WETSCAPES provides the basis for an inter-disciplinary research and development structure, addressing the biogeochemistry of primary production, metabolic processes, matter transport, gas exchange and peat formation in wetlands. It builds on existing structures at the Universities of Greifswald and Rostock and integrates them over other universities and institutes (DLR, LIKAT) with the goal to understand ecosystem interactions (upscaling) and to derive indicators for sustainable management. WETSCAPES integrates joint research at six central investigation sites and complex central experiments.
First results of WETSCAPES that is running since 2017 are presented as examples. Measurements of GHG emissions and microbial analyses indicate that CH_4 production in the coastal peatland is reduced considerably due to sulfate reduction. Multidisciplinary analyses of a peat core from a rewetted percolation fen showed different zones in line with changing historical land use. Rewetting increased root production and decreased decomposition, mainly above ground, indicating increased potential for carbon sequestration. Further, a joint mesocosm experiment is presented in which automatic measurements of biomass production and GHG emissions under controlled conditions are conducted.

Session 14-O3 - An interdisciplinary view on peatlands

Effects of wet fen utilisation on biodiversity – a literature-based review

Felix Närmann[1], Franziska Tanneberger[1]

[1]University of Greifswald, partner in the Greifswald Mire Centre, Greifswald, DE, felix.naermann@greifswaldmoor.de

Drainage-based utilisation of fen soils for agriculture and forestry leads to disproportionally high CO_2 emissions, but also to drastic losses of characteristic biodiversity in fen ecosystems. Rewetting followed by site-adapted, wet land use (paludiculture) can effectively lower emissions and may restore habitats for characteristic fen species. However, as there are only few pilot sites for paludiculture in Germany, effects on biodiversity cannot be sufficiently evaluated based on monitoring data.
We performed a literature review on the effects of rewetting and management (mowing and grazing, mainly for conservation purposes) on biodiversity of European fens. Potential benefits, losses and trade-offs were identified. Whenever possible we referred to literature from organic soils, but also included basic knowledge from mineral soils.
Biomass removal from rewetted fen sites via mowing and grazing clearly represents a disturbance. However, while in some habitats this kind of regular disturbance is necessary to promote and maintain high-valued species (e.g. fen meadows), it poses high risk to species sensitive to mowing/grazing.
Consequently, we developed biodiversity conservation measures to mitigate negative aspects of management on wet fen peatlands. Conservation measures include the establishment of rotational fallows, the adapted management of ditches, adapting the timing of mowing/grazing as well as the use of specific mowing techniques.
Finally, we conclude that rewetting and subsequent adapted land use has the potential to make an important contribution in conserving fen biodiversity. There is an urgent need for accompanying field research with regard to biodiversity on paludiculture pilot sites. As part of an R + D project, these results can feed directly into national and regional policies (e.g. agri-environmental programmes) via the Federal Agency for Nature Conservation and a working group of all German peatland-rich federal states.

Session 14-O4 - An interdisciplinary view on peatlands

Hand in hand? Restoration, *Sphagnum*, fauna and GHG-emission in a Dutch bog remnant

Gert-Jan van Duinen[1]

[1]Bargerveen Foundation, Nijmegen, NL, g.vanduinen@science.ru.nl

The raised bog remnants ‘Peelvenen’ are remnants of a previously much more extensive mire landscape. Due to climate the bog is situated at the southern edge of the distribution area of the Atlantic raised bog type. In this region the critical load of atmospheric nitrogen is significantly exceeded. Furthermore, drainage, peat extraction and cultivation severely degraded the bog landscape.
Restoration measures performed in the last decades considerably improved the hydrological situation and resulted in an increase of *Sphagnum*. Also, estimation of the past, current and future greenhouse gas emission (using the GEST approach developed by Couwenberg et al. 2011) show considerable improvements.
Plant and (in)vertebrate species naturally inhabiting the edges of the bog complexes either disappeared or survived the severe degradation of the bog landscapes inside the degrading remnants of the former mire expanse. To avoid restoration of the remnants to cause a further decline of the remaining populations of the characteristic and rare species, their current distribution in the reserves and their ecology were investigated. This resulted in practical recommendations for measures. These will both further improve the conditions for bog restoration and enable relict populations to persist in the reserves and migrate to newly developed laggs and buffer zones, possibly including areas with paludiculture.

Session 14-O5 - An interdisciplinary view on peatlands

Nature conservation considering vector ecological burdens

Tarja Dworrak[1], Ellen Kiel[1]

[1]Carl-von-Ossietzky University Oldenburg, Research group Aquatic Ecology and Nature Conservation, Oldenburg, DE, tarja.viviane.dworrak@uni-oldenburg.de

Wetlands are essential ecosystems for human health, climate mitigation, flood protection and biodiversity. More than 60% of the world's wetlands are degraded with the vastest decrease in Europe. To fulfill the different biodiversity and climate goals, nature conservation measures have been conducted to restore the wetlands. These measures are primarily based on rewetting the area. The crux is that these created habitats are suitable breeding sites for mosquitoes, which are known as nuisance and/or vector species. This can lead to an aversion against restoration measures by the local residents. The aim of our research is to analyse if and to what extent nature conservation measures influence mosquito populations. Six study areas were chosen by following criteria: 1) nature conservation measures were conducted since 2000; 2) protected sites; and 3) mosquito hotspots. In these six study areas the mosquito situation before the wetland restoration was derived from several monitoring reports. In 2019, we are conducting a field study to analyse the current mosquito fauna. We sample mosquitoes by CO_2-baited BG-traps and standard larvae dipper from March to October. The results of the mosquito monitoring before the measure is then compared to the results of the field study. Additionally, a survey about the nuisance perception for the local residents is carried out. In this presentation the project's preliminary results from one study area – the national park Müritz, northeast Germany – are presented. A rewetting was implemented in the early 2000s. Local residents expressed their reservation towards the nature conservation measure and were concerned about an increase in the mosquito populations. The pre- and post-mosquito nuisance are compared. With these results the goal is to develop a potential monitoring approach for future projects. The main aim is to minimise the collision of interest, support nature conservation and develop adequate local courses of action in wetlands.

Session 14-O6 - An interdisciplinary view on peatlands

Root carbon input to peatland soils as affected by plant functional types and temperature: insights from $^{13}CO_2$ pulse labelling

Lilli Zeh[1], Claudia Schmidt-Cotta[1], Juul Limpens[2], Luca Bragazza[3], Karsten Kalbitz[1]

[1]TU Dresden, Institut für Bodenkunde und Standortslehre, Tharandt, DE, lilli.zeh@tu-dresden.de
[2]Wageningen University, Plant Ecology and Nature conservation group, Wageningen, NL
[3]University of Ferrara, Department of Life Science and Biotechnologies, Ferrara, IT

Northern peatlands are predicted to experience profound changes regarding increasing temperatures and shift in vegetation composition with Climate Change. Particularly ericoid shrubs and graminoid sedges are expected to expand and affect peatland carbon (C) cycling via root C input. We examined effects of temperature and plant functional types (PFT) on root C input to the peat by a $^{13}CO_2$ stable isotope pulse labelling experiment on two ombrotrophic peatlands along an altitudinal gradient in the Alps in July 2016. Plots with either sedges and bryophytes or shrubs and bryophytes were labelled with a transparent chamber. We followed the tracer by measurements of $^{13}CO_2$ fluxes and its translocation into the various C pools (dissolved organic C (DOC), plants, peat) in different temporal resolutions for one week after label application. Soil respiration was measured every second day with a custom build chamber and a Picarro (G2201-i). DOC was collected directly after labelling, on the third and eighth day. DO^{13}C was analyzed using a combination of high-temperature combustion-based TOC analysis and IRMS. Peat cores were sampled on the third day after labelling and analyzed in high resolution in depth (4 increments in 20 cm) with vario PYRO CUBE coupled to VISION (Elementar - Isoprime). We used five spatial replicates on each peatland. Based on earlier work on the two peatlands, we hypothesized a larger C input by roots of the vascular plants with higher temperature. Furthermore, we expected shrubs to translocate more C via roots in comparison to the sedges at the warmer site. Thus, we presumed to see a relative increase in $^{13}CO_2$ fluxes, DO^{13}C concentrations and ^{13}C enrichment in the peat due to increased root C input from sedges and shrubs on the warmer peatland. This mechanism is assumed to stimulate microbial degradation of old peat underlining the concern of peatlands potentially shifting from net C sinks to net C sources with proceeding global warming.

Session 14-O7 - An interdisciplinary view on peatlands

Elevated Nitrogen Deposition Resulted in Enhanced Peat Decomposition Across Europe During the 20th Century

Henning Teickner[1], Cristian Estop-Aragonés[1,2], Katarzyna Zając[1,2], Christian Blodau[1,2], Klaus-Holger Knorr[1,2]

[1]University of Münster, Institute of Landscape Ecology, Münster, DE
[2]University of Bayreuth, Limnological Research Station, Department of Hydrology, Bayreuth, DE

Existing studies stress potential hazards of elevated anthropogenic N deposition levels to peatlands, but were mostly restricted to small spatial scales or short time periods.
We assessed the effect of anthropogenic N deposition on peat chemistry and C accumulation across Europe (from Ireland to Finland and from Sweden to Slovenia) during the last the 20th century in an observational study.
We linked peat chemistry (FTIR bands indicating carbohydrates, aromatics and intermolecular hydrogen bridges in lignins) and C accumulation rates of dated layers from 24 peatlands to environmental conditions during peat formation (temperature, precipitation, N deposition) extracted from modelled high-resolution historic data. Average random intercept regression models were used in order to describe how environmental factors and decomposition time affected peat chemistry and C accumulation.
The results indicate that N deposition during peat formation increased the relative amount of aromatics and decreased the relative amount of polysaccharides and intermolecular hydrogen bridges in lignins. Increasing the N deposition by 1 kg ha^{-1} yr^{-1} lowers the C accumulation rate over 100 years on average by approximately 20% (under average climate conditions). An interaction between N deposition and decomposition time suggests, in accordance with existing studies, that N deposition increases decomposition rates. Maps of predicted values highlight an increasing influence of (past) high N deposition levels in the future. Large inter-site variability not explained by environmental factors stresses the need for large spatio-temporal analyses.
We envisage collaborations with other peatland scientists interested in improving the predictive capabilities and spatial extent of the models.

Session 14-O8 - An interdisciplinary view on peatlands

Shrubs and degraded permafrost pave the way for tree establishment in subarctic peatlands

Juul Limpens[1], Milena Holmgren[1]

[1]WUR, Wageningen, NL, Juul.Limpens@wur.nl
[2]WUR, Wageningen, NL

High latitude ecosystems are changing rapidly in species composition and functioning as they warm twice as fast as the global average. Both expansion and decline of shrubs and trees have been locally reported. Yet little is known about the mechanisms that explain these contrasting vegetation trajectories. Understanding the conditions and mechanisms underlying vegetation changes in the subarctic and arctic regions is important to anticipate how climate change may further affect ecosystem structure and functioning. We conducted a field experiment to assess the role of permafrost condition, micro-topography and shrub canopy on tree establishment in subarctic peatlands. We monitored seedling establishment, abiotic and biotic conditions for three growing seasons. We found that early tree seedling establishment during the first year was most successful in moist and sheltered topographical microsites without permafrost. From the second year onward presence of an intact shrub canopy was the most important environmental factor explaining successful tree seedling establishment. A return visit after six years confirmed the patterns observed during the first three years. Our results show that absence of permafrost can enhance tree seedling establishment but shrub cover is the most important driver of tree seedling recruitment. The facilitative effect of shrubs in subarctic peatlands is stronger than the positive effects of shrubs reported for southern boreal peatlands. We conclude that strong positive interactions between shrubs and trees may facilitate tree expansion in the warming subarctic mediating shifts from open to tree-dominated ecosystems.

Session 14-P1 - An interdisciplinary view on peatlands

Introducing the VESBO Project - Impact assessment of vascular plant encroachment on water and carbon cycling in a *Sphagnum* dominated bog

Arndt Piayda[1], Maren Dubbert[2], Bärbel Tiemeyer[1], Ullrich Dettmann[1,3], Thomas Beuster[4], Samuli Launiainen[5], Antti-Jussi Kieloaho[5], Kersti Haahti[5]

[1]Thünen Institute of Climate-Smart Agriculture, Braunschweig, DE, arndt.piayda@thuenen.de
[2]University of Freiburg, Freiburg, DE
[3]Leibnitz University Hannover, Hannover, DE
[4]Ökologische Schutzstation Steinhuder Meer e.V., Rehburg-Loccum, DE
[5]Natural Resources Institute Finland (LUKE), Helsinki, FI

Boreal and temperate bogs cover less than 3% of the earth's surface but store nearly 30% of the terrestrial carbon. Natural raised bogs are characterized by a *Sphagnum*-moss dominated vegetation cover, but used by humans for centuries by peat extraction. The re-establishment of quasi-natural hydrological conditions as well as of ecosystem-typical vegetation is the main goal of ecological restoration conducted since decades.
Recently, a change in species composition of restored bogs from *Sphagnum*-dominated bryophyte communities to multi-layered tree and graminoid vegetation was observed. Current investigations report contradictory effects for the impact on throughfall, evapotranspiration (ET), gross primary productivity, respiration, net CO2 balance (NEE) as well as soil carbon sink strength. A final conclusion with respect to altered ecosystem functioning in the light of climate change is missing.
The VESBO project aims at the mechanistic analysis of ET, NEE and soil carbon sink strength of a restored, Atlantic-temperate raised bog during vascular plant encroachment. Focus will be placed on the partitioning of total ecosystem ET and NEE fluxes by Eddy Covariance and chamber measurements *in situ* into bryophyte, graminoid and tree contributions. Results are used to parameterize a modern soil-vegetation-atmosphere-transport model able to simulate bryophyte and vascular plant layers on peat soil. The model, jointly with the empirical data, is used to quantify seasonal changes in plant functional group flux contributions depending on altered environmental conditions. The holistic process understanding is of high relevance for the NEE estimation of restored bog ecosystems under changing climatic conditions and vegetation compositions. The knowledge about different interactions of plant functional groups with mass and energy fluxes of the bog ecosystem will be valorised by the assessment of restoration and emission mitigation measures throughout Europe.

Session 14-P2 - An interdisciplinary view on peatlands

KliMoBay - An Interdisciplinary Look at Bavaria's Peatlands

Martina Schlaipfer[1,2], Sylvia Holzträger[1], Clarisse Brehier[1], Heta Meyer[1], Michael Kraut[1], Matthias Drösler[1], Sebastian Friedrich[2], Michael Tarantik[2], Alexander Gerner[2], Gabriele Chiogna[2], Markus Disse[2], Gisbert Kuhn[3], Annette Freibauer[3], Verena Huber-Garcia[4], Raul Wood[4], Philip Marzahn[4], Ralf Ludwig[4]

[1]Weihenstephan-Triesdorf UAS, Freising, DE
[2]Technical University of Munich, Munich, DE
[3]Bavarian State Research Center for Agriculture, Freising, DE
[4]Ludwig Maximilian University of Munich, Munich, DE

KliMoBay brings together Bavarian experts in peatland ecology with special emphasis on GHG-exchange, hydrological modelling, agronomy/soil science, and remote sensing as well as climate change forecasting. The central outcome of the project will be the compilation of maps indicating the climate protection potential and climate adaptation potential of Bavaria's peatlands. These spatially and temporally explicit maps span till 2050 to trace a roadmap for the implementation of Bavaria's climate mitigation goals within the land-use sector. As a first step, all existing data on Bavarian peatlands will be collected and evaluated. The project will identify and try to close key knowledge gaps with regard to trace gas fluxes, peatland hydrology, changes in peat quality and subsidence, as well as shifts in the areal extent and condition of Bavarian peatlands. Potential focal points of the peatland ecology portion of the KliMoBay project will be the long-term effects of succession stages after peatland restoration and changes in management, and the effects of subsurface irrigation in agriculturally used drained peatlands. The former deserve attention as they can lead to an upsurge in CH_4 production, while there is some indication that the latter can result in increased N_2O emissions. Both newly acquired and existing data will serve as the basis for identifying crucial drivers of CO_2, CH_4 and N_2O flux processes. This information will then be combined with results from the respective sub-projects to upscale local trace gas fluxes to a regional level using a dynamic model-based scaling approach. We anticipate that such a revised quantification of Bavarian greenhouse gas emissions from different land-use categories on organic soils under a changing climate will lead to a significant decrease in prediction uncertainty. We, therefore, expect the KliMoBay project to constitute an essential contribution to Bavaria's political commitment to reduce the climatic impact of its peatlands.

Session 14-P3 - An interdisciplinary view on peatlands

Cooling or Warming? Climate impact of a NW German peatland, 16 years after rewetting

Carsten Schaller[1], Otto Klemm[1]

[1]University of Münster, Münster, DE

Peatland ecosystems cover only 3 % of the Earth's land surface, but store up to 30 % of the global carbon (C) pool. As long as they remain undisturbed, they act as major long-term C sinks. In Europe, almost 60 % of the peatland has been drained for the purpose of peat extraction and to obtain agricultural land. The drainage leads to a shift of the C dynamics, transforming the ecosystems into strong sources of greenhouse gases. Rewetting of peatlands therefore potentially aims at recovering their C mitigation capacity and thus to mitigate global warming.

The "Uchter Moor" in NW Germany (52° 30' N, 8° 49' E) is an oligotrophic, raised bog and part of the "Diepholzer Moorniederung". It has been drained for peat extraction, but was never used as farmland. The actual site remained undisturbed until 1950. Then, peat was cut until the year 2000, when rewetting began. Today, *Eriophorum vaginatum*, *Molinia caerulea,* and *Eriophorum angustifolium* are the dominant species.

To monitor the flux of the five most important greenhouse gases H_2O, CO_2, CH_4, N_2O and O_3, an eddy covariance setup was established in 2016 and operated over an 18-months period. The total annual balance in 2017, taking only CO_2, CH_4, N_2O into account, summed up to +410 ± 94 g CO_2-equiv m^{-2} a^{-1}. N_2O contributed less (10 %), while CH_4 emissions (72 %) dominated the balance. Considering also H_2O and O_3 turned the annual balance into a net sink of -832 ± 368 g CO_2-equiv m^{-2} a^{-1}.

SESSION 15

Parasite ecology and evolution: from theory to applications

Chairs: David Thieltges, Bernd Sures, Jörn Scharsack, Mathias Wegner, Dan Benesh

During the last decade an increasing number of studies have uncovered the pivotal ecological and evolutionary roles of parasites. Parasites have been shown to not only directly affect their hosts in manifold ways but also to have a multitude of indirect effects on communities and ecosystems, including effects on the topology and dynamics of food webs. Their effects on host fitness in turn create strong selective landscapes leading to evolutionary arms races with their hosts. It is also increasingly clear that parasite-host interactions do not happen in an ecological vacuum – they are affected by the ambient environment, leading to complex eco-evolutionary feedbacks and intricate relationships between abiotic and biotic factors and disease risk. While many of these studies have helped to shape our fundamental understanding of the ecological roles of parasites, they also have diverse repercussions for applied conservation issues such as disease management in threatened wildlife or the use of parasites as ecological indicators. This session aims to give a broad and diverse overview of the current frontiers of parasite ecology and evolutionary ecology. It will highlight the ecological effects of parasites on populations, communities and ecosystems and at the same time exemplify how ecological communities and anthropogenic stressors like climate change affect wildlife diseases. In addition, the session will exemplify how parasites serve as strong selective forces leading to complex eco-evolutionary feedbacks. Finally, it will illustrate some of the implications for conservation and management. Given the varied ecological impacts parasites can have, we believe a parasite-centred session will be of great interest to ecologists of all stripes and thus a welcome addition to the GfÖ conference.

Session 15-O1 - Parasite ecology & evolution

Some like it hot: Trematode transmission in changing ecosystems

Christian Selbach[1], Robert Poulin[2]

[1]Department of Bioscience, Aquatic Biology, Aarhus University, Aarhus, DK, christian.selbach@uni-due.de
[2]Department of Zoology, University of Otago, Dunedin, NZ

The transmission from one host to another constitutes a challenging event in the life cycle of parasites and is a key determinant of their fitness. Due to their complex life histories, the free-living dispersal stages of trematodes, the cercariae, show a huge diversity in morphology and behaviour. Abiotic and biotic factors, such as temperature and predation, have regulating effects on cercarial infection dynamics. Yet, on a finer scale, we still have a limited understanding of how and to what degree these factors affect the transmission of individual parasite species in an ecosystem. Here, we assessed how (i) changes in temperature and (ii) predation affect the transmission abilities of cercariae from the New Zealand mudsnail *Potamopyrgus antipodarum* and the marine snail *Zeacumantus subcarinatus*. Our results show that increases in temperature positively affect the transmission dynamics of cercariae, whereas predation leads to a significant reduction of dispersal stages from the environment. However, the impacts of both temperature and predation varied considerably between the transmission stages of different trematode species, depending on their morphology and behaviour. This varying susceptibility to biotic and abiotic factors is likely to have far-reaching implications for the disease dynamics in changing ecosystems, since increases in temperature or changes in predator abundance can shift parasite community structures. Understanding these species-specific parasite transmission traits therefore remains a fundamental requirement to predict parasite dynamics under current global change, e.g., climate change, scenarios.

Session 15-O2 - Parasite ecology & evolution

Rising temperature intensifies fitness conflicts in a host-parasite system

Joern Peter Scharsack[1], Frederik Franke[1], Joachim Kurtz[1]

[1]University of Münster, Münster, DE

Parasites are predicted to become more frequent with rising temperatures during climate change, but empirical evidence to this end is scarce. To investigate this hypothesis, we used three-spined sticklebacks (*Gasterosteus aculeatus*) and their tapeworm *Schistocephalus solidus*. We tested used F1 generations of hosts and parasites derived from locations with different temperature regimes, ranging from Iceland to Spain. In our laboratory, we exposed infected sticklebacks experimentally to temperatures between 9-24°C, a range within the natural temperature range of sticklebacks. We did not observe strong patterns of local adaptation to temperature. Generally, both, hosts and parasites responded relatively plastic to different experimental temperatures, presumably as an adaptive response to natural temperature variation. However, cold-origin sticklebacks tended to grow faster and parasite infection induced a stronger immune response. If parasites were transplanted to a foreign temperature regime (i.e., from cold to warm and vice versa) tolerance of sticklebacks to the infection increased.

The most striking result was that hosts and parasites have different temperature optima. In repeated experiments with five host-parasite origins, fitness correlates and immune parameters of sticklebacks were higher at low to intermediate (9-16°C) compared to higher temperatures (18-24°C). By contrast, parasites were growing much faster at elevated temperature, thus accumulating higher capacities for reproduction. At low temperature parasites did not even reach the threshold weight for reproduction, presumably due to a stronger suppression by the hosts immune system. Our results clearly illustrate, that rising temperatures have strong effects on host parasite interactions. The host parasite system investigated here is clearly an example for a parasite that benefits from rising temperature. Accordingly, global warming will exacerbate the fitness conflict of sticklebacks and *S. solidus*.

Session 15-O3 - Parasite ecology & evolution

Complex relationships between environments, hosts and parasites

Boris W. Berkhout[1], Joern Peter Scharsack[3], Iain Barber[2]

[1]University of Leicester, Leicester, UK, bwberkhout@protonmail.com
[2]Nottingham Trent University, Nottingham, UK
[3]University of Muenster, Institute for Evolution and Biodiversity, Muenster, DE

Understanding the impact of changing climates on host-parasite interactions remains a key challenge for ecology. For endoparasites with complex, multi-host life cycles that often also include free-living stages, predicting the impacts of elevated temperatures on life cycle dynamics is challenging. This is because parasite growth, development, transmission and sexual development are influenced not only directly by thermal regimes, but also indirectly, through effects on the biology of hosts. In particular, host attributes including size at infection, behaviour, growth rate and immunocompetence, can be influenced by thermal regimes. In an ecological context, these and many other factors are likely to act in concert and the overall effects of changes in environmental variables on parasitic species are expected to be complex.

The three-spined stickleback-*Schistocephalus solidus* model has been used successfully to investigate the impacts of temperature on host-parasite interactions, and data are available on the response of both sticklebacks and this cestode parasite to different temperature treatments. In this study, we collated data from these studies to examine on the effect of temperature on growth of *S. solidus* in sticklebacks (the second intermediate host in the life cycle) and investigate how host traits modulate the response of parasites to temperature.

We show that the response of parasite development to temperature can be complex, and is modulated by host traits as well as by thermal regimes. While parasite mass shows a non-linear dependence on environmental temperature, the growth rate of the parasite is linearly dependent on host parameters and temperature.

Our findings suggest that developing a better understanding of the likely effects of changing environments on parasite ecology will require the impacts on hosts and the timing of infections to also be taken into account.

Session 15-O4 - Parasite ecology & evolution

Characterization of nutritional relationships between parasites and their hosts using stable isotope analyses

Bernd Sures[1], Milen Nachev[1]

[1]Aquatic Ecology and Centre for Water and Environmental Research, University of Duisburg-Essen, Essen, DE, bernd.sures@uni-due.de

Stable isotope analysis of carbon and nitrogen can deliver insights into trophic interactions between organisms. While many studies on free-living organisms are available, the number of those focusing on trophic interactions between hosts and their associated parasites still remains scarce. Information about some taxa such as acanthocephalans or monogeneans is either very limited or even completely missing. Additionally, available data revealed different and occasionally contrasting patterns, which is most likely depending on the parasite's taxonomic position and its degree of development. Among others (monogeneans, cestodes nematodes) we have determined $\delta^{13}C$ and $\delta^{15}N$, in different acanthocephalan-host systems considering larval as well as adult stages of aquatic and terrestrial hosts. Herewith, we are able to evaluate the trophic position of acanthocephalans with respect to their hosts and to analyse a potential trophic level shift associated to the transmission from intermediate to definitive hosts.
In the context of a meta-analysis we have added this information to already existing data for approximately 100 host-parasite associations considering many taxonomic groups of parasites. This data compilation allowed us to describe patterns of nutritional relationships between hosts and their parasites. These findings will be presented and discussed.

Session 15-O5 - Parasite ecology & evolution

Biological invasions and their impact on parasite-host interactions

David Thieltges[1], M. Anouk Goedknegt[1]

[1]NIOZ Royal Netherlands Institute for Sea Research, Texel, NL, david.thieltges@nioz.nl

Biological invasions often result in dramatic impacts on native biota in recipient ecosystems and it is now increasingly recognised that they can also affect parasite-host interactions and diseases. In this presentation, I will give a conceptual overview of the different mechanisms of how invaders can affect diseases in invaded ecosystems and I will illustrate them with results of recent investigations on the invasion impacts of Pacific oysters. This marine bivalve has been introduced worldwide for aquaculture purposes and has become one of the most notorious invader in global coastal waters. The findings presented in this talk will highlight the intricate ecological complexity of the impacts of biological invasions on parasite-host interactions and diseases in recipient ecosystems.

Session 15-O6 - Parasite ecology & evolution

Invasions create competitors: How novel interactions among established and invasive parasites influence host parasite interactions

K. Mathias Wegner[1], Marieke E. Feis[1,2]

[1]AWI - Alfred Wegener Institute - Waddensea Station Sylt, List, DE, mathias.wegner@awi.de
[2]Station Biologique, Roscoff, FR

Within parasite communities infecting the same host, ecological theory predicts that two species occupying the same niche should evolve distinct niche use to avoid direct competition. Biological invasions can however create situations, where competition could not select for different niche occupancy and closely related parasites species find themselves competing for the same host resources for the first time since their lineages split. Such novel interactions cannot only alter the evolutionary trajectories of both parasite species, but will also feed back onto established coevolutionary interaction of native parasites with the host. Here, we show how the invasion of the parasitic copepod *Mytilicola orientalis* creates competition with the native congeneric parasite *Mytilicola intestinalis*, and how this novel menage a trois feeds back on the immune response of the blue mussel host *Mytilus edulis*. From a series of controlled infection experiments that manipulate competition among the parasites we can show that, although both species occur in the same section of the mussel gut, competition between the parasites is weak and shows similar impact on host condition in either simultaneous or sequential infections. Triplet transcriptomics of matching host (*M. edulis*) and parasite samples (*M. intestinalis* and *M. orientalis*) however revealed that the novel interaction of the invader with the host changes the transcriptional activity of many more genes and processes than the interaction with the established and coevolved parasite. Our results therefore not only show the utility of biological invasions of parasites to study coevolutionary processes, but also shows that responses to novel host-parasite interactions can lead to massive reactions on the molecular level that are not reflected in host or parasite phenotypes.

Session 15-O7 - Parasite ecology & evolution

Allometric Scaling of models for Parasitic Helminth

Andy Dobson[1], Peter Molnar[2]

[1]EEB, Princeton University, Princeton, US, dobber@Princeton.EDU
[2]University of Toronto, Toronto, CA

It is forty years since Anderson and May produced as series of classic papers that described models for the dynamics of parasitic helminths. These papers showed that models for these parasites require a more complex structure than those used for viral, bacterial and protozoan parasites. In this talk, I will revisit the classic Anderson and May models and examine the insights gained by rescaling their parameters by the body size of both the hosts and the parasites. The exercise provides a number of useful insights about the constraints on parasite body size, their influence on host abundance and their ability to coexist as communities of coexisting parasites. If time permits, I'll discuss how we might develop models to examine coevolution of macroparasites and their hosts.

Session 15-O8 - Parasite ecology & evolution

Responses of trematode communities to river restoration in Germany

Jessica Schwelm[1], Christian Selbach[2], Bernd Sures[1]

[1]Aquatic Ecology and Centre for Water and Environmental Research, University of Duisburg-Essen, Essen, DE, jessica.schwelm@uni-due.de
[2]Department of Bioscience – Aquatic Biology, Aarhus University, Aarhus, DK

Traditionally, benthic macroinvertebrates, fish and macrophytes are studied to determine the success of restoration measures. Since all free-living organisms host at least one parasitic species, we can expect the diversity of parasites to increase accordingly in restored ecosystems. Especially parasite taxa with a wide range of hosts and complex life cycles, such as digenetic trematodes, can be expected to react to changes in ecosystem dynamics. Knowledge about the occurrence and prevalence of specific trematodes can provide valuable information on the presence of the required hosts. Digenetic trematodes can, therefore, serve as an integrative measure and indicator for restoration success and local biodiversity, as they rely on the presence of a diverse and intact free-living species community.
To test this, aquatic gastropods were sampled in degraded, restored and near-natural river sections and examined for trematode infections in 2016 and 2017. In total, we sampled 12,715 snails, which hosted 70 different trematode species with an overall prevalence of 7.1%. Degraded sites showed a low trematode prevalence and a low species richness. While recently restored sites showed a higher prevalence and a lower species richness, sites being restored many years ago revealed a similar trematode prevalence, but a much higher species richness. The near-natural sites showed the highest trematode prevalence and a high species richness.
Overall, we found an increased prevalence and diversity of trematodes in restored sites compared to degraded sites. Presumably, certain species colonize recently restored sites quickly and in high numbers, but it takes time to re-establish a diverse and balanced community similar to sites being restored several years ago or to near-natural sites. Accordingly, the analysis of trematode diversity can be a useful tool for assessing the success of restoration measures.

Session 15-O9 - Parasite ecology & evolution

Trematode communities in the Lake Tanganyika's lates perches

Nikol Kmentová[1,2,3], Rodney Bray[4], Stephan Koblmüller[5], Tom Artois[2], Els L. R. De Keyzer[3], Maarten P. M. Vanhove[1,2,6], Simona Georgieva[7]

[1]Department of Botany and Zoology, Faculty of Science, Masaryk University, Brno, CZ
[2]Centre for Environmental Sciences, Research Group Zoology: Biodiversity & Toxicology, Hasselt University, Diepenbeek, BE
[3]Laboratory of Biodiversity and Evolutionary Genomics, Department of Biology, University of Leuven, Leuven, BE
[4]Parasitic Worms Division, Department of Life Sciences, The Natural History Museum, London, UK
[5]Institute of Biology, University of Graz, Graz, AT
[6]Zoology Unit, Finnish Museum of Natural History, University of Helsinki, Helsinki, FI
[7]Cavanilles Institute of Biodiversity and Evolutionary Biology, Science Park, University of Valencia, Valencia, ES, simona.georgieva@gmail.com

Lake Tanganyika has been considered a hotspot of biodiversity and diversification of global significance. Due to its unique flocks of vertebrate and invertebrate taxa the lake represents an unrivalled study system in biodiversity and evolution. Despite the high levels of interest in fish research the current knowledge on the parasite diversity in Lake Tanganyika is rather limited. This is especially true in respect to the trematode parasites, an essential component in aquatic ecosystems with strong impact on host community structure. Up to date a single trematode species, *Neocladocystis tanganikae* (Prudhoe, 1951) ex *Lamprichthys tanganicanus* (Boulenger), has been documented from this otherwise diverse freshwater ecosystem. The present study is the first attempt to assess the trematode diversity in lates perches (Latidae) in Lake Tanganyika. A total of 85 lates fishes of four species, *Lates angustifrons* Boulenger, *L. mariae* Steindachner, *L. microlepis* Boulenger and *L. stappersii* (Boulenger) was sampled opportunistically at four locations in 2016 and 2018. Morphological and molecular analyses of the entire dataset revealed the presence of five cryptogonimid trematode species. Analysis of the entire dataset revealed an effect of host and/or its depth preference on infection parameters of the five trematode species. Distinctive trematode community compositions in the four fish hosts at the different sampling locations studied was further detected. Our findings highlight the importance of extensive screening approaches to better understand the processes involved in the local host-parasite dynamics and population structuring.

Session 15-O10 - Parasite ecology & evolution

How parasitic worms infect grazing mammals

Daniel Benesh[1], James Chubb[2], Geoff Parker[2]

[1]Humboldt-Universität zu Berlin, Berlin, DE, daniel.benesh@hu-berlin.de
[2]University of Liverpool, Liverpool, UK

Parasitic worms are often transmitted trophically – one host is consumed by the next host. We previously found that parasitic nematodes have more successive hosts in their life cycle when their final host is at a high trophic level (i.e. top predator). But unexpectedly, we also observed that parasites of grazing mammals (ungulates) often have multi-host life cycles. This is puzzling, because ungulates consume herbage which can be contaminated with parasite eggs, so there is no obvious need for intermediate hosts and a complex life cycle. However, ungulates generally avoid grazing near their faeces, and we suggest this behavior is an obstacle for direct parasite transmission. This flips the dilemma. If grazers avoid areas with faeces (and parasite propagules), how do parasites directly infect them? We surveyed the literature to understand how parasitic worms typically infect ungulates. We found that ungulate parasitism has evolved at least 24 times, and the most common way it has evolved is through consumption of an intermediate host (14 times; at least once in the 4 major groups of parasitic worms). Another strategy to circumvent ungulate faecal avoidance is to have motile larvae that migrate to herbage. This has evolved 4 times, only in nematodes and trematodes, but has resulted in some of the largest clades of ungulate specialists. Finally, some worms are transmitted to ungulates by eggs deposited with faeces (4 times, once in cestodes and thrice in nematodes), and we explore how parasites navigate this seemingly problematic transmission route. In summary, we suggest that mammal grazing behavior creates a transmission barrier and that complex life cycles and larvae that migrate to vegetation herbage are parasite strategies to circumvent this barrier.

Session 15-O11 - Parasite ecology & evolution

Where the parasite goes, the host follows: Experimental evolution of parasitic host manipulation

Nina Hafer-Hahmann[1,2]

[1]Eawag, Dübendorf, CH, nina.hafer@eawag.ch
[2]MPI for Evolutionary Biology, Plön, DE, nina.hafer@eawag.ch

Many parasites have the ability to alter the behaviour of their host in a manner that increases their own fitness. Such host manipulation should be under selection in the parasite even though it is the host that expresses the altered trait. The cestode *Schistocephalus solidus* manipulates the behaviour of its first intermediate copepod host to reduce its predation susceptibility until the parasite is ready for transmission to the subsequent fish host. Thereafter, *S. solidus* increases host activity to facilitate transmission. To understand the evolvability of host manipulation und to test whether there is underlying genetic variation on which selection can act, I used an experimental evolution approach selecting either for strong or weak host manipulation. To which extend hosts can evolve resistance to such host manipulation is unclear. Hence, in a second experiment, I tested for the evolvability of host resistance to host manipulation by selecting hosts for being either strongly or weakly manipulated. Additionally, in both experiments, I measured various other traits to identify potential trade-offs with host manipulation. Such trade-offs could for example depict costs of host manipulation. The parasite, but not the host, responded readily to selection on host manipulation confirming that the parasite rather than the host controls host manipulation.

Session 15-P1 - Parasite ecology & evolution

Gut inflammation is causing a Change in the Microbiome of *Manduca sexta*

Anton G. Müller[1], Tina Trenczek[1]

[1]Justus-Liebig-Universität Gießen, Giessen, DE, Anton.G.Mueller@med.uni-giessen.de

A disturbance of the gut microbiome regularly accompanies inflammatory bowel diseases. However, it is still in debate whether this bacterial disturbance is the cause or a consequence of inflammatory bowel diseases. The purpose of the present study is to use the insect *Manduca sexta*as a model for inflammatory bowel diseases and to examine if an experimental inflammatory bowel like gut inflammation is leading to a change in the gut microbiome of *M. sexta*.
We have previously shown that the oral application of uracil is inducing an inflammatory bowel like gut inflammation through the production of ROS in *M. sexta*. Bacteria from feces of *M. sexta* fed with uracil (n = 12) and control diet (n = 14) were isolated and characterized via 16S rRNA Gene sequencing. CFUs of the feces from experimental and control larvae were quantified and analyzed.
The bacterial community of *M. sexta* feces has not been characterized till now. The community was essentially composed of Actinomycetales and Lactobacillales. Rarefaction curve of ACE and Chao 1 showed saturation. There was a significant reduction of the bacterial load (p = 0.0037), as well as a perturbation within the *Enterococcus* community (p = 0.0211) in uracil treated animals.
We show that an inflammatory bowel like gut inflammation in *M. sexta* is leading to a total reduction and a community shift in gut bacteria. These results indicate that inflammation on its own can change the abundance and composition of colon bacteria and may lead to a better understanding of inflammatory bowel diseases.

SESSION 16

Microplastic pollution - distribution and effects on organisms and ecosystems

Chairs: Friederike Gabel, Katrin Wendt-Potthoff, Bodo Philipp

Microplastic pollution is regarded as a major threat to ecosystems and there are news about it in the media nearly each week. While public media mostly focuses on marine ecosystems, microplastic is also found in terrestrial and limnic systems. This session aims to bring together researchers investigating the distribution and entry paths of plastic particles in aquatic and terrestrial ecosystems or developing methods for identifying plastic in the environment. Another focus of this session is to elucidate the effects of plastic polymers and their additives on organisms and ecosystems.

Session 16-O1 - Microplastic pollution

Estimating the spatial distribution of microplastics in agricultural soils – a top-down approach

Elke Brandes[1], Martin Henseler[1], Peter Kreins[1], Frank Herrmann[2], Frank Wendland[2], Alexander Tagg[3], Matthias Labrenz[3]

[1]Thünen-Institute für Ländliche Räume, Braunschweig, DE, elke.brandes@thuenen.de
[2]Forschungszentrum Jülich, Jülich, DE
[3]Leibniz Institut für Ostseeforschung, Warnemünde, DE

The topic of microplastic contamination in agricultural soils has recently gained attention in science and society. Many unknowns exist in this new research field, e.g., about effects on ecological functions and the transport processes of microplastic between the terrestrial and aquatic environment. The most discussed sources for microplastic contamination of cropland are biosolids applied as organic fertilizer to fields, such as sewage sludge and compost. However, knowledge about how much microplastic is accumulating in agricultural soils is scarce. Only a few analytic quantification studies have been published so far. Existing estimates from production and consumptions statistics have been performed at national level, but as of yet, spatially explicit regional quantification of microplastic immissions into agricultural soils are missing in the scientific literature.
Using data on microplastic concentrations found in biosolids in combination with spatially explicit sewage sludge application records, we estimated annual microplastic immissions into agricultural soils in a river catchment draining to the Baltic Sea in northeast Germany. This top-down approach allowed us to identify hot spots where potential microplastic contamination is high. Although these estimates are subject to many assumptions, they provide an understanding of the spatial distribution of potential microplastic contamination in agricultural soils.
Our results indicate locations where detailed soil analysis could be useful to investigate in situ processes and impacts (e.g., transport within the soil, effects on biota). The contamination potentials will be coupled to hydrologic models to estimate the further pathways into aquatic systems and the Baltic Sea. This top-down approach can be applied to other regions and continuously adapted when more knowledge on relevant sources, transport, accumulation, and degradation rates of microplastic in soils is gained in the future.

Session 16-O2 - Microplastic pollution

Soil erosion as a transport pathway of microplastic from agricultural soils to inland waters

Raphael Pinheiro Machado Rehm[1], Peter Fiener[1]

[1]Institut für Geographie, Universität Augsburg, Augsburg, DE, raphael.rehm@geo.uni-augsburg.de

Agricultural soils may play a key role as sink of microplastic (MP) in the terrestrial ecosystem. They show specific entry paths like the application of sewage sludge and compost, the decay of plastic mulch, and tire ware particles along streets. However, this sink might be substantially reduced in areas subjected to water erosion. The aim of our study is to determine the transport potential of MP during erosion events on agricultural land. We are interested if MP is preferentially transported or if it is attached to soil aggregates leading to more conservative transport rates. The transport behavior is studied based on a series of rainfall simulations on two different soil types (i) a silt loam (16 % sand, 59 % silt, 25% clay; 1.3 % OC) and (ii) loamy sand soil (72 % sand, 18 % silt, 10 % clay; 0.9 % OC) located at two experimental farms in Southern Germany. To simulate a heavy rain on a dry and a wet soil, two simulations with a gap of 30 min were performed for 30 min each (rainfall intensity 60 mm/h) on four plots (2 m x 5 m). The simulations are repeated in spring and autumn of two consecutive years. Before the beginning of the experiment, the topsoil layer (upper 10 cm) of all plots was contaminated with fine (50-100 µm) and coarse (250-300 µm) microplastics (HDPE) in a concentration of 10 g/m² and 50 g/m². During the dry run (2 l/min) all plots show similar average runoff rates whereas the wet run produced slightly higher rates on the loamy soil (5.5 l/min) compared to the sandy soil (4 l/min). The loamy soil produced more sediment delivery and by that higher MP enrichment compared to the sandy soil. The results of the first rainfall simulations clearly indicate a pronounced transport of MP via soil erosion. Due to an increasing incorporation of MP into soil aggregates, the MP delivery may decrease with time since contamination. Overall, this study will provide a valid data collection to quantify soil erosion as a pathway of MP transport in agricultural soils.

Session 16-O3 - Microplastic pollution

All rivers flow into the ocean – all their plastic too? (Temporal) sinks of microplastics in freshwaters

Friederike Gabel[1], Diana Michler-Kozma[1]

[1]WWU Münster, Münster, DE, gabelf@uni-muenster.de

It is assumed that 80% of the marine plastic originates from land and major parts may be transported via rivers. Plastic debris has been found in all rivers studied, however, its longitudinal distribution is largely unknown. First studies indicate that the amount of suspended plastic does not correlate with the kilometers flown. Some sampling points downstream contain less plastic than sites located more upstream. In this presentation we investigate the possible sinks of microplastics in rivers. Decreases of flow velocities e.g. caused by dams and reservoirs can lead to higher sedimentation rates and the uptake by organisms (temporally) removes plastic from the water column. This may result in unexpected patterns of plastic distribution in freshwaters.

Session 16-O4 - Microplastic pollution

Functional analysis of microbial biofilm communities on polyethylene-microplastic particles in freshwater environments

Rense Jongsma[1], Anna Huebenthal[1], Rebecca Lülf[1], Bodo Philipp[1]

[1]Institute for Molecular Microbiology and Biotechnology, Faculty of Biology, University of Münster, Münster, DE, bodo.philipp@uni-muenster.de

The accumulation of microplastic particles (MPs; <5 mm in size) in the environment is of high ecological concern because the fate and effects of MPs are largely unknown. In aquatic environments, MPs are rapidly colonized by microorganisms, and this biofilm formation may alter the distribution of MPs as well as their effects on MP-ingesting biota. The BMBF-funded research consortium MikroPlaTaS investigates the distribution and ecological effects of biofilm-coated MPs in freshwater habitats. The aim of the sub-project presented in this study was the functional community analysis of biofilms on MPs as well the elucidation biofilm-formation mechanisms with special emphasis on metabolic networks.
MPs were incubated *in situ* at three different freshwater sites under photic conditions for five weeks. Biofilm formation was monitored by crystal violet staining and chlorophyll fluorescence. Biofilms formed rapidly during *in situ* incubation of MPs, and microscopic and cultivation-based analysis revealed photoautotrophic microalgae and heterotrophic bacteria as the dominant microbiota. For investigating potential metabolic interactions *in situ*-formed biofilms were further cultivated in the laboratory under photoautotrophic conditions selecting for adhesion to MPs made of polyethylene (PE). These enrichment studies led to stable biofilm communities, in which the heterotrophic bacteria grew apparently with organic compounds released from the microalgae. Taxonomic analysis revealed that the bacterial flora frequently comprised members the poorly investigated genus *Gemmobacter* belonging to the family of *Rhodobactereceae*, which are well-known alga-associated bacteria from marine habitats. Detailed metabolic analysis of these consortia on PE-particles are currently being performed for creating ecologically relevant model biofilm communities for studying general mechanisms of MP-colonization as well as the effects ingestion of MPs by limnic invertebrates.

Session 16-O5 - Microplastic pollution

The effects of different concentrations of different polymer particles on the earthworm *Eisenia fetida*

Anja Holzinger[1], Annika Heymann[1], Elmar Sehl[2], Seema Agarwal[2], Heike Feldhaar[1]

[1]Animal Ecology I, Bayreuth Centre for Ecology and Environmental Research (BayCEER), University of Bayreuth, Universitätsstr. 30, Bayreuth, DE, anja1.holzinger@uni-bayreuth.de
[2]Macromolecular Chemistry II, University of Bayreuth, Universitätsstr. 30, Bayreuth, DE

Microplastic pollution has become an increasing environmental problem and a growing global concern over the past decade. Large amounts of microplastic particles have not only been found in aquatic habitats, but also in the terrestrial environments or in compost. However, there is a lack of understanding of the effects of these pollutants on soil-living organisms. In particular, the substrate feeding earthworm *Eisenia fetida* is likely to come into contact with these particles during food uptake. We have therefore assessed the effects of ingested microplastic particles (45 – 350 µm diameter) of different concentrations of biodegradable (PCL, PLLA) and non-biodegradable (PET, PP, PS) polymer types on the growth rate and mortality of *E. fetida*. Furthermore, every polymer type was used with additives and with a reduced amount of additives to study if there are potential toxic effects of these chemicals. Individuals were exposed for 28 days to soil containing either 1% or 2,5 % of the microplastic particles mentioned above. Polymer type, including biodegradable materials, did not have a significant influence on mortality or growth rate. For some polymer types a higher particle concentration (PLLA, PET) or particles with additives (PET) had a positive effect on growth rate. While the low mortality suggests minor effects of microplastic on *E. fetida* the long-term effects, e.g. on reproductive success, still have to be investigated.

Session 16-O6 - Microplastic pollution

Served on a plastic plate - Testing the nutritional value of plastic-associated biofilm for the freshwater pulmonate *Physa fontinalis.*

Diana Michler-Kozma[1], Friederike Gabel[1]

[1]University of Münster, Münster, DE, diana.michler@uni-muenster.de

The annual use of plastic products is rising globally and large amounts of its waste enter the environment through various pathways. This poses a potential hazard to the aquatic fauna in freshwater systems. Dense materials like PET sink to the ground of the water body and accumulate there. Further, the growth of biofilms and other degradation processes can promote the sedimentation of less dense materials as well and therefore make them accessible for benthic communities. It is widely unknown whether these plastic-associated biofilms have any effects on higher trophic levels, but recent studies indicate an alteration of the biofilm composition and their nutritional value for benthic grazers.
In feeding experiments, we tested the influence of plastic associated biofilms on different endpoints in the life cycle of the freshwater pulmunate *Physa fontinalis.* Three common plastic types (PS, PE and PET) and glass as control were placed in a eutrophic stream for three weeks to allow the growth of a natural biofilm. The test organisms were then fed exclusively with the biofilm of one substratum for six weeks. The documented endpoints were mortality, shell growth, wet weight and reproduction.
Two experiments were conducted, in early spring and summer, respectively to identify possible seasonal variation in the composition of the biofilm. Data from the first experiment show a significant decrease in growth and reproduction of the snails grazing on PET, while in summer this effect could not be observed.

Session 16-O7 - Microplastic pollution

Effekte von Mikroschadstoffen aus konventionellem und ozoniertem Abwasser auf Makrozoobenthosorganismen: Ein Projektüberblick

Louisa Ellen Rothe[1], Christian Karl Feld[1], Michael Weyand[2], Almut Gerhardt[3], Bernd Sures[1]

[1]Universität Duisburg-Essen, Essen, DE, louisa.rothe@uni-due.de
[2]Ruhrverband, Abteilung Flussgebietsmanagement, Essen, DE
[3]LimCo International GmbH, Konstanz, DE

Mikroschadstoffe können trotz ihrer geringen Konzentrationen (pg bis ng/L) negative Effekte auf Gewässerorganismen haben und beispielsweise zur Verweiblichung von Fischen und Amphibien führen. Seitdem bekannt ist, dass Mikroschadstoffe durch gereinigtes Abwasser in Oberflächenwässer gelangen können, gibt es vermehrt Bedenken bezüglich der damit verbundenen Auswirkungen auf die Umwelt. Für viele Kläranlagen wird deshalb eine vierte Reinigungsstufe gefordert, die die verbliebenen Mikroschadstoffe im Abwasser eliminieren soll.
Um den Erfolg einer erweiterten Abwasserreinigung durch das Ozonierungsverfahren abschätzen zu können, untersuchen wir unter Verwendung von Fließrinnen die Wirkungen von konventionell gereinigtem und ozoniertem Abwasser auf ausgewählte Arten des Makrozoobenthos. Durch die Verwendung von bewertungsrelevanten Makrozoobenthosarten ist es möglich, Aussagen zur Wirkung von Mikroschadstoffen auf den ökologischen Gewässerzustand nach EG-WRRL zu machen. Im Fokus der Arbeit stehen zwei Fragen: i) wirken sich Mikroschadstoffe negativ auf die untersuchten Organismen aus und ii) werden eventuelle Effekte der Mikroschadstoffe durch die Ozonierung reduziert?
In sechs Fließrinnen auf der Kläranlage Schwerte (NRW), von denen jeweils zwei mit konventionell gereinigtem Abwasser, ozoniertem Abwasser und Flusswasser aus der Ruhr (Kontrolle) beschickt werden, erfolgt die Exposition der Organismen in Biomonitoren (LIMCOBioSensorSystem) über zwei Wochen. Die Biomonitore zeichnen die Frequenz und Stärke der Bewegungen der Organismen in einem elektrischen Feld auf und machen einen Vergleich der Bewegungsmuster der Versuchsgruppen mit der Kontrollgruppe möglich. Zusätzlich zu den Verhaltensreaktionen werden die Mortalitätsraten bestimmt und Biomarkeranalysen sowie chemische Analysen der Wässer durchgeführt. Erste Ergebnisse der Versuche aus den Jahren 2018 und 2019 werden präsentiert und diskutiert.

Session 16-P1 - Microplastic pollution

Effects of polyethylene terephthalate microfibers on the growth and emergence of *Chironomus riparius*

Lydia Setyorini[1], Diana Michler - Kozma[2], Friederike Gabel[2], Bernd Sures[1]

[1]Universität Duisburg - Essen, Essen, DE, lydia.setyorini@stud.uni-due.de
[2]Institut für Landschaftsökologie, Münster, DE

Microplastics occurrence in the coastal and marine environment has been frequently reported in the past 10 years. More recent studies conducted in freshwater ecosystem have verified that microplastics are present in water columns, sediment, and organisms as well. Based on these studies, it could be concluded that the presence of microplastics in sediments may pose risks to the ecosystem, in particular benthic organisms as the microplastics may settle down and accumulate in the sediment. Polyethylene terephthalate (PET) is one of the polymers that has been frequently found in these studies. It is mostly utilized for beverage bottles with a density of around 1.4 g/cm^3 which causes it to sink. It is also used and recycled as fibers for clothing and highly resistant to environmental biodegradation.

Laboratory studies have shown that microplastics are taken up by benthic organisms. However, there is still a need to determine the uptake and biological effects of different plastic types on wide range of organisms. *Chironomus* larvae have been used frequently as test organisms in ecotoxicological research with advantages such as wide geographic distribution, high sensitivity and compatibility throughout interlaboratory studies.

This study aims to observe the effects of PET microfibers to the survival, growth, and stress response of *Chironomus riparius*. To assess the development of *Chironomus*, a modified 28-day sediment toxicity test based on OECD Guideline no. 218 was used, where the main endpoint is the duration until emergence of the larvae. In this assay, *Chironomus* were exposed to artificial sediment spiked with PET microfibers. In addition to the chronic toxicity test, the subcellular stress response represented by Heat Shock Protein 70 (HSP70) were measured.

Preliminary results showed that exposure to PET does not significantly affect the growth and emergence of *Chironomus riparius* on individual level. Further research on biomarker analysis are currently being conducted to determine the ecotoxicological stress level between different exposure groups.

Session 16-P2 - Microplastic pollution

Ingestion of microplastics and life history study in the monogonont rotifer *Brachionus calyciflorus.*

Claudia Drago[1], Julia Pawlak[1], Guntram Weithoff[1]

[1]University of Potsdam, Potsdam, DE, drago@uni-potsdam.de

Microplastic is a ubiquitous problem in both, aquatic and terrestrial environments. Most knowledge on the effect and the behaviour of microplastic in aquatic environments stems from marine systems, whereas the attention on microplastics in freshwater ecosystems is scarce. As part of freshwater systems, impoundments and reservoir may play a relevant role because of reduced flow velocity and increased sedimentation. In aquatic environments, microplastic interact with freshwater biota and potentially affect feeding, reproduction, growth rate and the survival of aquatic invertebrates.
The risk for the pelagic fauna is assessed by laboratory experiment on the uptake of microplastic and life history in short- and long-term exposure to microplastics.
To determine the uptake of microplastic by freshwater organisms, we performed a series of experiments with rotifers, in particular, *Brachionus calyciflorus* as model species.
The aim of the experiments is to assess the variation of microplastics ingestion in association with algae and bacteria and natural water. We test different sizes of fluorescent polystyrene microsphere (1, 3, 6 µm) at different concentrations. Moreover, life table experiments were performed to evaluate the effect of microplastic on reproduction and survival. The rotifers were exposed to the polystyrene spheres as a sole food source, in association with algae as food and incubated with natural water and bacteria.
B. calyciflorus shows different ingestion rate depending on the size, concentration and incubation of the microspheres. In addition, the survival indicates no toxic effect derived from the presence of plastic microspheres. Nevertheless, the results from the reproduction show a reduction in egg production when *B. calyciflorus* is exposed to 3µm spheres.

Session 16-P3 - Microplastic pollution

Microplastic in bird droppings in the Rieselfelder of Münster

Sam Lucy Behle[1], Friederike Gabel[1]

[1]WWU Münster, Münster, DE

Nearly all studied marine birds ingest plastic waste. If also other birds do so is not well studied yet. Furthermore, investigations of microplastic ingestion are rare. Microplastics may be hazardous as toxic substances can attach to its surfaces and may be ingested as well. A large part of the ubiquitous microplastics enters freshwaters and oceans via wastewater treatment plants. The Rieselfelder of Münster, an important bird protection area, are irrigated by the cleaned effluents of a wastewater treatment plant and microplastic particles and fibres have been found in this water. However, if birds feeding in the Rieselfelder ingest microplastics is not known. Hence, we investigated the bird droppings for microplastic contents. Samples of bird droppings were filtered in the laboratory, separated optically and afterwards identified by FTIR-analyses. Results show that birds of the Rieselfelder of Münster ingest microplastics characterized as PE. Hence, we could show that also other birds than marine ones ingest microplastics.

SESSION 17

The Dutch way. 30 years of experience to develop, share and disseminate knowledge about practical restoration

Chairs: Leon Lamers , Eva Remke

The Dutch OBN Knowledge Network ("OBN - Kennisnetwerk Ontwikkeling en Beheer Natuurkwaliteit") for Nature Restoration and Management is an independent and innovative platform where policy makers, site managers and scientists cooperate in the management and restoration of natural areas. It develops and disseminates knowledge to enhance nature quality management and conservation in the Dutch landscapes and in the Atlantic Region. We want to share this way of working and major results of our practical restoration work. Each presentation should clearly present how the network contributes to the research question, research results as well as practical advices for the restoration of habitats and species populations. Furthermore, overall achievements and improvements for the Dutch nature and biodiversity should be stated. These key lessons learnt can also be used for the restoration in comparable landscapes and ecosystems. But also the kind of dialog and set-up of the network can be valuable for other countries.

Session 17-O1 - The Dutch way of restoration

The history of the OBN network – how did it evolve?

Jan Roelofs[1], Eva Remke[1], Wim Wiersinga[2]

[1]B-Ware Research Centre, Nijmegen, NL, j.roelofs@b-ware.eu
[2]VBNE (Vereniging van Bos- en Natuurterreineigenaren), Driebergen-Rijsenburg, NL

In the mid 1980’s the need to tackle continuing serious problems for the Dutch nature such as acidification, eutrophication and overdrafting more intensively than before has led to the idea that a new policy and additional measures are needed. This formed the core of the EGM “Regeling Effectgerichte Maatregelen in natuurtereinen” (“Order effect aimed measures in nature areas”) at the start 1989. From 1995 until 2010 this program has been followed by “OBN – Overlevingsplan Bos en Natuur” (“Survival plan Forest and Nature”). At the start this has been set up as a temporary program and working groups, but successful measures in nature areas combined with good results of applied research resulted in a continuation of the program. A slight change in focus came up in 2006, when the aim broadened to restoration of nature in general and also the landscape scale has been added as aworking form. OBN is called from then onwards “Ontwikkeling & Beheer Natuurkwaliteit” (Development & Management of Nature quality). This advice and research network got subsidies from the department of environmental and economic affairs throughout the years – amounts changed quite a lot. Therefore possible advice and also research project volume varied quite remarkably.
The network consists now of several, permanent expert groups. Restoration measures are monitored and innovative measures are developed and tested. Several threatened species have recovered and ecosystems expand due to this program’s. Examples are shortly presented.

Session 17-O2 - The Dutch way of restoration

The Dutch Approach: the present OBN network and program on research and knowledge transfer on ecological restoration

Wim Wiersinga[1]

[1]Coordinator Dutch Knowledge Network for Restoration and Management of Nature (OBN), Driebergen-Rijsenburg, NL, w.wiersinga@vbne.nl

During the 20th century scientific evidence for the role of acidification, eutrophication, nitrogen deposition, desiccation and fragmentation in the strong decline of the Dutch biodiversity became eminent. As a response in 1990 the Dutch government initiated a policy combining 1) an extended and connected nature network, 2) reduced deposition levels (S, N) and desiccation, 3) subsidized nature management and restoration, 4) monitoring of nature quality and 5) mitigating measures in the nature reserves.
Since then a network of scientists, nature-managers and policy makers, the 'Knowledge Network for Restoration and Management of Nature', came established focusing on monitoring and underpinning (experimental field) research of restoration and mitigation measures and translating these new scientific insights into 'evidence based' effective and practical management.
This network has a broad focus on the national nature (Natura2000) network, including its habitats and species, waterbodies and the cultural landscape. The 12 Dutch Provinces and the Ministry of Agriculture, Nature and Food quality (LNV) provide an annual budget (€1,8 M/y) for research, networking and communication.
The knowledge network consist of 8 Expert Teams (with in total 140 members), each dedicated to a landscape discerned in the Netherlands e.g. coastal, peat, riverine and sandy areas. In these teams site managers, researchers and policy makers cooperate to formulate landscape-specific questions, supervise research and monitoring projects, giving advice and organise knowledge dissemination. Themes in the research are hydrological conditions, soil buffering, nutrients removal, plant food quality, dynamic processes, colonization and connectivity.
With a combination of methods the knowledge dedicated to ecological restoration disseminates to site owners and managers: reports, (scientific) articles, brochures, leaflets, website, symposiums, field workshops etc.; all are available at www.natuurkennis.nl.

Session 17-O3 - The Dutch way of restoration

Management and restoration of softwater lakes in The Netherlands

Emiel Brouwer[1]

[1]Research Centre B-WARE, Nijmegen, NL, e.brouwer@b-ware.eu

Because of human settlement in Western-Europe, pristine growth sites of soft water communities have virtually disappeared long ago. But many alternative sites were present in the resulting agricultural landscape. Nowadays, these alternative sites are also disappearing due to further intensification of land-use. The last remnants can be found in nature reserves primarily combining elements from this former agricultural landscape such as heathland, pastures, ponds and small lakes. Even in nature reserves a strong decline and deterioration occurs, indicating that improvement of site conditions is urgently needed.
To stop further decline, it is of crucial importance to understand the factors that determine growth conditions. In the past decades, new insights have been gained, such as the role of acidification, nitrogen, sulphur and carbon in soft water lakes. Based on these insights, a set of restoration measures was designed in The Netherlands. From 1985 onwards, these measures were tested and after that applied in many hundreds of nature reserves. This set includes sludge removal, topsoil removal, clearing of the shores, inlet of groundwater, liming of acidified lakes and catchments, and recreating former lakes on agricultural land. It soon became clear that local site conditions strongly determine the outcome of restoration measures. For designing an optimal set of restoration measures, a thorough understanding of these conditions is needed. Some examples of site-specific research, the subsequent application of restoration measures and the recovery of soft water vegetation are shown.

Session 17-O4 - The Dutch way of restoration

Stepwise from wetness and *Sphagnum* mosses to fauna and bog landscapes

Gert-Jan van Duinen[1], Gert-Jan van Duinen[1]

[1]Bargerveen Foundation, Nijmegen, NL, g.vanduinen@science.ru.nl

The largest part of the Netherlands was once covered with mires. Drainage, cultivation and peat extraction caused the loss of natural raised bogs. Since about 1960 restoration measures are taken to restore raised bogs in degraded and cut-over bog remnants. These measures varied in effectiveness. To elaborate the key factors in restoration an international and interdisciplinary research programme was started, resulting in a much better understanding of the main biogeochemical processes and of the constraints of nitrogen deposition in growth of different *Sphagnum* species as well as grasses and birches. This understanding provided the site managers the required information to apply the most effective restoration measures for their bog remnants. The investigation of invertebrate fauna in degraded and pristine bogs stressed the importance to not only consider the best hydrological conditions for *Sphagnum* mosses, but also the larger landscape and time scales. If possible, restore gradients from groundwater influenced to acid parts of raised bog landscapes. Opportunities may be found in buffer zones on former agricultural grounds adjacent to current bog remnants, as well as in fen reserves that include patches in succession to bog. Furthermore, conservation of relict populations of characteristic species of raised bog landscapes currently present in bog remnants, as well as fen reserves and moorland pools is recommended. Last but not least, measures to further reduce atmospheric nitrogen deposition and to reduce the elevated phosphate concentration in Dutch bog remnants are required to allow for further rehabilitation of both plant and fauna communities of raised bog landscapes.

Session 17-O5 - The Dutch way of restoration

Species richness of limestone grasslands in the Netherlands

Bart van Tooren[1]

[1]Natuurmonumenten, 's-Graveland, NL, b.vantooren@natuurmonumenten.nl

The variety of species in the limestone grasslands in South Limburg (the Netherlands) is under severe pressure. That applies to the flora, but even more so to the fauna. Important causes are the far too high nitrogen deposition, mainly from agriculture, and the strong fragmentation of the generally very small lime stone grasslands. A related factor is that species diversity in the rural area around the limestone grasslands continues to decline. Parts have become ecological deserts. Research from OBN has focused on a few aspects:
1. Restoration of connections between limestone grasslands. Together with authorities and nature conservancy organisations, among others, a search was made for the possibilities of repairing connections. Opportunities have been found but it is up to the authorities to implement them.
2. Management optimization. Due to the high nitrogen deposition, intensive management is required to prevent a dominance of tall grasses like *Brachypodium pinnatum*. On the other hand the insect fauna benefits from a very extensive management. In order to find the right balance, an optimization of grazing management was investigated.
3. Restoration of species-rich grassland after removal of the topsoil of intensively used cultivated grasslands.

The research certainly leads to the preservation and perhaps even restoration of species diversity, but a more substantial improvement is only possible after a dramatic reduction in nitrogen deposition and thus, among other things, a completely different way of farming in our country, in combination with a landscape that also outside the nature reserves offers opportunities for flora and fauna.

Session 17-O6 - The Dutch way of restoration

What goes up, must come down? Effect of soil pH-manipulation, addition of soil biota and addition of plant-material on heathland development on former agricultural soils

Maaike Weijters[1], Roland Bobbink[1], Rudy Van Diggelen[2], Dajana Radujkovic[2], Erik Verbruggen[2]

[1]B-WARE research centre/Radboud University Nijmegen, Nijmegen, NL, m.weijters@b-ware.eu
[2]University of Antwerp, Antwerp, BE

Heathland restoration remains an urgent topic as the area of lowland heathland has declined severely in the Atlantic regions of North-West Europe. Restoration possibilities exist in the reclamation of former agricultural fields. Although common practice in the Netherlands success is not always granted. Besides abiotic constraints, the dispersion of both above- and belowground communities can be a limiting factor. In the framework of O+BN, LIFE and NATURA2000 a field trial has been set up. The nutrient rich topsoil of former agricultural fields was removed, and soil pH manipulated. The development of the above ground community was manipulated by the addition of fresh hay and the development of both above- and belowground communities by the addition of sods (soil+seedbank), both from nearby heathland. The development of the soil, aboveground community (vegetation) and belowground community (bacteria, fungi) was studied for 7 years. Is it possible to direct the development of the above- and belowground communities? And what is their interaction? Which tools can we handle to practitioners to increase restoration success? In this presentation we show the main results of this experiment by B-WARE Research Centre in close collaboration with University of Antwerp, Cranfield University, Institute of soil Biology and the WBBS-foundation.

SESSION 18

Die "neue" Agrarökologie: Ein Ansatz für eine nachhaltige Landwirtschaft?

Chairs: Tillmann Buttschardt

Unter Agrarökologie wurde bis zur Mitte der 1990er Jahre des letzten Jahrhunderts die Wissenschaft verstanden welche die Anwendung aus ökologischer Forschung entsprungener Konzepte auf das Design und Management von Agrarökosystemen zum Inhalt hatte. Anfang des neuen Jahrtausends wurde diese Definition erweitert durch Betrachtungen des gesamten Ernährungssystems (food system). Es entstand also eine wissenschaftliche Definition, die über die reine Naturwissenschaft hinaus reichte und interdisziplinär wurde. Auch wurden stärker Fragen der Wissensintegration, der Bildung, der kleinbäuerlichen Landwirtschaft und Ernährungssouveränität und Kreislaufwirtschaft hervor gehoben. Noch immer existieren nebeneinander verschiedene Ansätze: (1) Der Plot- bzw. Feldmaßstab der "klassischen" Ökologie, wie er in vielen großen Forschungsvorhaben untersucht wird (Biodiversitätsexploratorien, Jena Experiment). Bei diesen spielt die Bewirtschaftung meist nur als diffuse "Intensitätsgröße" eine Rolle, häufig indexiert (z.B. LUI) und für die landwirtschaftliche Praxis wenig operabel. (2) Daneben gibt es den Ansatz des Agrarökosystems bzw. den Maßstab der landwirtschaftlichen Betriebe. Dieser integriert betriebliche Abläufe und Bilanzen (Hoftorbilanz) ebenso, wie Raumkonfigurationen, naturnahe Restflächen oder produktionsintegrierte Naturschutzmaßnahmen (PIK). Schließlich (3) betrachtet eine "neue" Agrarökologie das gesamte Ernährungssystem mitsamt der wirtschaftlichen Rahmenbedingungen, Mensch-Natur-Verhältnisse und der laufenden Diskurse. Kurz zusammengefasst wird in der internationalen Forschung die Agrarökologie heute in dreierlei Dimensionen interpretiert: als Wissenschaft, als Praxis und als Bewegung. Die Session möchte dies Thematik vor dem Hintergrund derzeit stattfindenden intensiven gesellschaftlichen Auseinandersetzung um Themen wie Insektenschwund, Pestizide, Tierwohl, Eutrophierung, Agrarförderung, Naturschutz vs. Landwirtschaft diskutieren. Leitfragen sind: Welchen Beitrag leistet die klassische Agrarökologie als Wissenschaft? Wie läuft die interdisziplinäre Zusammenarbeit zwischen natur- und gesellschaftswissenschaftlichen sowie ökonomischen Fächern in der Wissenschaft? Welche Fragen hat die Praxis an die Wissenschaft? Wie wird die Praxis, wie werden die Bewegungen innerhalb der Wissenschaft wahrgenommen? Liefert die "neue" Interpretation als Wissenschaft, Praxis, Bewegung Lösungen, die zu biodiversen und nachhaltigen Landschaften führen.

Session 18-O1 - Die ”neue” Agrarökologie

Die ”neue” Agrarökologie: Ein Ansatz für eine nachhaltige Landwirtschaft?

Tillmann Buttschardt[1]

[1]Institut für Landschaftsökologie, Universität Münster, DE, tillmann.buttschardt@uni-muenster.de

Einleitung in die Session

Session 18-O2 - Die "neue" Agrarökologie

Optimierung und Verstetigung von großen Naturschutzprojekten durch Ansätze der „neuen“ Agrarökologie

Anne Hopf[1], Anya Wichelhaus[1], Gert Rosenthal[1]

[1]Universität Kassel, Kassel, DE, anne.hopf@uni-kassel.de

Bei großen, umsetzungsorientierten Naturschutzprojekten stehen die begleitenden Wissenschaften vor neuen Herausforderungen hinsichtlich Planung, zeitlich-räumlicher Maßstabsebenen sowie Inter- und Transdisziplinarität. Anhand eines neuen Projekts aus dem „Bundesprogramm Biologische Vielfalt“ erläutern wir beispielhaft, wie hierzu Ansätze und Methoden der „neuen“ Agrarökologie aufgegriffen und weiterentwickelt werden können. Ziel des Projekts „*Schaf* schafft Land*schaft*“ ist die Förderung der Biodiversität in der Hotspot-Region Werra-Meißner u. a. durch großflächige Hüteschafhaltung und begleitende Maßnahmen, wie Regionalvermarktung, Umweltbildung und sanften Tourismus. Die wissenschaftlichen Herausforderungen, die sich im Projekt stellen, sind: (i) die Bearbeitung verschiedener Maßstabsebenen, die mit unterschiedlichen Zuständigkeiten, Interessen und potentiellen Konflikten verknüpft sind (Stichwort multifunktionale Landschaften), (ii) die Zusammenarbeit zwischen verschiedenen Wissenschaftsdisziplinen, hier Ökologie und Betriebsökonomie (Interdisziplinarität) und (iii) der Brückenschlag zwischen Praxis (Naturschutz, Landwirtschaft, Verwaltung, Verbände) und Forschung (Transdisziplinarität). In unserem Vortrag fokussieren wir auf den letztgenannten Punkt und die Übersetzung von Fragen aus der Praxis in wissenschaftlich bearbeitbare Hypothesen sowie die Rückübersetzung der wissenschaftlichen Ergebnisse in operable Handlungsempfehlungen. Hierbei nutzen wir verschiedene methodische Ansätze, wie Szenarienentwicklung, adaptives Management und Experimente im Landschaftsmaßstab, um Maßnahmen zuerst präventiv und dann umsetzungsbegleitend auf Erfolg zu kontrollieren, Handlungsalternativen zu erarbeiten und das notwendige Handwerkszeug zur effizienten Umsetzung zu liefern. Die Ergebnisse der interdisziplinären Zusammenarbeit sollen den Projektverlauf optimieren und Maßnahmen verstetigen helfen.

Session 18-O3 - Die "neue" Agrarökologie

Perspektiven innovativer Technologien in einem integrativen Ansatz für eine nachhaltigere Weidebewirtschaftung

Juliane Horn[1], Johannes Isselstein[1]

[1]Graslandwissenschaft Georg-August-Universität Göttingen, Göttingen, DE, juliane.horn@uni-goettingen.de

Die intensive Viehhaltung verstärkt den Druck auf den Acker. Die Bedeutung des Grünlands ist für die Milch- und Fleischproduktion und Bereitstellung wichtiger Ökosystemleistungen zurückgegangen. Die Fütterung von Silagen, Getreide und Soja produziert auf Ackerflächen sind üblich. Die Rückkehr zu Nutztiersystemen von Wiederkäuern mit Weidegang mit Hilfe innovativer Technologien bietet die Perspektive einer nachhaltigen Grünlandnutzung und der Entlastung des Ackers. Ein räumlich und zeitlich präzises Weidemanagement ermöglicht die Energie- und Eiweiß-Versorgung der Tiere größtenteils über Gras zu sichern sowie die strukturelle und funktionelle Vielfalt der Landschaft gezielt zu optimieren. Dafür werden räumlich und zeitlich präzise Informationen der verfügbaren Biomasse und Qualität des Futters benötigt, um den Nährstoffbedarf der Rinder zu decken sowie das Pflanzenwachstum durch Beweidung und Exkrementenverteilung zu optimieren. Aktuell bedeutet dies einen hohen Zäunungsaufwand. Immer mehr Fortschritte werden bei Technologien des virtuellen Zäunens (‚virtual fencing') und der Fernerkundung erzielt. Virtuelle Zäune steuern die Zugänglichkeit der Fläche. Die für das Setzen und Verändern der Zäune erforderlichen Daten stammen aus der Fernerkundung. Fortschritte in der Sensortechnik erlauben die Erfassung der räumlichen Verteilung von Lebensräumen und Pflanzengemeinschaften sowie der Futterpflanzen in hoher Auflösung. Die Zäune können variabel gesetzt werden, um sowohl Landschaftsstruktur und Artenvielfalt zu fördern als auch ausreichend Futter anzubieten. Die Etablierung eines nachhaltigen Weidesystems bedarf eines integrativen Ansatzes, der die vorhandenen Bausteine weiterentwickelt und unter Partizipation verschiedener Stakeholder erprobt. Der vom BMBF-geförderte Verbund GreenGrass entwickelt neue Weidesysteme mit Hilfe dieser Technologien. Eine Wissens-basierende Weidewirtschaft birgt das Potenzial die Zielkonflikte zwischen Nutzung und Naturschutz zu mindern.

Session 18-O4 - Die ”neue” Agrarökologie

Naturschutzberatung in der Landwirtschaft - Eine Chance zur effizienten Umsetzung von Förderprogrammen und der Übermittlung von ökologischen Zielen.

Gisela Wicke[1]

[1]NLWKN a.D., Gehrden, DE, giselawicke52@gmail.com

Die Vermittlung von wissenschaftlichen Erkenntnissen zu ökologischen Zusammenhängen und die Umsetzung von Maßnahmen können durch eine Naturschutz-Beratung erfolgen. Die Vorteile sind eine Wissenserweiterung, ein gemeinsames Verständnis für Probleme im Naturschutz, eine Motivation zur Teilnahme z.B. an Agrar-Naturschutzprogrammen und letztendlich ein Miteinander der Akteure.
Eine Beratung in der Landwirtschaft erfolgte bisher vor allem zur Erreichung ökonomischer Ziele durch Beratungsbüros und Landwirtschaftkammern. Durch die gestiegenen gesellschaftlichen Anforderungen gibt es in Niedersachsen seit 2007 eine Naturschutzberatung und seit 2012 eine Beratung zu den sog. neuen Herausforderungen zu den Themen Biodiversität, Wasser- und Klimaschutz. In anderen Bundesländern wird z.T. eine gesamtbetriebliche Naturschutzberatung angeboten. Das Projekt „Focus Naturtag“ hat ebenfalls einen gesamtbetrieblichen Ansatz.
Um die neuen Inhalte durch die Berater/-innen zu den Landwirten zu transportieren, mussten ca. 600 Berater/-innen z.B. zur Lebensweise einer Feldlerche oder der Vorteil von mehrjährigen Blühstreifen für Insekten in Form von Vorträgen weitergebildet werden. Bei Exkursionen und Gesprächen mit Landwirten konnten die ökologischen Ziele anschaulich vor Ort in der Praxis mit einer gewissen Begeisterung vermittelt werden. Eine wichtige Voraussetzung für die effiziente Umsetzung der Programme.
Bei der Transformation von wissenschaftlichen Erkenntnissen in die Praxis nehmen die Landesnaturschutzverwaltungen mit dem Fachpersonal eine wichtige Rolle ein. Sie sind bei der Konzeption der Agrar-Naturschutzprogramme beteiligt und müssen die Ziele in öffentlichkeitswirksamen Medien wie Flyer etc. auch an die Berater/-innen und Landwirte kommunizieren.

Session 18-O5 - Die "neue" Agrarökologie

GrünSchatz – Möglichkeiten der Erhöhung der Biodiversität innerhalb ökonomisch orientierter landwirtschaftlicher Kulturen

Sabine Paltrinieri[1], Pattrick Günner[1], Tillmann Buttschardt[1]

[1]Institute of Landscape Ecology, Münster, DE, paltrinieri@uni-muenster.de

Landwirtschaftliche Bearbeitung hat jahrhundertelang zu einer Erhöhung der Vielfalt sowohl auf Biotop- als auch Artenebene geführt. Die zunehmend intensive und industriell agierende Landwirtschaft der letzten Jahrzehnte allerdings führte und führt immer noch zu massiven Verlusten bezüglich der Biodiversität. Dieser Verlust fällt so gravierend aus, da etwa 50 % der Fläche der Bundesrepublik Deutschland landwirtschaftlicher Bearbeitung unterliegen. An dieser Stelle setzte das Projekt GrünSchatz an. Es untersucht, ob eine ökonomisch ausgerichtete Kultur wie die Wildpflanzenmischung BG70, die angebaut wird, um Substrat zur Vergärung in Biogasanlagen zu gewinnen, gleichzeitig förderlich zur Erhöhung der Biodiversität sein kann. Die Wildpflanzenmischung besteht aus 22 verschiedenen mehrjährigen Arten. Dadurch, dass die Kultur über fünf Jahre stehen bleibt und nur zu Beginn (wenn überhaupt) vor Anlage der Kultur mit Pestiziden behandelt wird und in den Folgejahren nur noch jeweils einmal im Frühjahr zur Düngung und einmal im August zur Ernte befahren wird, entstehen hier vergleichsweise wenig von Pestiziden beeinflusste und vergleichsweise störungsfreie Flächen. Untersuchungen zur Diversität auf botanischer und faunistischer Ebene belegen dies. Der Ansatz „Wildpflanzen für Biogas" birgt die Möglichkeit/Chance ökologische Ziele dort zu erreichen, wo das Flächenpotential am größten ist. Die bisherigen Ergebnisse zeigen, dass die Erfolge auch von den Bewirtschaftern als Gewinn geschätzt werden und „Leuchtturm-Charakter" haben könnten.

SESSION 19

Ecological intensification: biodiversity-enhancing measures that work for farmers

Chairs: Thijs Fijen, David Kleijn, Matthias Albrecht

Ecological intensification of agriculture proposes that actively managing for more ecosystem services can, in part, replace external inputs allowing farmers to maintain high crop yields while reducing adverse effects on the environment. Measures to enhance ecosystem services delivery usually require to take productive land out of production to establish, for example, wildflower strips or hedgerows. There is a growing scientific evidence base showing that these measures have the potential to increase the ecosystem service delivery to crops. However, it is not always clear whether the potential benefits of higher crop yields or revenue outweigh the establishment and opportunity costs of the measures. Recently, studies have started to take the service delivery effects on agricultural production into account, which is required to convince farmers of the benefits of ecological intensification. This session brings together state-of-the-art results of research highlighting the importance of translating service delivery to the concrete benefits for crop yield or revenue at spatial and temporal scales that are relevant to farmers.

Session 19-O1 - Enticing farmers for ecological intensification

Ecological intensification: bridging the gap between science and practice

David Kleijn[1], Thijs Fijen[1], Matthias Albrecht[2]

[1]Plant Ecology and Nature Conservation Groups, Wageningen University, Wageningen, NL, david.kleijn@wur.nl
[2]Agroscope, Zurich, CH

There is worldwide concern about the environmental costs of conventional intensification of agriculture. Growing evidence suggests that ecological intensification of mainstream farming can safeguard food production, with accompanying environmental benefits. Scientists are increasingly highlighting the benefits of ecologically intensifying agriculture through a greater reliance on biodiversity and ecosystem services. Policy makers likewise embrace ecological intensification as an environmentally friendly way towards food security by supporting the implementation of biodiversity and ecosystem service-enhancing practices. However, the approach is rarely adopted by farmers. This is possibly caused by scientists focusing on processes (e.g., pollination) rather than outcomes (e.g., profits), and express benefits at spatio-temporal scales that are not always relevant to farmers. This results in mismatches in perceived benefits of ecological intensification between scientists and farmers, which hinders its uptake. This presentation sets the scene for subsequent presentations in this session by discussing key knowledge gaps that should be addressed to overcome these mismatches and identify promising ways to make ecological intensification more attractive to groups that need to adopt it for it to have an impact.

Session 19-O2 - Enticing farmers for ecological intensification

Combining landscape and functional trait research to build ecological intensification in crops

Emily Martin[1], Matteo Dainese[2], Yann Clough[3], Nikos Alexandridis[3], Ingolf Steffan-Dewenter[1]

[1]University of Würzburg, Würzburg, DE, emily.martin@uni-wuerzburg.de
[2]EURAC, Bozen, IT
[3]Lund University, Lund, SE

Managing agricultural landscapes to support biodiversity and associated ecosystem services, such as pollination and natural pest control, could be a key avenue towards sustainable and climate-resilient agriculture that works for farmers. However, precisely how to manage these landscapes – and how effective this will be - is unclear. In a synthesis of data from 49 studies (1,515 landscapes) across Europe, we examined how landscape composition (% semi-natural habitat and arable land) and configuration (density of edges including crop/crop and crop/non-crop boundaries) impact arthropods in fields and their margins, pest control, pollination and yields. We show that edge density interacted with proportions of crop and non-crop habitats, and species' dietary, dispersal and overwintering traits led to contrasting responses. Overall, highest total arthropod densities were reached in landscapes combining high amounts of non-crop habitat and high edge density. In landscapes with high edge density, 70% of pollinator and 44% of natural enemy species reached highest densities and pollination and pest control improved 1.7 and 1.4-fold, respectively. Based on these results and 'syndromes' of species' traits, pathways to predictively assess ecosystem service potential can be derived to anticipate the effects of landscape- and field-scale management, towards a workable ecological intensification of agricultural production under global change.

Session 19-O3 - Enticing farmers for ecological intensification

Conserving biodiversity in agricultural landscapes: a win-win for farmer and wildlife?

Thijs Fijen[1]

[1]Wageningen University & Research, Wageningen, NL, thijs.fijen@wur.nl

Although agriculture depends critically on biodiversity-based ecosystem services such as insect pollination, conservation of biodiversity in agricultural landscapes has seen little uptake by the agricultural sector. We argue that this is largely because we lack knowledge on the relative importance of pollination compared to conventional agricultural inputs. Using the real-world variation in pollination and agricultural management of 36 commercial leek seed production fields, we show that the benefits of having more wild pollinators is just as large as the benefits of management enhancing plant quality. Although the bulk of the pollination services was delivered by a few abundant bumblebee species, a diverse pollinator community replaced, or complemented these dominant species, depending on the crop variety. We furthermore show that crop yields are equally large, or even larger with 50% reduced agricultural input levels, but that crop yield decreases substantially with reduced pollination. Both the dominant and the scarce crop pollinators were positively correlated with cover of semi-natural habitats and the regional pollinator species pool, illustrating the benefit of conserving natural elements in agricultural landscapes. However, the dominant crop pollinators were largely absent in the landscape just prior to leek flowering, possibly because they are specialized in exploiting mass-flowering (crop) plants. Identifying where these important pollinators acquire their resources in agricultural landscapes throughout their flight period is essential to convince the agricultural sector to conserve biodiversity in agricultural landscapes and how to take measures.

Session 19-O4 - Enticing farmers for ecological intensification

Agricultural diversification supports biodiversity and multiple ecosystem services without compromising yields

Giovanni Tamburini[1,2], Riccardo Bommarco[1], Thomas Cherico Wanger[1], Claire Kremen[3], Marcel G.A. van der Heijden[4], Matt Liebman[5], Sara Hallin[1]

[1]Swedish University of Agricultural Sciences, Uppsala, SE, giovanni.tamburini@nature.uni-freiburg.de
[2]University of Freiburg, Freiburg im Breisgau, DE, giovanni.tamburini@nature.uni-freiburg.de
[3]University of California, Berkeley, US
[4]Agroscope, Zürich, CH
[5]Iowa State University, Ames, US

Agriculture based on Green Revolution principles has been unable to deliver sustainable food production. High-input, resource-intensive farming systems have dramatically impacted the environment and jeopardized the ability of ecosystems to provide goods and services with negative implications for global food security. Agricultural diversification has been proposed as an alternative farming system and aims to support Biodiversity and related Ecosystem Services (BES) with reduced anthropogenic inputs and without affecting crop yields. So far, a comprehensive assessment of the effects of diversification practices on crop yield and BES is lacking. Here, we systematically reviewed published meta-analyses and performed a second-order meta-analysis based on a total of 5,188 original studies and 44,648 original comparisons. We show that agricultural diversification enhances biodiversity, nutrient cycling, soil fertility and water regulation without compromising crop yields. The variability observed in many BES responses indicates that the effects of diversification practices are context-dependent and highlights opportunities for realizing its benefits. Most often, we found agricultural diversification to promote win-win situations, simultaneously supporting the provision of several services while maintaining high levels of crop production. Our results suggest that the strategic adoption of diversification practices could contribute substantially to global food security, supporting yields while reducing negative impacts of crop production systems on the environment.

Session 19-O5 - Enticing farmers for ecological intensification

Adjacent agri-environmental schemes and landscape context shape distance functions for natural pest control in cereal fields

Fabian A. Boetzl[1], Maren Schuele[1], Jochen Krauss[1], Ingolf Steffan-Dewenter[1]

[1]Department for Animal Ecology and Tropical Biology (Zoology III), University of Würzburg, Würzburg, DE, fabian.boetzl@uni-wuerzburg.de

In the context of ecological intensification, natural pest control has gained increasing attention over the last decades. The effects of landscape composition and configuration on natural pest control and pest control agents have been studied intensively, but distance effects within crop fields have rarely been assessed. However, adjacent habitats and distance decay functions might affect the distribution of biocontrol providers. In a large scale field study featuring different agri-environmental schemes adjacent to oilseed rape within a landscape gradient of semi-natural habitat, we could show distance decay functions of ground dwelling predators from the field edge into the field centres. Reusing the same study design in the following year, we repeated ground dwelling predator recording and additionally recorded crop pests, predation rates, parasitoids as well as crop yields in winter cereals in order to see whether distance decay functions are similar for different crops. We found partly different distance functions of ground dwelling predators than reported for oilseed rape in the same design. Distance functions also differed between trophic levels and were modified by the amount of semi-natural habitat in the surrounding landscape. Thus, distance functions might be affected by various factors, among them crop type as well as landscape composition. Moreover, distance functions were not uniform across the trophic levels studied underpinning the need for a more mechanistic understanding of how ecosystem services respond to within field and landscape management. Once these response functions and their drivers are revealed, ecosystem service potentials can be predicted and ecological intensification approaches can be fostered and adjusted to specific needs.

Effectiveness of hedgerows for promoting biodiversity and ecosystem services in Mediterranean farmlands

Matteo Dainese[1], Lorenzo Marini[2]

[1]Eurac Research - Institute for Alpine Environment, Bolzano, IT, matteo.dainese@eurac.edu
[2]University of Padova - DAFNAE, Padova, IT

Over the past half-century, agricultural intensification has dramatically increased, transforming agricultural landscapes into simplified monocultures with a low cover of semi-natural habitat. This trend has led to severe biodiversity loss and the deterioration of key ecosystem services to agriculture. To reverse these negative trends several interventions have been suggested. Field-margin diversification through the conservation and restoration of hedgerows is becoming a prominent intervention for promoting biodiversity and ecosystem services in intensive agricultural landscapes. The effectiveness of introducing a hedgerow to improve farmland biodiversity and ecosystem services may depend, however, not only on the quality of the hedgerow, but also on the surrounding landscape. We will here present how hedgerows contribute to farmland biodiversity and ecosystem service delivery in Italian cereal fields under varying landscape complexity. In recent works, we found that the introduction of hedgerows was a key intervention to support high farmland biodiversity. We also found that ecosystem service delivery depended on the total cover of hedgerows in the surrounding landscape but not on the quality of the neighbouring field margins. While increasing the structural complexity and vegetation diversity of single hedgerows are certainly beneficial for conserving farmland biodiversity, our results suggest that, for supporting multiple ecosystem services, there is a need to promote the conservation of hedgerows at larger spatial scales. Specifically, hedgerows can serve to develop a network of ecological corridors that can facilitate the movement of beneficial organisms in the agricultural matrix. Such interventions may be a 'low cost–high benefit solution', since farmers can create or conserve high quality habitats taking little or no land from crop production and without the need to change their crop management.

Session 19-O7 - Enticing farmers for ecological intensification

Do wildflower plantings enhance crop pollination and pest control services? A quantitative synthesis on effectiveness, drivers and impacts on crop yield

Matthias Albrecht[1], David Kleijn[2], Louis Sutter[3]

[1]Agroscope, Zürich, CH, matthias.albrecht@agroscope.admin.ch
[2]Wageningen University & Research, Wageningen, NL
[3]Agroscope, Zürich, CH
[4]et al.

Wildflower plantings are promising measures to foster ecological intensification of agriculture through enhanced provisions of biodiversity-based ecosystem services. However, synthetic knowledge on the effectiveness of different types of wildflower plantings, their drivers and consequences on crop yield is currently lacking, hampering general conclusions and management recommendations for farmers. In this synthesis, we quantified the local impacts of flower strips and hedgerows on crop pollination and pest control services in adjacent fields compared to control fields lacking such plantings using empirical data of more than 500 sites across agricultural landscapes in Europe, North America and New Zealand. Strongest and most consistent benefits were found for flower strips enhancing pest control services in adjacent crop fields by more than 16% on average. Crop pollination was also enhanced by both flower strips and hedgerows, but effects were more variable. Time since establishment of flower strips and flowering plant species diversity were identified as important drivers of this variability: perennial flower strips in place for several years and more diverse plantings enhanced crop pollination most effectively. In general, crop pollination services declined exponentially from wildflower plantings and were increased up to distances of some tens of meters from plantings. Effects of wildflower plantings did not depend on landscape context. However, both pollination and pest control services declined with landscape simplification. In a subset of 194 sites impact of flower strips on crop yield could be examined but no consistent effects could be detected. We conclude that wildflower plantings are suitable measures to promote crop pollination and natural pest control services underpinning ecological intensification of agriculture.

Session 19-O8 - Enticing farmers for ecological intensification

Reducing grassland land use intensity promotes pollination and yield of adjacent sunflower crop fields, but economic benefits do not outweigh opportunity costs

Jeroen Scheper[1], Isabelle Badenhausser[2], Stefan Kirchweger[3], Carlos Zaragoza Trello[4], Ignasi Bartomeus[4], Vincent Bretagnolle[2], Yann Clough[5], Nicolas Gross[2], Jochen Kantelhardt[3], Ivo Raemakers[6], Montserrat Vila[4], David Kleijn[1]

[1]Plant Ecology and Nature Conservation Group, Wageningen University, Wageningen, NL, jeroen.scheper@wur.nl
[2]Centre d Etudes Biologiques de Chize, Villiers en Bois, FR
[3]Institute of Agricultural and Forestry Economics, University of Natural Resources and Life Sciences Vienna, Vienna, AT
[4]Estacion Biologica de Donana (EBD-CSIC), Seville, ES
[5]Centre for Environmental and Climate Research, Lund University, Lund, SE
[6]Ecologica, Maarheeze, NL

Ecological intensification, i.e. the integration of ecosystem service management into farming practices, has been advocated as an ecologically sustainable pathway to maintain and improve agricultural productivity, but little is known about its economic sustainability.
Using sunflower crop pollination as a model system, we show that pollination of sunflower crops can be enhanced by reducing the land use intensity of adjacent grassland, and that enhanced pollination can compensate for reduced external fertilizer input in the sunflower field. Grassland extensification also had clear positive effects on plant and bee diversity, including rare species. However, the economic benefits of enhanced pollination alone did not compensate for the opportunity costs of reduced grassland yield.
We argue that the merits of ecological intensification should be evaluated based on its impact on multiple ecosystem services, including the conservation of intrinsic biodiversity values.

Session 19-P1 - Enticing farmers for ecological intensification

Modelling the dynamics of soil functions for agricultural land use: how to adequately represent biological processes

Sara König[1,2], Birgit Lang[2,3], David Russell[2,3], Hans-Jörg Vogel[1,2], Ulrich Weller[1,2], Ute Wollschläger[1,2]

[1]UFZ - Helmholtz Centre for Environmental Research, Department of Soil System Science, Halle (Saale), DE, sara.koenig@ufz.de
[2]BonaRes - Centre for Soil Research, , DE, sara.koenig@ufz.de
[3]Senckenberg Museum of Natural History, Görlitz, DE

The increasing demand for food and bio-energy gives need to optimize soil productivity, while securing other soil functions such as nutrient cycling or water filtering. Soils are to a very large extent biologically driven systems and virtually all soil functions depend on ecological processes. These processes are accomplished by a myriad of organisms interacting along complex food webs within a highly heterogeneous habitat in terms of its physical and chemical properties. During the last decade, our technical capabilities to measure and characterize (micro) biological communities in soil increased enormously. Yet, it is not obvious how to use this information for modeling soil functional dynamics in response to perturbations.
It is an ongoing matter of debate in how far and to what detail biological processes and interactions need to be represented in modeling soil functions. Or, vice versa, in how far and to what extent biological processes can be adequately captured into "effective" descriptions and what these should be. This is a formidable scientific challenge related to upscaling biological processes from detailed interactions at the pore scale to effective soil functions at the scale of soil profiles which need to be tackled in a joined effort of soil ecologists and modelers.
Here, we take the modeling perspective by asking the question: what biological processes do we need to consider for modeling the dynamics of soil functions? We focus on five central soil functions: productivity, water storage and filtering, carbon storage, nutrient cycling and habitat for biological activity. We present our systemic soil model "Bodium" operating on a 1d soil profile to simulate the impact of different management options on soil functions and delineate our current approach to explicitly or implicitly consider biological processes. We discuss functional aspects relevant to address the five central soil functions and how they are linked to physical and chemical soil properties.

Session 19-P2 - Enticing farmers for ecological intensification

OptAKlim - Optimizing agricultural cropping strategies and measures for climate adaptation

Sandra Krengel[1], Jörn Strassemeyer[1], Anto Raja Dominic[1], Madeleine Paap[1], Michael Glemnitz[2], Claudia Bethwell[2], Ralf Bloch[2], Tobias Conradt[3], Christoph Menz[3], Stefan Lange[3], Joachim Aurbacher[4], Janine Müller[4], Philip Rabenau[4], Christine von Buttlar[5]

[1] Julius Kühn-Institut, Kleinmachnow, DE
[2] Leibniz-Zentrum für Agrarlandschaftsforschung e.V., Müncheberg, DE
[3] Potsdam-Institut für Klimafolgenforschung, Potsdam, DE
[4] Justus-Liebig-Universität Gießen, Gießen, DE
[5] Ingenieurgemeinschaft für Landwirtschaft und Umwelt, Göttingen, DE

The aim of the project is to analyse the impact of climate change on agricultural cropping systems under current climate and future climate scenarios on a regional scale and to optimize cropping strategies and measures for climate adaptation and greenhouse gas emission mitigation.
Climate change has multiple effects on the emergence of crop pests, the relative economic performance of particular crops as well as regional crop patterns in general. We consider three case study regions in Germany, representing different soil climate conditions (ERA-regions, Roßberg et al. 2007) and model future climate change effects on agriculture. Based on current cropping systems, pests emergence patterns (from literature review), plant protection scenarios (data from plant protection farm networks) and the trade-offs to environmental services (e.g. with SYNOPS to assess environmental risk from pesticide applications) future scenarios will be created with climate scenario projections (ISI-MIP, Warszawski et al., 2014). In cooperation with farmers and experts we adjust the adaptation and mitigation measures to specific, regional key problems and trade-offs, both ecological and economic. Through extensive networking with stakeholders, the results from the project will be tested and put into practice.

Session 19-P3 - Enticing farmers for ecological intensification

Divergent perspectives of farmers and scientists on biodiversity

Bea Maas[2], Yvonne Fabian[1], Anett Richter[4,5]

[1]Agroecology, Georg-August University Göttingen, Göttingen, DE, yvonne.fabian33@gmail.com
[2]Department of Botany and Biodiversity Research, University of Vienna, Vienna, AT
[4]Helmholtz Centre for Environmental Research - UFZ, Leipzig, DE
[5]German Centre for Integrative Biodiversity Research (iDiv) Halle-Jena-Leipzig, Leipzig, DE

Biodiversity and associated ecosystem services are increasingly threatened by the intensification of land use. Measures for the conservation of biodiversity in agricultural landscapes are increasingly being developed, but are also perceived differently by members of science and society.
In 2018, we conducted an online survey to understand perspectives of early career life scientists (n = 98) and farmers (n = 208) in Germany and Austria towards the importance of (1) biodiversity and ecosystem services, (2) agri-environment schemes and conservation measures, and (3) information sources and transfer for agricultural productivity and decision-making.
Farmers and scientists showed divergent perspectives on the topics, but also numerous similarities indicating different knowledge and implementation spaces. For example, our results demonstrate a high appreciation of pollination services independent of profession, but surprisingly low regard for pest control by farmers. Scientists generally showed more positive attitudes towards biodiversity and conservation measures than farmers. Hunting measures showed the largest uni-security area in both groups. The most divergent perspectives were observed in relation to information exchange in agriculture, with only 15% of farmers evaluating scientific publications as important for agricultural decision-making processes. Farmers' perceptions significantly differed depending on socio-demographic factors such as gender, education level and farming approach (i.e., organic, conventional and dual farming).
Our results provide crucial insights into various perceptions of biodiversity, related ecosystem services and conservation measures within the European land use context. Based on these new findings, we discuss how to improve the planning and implementation of agro-ecological conservation studies, and measures for agricultural policy- and decision-making.

SESSION 20

Agroecology - from local to landscape management

Chairs: Christoph Scherber, Teja Tscharntke

Agroecosystems are under increasing pressure worldwide to produce food and feed but simultaneously support both on-farm and surrounding biodiversity at multiple spatial scales. Current management incentives either focus on creating or enhancing local habitats, buffering negative management effects to natural landscape elements, or enhancing of on-farm biodiversity in space and time (crop rotations, intercropping). The science of agroecology has never been faced with so many challenges from so many different interest groups, including nature conservationists, farmer associations and the general public. In this session, we will bring together key scientists from basic and applied fields of agroecology to discuss recent developments and approaches from science to practice. Talks will cover ecological networks in agroecosystems, multifunctionality, multi-scale approaches to biodiversity monitoring and recent developments in agrobiodiversity management and conservation.

Session 20-O1 - Agroecology

Certification of biodiversity-friendly farming needs a landscape perspective

Teja Tscharntke[1], Péter Batáry[2]

[1]Agroecology, University of Göttingen, Göttingen, DE, ttschar@gwdg.de
[2]Landscape and Conservation Ecology, MTA Centre for Ecological Research, Vacratot, HU

Certification offers a promising mechanism to mitigate the severe negative impacts of agricultural expansion and intensification on biodiversity. From a conservation standpoint, organic certification of crops is of particular interest given the potential biodiversity value organic farming and its substantial market penetration in recent years.
Here, we summarize evidence for conservation impact and explore future needs. While there is much evidence that reductions in pesticide and mineral fertilizer use enhance biodiversity, the farm-scale focus of current certification models limits delivery of biodiversity conservation benefits, as maintenance of biodiversity depends on processes at larger landscape scales. To address this scale mismatch, we suggest that investment and innovation in certification over the next decade prioritize landscape conservation outcomes. This may be achieved by (1) linking organic certification with broader landscape and ecosystem service management approaches and/or (2) expanding current certification models to consider the landscape itself as the certified unit.

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Session 20-O2 - Agroecology

The cultivation of faba beans increases bumblebee abundances at landscape scale

Nicole Beyer[1], Felix Kirsch[1], Katharina Schulz[2], Georg Everwand[2], Stefan Mecke[2], Doreen Gabriel[3], Jens Dauber[2], Catrin Westphal[1]

[1]Functional Agrobiodiversity, Department of Crop Sciences, University of Göttingen, Göttingen, DE, nicole.beyer@uni-goettingen.de
[2]Thünen Institute of Biodiversity, Braunschweig, DE
[3]Institute of Crop and Soil Science, Julius Kühn-Institut, Braunschweig, DE

The use of grain legumes in crop rotations provides several environmental benefits, like increased soil fertility, diversification of crop rotations or the provision of pollen and nectar for insects. Faba beans (*Vicia faba*) may play an important role as supplementary food resource for pollinators during midsummer when floral resources are often lacking in simplified agricultural landscapes. Nevertheless, grain legumes make up only approx. 1 % of the total agricultural production area in Germany but their cultivation increased since 2014, when they got approved as ecological focus area as part of the greening measures promoted by the CAP. However, their contribution to biodiversity has been questioned.
We hypothesize that diversified crop sequences with faba beans enhance the abundance and diversity of bumblebees at landscape scale. Furthermore, we expect that long-tongued bumblebees benefit more from the cultivation of faba beans than short-tongued individuals due to the morphology of the tubular bean flowers with low nectar accessibility.
Using a landscape-scale approach, we selected 30 paired study landscapes in Germany, i.e. 15 landscapes comprising at least one faba bean field and 15 landscapes without grain legumes. In 2017 seven standardized transect walks were conducted at the field margins of the different crop types in every landscape (repeated 3 times). The abundance and diversity of bumblebees was recorded.
Our results show that bumblebees were more abundant in landscapes with faba beans. This effect remained after the flowering of the beans had ceased. The presence of *Vicia faba* fields was more important for long- than short-tongued bumblebees.
We conclude that the cultivation of grain legumes offers an additional food supply that positively affects bumblebee densities. Diversification of crop sequences with faba beans might be an important conservation measure to promote in particular long-tonged pollinators in agricultural landscapes.

Session 20-O3 - Agroecology

Complementarity vs. selection: Is flowering plant diversity or identity more important for the reproductive success of solitary wild bees?

Felix Klaus[1], Teja Tscharntke[1], Ingo Grass[1]

[1]Agroecology Group, Georg August University of Göttingen, Göttingen, DE, felix.klaus@uni-goettingen.de

Two hypotheses in ecology describe how biodiversity can increase ecosystem functioning. The selection hypothesis states that there is a higher chance of having exceptionally beneficial species (those contributing most to ecosystem functioning) in more diverse communities. Alternatively, the complementarity hypothesis states that diverse communities enhance ecosystem functioning due to partitioning of resource use or facilitation.
Here, we tested these hypotheses in a mesocosm experiment consisting of 60 mesocosms with gradients of flowering plant species richness and composition. The reproductive success of solitary bees (offspring of *Osmia bicornis*) was measured as a functional response to plant resources.
The results indicate that both complementarity and selection effects positively affected solitary bee reproductive success. The Shannon diversity of flowering plants increased the number of brood cells, indicating complementarity effects. In addition, the presence of oilseed rape (*Brassica napus*) and *Phacelia tanacetifolia* further increased reproduction (selection effect).
In conclusion, both resource diversity, as well as the identity of some key species increased the reproductive success of solitary wild bees. The complementarity and selection hypotheses are both relevant to best describe the patterns observed. With greater knowledge of floral resource utilization and diversity effects on solitary bees, seed mixes for flower strips can be improved contributing to more targeted and effective agri-environmental schemes.

Session 20-O4 - Agroecology

Crop rotations determine bumblebee communities via flower resources

Riho Marja[1], Eneli Viik[2], Marika Mänd[3], James Phillips[4], Alexandra-Maria Klein[5], Péter Batáry[6]

[1]Landscape and Conservation Ecology, MTA Centre for Ecological Research, Vácrátót, HU, Riho.Marja@gmail.com
[2]Agricultural Research Centre, Tartu, EE
[3]University of Life Science, Tartu, EE
[4]University of Brighton, Tartu, EE
[5]University of Freiburg, Freiburg, DE
[6]Landscape and Conservation Ecology, MTA Centre for Ecological Research, Vácrátót, HU

In many parts of the world, farmland pollinators decreased significantly during the last half of the 20th century. We studied the effect of different typical crop rotations and agri-environment schemes (AES) on bumblebee diversity. We compared species abundances between four crop rotation types [cereal rollover (no change from one year to the next), cereal to mass flowering crops (hereafter MFC), MFC rollover, and MFC to cereal fields], where all counts were conducted in the second year, and three farming types (conventional farming, and two AES: organic; the less strict than organic environmentally friendly management). We recorded bumblebee species richness and abundance, but also flower cover along 401 field margin transects. Bumblebee species were grouped based on functional traits and threat status. Flower cover was higher in the field margins of MFC rollover and cereal to MFC fields, than the reference cereal rollover fields. Abundances of long-tongued and threatened bumblebee species were higher at the field margins of cereal rollover fields than the field margins of the other three crop rotation types. In addition, cereal rollover field margins had significantly higher abundances of medium colony species, generalists, and forest-scrub species than MFC rollover and MFC to cereal field margins. Bumblebee species richness was significantly higher at the field margins of both AES types than those of conventional farming. However, in general the strongest driver of bumblebee presence was flower cover. Higher bumblebee abundances in cereal rollover field margins were probably owing to a concentration effect at the field margins of cereal fields and/or a dilution effect into MFC fields. Both Estonian AES schemes supported increasing flower cover in field margins and thereby diversity of bumblebees, indicating positive AES impacts upon wild pollinators. Crop rotation could be a simple, but efficient solution to increasing the biodiversity of agricultural landscapes.

Session 20-O5 - Agroecology

Flower strips and organic farming support biological pest control and pollination differently along a gradient in landscape configurational heterogeneity

Peter Batary[1], Edina Török[1], Costanza Geppert[2], Rita Földesi[3], Sinja Zieger[3], Jacob Rosenthal[3], Bettina Donko[3], Asma Akter[4], Robert Galle[1], Annika Hass[3], Teja Tscharntke[3]

[1]Hungarian Academy of Sciences, Landscape and Conservation Ecology, Vacratot, HU, batary.peter@okologia.mta.hu
[2]University of Padova, DAFNAEEntomology, Padova, IT
[3]University of Goettingen, Agroecology, Göttingen, DE
[4]Biology Centre of the Czech Academy of Sciences, Institute of Entomology, Ceske Budejovice, CZ

Agri-environment scheme (AES) approaches can be classified according to whether they prescribe management in non-productive areas, such as field boundaries and wildflower strips, or in productive areas, such as arable crops or grasslands. Here we test the ecological effectiveness of two popular AESs in Germany: wildflower strips next to winter wheat fields as off-field practice and organic farming on winter wheat fields as on-field practice. For doing this, we selected ten landscapes along a field size gradient with three wheat fields, one conventional field with flower strip, one organic field and one conventional field without flower strip as a common control. We sampled cereal leaf beetles (CLB) and cereal aphids and their natural enemies, and performed an aphid card experiment in field edges and field interiors. Furthermore, we performed a colony performance experiment with commercial bumblebee colonies in field margins. Organic farming had the lowest number of CLB larvae. In contrast, conventional fields with adjacent flower strips harbored highest numbers of aphids, but also exhibited highest rates of parasitism, potentially outweighing the negative effect of flowers strips on aphid infestation. On a landscape scale, CLB natural enemies were supported by smaller field sizes. Bumblebee colony growth and richness of insect-pollinated plants benefited equally from organic and flower strip schemes. Smaller fields, i.e. increasing configurational landscape heterogeneity, also had a positive effect on the richness of insect-pollinated plants and on bumblebee reproduction in flower strips, whereas bumblebee colonies in organic agriculture benefited most from large fields. In summary, both AES as well as landscape heterogeneity support farmland biodiversity and ecosystem services depending on the taxonomic group.

Session 20-O6 - Agroecology

Agrobiodiversity: abandonment of mountainous grasslands and establishment of lowland grasslands

Thomas Frank[1], Arne Arnberger[2], Andreas Bohner[3], Manuela Brandl[1], Raja I. Hussain[1], Bea Maas[4], Dietmar Moser[4], Ronnie Walcher[1], Johann G. Zaller[1]

[1]University of Natural Resources and Life Sciences Vienna (BOKU), Institute of Zoology, Vienna, Austria, Vienna, AT, thomas.frank@boku.ac.at
[2]University of Natural Resources and Life Sciences Vienna (BOKU), Institute of Landscape Development, Recreation and Conservation Planning (ILEN), Vienna, Austria, Vienna, AT
[3]Agricultural Research and Education Centre Raumberg-Gumpenstein, Irdning-Donnersbachtal, Austria, Irdning-Donnersbachtal, AT
[4]University of Vienna, Department of Conservation Biology, Vegetation Ecology and Landscape Ecology, Austria, Vienna, AT

Abandonment of extensively managed mountainous meadows represents an increasing threat to biodiversity and ecosystem functions that benefit human well-being. To address associated socio-ecological challenges, we studied the effects of meadow abandonment on species richness and composition of plants and insects, human health and well-being in a Swiss and two Austrian alpine regions in the "Healthy Alps" research project. Plant and bumblebee richness were significantly higher in extensively mown meadows compared to abandoned meadows. However, species numbers of true bugs and grasshoppers did not differ between both management types. Abandoned and managed meadows harbored significantly different assemblages of bugs and grasshoppers, but not of bumblebees. From an insect conservation perspective, maintaining a mosaic of both abandoned and extensively managed meadows appears desirable. Perceived health benefits of 22 study participants were significantly higher in mown meadows than in abandoned ones, suggesting crucial benefits of managed meadows. Perceived naturalness by humans was positively correlated with plant richness and flower cover. However, we found a negative relationship between grasshopper diversity and both stress reduction, and human well-being.
Agri-environment schemes have been initiated to counteract the rapid loss of biodiversity in European agroecosystems caused by agricultural intensification and decreased landscape heterogeneity. In the current research project "REGRASS" we compare arthropod diversity between long-existing extensively managed meadows, newly-established grasslands by the project, and Austrian "biodiversity areas" being part of ongoing agri-environment measures. According to preliminary results, the newly_established grasslands appear to be particularly attractive to insect pollinators, thus perhaps being a promising complement to already existing agri-environment schemes.

Session 20-O7 - Agroecology

Alternating annual and biennial flower fields – an effective measure for promoting farmland biodiversity?

Annika Hass[1,2], Julia Piko[1,2], Andreas Wiedenmann[2,3], Eckhard Gottschalk[3], Costanza Geppert[2,5], Yvonne Fabian[2], Teja Tscharntke[2], Catrin Westphal[1], Péter Batáry[4]

[1]Functional Agrobiodiversity, Department of Crop Sciences, University of Göttingen, Göttingen, DE, ahass@gwdg.de
[2]Agroecology, Department of Crop Sciences, University of Göttingen, Göttingen, DE, ahass@gwdg.de
[3]Conservation Biology, University of Göttingen, Göttingen, DE
[4]Landscape and Conservation Ecology, MTA Centre for Ecological Research, Vácrátót, HU
[5]DAFNAE, University of Padova, Padova, IT

In the EU, agri-environment schemes were developed to counteract the dramatic losses of farmland biodiversity and one popular measure are flower strips and flower fields. In Lower Saxony, Germany farmers receive payments for three different flower field types (FFT): annual flower fields, perennial flower fields (persist at least 5 years) and alternating flower fields with an annual and a biennial part which are alternated every year.
We studied species richness and abundance of nine different taxa (birds, solitary bees, bumble bees, hoverflies, leafhoppers, true bugs, leaf beetles, weevils and spiders) in the three different FFT and compared them to conventionally managed cereal fields (overall 28 sites). We expected that species richness and abundance of most taxa would be highest in alternating flower fields due to the highest structural diversity and the combination of flower rich annual and more undisturbed biennial parts.
Results show that bird species richness and abundance was significantly higher in alternating flower fields compared to cereal fields as predicted, but surprisingly not in annual and perennial flower fields. The abundance of solitary bees was equally enhanced in all FFT, but bumble bees had the highest abundance in annual flower fields due to the high floral resource availability. Hoverflies had equal abundances across all habitat types.
We conclude that alternating flower fields are a promising measure to enhance biodiversity, especially of farmland birds. However, all FFT could be improved to offer essential resources for a wide range of taxa. Furthermore, each FFT benefits different taxa indicating that a combination of different FFT at the landscape scale could enhance multi-taxa diversity in agricultural landscapes.

Session 20-O8 - Agroecology

Wildflower strips as an integral part of multifunctional agricultural landscapes – synthesizing a potpourri of empirical knowledge

Tim Diekötter[1]

[1]Kiel University, Kiel, DE, tdiekoetter@ecology.uni-kiel.de

Sown wildflower strips are a popular agri-environment scheme to maintain biodiversity and to promote associated ecosystem services in agricultural landscapes. As such, they have frequently been assessed in their efficiency. Often, however, these assessments have focused on the obvious beneficiaries like flower-visiting or pollinating insects and largely ignored other trophic guilds such as invertebrate predators and parasitoids which provide equally important ecosystem services. In addition, biodiversity effects of sown wildflower strips have almost exclusively been assessed during the vegetation period, whereas studies on their suitability as an overwintering habitat remain scarce. While varying effects of wildflower strips on the biodiversity in agricultural landscapes in these studies have been attributed to the landscape context and the associated contrast in resources, the potentially different roles of transient (e.g. other wildflower strips) or permanent (e.g. hedgerows) landscape elements in the functioning of wildflower strips have not been studied so far. Against this background, we compiled more than one decade of our own research on the effects of sown wildflower strips on biodiversity and ecosystem services, discuss our findings in the context of current research and advocate an integration of today´s often guild-specific approaches as a way towards more biodiverse and multifunctional agricultural landscapes of tomorrow.

Session 20-O9 - Agroecology

Landscape management of nocturnal wildlife by flower fields and hedgerows

Yvonne Fabian[1], Celina Herrera Krings[1], Annika Hass[1,3], Peter Batary[1,2], Teja Tscharntke[1]

[1]University of Göttingen, Agroecology, Georg-August University Göttingen, Göttingen, DE, yvonne.fabian33@gmail.com
[2]Landscape and Conservation Ecology, MTA Centre for Ecological Research, Vácrátót, HU
[3]University of Göttingen, Functional Agrobiodiversity, Georg-August University Göttingen, Göttingen, DE

Mitigating the detrimental impacts of intensive farming on agricultural biodiversity requires the implementation of targeted agri-environmental schemes (AES) to enhance populations of threatened species inhabiting farmland. Yet the effectiveness of such schemes for nocturnal wildlife remains unknown. In 2018, we compared activity and species richness of bats and their prey in annual-, alternating- and perennial wildflower fields, hedges or winter wheat fields (35 plots in total) in intensively used agricultural landscapes in western Germany. We investigated the effect of landscape context on bats as we expect that highly mobile species would benefit further from landscape-scale management as e.g. a higher landscape composition.
Hedges, perennial - and alternating wildflower fields showed the highest bat activity and species richness compared to annual wildflower fields and winter wheat fields. These results appeared to be due to the increased abundance of nocturnal prey in AESs. Bat activity was also influenced by landscape attributes, as bats are highly mobile species. We conclude that the combination and spatial arrangement of different AES could strongly improve nocturnal biodiversity in intensively used agricultural landscapes.

Session 20-O10 - Agroecology

Farming for the future: Approaches to reconcile biodiversity and production in European farming systems

Christoph Scherber[1]

[1]University of Muenster, Muenster, DE, Christoph.Scherber@uni-muenster.de

Increased agricultural production intensity and land-use change are currently considered to be major drivers of anthropogenic biodiversity loss. Consequently, a variety of approaches have been developed that aim to conserve biodiversity in agricultural landscapes without losses in crop yield. In this talk, I will show results from a wide range of agro-ecological experiments and systems (e.g. intercropping and crop rotation experiments) and provide scenarios for optimized land-use that allows both high yield and high biodiversity in European farming systems. I will compare a range of strategies such as organic farming, set-aside management, intercropping, crop rotations, and field margin management. The talk will conclude with recommendations for the future of biodiversity-friendly farming systems across Europe.

Session 20-O11 - Agroecology

Effects of farming practice on the establishment of rare arable plant species in different three-year crop rotations

Marion Lang[1], Johannes Kollmann[1], Harald Albrecht[1]

[1]Chair of Restoration Ecology, Technical University of Munich, Munich, DE, marion.lang@tum.de

The vegetation of arable fields has been dramatically depleted in the last decades. In addition to preserving remnant populations, the introduction of autochthonous seeds is a promising measure to promote threatened plant species and to restore agro-ecosystems. However, knowledge about suitable establishment conditions for sown species is scarce.

We set up a field experiment with different three-year crop rotations on an organic farm near Munich, Germany. The impact of crop sowing density, crop type and soil tillage on establishment of three winter annuals (*Legousia speculum-veneris*, *Consolida regalis*, *Lithospermum arvense*) was investigated. Arable plants were sown in a mixture of 850 m^{-2} on 80 plots, arranged in a Latin square design with 14 treatments and five repetitions.

Establishment was highest in *L. speculum-veneris*, followed by *C. regalis* and *L. arvense* being highly correlated with cover of crops and weeds during the study period. Initial crop sowing densities led to significant differences in establishment of the study species (0%>25%>100% spelt sowing density). Density and seed production of rare arable plants in the second year were significantly affected by crop type (spelt>summer triticale>pea>clover-grass), but not soil tillage (harrow vs. plough). In the third year, all plots were cultivated with rye and all study species were present in aboveground vegetation as well as in the soil seed bank. Overall, establishment was highest in the crop rotation no crop/rye/rye and lowest in rye/clover-grass/rye.

Our study demonstrates that the reintroduction of rare arable plants can be implemented in different crop rotations, with best results in extensively managed fields with low crop competition.

Session 20-O12 - Agroecology

Arable weed diversity in intensive agricultural landscapes: does scale matter?

Laura Sutcliffe[1], Liesa Schnee[1], Christoph Leuschner[1]

[1]Georg-August University of Göttingen, Göttingen, DE, lsutcli@uni-goettingen.de

With arable land covering around 70% of the utilized agricultural area in Germany (59% in the EU), arable weed communities lie at the heart of European agroecosystems. This group of plant species forms the basis of trophic webs, and their precipitous decline over the last century has been one of the central factors in the biodiversity crisis currently observed in intensively farmed European landscapes.
In this study, we first test the hypothesis that diverse arable weed communities are less prone to dominance of problematic (i.e. yield-reducing) species. Based on the premise that the benefits of a sparse but diverse weed community outweigh threats to crop production, we look at how plant movement and persistence in the landscape might affect local diversity, and how this interacts with conservation measures such as sown flower strips and extensive cereals (i.e. without application of fertiliser or pesticides). Our central question is which spatial scale has the greatest influence on arable weed vegetation: the seed bank (immediate local), neighboring habitats (small-scale spillover) or landscape (1 km radius), and how do these scales interact?
The dataset stems from four years of monitoring on nine intensive arable farms distributed over the whole of Germany. They form part of a long-term conservation project aiming to improve the functional biodiversity on agricultural land from a very low starting point. The question of scale is of great relevance to conservation practice in intensive agricultural landscapes, where allowing spontaneous regeneration from the seedbank might be the easiest approach to increasing plant diversity, but may not be effective without diaspores from small-scale or large-scale dispersal.

Session 20-O13 - Agroecology

Trade-offs between multifunctionality and profit in tropical smallholder landscapes

Ingo Grass[1]

[1]University of Goettingen, Göttingen, DE, igrass@gwdg.de

Land-use transitions can enhance the livelihoods of smallholder farmers but potential economic-ecological trade-offs remain poorly understood. We present a multidisciplinary study of a tropical smallholder landscape and find widespread biodiversity-profit trade-offs resulting from land-use transitions from forest and agroforestry systems to rubber and oil palm monocultures, for 26,894 aboveground and belowground species and ecosystem multidiversity. Despite variation between ecosystem functions, profit gains come at the expense of ecosystem multifunctionality, indicating far-reaching ecosystem deterioration. Using a genetic algorithm we identify landscape compositions that can mitigate trade-offs under optimal land-use allocation but also show that intensive monocultures always lead to higher profits. These findings suggest that losses in biodiversity and ecosystem functioning can only be reduced if economic incentive structures are changed through well-designed policies.

Session 20-O14 - Agroecology

Wildflower strips enhance wild bee reproductive success

Dominik Ganser[1,2], Matthias Albrecht[1], Eva Knop[2]

[1]Agroscope, Zürich, CH, dominik.ganser@iee.unibe.ch
[2]University of Bern, Bern, CH, dominik.ganser@iee.unibe.ch

The intensification of agricultural practices has led to a decline of pollinators. To mitigate the negative consequences of intensified agricultural practices, wildflower strips are sown as part of national agri-environmental schemes in many European countries. While several studies have shown that wild pollinator abundance and diversity are increased on such wildflower strips, we lack evidence whether they also enhance pollinator fitness and population size. We thus asked whether wildflower strips or forests are i) used by bees to provision offspring with pollen, ii) reducing foraging trip duration and iii) parasitism rate, and thereby iv) increasing reproductive success. To do so, we experimentally set up founder populations of seven wild bee species on sites subject to three different treatments: with floral enhancements, close to forest, and without semi-natural habitats in the surroundings of 350m. We show that bee offspring was provisioned primarily with pollen from sown flowers in wildflower strips. This led to shorter foraging trips, reduced parasitism rates and increased reproductive success. Less mobile, smaller species benefitted strongest. Our findings demonstrate that wildflower strips enhance wild bee reproductive success and mitigate negative impacts of agroecosystem simplification, primarily through the provision of suitable floral resources and reduced foraging times required for offspring provisioning.

Session 20-O15 - Agroecology

Soil microbial indicators for the assessment of temporal diversification in agro-ecosystems

Ute Hamer[1], Ulf-Niklas Meyer[1], Michael Ulrich Thomas Meyer[1], Christoph Scherber[1]

[1]Institute of Landscape Ecology, WWU Münster, Münster, DE, ute.hamer@uni-muenster.de

Soil organisms are important for the conservation of most ecosystem services and they react very fast on changes in environmental conditions. Thus, soil biological parameters are considered as valuable indicators to identify sustainable soil management strategies. However, there is still a lack of standardized methods and assessment criteria which should be robust and sensitive, warn early, facilitate reliable projections and show site specific potentials. Ideally all aspects of soil microbial biodiversity e.g. activity, biomass and community structure should be taken into account. A short overview of European approaches will be given and combined with data obtained in a long-term agricultural field experiment with temporal diversification. The crop rotation trial was set up in 2006 in Lower Saxony, Germany close to the city of Göttingen. During the last 2.5 years, soil microbial biomass as well as enzyme kinetics were measured in the topsoil (0-10 cm depth, Luvisol). In addition below- and aboveground biodiversity will be linked.

Session 20-O16 - Agroecology

The influence of habitat, colony density and nest marking on Northern Lapwing (*Vanellus vanellus*) nest survival in an industrial agricultural landscape

Dora Schilling[1], Aline Förster[2], Kristian Lilje[2], Anneka Pelster[3], Ilona Bertling[1], Frederik Wietheger[3], Lars Gaedicke[1], Johannes Kamp[1,4]

[1]Westfälische Wilhelms-Universität, Münster, DE, schilling@wwu.de
[2]NABU Naturschutzstation Münsterland, Münster, DE
[3]Hochschule Osnabrück, Osnabrück, DE
[4]Dachverband Deutscher Avifaunisten, Münster, DE

Agricultural intensification has resulted in a loss of farmland biodiversity across Europe. Farmland birds are often used as indicators in agricultural landscapes. A particularly strong decline was observed in the Northern Lapwing (*Vanellus vanellus*) whose numbers dropped by 80% in Germany between 1990 and 2016. Low breeding success has been proposed as a key driver of declines, and measures to increase reproductive output were developed. A popular measure among conservationists is to mark nests before tillage to prevent them from being destroyed, but the effectiveness of this time-consuming and expensive measure has never been tested.
We monitored the fates of 1,155 lapwing nests in the Münsterland region, NW Germany, over a period of seven years. We compared nesting success across breeding habitats and related it to colony density and nest marking activities.
Nest survival varied strongly between habitats. Low survival probabilities were found in colonies that were initiated on cropland prior to tillage, and higher survival rates where they established after tillage operations. Nests on urban brownfields (with no agricultural operations) had particular high hatching success. The most important cause for nest failure was depredation, but this again was habitat-specific. Nests in larger colonies were more likely to survive. Nests on cropland that were marked had a higher daily survival probability (0.478) than those that remained unmarked (0.312).
We conclude that marking nests is an efficient measure to increase nest survival of cropland-breeding birds, but that interactions with habitat and predation need to be considered.

Effects of food availability, vegetation and landscape structure on woodlark *Lullula arborea* in vineyards

Verena Rösch[1], Pascal Aloisio[1], Martin H Entling[1]

[1]Universität Koblenz-Landau, Institute for Environmental Sciences, Landau, DE, roesch@uni-landau.de

Vineyards can offer attractive habitats for a range of species, despite being one of the most intensively managed agro-ecosystems due to frequent soil tillage, pesticide applications and landscape simplification. In Germany, Palatinate is the largest wine-producing region. The vineyards in the Haardtrand area west of the city of Landau harbor over a third of its woodlark (*Lullula arborea*) population of the state. In this region most vineyards harbor a high amount of ground vegetation. However, while in some vineyards all the ground between the vine rows (inter-rows) is vegetated, others are managed under an alternating system of vegetated and bare inter-rows.

During this study, we compared how different vineyard management practices and resource availability (arthropods, dicotyledonous herbs) affect woodlark territory selection. In spring 2018 we identified 26 vineyard areas in which woodlark territories were present (presence areas) and as well as 26 nearby areas where woodlarks were absent (absence areas). Ground cover type (vegetated or bare) as well as vegetation composition (herbs vs. grasses) and height in both presence and absence areas were recorded. Arthropods were sampled using pitfall traps.

The vegetation in woodlark territories was shorter and more dominated by herbs than in absence areas. The amount of bare soil had no effect on woodlark territory presence or absence. Woodlarks also favoured areas with a higher abundance of arthropods and a larger distance to urban areas.

We conclude that in order to promote the woodlark in vine growing areas the vegetation should be kept short to facilitate foraging. Furthermore, pesticide applications should be kept at a minimum to increase arthropod abundances which are the main food source for woodlark chicks. This could in part be achieved through the use of novel fungus resistant vine cultivars.

Session 20-P1 - Agroecology

Effects of organic farming on ecosystem services and grassland multifunctionality: the *ServiceGrass* project

Valentin H. Klaus[1], Nadja El Benni[2], Andreas Lüscher[3]

[1]ETH Zürich, Zürich, CH, valentin.klaus@usys.ethz.ch
[2]Agroscope, Tänikon, CH
[3]Agroscope, Reckenholz, CH

Sustainable agriculture delivers not only private ecosystem services such as market goods, but also many public ecosystem services, i.e. non-market goods and services. All these services are vitally needed to secure human well-being. Agricultural intensification, however, undermines the delivery of many public ecosystem services. Organic farming can decrease the environmental impact of intensive food production and might therefore be able to sustain the delivery of both private and public ecosystem services. However, this has never been comprehensively tested, especially not for organically managed grasslands. In the project *ServiceGrass*, we explore effects of organic grassland farming on 18 different ecosystem services and their simultaneous provisioning, referred to as multifunctionality. The principal aims are i) to compare the ability of organic and conventional grasslands to deliver ecosystem services, ii) to explain the impact of management (intensification) on multifunctionality, and iii) to upscale plot-level results to entire farms. Ecosystem services will be assessed within two study systems: in the DOC trial containing organically and conventionally managed temporary grasslands and in on-farm plots in organic and conventional permanent grasslands in Switzerland. To assess the delivery of ecosystem services of grassland at farm-level, we will combine plot-level measurements with the Swiss Farm Accountancy Data Network, a database that contains detailed information on technical, structural and economic properties of more than 1000 Swiss grassland based farms. For overarching synthesis, we look for further available data on any type of organically managed grassland from previous projects. Findings of this project will underline strengths and weaknesses of organic and conventional farming systems in delivering private and public ecosystem services, helping to improve grassland farming for a more sustainable future.

Session 20-P2 - Agroecology

Redesign agricultural landscapes towards climate-smart agriculture: integration of shelterbelts reduce evapotranspiration in vineyards in the Western Cape, South Africa

Maik Veste[1,2], Thomas Littmann[3], Anton Kunneke[4], Ben du Toit[4]

[1]Brandenburgische Technische Universität Cottbus-Senftenberg, Cottbus, DE, maik.veste@icloud.com
[2]CEBra - Centrum für Energietechnologie Brandenburg e.V., Cottbus, DE, maik.veste@icloud.com
[3]DLC - Dr. Littmann Consulting, Ennepetal, DE
[4]Stellenbosch University, AgriSciences, Stellenbosch, ZA

With increasing human population and agricultural production, water and land will become precious resources in South Africa and the reduction of crop water consumption is an important challenge for sustainable agriculture. A key approach to reduce water demands are eco-engineering measures influencing directly soil evaporation and crop transpiration. The redesign of the agricultural landscape by the introduction of specifically designed obstacles to air flow will significantly influence the near-ground wind field. In a first step we analyzed the influence of a planted tree hedgerow within the vineyard on the reduction of near-ground wind speed and evapotranspiration near Paarl (Western Cape, South Africa). Detailed measurements of meteorological parameters relevant for the computation of reference and crop specific evapotranspiration following the FAO 56 approach within a vineyard in the Western Cape Province of South Africa have shown the beneficial effect of an existing hedgerow consisting of 6 m high poplars (*Populus simonii*). With reference to a control station in the open field, mean wind speed in a position about 18 m from the hedgerow at canopy level was reduced by 28 % over the entire year and by 39 % over the summer growth season. This effect leads to a parallel reduction of reference evapotranspiration. The experimental results clearly showed that the integration of tree shelterbelts may reduce wind speed and evapotranspiration up to 20 % within a range of about 5 times of the hedgerow height. Our findings support the importance of the implementation of tree shelterbelt as a resource-preserving measure in viticulture in the Western Cape. This is a major implication for revisions of trickle irrigation control and planning of hedgerow plantings within the individual spatial pattern of fields at farm level.
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Session 20-P3 - Agroecology

Ecosystem effects of reduced insect abundance in agricultural landscapes

Wiebke Ullmann[1], Stephanie Kramer-Schadt[2,3], Niels Blaum[1]

[1]University of Potsdam, Potsdam, DE, wiebke.ullmann@uni-potsdam.de
[2]Leibniz Institute for Zoo and Wildlife Research, Berlin, DE
[3]Technical University, Berlin, DE

The current loss of structural complexity in agricultural landscapes is often associated with the reduction of plant diversity, which in turn negatively affects insect populations and subsequently reduces insectivorous bird diversity and abundance in farmlands. A slow, constant decline in food resources might enhance competition between different insectivorous species. This might destabilize delicate equalizing and stabilizing coexistence mechanisms that have allowed sympatric species to coexist in the past. We aim at understanding possible changes in coexistence mechanisms of sympatric aerial insectivores (barn swallow (*Hirundo rustica*), house martin (*Delichon urbicum*), sand martin (*Riparia riparia*) under consistently low food availability.
We relate local insect abundance and diversity to the main segregating niche axes of the three passerine species: air-space and the feeding niche. Passerines will be tagged with ultra-light radio tags (~1g) in intensively used agricultural landscapes where we expect food depletion. The ATLAS tracking system provides an almost exact movement path of many bird individuals simultaneous. We will analyze the animals' movement paths and their intra- and interspecific interactions in relation to insect abundance, diversity and size. Insects will be trapped with malaise traps and with a drone flying in different heights relating insect occurrence to passerine air-space.
We expect that synergistic effects of constantly reduced insect abundance and unfavorable weather conditions over long time periods might affect the previous mechanisms promoting coexistence of insectivorous aerial predators. As barn swallows are the most specialized in their feeding habits, they may eventually be out-competed by the more generalist passerines. However, individual movement variation, behavior-mediated adaptability and non-linear feedbacks in foraging movement behavior may mitigate negative effects, delaying or even buffering competitive exclusion.

Session 20-P4 - Agroecology

Terracing in steep slope viticulture and its potential for carabid diversity

Vera Wersebeckmann[1], Ilona Leyer[1]

[1]Department of Applied Ecology, University of Geisenheim, Geisenheim, DE, vera.wersebeckmann@hs-gm.de

Viticulture on steep slopes has shaped both landscape and biodiversity in Germany's wine growing regions such as the Middle Rhine Valley and the Moselle Valley for centuries. However, it is becoming increasingly difficult to manage today's vertically planted vineyards profitably and the many fallow vineyards in these regions clearly reflect this development. A possible solution for maintaining steep slope viticulture could be the terracing. Here, vineyard rows run parallel to the hillside, which is far less labor intensive. At the same time, with the established embankments, terraced vineyards offer large non-cropped areas between the grape vines that could make a significant contribution to biodiversity. However, little is known about the specific effects of these different vineyard types, also in comparison with vineyard fallows for carabid diversity and abundance. In this study we analyzed carabid communities in 15 triplets of terraced, vertically planted and fallow vineyards along the slopes of the Middle Rhine Valley. In each vineyard, three pitfall traps were placed 5 m apart taking into account rows beneath the vines as well as the adjacent rows and embankments. Sampling of 10 days took place in May and August 2018.
Results show differences in carabid communities and diversity among the three different vineyard types underlining the significance of cultivated vineyards for carabid diversity.

Session 20-P5 - Agroecology

Multi-trophic interactions influence the effect of beneficial microbes on plant growth and pest suppression

Oriana Sanchez[1], Sophia Klink[2], Michael Rothballer[2], Peter Schröder[2], Wolfgang W Weisser[1], Sharon E Zytynska[1]

[1]Terrestrial Ecology Research Group, Department of Ecology and Ecosystem Management, School of Life Sciences Weihenstephan, Technical University of Munich, Freising, DE, oriana.sanchez@tum.de
[2]Institute of Network Biology, German Research Center for Environmental Health, Neuherberg, München, DE

Plants are fundamental organisms for terrestrial ecosystems, they interact both aboveground and belowground with multiple organisms (beneficial or detrimental). Plant-growth-promoting-rhizobacteria (PGPR) are found in close association with plant roots and can promote plant growth and induce resistance to pests and diseases. Through signaling molecules, PGPR communicate with their plant host and can modulate its response to third parties such as herbivores insects (e.g. aphids). Although many advances on plant-microbe interactions have been made, the comprehension of its ecological background is still unclear, especially when considering the wider community associated with the plants, i.e. beyond pairwise interactions. Our research is focused on understanding the functional relevance and mechanisms of microbe-mediated plant-insect interactions in an agricultural system. We present results from recent experiments on the plant barley (*Hordeum vulgare*) that was exposed to multiple biotic treatments: two PGPR (*Acidovorax radicis* and *Rhizobium radiobacter)*, two different genotypes of the phloem-feeding aphid *Sitobion avenae* and the epigeic earthworm *Dendrovaena veneta*. We found that PGPR-inoculated barley cultivars hosted fewer aphids, but the strength of this effect varied across aphid genotypes and the PGPR used. Additionally, the effect of the bacteria and its strength depended on the barley cultivar and the presence of earthworms. This work illustrates the complexity of these interactions between the plants and other organisms, we suspect that studying these ecological interactions will bring us one step further to understand how the effect of beneficial organisms on the plants and insects is enhanced/disrupted by other interacting organisms.

Session 20-P6 - Agroecology

Network thinking in agroecosystem functioning and productivity

Silvia Pappagallo[1], Jana Brandmeier[1], Christoph Scherber[1]

[1]Münster University, Münster, DE, silvia.pappagallo@uni-muenster.de

The global increase of food demand at reduced environmental impact is a pressing issue that requires solutions. To meet this goal, new farming strategies considering multiple aspects of ecosystem functioning will need to be developed. A network approach to statistical hypothesis testing is increasingly evaluated to meet this necessity and produce a system understanding of agroecosystems. Such methods can aid farmers in decision-making, such as in planning profitable ecological strategies during transition from high to low input farming management regimes. Here, we propose structural equation modelling (SEM) as a suitable statistical approach that can lead to network thinking in agricultural systems. Such a tool enables to unravel direct and indirect cause-effect relationships among management strategies and ecosystem processes. We applied SEM to an intercropping experiment (EU-H2020 project "DIVERSify"). Faba bean (*Vicia faba*) and summer wheat (*Triticum aestivum*) were cultivated either in monocultures or intercropped at 50:50 rate. Plots were either treated with high input management (fertilizer and herbicide) or left untreated (low input). We monitored weed species richness, abundance of main functional groups pf insects and ecosystem process such as herbivory, predation rates and pollination efficiency, as well as crop yield. We employed structural equation models with management practices and crop diversification as the main drivers of the system. We tested whether direct effects of management and crop diversification affect yield more than indirect effects from ecosystem processes. Results highlighted farming management as the main driver of productivity, followed by crop diversification. Intermediate agroecosystem processes had only minor influence on final yield. Such insights can be used to plan farming strategies supporting ecosystem processes while ensuring sufficient yield. Feeding existing structural equation models with an increasing number of case studies will be necessary to validate its general applicability.

Session 20-P7 - Agroecology

Establishment of perennial field margins and the development of site-adapted seed mixtures

Sebastian Glandorf[1], Birgit Petersen[2], Dieter Trautz[1], Kathrin Kiehl[1]

[1]Hochschule Osnabrück, University of Applied Sciences, Osnabrück, DE, S.Glandorf@hs-osnabrueck.de
[2]Kompetenzzentrum Ökolandbau Niedersachsen (KÖN) GmbH, Visselhövede, DE

In Central Europe, 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 20 native wildflower species of regional provenance and some short-lived crop species. In 2015, we started first field experiments to test the prescribed AES seed mixtures with different management variants (mulching in July, September or March).
In general, all treatments led to structurally diverse vegetation with a distinct flowering aspect and 75-100% of the sown species established successfully in the first year. During the first years differences between management treatments were not significant, but differences in vegetation development between and within study sites indicated strong effects of soil conditions and shading. In the fourth year of the experiment the cover of grasses was significantly higher and the cover of the sown wildflowers was lower on plots mulched in September than on July-mulched plots. This was especially the case when plots were shaded. This means that the prescribed management by mulching between September and March in AES of Lower Saxony is less suitable to provide a flower-rich vegetation over the whole AES program period of 5 years.
In 2017, we started additional experiments to test newly developed seed mixtures with 31 wildflower species for different environmental conditions (e.g. for dry sites or for forest edges) and to compare them to the prescribed AES mixture with only 20 wildflowers under different management regimes. Until 2018, establishment rates of the sown wildflowers reached 74-90% on most plots. The monitoring will be continued until 2020 in order to give recommendations for the AES of Lower Saxony in the next funding period.

Session 20-P8 - Agroecology

Effects of flowering crops on resource utilization and colony growth of bumble-bees

Sandra Schweiger[1], Nicole Beyer[1], Catrin Westphal[1]

[1]Functional Agrobiodiversity, Department of Crop Sciences, University of Göttingen, Göttingen, DE, sandra.schweiger@web.de

The main driver of the current global pollinators' decline is agricultural intensification, which changes our landscapes considerably. Declining areas of semi-natural habitats (SNH) which provide vital nesting and food resources impair the pollinators' fitness and can disrupt ecosystem services like pollination. A food pulse provided by early mass-flowering crops, such as oilseed rape (OSR), can therefore enhance the population growth of bees. Nevertheless, the contribution of mass-flowering crops to bee conservation was often questioned because of their short flowering period in comparison to semi-natural habitats that provide a continuous food source.
We investigated how local resources such as early (OSR) and mid-season (faba bean (*Vicia faba* L.)) mass flowering crops and SNH affect the colony development (weight gain) and reproductive success (number of produced males and young queens) of *Bombus terrestris* L.. Moreover, corbicular pollen was collected and analyzed to reveal the influence of landscape composition (cover of OSR, *V. faba* and SNH) on the larval food supply.
Preliminary results indicate that reproductive success of *B. terrestris* was not affected by the cover of mass flowering crops in the landscapes but by the cover of SNH. Moreover, the reproductive success was strongly related to the colony weight, with only the heavier colonies successfully producing young queens. The corbicular pollen was heavier early in the season (during the flowering of OSR) but pollen diversity was higher during mid-season.
We conclude that *B. terrestris* colony development and reproductive success rely on permanent resource availability which can be enhanced by mass-flowering crops. Despite these temporal resource pulses, pollen food plants in SNH are of vital importance for successful growth and reproduction.

SYNOPS-WEB+, an online risk indicator tool to support farmer's decisions on sustainable mitigation of environmental risk from pesticide applications

Anto Raja Dominic[1], Madeleine Paap[1], Jörn Strassemeyer[1], Sandra Krengel[1]

[1]Julius Kühn Institut, Kleinmachnow, DE, Anto.Raja@julius-kuehn.de

Farmers and advisors are increasingly required to take environmental protection and climate change mitigation into consideration in their agricultural production systems. Pesticide applications and farm management strategies often result in an adverse impact on the environment.
We present SYNOPS-WEB (Strassemeyer et. al., 2017), an online tool with a user-friendly interface to assess environmental risk from pesticide applications, bridging the gap between research and practice. The tool is based on realistic field applications, actual weather data from German Weather Service (DWD), and field-specific parameters for soil, surface waters and topography. The environmental pathways such as drift, runoff, drainage, leaching and volatilization by which the chemicals reach the adjacent environmental compartments are modelled to calculate the Predicted Environmental Concentration (PEC). Risk from an active ingredient is presented as a ratio of the PEC to its toxicity to specific reference organisms (Exposure-Toxicity Ratio, ETR) in aquatic, soil and field margin ecosystems. The user then has the option to select various mitigation measures such as tillage techniques, installation of field-edge buffers, vegetation strips and hedges to reduce the impact of his application on the environment.
SYNOPS is already used in the context of the German NAP to demonstrate the risk trend on national level. Online versions have been developed to serve as advisory tools for farmers in North Rhine-Westphalia, Germany and Norway. In the project OptAKlim, SYNOPS-WEB+ will be developed with additional modules to provide the user with options to assess the economic trade-offs and greenhouse gas emissions to choose the optimal farming strategy for specific field and application scenarios.

Session 20-P10 - Agroecology

FInAL - Facilitating insects in agricultural landscapes

Fabian Nürnberger[1], Jens Dauber[1], Burkhard Golla[2], Nora Kretzschmar[3], Tanja Rottstock[2], Ulrich Stachow[4]

[1]Thünen Institute of Biodiversity, Braunschweig, DE, fabian.nuernberger@thuenen.de
[2]Julius Kühn-Institut (JKI), Federal Research Centre for Cultivated Plants, Institute for Strategies and Technology Assessment, Kleinmachnow, DE
[3]Chamber of Agriculture of Lower Saxony, Oldenburg, DE
[4]Leibniz Centre for Agricultural Landscape Research (ZALF), Müncheberg, DE

Insect diversity and abundance are decreasing with negative consequences for ecosystem functioning. Especially changes in cultivation practices, often summarized as intensification, are discussed as major drivers of insect decline. However, agricultural landscapes, covering over 50% of Germany, have the potential to provide valuable habitats for insects, if managed accordingly.
The FInAL-project aims to develop and demonstrate innovative agricultural cultivation practices that sustain, support and increase insect diversity and biomass as well as ecosystem functions provided by insects. This is to be achieved primarily by the integration of renewable resources and integrated pest management. Therefore, a large-scale, long-term transformation process will be launched on the landscapes scale within three approx. 3x3 km size "landscape laboratories" across Germany. In close cooperation between researchers and stakeholders, especially farmers, locally adapted measures to promote insects will be conceptualised in a co-designing process and then implemented. In a multidisciplinary approach, impacts of the landscape transformation on biodiversity, its economic viability, and the social acceptance are going to be evaluated. Monitoring the transformation processes in landscape laboratories for ten years will allow the detection of long-term impacts of the transformation, refine measures to facilitate insects, establish value-chains for alternative crops, and enable comprehensive comparisons with reference landscapes that will be established in the vicinity of the landscape labs.

Session 20-P11 - Agroecology

Effects of crop diversity and management on pollinators in an intercropping experiment

Jana Brandmeier[1], Hilke Hollens-Kuhr[1], Silvia Pappagallo[1], Christoph Scherber[1]

[1]University of Münster, Münster, DE, jana.brandmeier@uni-muenster.de

More than 40 percent of Europe´s terrestrial land surface is dominated by agriculture, with only low proportions of organic or low-intensity farming. Although organic or low-intensity farming may promote biodiversity, it will likely never exceed a threshold of c. 20 per cent. At the same time, insect biodiversity loss, especially of flower visitors, may reduce ecosystem service provisioning and induce cascading effects across trophic levels. Thus, to promote large-scale agrobiodiversity, conservation across Europe will require measures targeting the heart of farming systems themselves. We set up a summer wheat - faba bean intercropping trial and manipulated management intensity (high vs. low management input) and cropping system diversity (monoculture vs. mixture) in a randomized complete blocks design (N=96 plots).
Pollinator abundance was higher in legume-rich plots managed at low intensity, except for legume monocultures where high management showed highest abundance. Pollinator diversity was maximized in 50/50 mixtures for low management input and in 75/25 mixtures for high management input.
These findings suggest that there is a positive effect of growing faba bean together with summer wheat due to provisioning of nectar for insects. Increased abundance/richness in low-input plots was likely due to a higher number of weed species to interact with. Notably, in highly managed plots, summer wheat - faba bean mixtures showed higher pollinator abundance and diversity than wheat monocultures. Thus, legume-based intercropping and the accompanying diversification of agriculture can be seen as an important step to integrating conservation aspects into conventional food production systems.

Session 20-P12 - Agroecology

Aphid cards – a useful model for assessing predation rates or bias-prone nonsense?

Fabian A. Boetzl[1], Antonia Konle[1], Jochen Krauss[1]

[1]Department for Animal Ecology and Tropical Biology (Zoology III), University of Würzburg, Würzburg, DE, fabian.boetzl@uni-wuerzburg.de

Predation is an essential ecosystem function ensuring yields in modern agriculture. However, assessing predation rates is intricate and they can rarely be linked directly to predator densities or functions. We tested whether sentinel prey aphid cards are useful tools to assess predation rates in the field. For this purpose, we employed aphid cards of different sizes on the ground level as well as within the vegetation. Additionally, by trapping ground dwelling predators, we examined whether obtained predation rates could be linked to predator assemblages. Predation rates recorded with aphid cards were independent of aphid card size. However, predation rates on the ground level were three times higher than within the vegetation. We found both predatory carabid activity densities as well as community-weighted mean body size to be good predictors for predation rates. Predation rates obtained from aphid cards were stable and related to predator assemblages. Aphid cards therefore are a useful, efficient method for rapidly assessing the ecosystem function predation. Their use can especially be recommended for assessments on the ground level and when time and resource limitations rule out more elaborate sentinel prey methods using exclosures with living prey animals.

Session 20-P13 - Agroecology

Steroids originating from bacterial bile acid degradation affect *Caenorhabditis elegans* and indicate potential risks for the fauna of manured soils

Martha Mendelski[2], Ramona Dölling[2], Franziska Feller[1], Dennis Hoffmann[2], Lisa Ramos Fangmeier[2], Kevin Ludwig[1], Onur Yücel[1], Almuth Mährlein[1], Rüdiger Paul[2], Bodo Philipp[1]

[1]Institute for Molecular Microbiology and Biotechnology, Faculty of Biology, University of Münster, Münster, DE, bodo.philipp@uni-muenster.de
[2]Institute for Zoophysiology, Faculty of Biology, University of Münster, Münster, DE

Bile acids are steroid compounds from the digestive tracts of vertebrates that enter agricultural environments in unusual high amounts with manure. Bacteria degrading bile acids can readily be isolated from soils and waters including agricultural areas. Under laboratory conditions, these bacteria transiently release steroid compounds as degradation intermediates into the environment. These compounds include androstadienediones (ADDs), which are C_{19}-steroids with potential hormonal effects. Experiments with Caenorhabditis elegans showed that ADDs derived from bacterial bile acid degradation had effects on its tactile response, reproduction rate, and developmental speed. Additional experiments with a deletion mutant as well as transcriptomic analyses indicated that these effects might be conveyed by the putative testosterone receptor NHR-69. Soil microcosms showed that the natural microflora of agricultural soil is readily induced for bile acid degradation accompanied by the transient release of steroid intermediates. Establishment of a model system with a Pseudomonas strain and C. elegans in sand microcosms indicated transient release of ADDs during the course of bile acid degradation and negative effects on the reproduction rate of the nematode. This proof-of-principle study points at bacterial degradation of manure-derived bile acids as a potential and so-far overlooked risk for invertebrates in agricultural soils.

Session 20-P14 - Agroecology

Short- and long-term effects of sublethal insecticide concentration on beetle food consumption and reproduction

Marina Wolz[1], Caroline Müller[1]

[1]Universität Bielefeld, Bielefeld, DE, marina.wolz@uni-bielefeld.de

The areas of agriculturally used land are steadily increasing and with this the use of pesticides such as insecticides for pest control. The active substances in these pesticides can accumulate in the environment at sublethal concentrations and impair the fitness of target as well as non-target organisms. Sublethal insecticide concentrations may not only directly affect the exposed individuals, but also harm subsequently un-exposed generations. However, little is known about the impacts of sublethal insecticide concentrations on food consumption and on the persistence of the impacts of sublethal insecticide concentrations on the performance and fitness traits of organisms. Therefore, we investigated the effects of a sublethal insecticide concentration on adult food consumption and on reproductive traits in the mustard leaf beetle, *Phaedon cochleariae*. Adult beetles were exposed for 14 d and the persistence of insecticide effects studied in this generation as well as in their offspring. We hypothesized that the food consumption and reproduction are reduced in insecticide-exposed compared to unexposed beetles. Moreover, we expected a delayed recovery phase after ending the insecticide exposure, leading to increased nutritional requirements and a higher reproduction. We found no significant short-term effects of the insecticide treatment on food consumption and reproduction, but our results provide evidence of a recovery phase and detrimental long-term effects. Overall, our study highlights the complex effects of sublethal insecticide concentrations on fitness-related traits and provides insight into short- and long-term effects of this anthropogenic pollution.

Session 20-P15 - Agroecology

Improvement of meadow bird management by an online knowledge system

Dick Melman[1], Tim Visser[1]

[1]WUR, Wageningen, NL, dick.melman@wur.nl

Despite many efforts, the Dutch meadow bird population is still declining. Limited access to scientific knowledge on meadow bird management might be a cause. An online system makes this knowledge available, as support for managers.

Tailor-Made-Management (TMM) is an online tool, aimed at optimizing meadow bird management. It provides insight into the suitability of grasslands as a habitat for meadow birds chicks. The suitability of an area is assessed in two steps. First, the <u>potential quality</u> is assessed. This quality is based on:

- drainage
- openness of the landscape
- disturbance
- biomass and heterogeneity of vegetation

This results into a map indicating locations where meadow bird management will be most effective. With a low potential habitat quality, management is ineffective.

In the second step the <u>realized quality</u> of the habitat is assessed. With the currently regular dairy farming management (high fertilization, early mowing) the potential quality is not realized. With appropriate management (modest fertilization, a delayed cutting date) the potential quality is utilized and turned into realized quality.

The map with realized quality shows the location of suitable chick habitat. The next question is whether the realized habitat is sufficient for conservation of the present meadow bird population. This is assessed by information on the area and quality of the chick land, the number of meadow bird families and the required habitat per family. The amount of suitable habitat is shown in pie charts. Up till now we focus on the Black-tailed godwit, some attention is given to Common redshank, Northern lapwing and Oystercatcher.

Crucial is the adoption of the system by farmers. Important is experiencing TMM as a support to increase their quality as managers and not as a sanctioning instrument. In addition, technical quality and user-friendliness are important. Over years we see a gradual growing acceptance of TMM. It might become an effective learning management tool.

Session 20-P16 - Agroecology

Beyond the forest: assessing the importance of the surrounding landscape on the occupancy of mammal species in the Chaco

Julieta Decarre[1], Carolina Jankowicz[2], Daniela Gonzalez[1,3], Yanina Sica[4]

[1]National Institute of Agricultural Technology, IRB-CNIA, AR, decarre.julieta@inta.gob.ar
[2]School of Agriculture, University of Buenos Aires, Buenos Aires, AR
[3]CONICET, Buenos Aires, AR
[4]Ecology and Evolutionary Biology, Yale University, New Haven, US

Land-use change is a major threat to biodiversity globally, yet the effects aside from habitat loss remain poorly understood. This is particularly so regarding the importance of the matrix in agricultural modified landscapes. The Chaco region in South America is experiencing one of the highest deforestation rates worldwide. At the same time, it represents a hotspot of biodiversity and holds exceptional cultural and natural resources. Here we examined how landscape features determine the occupancy of two characteristic mammal species: the three-banded armadillo (*Tolypeutes matacus*) and the crab-eating fox (*Cerdocyon thous*). Using camera-trapping records from 2012 to 2017 in the semiarid Chaco of Argentina, we fitted single-season occupancy models to assess: 1) how landscape composition and configuration relate to each species' occupancy, 2) the importance of on-site and surrounding landscape features at multiple spatial scales for each species, and 3) if there are differences in the responses influenced by their distinctive life history traits. Preliminary results indicate that forest cover plays a key role for these two species while a high percentage of edges also favors their occupancy. Local-scale variables fitted best for the armadillo whereas the crab-eating fox responded to landscape features at a greater extent. In this area of Chaco, rapid transformations have resulted in a mosaic of environments ranging from highly modified croplands to friendlier silvopasture plots interconnected by linear elements of natural vegetation and interspersed forest stands. This heterogeneous matrix is supporting an everyday decreasing native fauna. Information derived from this study will drive and reinforce specific management decisions fostering production and conservation alike.

Session 20-P17 - Agroecology

Effect of varying food placements due to tillage on two earthworm species (*Lumbricus terrestris* vs. *Octolasion cyaneum*), representing different ecological groups

Ilka Schmoock[1], Deborah Linsler[1], Stefan Schrader[2], Astrid Taylor[3], Martin Potthoff[1]

[1]Centre of Biodiversity and Sustainable Landuse, Göttingen, DE
[2]Thünen-Institute, Braunschweig, DE
[3]Swedish University of Agricultural Sciences, Uppsala, SE

To demonstrate the behavior of two different ecological groups of earthworms, stable isotopes ratios of nitrogen ($\delta^{15}N$) and carbon ($\delta^{13}C$) were measured under two different simulated tillage systems. For this purpose, from October 2017 to February 2018, a microcosm study was carried out in a dark climate chamber at 10°C. With undisturbed soil columns (15 cm Ø , 30 cm high), two tillage treatments were simulated: No-Tillage (organic material on the surface) and simulated tillage (organic material in a depth of 15 cm). For each column, 5 grams of maize leaves were used to simulate crop residues. For every treatment combination (organism x tillage simulation) plus control columns, four replications were applied. The anecic earthworm species *Lumbricus terrestris* and the endogeic species *Octolasion cyaneum* were taken. The adult individuals derived from a long-term experimental field-site close to Göttingen, Lower Saxony. In addition, fluxes of CO_2 and N_2O were measured automatically every 4.5 hours as a proxy of biological activity.
The isotope ratios of earthworms show grouping into different ecological categories. The analysis of earthworm tissues revealed that anecic earthworms took up averaged 11-16 % more carbon, derived from maize leaves, than endogeic earthworms. For the endogeic species, significant differences ($p < 0.05$) were found between the two tillage simulation systems, where simulated ploughing have led to higher uptake of maize leaves indicated by lower $\delta^{13}C$ values. The results of emission measurements will provide further insights on the activity of earthworms.

Session 20-P18 - Agroecology

How do kettle holes influence the abundance and the distribution of phytopathogenic fungi in wheat fields?

Marina Schnabel[1]

[1]Leibniz-Zentrum für Agrarlandschaftsforschung, Müncheberg, DE, Marina.Schnabel@zalf.de

Kettle holes are regarded as hot spots of biodiversity in intensively agriculturally used landscapes in Europe. Northeast Germany is spotted with up to 40 kettle holes per km². Besides the ecosystem services provided by them, they have also been hypothesized to enhance fungal spread and thus increase the infestation risk of adjacent agricultural fields. Kettle holes have various effects on the distribution of diseases through their water flow and temporal flooding as well as through the increased air humidity in their surrounding area. They can influence the biodiversity of all organisms, which are influenced in their development by water or air humidity. In particular, phytopathogenic fungi are significantly influenced by the moisture conditions within a field. In the case of fungi, different plants and especially grasses at the edge of kettle holes can be considered as a permanent habitat for the development and spore production of these fungi. Thus the kettles holes are a source of inoculation for a long-lasting infection of the neighboring field. During our field experiment in 2019, 10 different kettle holes (flooding type, storage type) were examined. We set up the following hypotheses: 1. Increasing air humidity leads to an increased spread of fungal spores from kettle holes into the field; and 2. Edges of kettle holes are the main habitat for fungal diversity. For this study, 10 transects between kettle holes and the adjacent agricultural wheat fields were established. A sample collection is going to be analyzed in the laboratory by culture-dependent and culture-independent methods to determine the abundance and spread of phytopathogenic fungi of the genera *Fusarium* and *Alternaria*.
The responses of single organisms to floods have been analyzed, but the interactions of different organisms during and after such events have not been studied so far. Because of this, analyses of the interactions between soil fungi, grasses and collembola, protists and earthworms are also planned in the next years.

Session 20-P19 - Agroecology

Organic matter dynamics in agricultural soils of NE-China with different fertilization history

Ute Hamer[1], Ulf-Niklas Meyer[1], Bettina Haas[1], Ya Han[2], Shuihong Yao[2], Kai Liu[2], Yuzhi Xu[2], Qianqian Wang[2], Bin Zhang[2]

[1]Institute of Landscape Ecology, WWU Münster, Münster, DE, ute.hamer@uni-muenster.de
[2]Institute of Agricultural Resources and Regional Planning, Chinese Academy of Agricultural Sciences, Beijing, CN

A long-term agricultural field experiment established in 1979 in Gongzhuling, Jilin province, NE China was chosen to investigate the effects of different fertilization history on the dynamics of soil organic matter in Mollisols. Treatments with different soil nutrient status e.g. NPK fertilization (urea, multiple superphosphate, potassium sulfate) and NPK plus manure (fresh pig and cattle manure compost) were chosen. The formation of macro- and microaggregates as distinct habitats for soil microorganisms is expected to play an important role in organic matter dynamics. Thereby, type and amount of fertilizer is an important trigger for soil microorganisms and the production of extracellular hydrolytic (EHEs) and oxidative enzymes catalyzing organic matter turnover. Within the complex three dimensional soil matrix, priming effects (i.e. changes in soil organic matter turnover after addition of an easily available C-source) are expected to vary locally. Therefore our soil samples have been separated into four aggregate fractions (microaggregates <0.25mm, small macroaggregates 0.25-1 mm, macroaggregates 1-2mm and large macroaggregates >2-8 mm). All fractions were incubated for 77 days to measure the priming effect induced by glucose addition (^{13}C-labelled; addition of 0, 500 and 2000 mg glucose-C kg^{-1} soil dw) and to monitor the catalytic behavior of EHEs with Michaelis-Menten kinetics.

Session 20-P20 - Agroecology

Soils and soil biota values for European farmers: investigating the existence of geographical variations using the valuating milieu approach

Morgane E.T. Hervé[1,2,3], Michel Renault[3], Daniel Cluzeau[2], Martin Potthoff[1], Rebekka Schuette[1,4], Elke Plaas[4], Annegret Nicolai[2,5]

[1]Center of Biodiversity and Sustainable Land Use, University of Goettingen, D-37077 Goettingen, DE, morgane.herve@univ-rennes1.fr
[2]ECOBIO – UMR 6553, Biological Station Paimpont, Univ Rennes, F-35000 Rennes, FR, morgane.herve@univ-rennes1.fr
[3]CREM – UMR 6211, Univ Rennes, F-35000 Rennes, FR, morgane.herve@univ-rennes1.fr
[4]Department of Agricultural Economics and Rural Development, University of Goettingen, D-37073 Goettingen, DE
[5]SAS – UMR 1069, Agrocampus Ouest, F-35000 Rennes, FR

Soils provide a wide range of functions whereof many are depending on soil biota. Human activities, especially agriculture, benefit from these functions. However, some management practices can threaten soil biota. New tools need to be developed to enhance soil management sustainability in Europe. John Dewey's pragmatic theory states that values underpin individuals' actions. These values are the result of intelligence activity performed to solve of problematic situation. They are also influenced by the characteristics of this situation. Previous results have shown that different values were associated with soil biota by European farmers. These values may differ between European regions, underlying variable ability and willingness to develop soil-friendly management practices among farmers.
Our aim is to better understand soil and soil biota values construction in specific geographical situations in Europe. We hypothesize that local characteristics of agricultural systems influence the construction these values, which then vary between regions.
Using the concept of "valuating milieu", we carried out our study in five regions situated in France, Germany, Romania, Spain and Sweden. We conducted one focus group per region, and exploratory semi-directed interviews. We collected farmers' description of the local situation in which they operate their soil management practices. We gathered documents related to agriculture policy and orientation framing the agriculture sector (at European, national, regional scale) to complete farmers' discourse. Results showed that despite the overlook of the PAC on European agriculture activities, local territories specificities steer to different values associated with soils and soil biota. These differences hinge on socio-technical configurations but environmental elements also constitute a central situational element. Valuating milieu characteristics can represent an opportunity to design sustainable soil management policies in Europe.

Session 20-P21 - Agroecology

Effect of management practices on soil nitrogen cycling in a large-scale oil palm plantation

Greta Formaglio[1], Edzo Veldkamp[1], Muhammad Damris[3], Aiyen Tjoa[2], Marife D. Corre[1]

[1]Soil Science of Tropical and Subtropical Ecosystems, University of Göttingen, Göttingen, DE, greta.formaglio@forst.uni-goettingen.de
[2]Faculty of Agriculture, Tadulako University, Palu, ID
[3]Faculty of Engineering, University of Jambi, Jambi, ID

Oil palm is one of the most important agricultural crops in the tropics, being the world´s leading vegetable oil. Large-scale oil palm plantations are intensively managed with high fertilizer and herbicide application, resulting in a reduced nutrient cycling in the soil. Quantifying soil nitrogen transformation rates is fundamental to understand efficiency of soil nitrogen cycling. We established a management experiment in a large-scale oil palm plantation in order to compare conventional management practices with a reduced intensity of management. The treatments were: conventional fertilization (260 N, 50 P, 220 K kg ha^{-1} yr^{-1}) with herbicide application (2.25 L glyphosate ha^{-1} yr^{-1}), conventional fertilization with mechanical weeding, reduced fertilization (136 N, 17 P, 187 K kg ha^{-1} yr^{-1}) with herbicide spraying, and reduced fertilization with mechanical weeding. There were three distinct management zones: fertilized palm circle, inter-rows and the frond-stacked area. We assessed the differences in gross rates of soil-N cycling between conventional and reduced management, and among management zones. We used the ^{15}N pool dilution technique on intact soil cores with in-situ incubation and conducted the measurements at the three management zones in each treatment with four replicate plots (50m x 50m each). The results showed no differences among treatments but clear differences among management zones. Gross N-cycling rates were highest at the frond-stacked area, and gross N mineralization and NH_4^+ immobilization were the lowest in the palm circle. Dissimilatory nitrate reduction to ammonium was a negligible process. Gross N mineralization and nitrification rates correlated strongly with microbial biomass N, which in turn correlated with extractable organic N as well as total N. Low soil-N-cycling rates at the palm circle suggest possibility of N losses, while high rates in the frond-stacked area indicate the importance of piling fronds as an additional source of nutrients.

Session 20-P22 - Agroecology

Effectiveness of ecological intensification in viticulture

Silke Rascher[1], Elke Plaas[1], Holger Bergmann[1]

[1]Department of Agricultural Economics and Rural Development, Georg-August-University Goettingen, Goettingen, DE, silke.rascher@uni-goettingen.de

Vineyards are treated with higher amounts of pesticides than other farmland. The conjunction of monocultural cultivation and high pesticide use has caused serious negative external effects on biodiversity and ecosystem services (ES). Besides provoking environmental problems, agrochemicals have severe negative impacts on human health. In order to meet Sustainable Development Goals and consumers' demand for a sustainable and biodiversity friendly production, these externalities have to be reduced. Thus, an ecological intensification strategy (EIS) needs to be deployed in viticulture.

We interviewed 51 different stakeholders, such as winegrowers, scientists and employees of environmental organizations and agencies, in five European countries about issues and the importance of biodiversity in viticulture. The stakeholders mentioned high pesticide usage, climate change, intensification, decreased biodiversity and labor intensity as the main issues in viticulture. This underlines the importance of an EIS to lessen externalities. Although, 91 % of the stakeholders (totally) agreed that it is important to increase biodiversity in vineyards, EIS has not been deployed exhaustively yet. Winegrowers often refuse alternative management strategies to provide ES because of their unawareness of these strategies' (cost) effectiveness. We investigate how extensive inter-row vegetation, low tillage frequencies, low pest management and support of landscape elements affects biodiversity and ES. Our calculations of contribution margins in viticulture showed that EIS can raise the amount of coverage. Based on these calculations we are developing a linear programming model in which we consider ecological cycles and economic profitability. The results show that EIS can solve besides environmental issues also the issues of high input costs.

Session 20-P23 - Agroecology

FInAL- Innovative integrated cultivation strategies to promote insect diversity

Tanja Rottstock[1], Silke Dachbrodt-Saaydeh[1], Jörn Strassemeyer[1], Burkhard Golla[1]

[1]Julius Kühn-Institute, Institute for Strategies and Technology Assessment, Kleinmachnow, DE, Tanja.Rottstock@julius-kuehn.de

In Germany, agricultural land use covers more than 50% land and thus agricultural systems have a considerable impact on biodiversity. On the one hand, these systems contribute to the decline of biodiversity – to different extends - but on the other hand, they also offer a great potential for the promotion of biodiversity in general, and the diversity, abundance of and ecosystem functions provided by insects, in particular.

Scientists of the Julius Kühn-Institute, Thünen Institute and Leibniz Centre for Agricultural Landscape Research as well as farmers and advisors join the interdisciplinary research consortium "FInAL", where they bring together their particular areas of expertise for novel explorations in the search for innovative integrated cultivation strategies. Therefore, a long-term (up to 12 years) and large-scale transformation process in 3 "landscape laboratories" of 3 x 3 km size will be set up. The ecological and economic potential of the integration of renewable resources combined with integrated pest management with particular attention to the protection of the insect diversity will be tested and evaluated (Nürnberger et al. 2019; oral presentation). The poster focuses on tools offered by integrated pest management in terms of prevention and non-chemical methods as well as approaches to promote beneficial organisms and methods for the multi-criteria assessment, which will be developed and conducted by the Julius Kühn-Institute of Strategies and Technology Assessment.

Session 20-P24 - Agroecology

Identification, comparison, and analysis of hypotheses in systematic review

Alejandra Parreno[1], Owen Petchey[1], Bernhard Schmid[1]

[1]University of Zurich, Zurich, CH, alejandra.parreno@ieu.uzh.ch

For any given system of variables, such as those relating biodiversity, environment, and ecosystem processes, alternative hypotheses about the effects observed in nature and in experiments may be proposed. Identifying comparable hypotheses in the literature is often difficult for complex ecological systems. In this study, we propose a method to identify, compare and analyze hypotheses for a complex system, using tools from quantitative review and statistics.

Our method consists of four steps: a systematic literature search for study selection, the identification of hypotheses through "backwards inference" from the original statistical analyses, the elimination of additional variables where experimental designs allow for it without altering the relation between remaining variables, and classification of compatible hypotheses into groups suitable for quantitative analysis. To describe our method, we provide a detailed case study of a system with relationships between biodiversity, productivity, light and nutrients.

In our case study, we identified 760 initial papers, of which 74 (123 independent studies) met our selection criteria. From these, we identified 34 different hypotheses, which were reduced to 15 when we eliminated additional variables. Only five hypotheses have been considered in more than one study. We found substantial differences between proposed hypotheses in terms of causality, with more intricate hypotheses that would presumably better represent the higher complexity of the natural system tested only a handful of times. Additionally, we recorded features that would be of relevance for a quantitative analysis (e.g., reported effect and study sizes, data availability, ecosystem type, etc.).

Our method allows for an accurate depiction of the number of times that compatible hypotheses are tested. This is particularly valuable for evaluating whether it is possible or not to proceed with a rigorous quantitative review that produces unbiased and robust statistical results. Moreover, our method facilitates the identification of knowledge gaps and mismatches between hypotheses, study designs and statistical tests in a given area of research.

SESSION 21

Forest Ecology -
from scientific methods to practice-relevant management strategies

Chairs: Dr. Franka Huth, Prof. Dr. Michael Bredemeier

The scientific methods and technologies employed across the various fields of forest ecology research are myriad. Forest research is driven both by acute environmental threats and by persistent problems in forest ecosystems. In many cases the development of new scientific methods and technical innovations helps solve these problems, while simultaneously creating new opportunities and generating new questions. However, finding answers to scientific questions pertaining to forest ecology does not automatically lead to greater adaptation of forest management practices. The session seeks to address a broad range of ecological issues arising in areas of practice-relevant forest research. Of particular interest are presentations demonstrating the practical relevance of particular methods and their direct links to target-oriented forest management strategies. Recommendations for action and conflicting facets of different ecosystem services connected with forests can be derived from forest research issues related to biodiversity, species extinction and climate change. Key strategic considerations about whether to adopt integrative or segregative approaches to forest ecosystem protection, restoration and utilisation will be discussed critically. This will include the scientific analyses and the practical use of spatial and temporal components within forest ecosystems.

Session 21-O1 - Forest Ecology - methods and management strategies

Stand-scale climate change impacts on forests over large areas: transient responses and projection uncertainties

Harald Bugmann[1], Nica Huber[1], Maxime Cailleret[2], Nicolas Bircher[1], Valentine Lafond[1,3]

[1]Forest Ecology, ETH Zurich, Zurich, CH, harald.bugmann@env.ethz.ch
[2]2UMR RECOVER, Aix-Marseille University, Aix-en-Provence, FR
[3]Faculty of Forestry, University of British Columbia, Vancouver, CA

Anthropogenic climate change has triggered multiple model-based impact forest impact assessments, typically focusing on large scales (i.e., continental to global) or a small set of stand-scale case studies. Substantial uncertainty remains regarding the local impacts over larger areas (i.e., regions to countries), which is particularly problematic for forest planning and management.
We provide a comprehensive, high-resolution assessment of the climate change sensitivity of managed Swiss forests (ca. 10'000 km^2), covering a wide range of environmental conditions. We used a dynamic vegetation model to project the development of typical forest stands derived from a stratification of the 3rd National Forest Inventory. One type of simulation was limited to using the current local species pool of the typical stands, whereas the other included the immigration of new, potentially more climate-adapted species. We also quantified and decomposed the uncertainty in the projections resulting from (i) climate change scenarios, (ii) local site conditions and (iii) structural and parameter-related model uncertainty, an aspect hitherto rarely taken into account.
We found substantial changes of basal area and species composition, with dissimilar responses to climate change across and within elevation zones. Higher-elevation stands tend to profit from higher temperature, with strong modulation by soil conditions. Low-elevation stands are increasingly subject to drought, with strong negative impacts on forest growth. Current stand structure was found to have a strong effect on the simulated response as well. Admixing drought-tolerant species is advisable across all elevations to mitigate adverse climate effects. The largest uncertainty in the projections was due to the climate change scenarios. Uncertainty induced by model structure or parameter values was generally largest where overall simulated impacts were small, thus corroborating the utility of the model for making future projections. Yet, the large influence of site conditions and the choice of the forest model on some projections indicate that uncertainty sources other than climate change need to be considered in impact assessments.

Session 21-O2 - Forest Ecology - methods and management strategies

From tree to stand-level structural complexity

Dominik Seidel[1], Martin Ehbrecht[1], Peter Annighöfer[1], Christian Ammer[1]

[1]University of Göttingen, Göttingen, DE, dseidel@gwdg.de

Management for complexity is gaining importance as a new strategy in forest management in Europe and North America to prepare our forest for an uncertain future. Objective descriptions of complexity are difficult. For structural complexity, as one aspect of forest complexity, new methods to acquire and process high-resolution 3D data provide new possibilities for research.
In our study, we used 3D data from terrestrial laser scanning in an exemplary temperate broad-leaved forest in Thuringia, Germany, to investigate the relationship between structural complexity on tree-level and stand-level. To describe the structural complexity of trees or groups of trees we applied fractal analysis, more specifically the box-dimension.
Our data show that the stand structural complexity of plots up to 20 x 20 m was largely determined by the complexity of the most complex-structured tree individuals. Additionally, high complexity of an individual tree and a large variability of tree complexities across the stand had a positive effect on stand structural complexity. Other characteristics of individual trees, such as the size of their crowns, were also positively related the plot-level complexity.
We therefore argue that management for complexity should focus on the retention of large-crowned and therefore highly complex tree individuals. Based on our quantitative assessment we could verify that such trees can be considered key elements of stand structural complexity. At the same time, they are often of great importance as habitat trees potentially increasing biodiversity.

Session 21-O3 - Forest Ecology - methods and management strategies

Response of internal architecture of beech trees to intra and interspecific competition

Yonten Dorji[1], Peter Annighöfer[1], Dominik Seidel[1]

[1]University of Göttingen, Göttingen, DE, yonten.dorji@uni-goettingen.de

Individual tree architecture and the composition of tree species in a forest play a vital role for many ecosystem functions and services provided by a forest, such as timber value, habitat diversity and ecosystem resilience. However, knowledge is limited when it comes to understanding how tree architecture changes in relation to competition. This study delves into the architectural response of beech trees to intra- and interspecific competition. Using 3D-laser scanning data from the German Biodiversity Exploratories, we investigated the detailed three-dimensional architecture of 24 beech (*Fagus sylvatica* L.) trees that grow under different levels of competitional pressure. This pressure was imposed through con- or allospecific neighborhoods of conifers, such as spruce (*Picea abies* L.) and pine (*Pinus sylvestris* L.) and other hardwood species (*Acer pseudoplatanus* L., *Tilia cordata* Mill., *Fraxinus excelsior* L., *Quercus robur* L.). We created quantitative structure models (QSMs) for all individual trees to describe their internal architecture. Furthermore, structural complexity and architectural self-similarity, both integrating measures of tree structural complexity, were measured using the box-dimension approach. Relating these measures to the strength of competition the trees are exposed to revealed strong responses for a wide range of tree architectural measures indicating that competition strongly changes the internal architecture of trees.

Session 21-O4 - Forest Ecology - methods and management strategies

On species diversity in forests: revisiting the habitat-heterogeneity hypothesis in a multi-taxon approach

Lea Heidrich[1], Soyeon Bae[1], Peter Krzystek[2], Shaun Levick[3,4], Paul Magdon[5], Thomas Nauss[6], Peter Schall[7], Alla Serebryanyk[2], Stephan Wöllauer[6], Christian Ammer[7], Claus Bässler[8,9], Inken Doerfler[9,10], Markus Fischer[11], Martin M. Gossner[12], Marco Heurich[8,13], Torsten Hothorn[14], Kirsten Jung[15], Holger Kreft[16], Ernst-Detlef Schulze[18], Sebastian Seibold[1,9], Simon Thorn[1], Wolfgang Weisser[9], Jörg Müller[1,8]

[1]Department of Animal Ecology and Tropical Biology, University of Würzburg, Würzburg, DE, lea.heidrich@uni-wuerzburg.de
[2]Department of Geoinformatics, Munich University of Applied Sciences, Munich, DE
[3]CSIRO Land and Water, 0822 NT, AU
[4]College of Engineering, IT, and Environment, Charles Darwin University, 0909 NT, AU
[5]Forest Inventory and Remote Sensing, Faculty of Forest Sciences and Forest Ecology, University of Göttingen, Göttingen, DE
[6]Faculty of Geography, Philipps-University Marburg, Marburg, DE
[7]Silviculture and Forest Ecology of the temperate Zones, Faculty of Forest Sciences and Forest Ecology, University of Goettingen, Göttingen, DE
[8]Bavarian Forest National Park, Grafenau, DE
[9]Terrestrial Ecology Research Group, Technical University of Munich, Freising, DE
[10]Institute of Biology and Environmental science, Vegetation science & Nature conservation, University of Oldenburg, Oldenburg, DE
[11]Institute of Plant Sciences, University of Bern, Bern, CH
[12]Forest Entomology, Swiss Federal Research Institute WSL, Birmensdorf, CH
[13]Chair of Wildlife Ecology and Wildlife Management, University of Freiburg, Freiburg, DE
[14]Epidemiology, Biostatistics and Prevention Institute, University of Zurich, Zurich, CH
[15]Evolutionary Ecology and Conservation Genomics, University Ulm, Ulm, DE
[16]Biodiversity, Macroecology & Biogeography, University of Goettingen, Göttingen, DE
[17]Centre of Biodiversity and Sustainable Land Use (CBL), University of Goettingen, Göttingen, DE
[18]Max Planck Institute for Biogeochemistry, Jena, DE

The *habitat-heterogeneity hypothesis* is a main principle in ecology and predicts increasing biodiversity with increasing habitat heterogeneity due to an increasing number of niches. The *area-heterogeneity-trade-off hypothesis*, however, predicts a decrease in biodiversity at high levels of habitat heterogeneity because of a trade-off between heterogeneity and effective niche area. To test these hypotheses, we used biodiversity data of 12 species groups encompassing 2559 species from ~500 plots in five temperate forests and classified a set of variables with support of airborne laser scanning to capture different aspects of heterogeneity. Species groups responded differently to the single aspects of heterogeneity, and specialists of closed forest were penalized by an increasing horizontal habitat heterogeneity. Yet, most species groups reacted positively to

habitat heterogeneity and we found little support for area-trade-offs at high levels of the biotic aspects of heterogeneity. Our results thus support the generality of the *habitat-heterogeneity hypothesis.*

Session 21-O5 - Forest Ecology - methods and management strategies

The effect of tree species mixtures with European beech on biodiversity of plants, bryophytes and lichens at the landscape scale

Steffi Heinrichs[1], Christian Ammer[1], Peter Schall[1]

[1]University of Goettingen; Dep. Silviculture & Forest Ecology of the Temperate Zones, Goettingen, DE, sheinri@gwdg.de

Stand-scale tree species mixtures positively affect the multifunctionality of forest stands. Beside an increased stability, mixed stands are also assumed to facilitate forest biodiversity conservation due to an increased habitat heterogeneity compared to monocultures. Thus, the promotion of broadleaved and broadleaved-conifer mixed stands is one main silvicultural goal in many forest programs of the federal states in Germany. We used the framework of the Biodiversity Exploratories to verify a positive effect of two species mixed stands on landscape level (gamma diversity) biodiversity of vascular plants, bryophytes and lichens compared to respective pure stands. We investigated mixtures of European beech with 1) Scots Pine in Schorfheide-Chorin, 2) with Norway Spruce in Schwäbische Alb and 3) with Sessil/Common Oak in Schorfheide-Chorin. We generated hypothetical stand type compositions by resampling plots of pure and mixed stands so that all compositional combinations were represented in steps of 10% with up to 1000 replications.
In terms of beech-conifer mixtures, results show that gamma diversity of the investigated groups is highest when a landscape comprises different pure stands rather than stand-scale tree species mixtures. While the reduction of gamma-multidiversity was moderate in beech-spruce mixtures (7%) compared to a combination of pure stands, beech-pine mixtures reduced multidiversity by 20%. We found a similar reduction for beech-oak mixtures (19.8%) compared to oak stands. The latter comprised species of oak, beech and pine stands explaining the high biodiversity. Combining different stand types in Schorfheide-Choin showed that biodiversity is best preserved when the landscape is composed of different pure stand types (53% Oak, 25% Pine, 12% Beech) indicating that the habitat heterogeneity provided by different pure stands at the landscape scale is more effective for biodiversity than the heterogeneity by mixed beech stands at the stand-scale.

Session 21-O6 - Forest Ecology - methods and management strategies

How to pile up oranges - the ambiguous role of science in the dispute over naturally developing forests in Germany

Peter Meyer[1]

[1]Nordwestdeutsche Forstliche Versuchsanstalt, Göttingen, DE, peter.meyer@nw-fva.de

In Germany, the target to leave 5 % of the forest area to natural development is controversial. We evaluated the different scientific approaches aimed at understanding the ecological effects of this conservation measure.
Space-for-time substitutions and comparative studies along gradients of management intensity or naturalness prevail. Contradictory results from these studies call for the scrutinizing and further improving of their methodological basis. Typical problems are short time-scales, securing comparability, and a simplistic perception of both forestry and natural dynamics. To remedy the latter, a typology of anthropogenic interventions and natural events based on disturbance ecology is suggested.
Long-term research in strict forest reserves (SFR) serves as an alternative to space-for-time substitutions and comparative studies. The majority of ecologists recognise the merits of long-term studies to better understand the complex dynamics of forest ecosystems. Nonetheless, the scientific impact of SFR time-series is still limited, partly due to a lack of conceptual foundation. For long-term development of biodiversity in beech (*Fagus sylvatica* L.) SFR we suggest a conceptual model, derive research questions and review the current knowledge.
How to pile up oranges has never been a difficult practical, yet a substantial mathematical problem. Similarly, the political target of leaving 5 % of forests to natural development was set without an unequivocal scientific basis. This applies to many practical decisions in forestry and conservation. Adaptive management and heuristic reasoning can cope with the resulting uncertainty. Science can significantly contribute reproducible methods for monitoring and a better causal understanding of the effects of management and protection measures. However, an even stronger focus should be laid on long-term research.

Session 21-O7 - Forest Ecology - methods and management strategies

Integrative management to sustain biodiversity and ecological continuity in Central European oak forests

Andreas Mölder[1], Peter Meyer[1], Ralf-Volker Nagel[1]

[1]Northwest German Forest Research Institute, Göttingen, DE, andreas.moelder@nw-fva.de

Central European temperate oak (*Quercus robur*, *Q. petraea*) forests are highly valued for their rich biodiversity. They are also of great economic importance and forest management aims to produce high quality timber. We conducted a literature review to identify management options for forestry and nature conservation that sustain both the ecological value of oak forests and the economic viability of oak silviculture.

We addressed three main questions: a) Oaks and close-to-nature forestry – what are the key silvicultural challenges and options?, b) What is the particular significance of ecological continuity and which structural features are of importance for biodiversity conservation in oak forests?, c) What are the key elements and possible strategies of forest management that sustain the ecological values in oak forests in combination with viable forestry?

Light availability appeared to be a strong link connecting the conservation and the silvicultural aspects of multifunctional oak forest management: Both young oak trees and multiple oak forest specialist species are characterized by their need for sunlight exposure. The concept of retention forestry offers purposeful approaches in this context. Also, the re-establishment of (modified) historical forest management techniques, which increase stand openness and create suitable oak regeneration niches, seems to be necessary.

Furthermore, the uninterrupted temporal continuity and availability of wood-related structural features appeared to be highly important for oak forest biodiversity. There is an urgent need for systematic forest planning approaches that secure the long-term availability of these structural features within areas or "sustainability units" that are large enough to maintain viable populations of oak forest specialist species. In the sustainability units, oak regeneration measures ought to take place either in close vicinity to old oak stands or directly in these stands. Here, the needs and possibilities of both silvicultural and nature conservation management should be considered.

Session 21-O8 - Forest Ecology - methods and management strategies

Primary determinants of community composition vary among taxa in a brown food web

Jörg Müller[1], Mike Ulyshen[2], Claus Bässler[1], Marc Cadotte[3], Sebastian Seibold[4], Simon Thorn[1]

[1]Universität Würzburg, Fabrikschleichach, DE
[2]3USDA Forest Service, Southern Research Station, Athens, US
[3]University of Toronto–Scarborough, Toronto, CA
[4]TU München, Freising, DE

The evolutionary split between gymnosperms and angiosperms has far-reaching implications for the current community composition of many taxa colonizing trees. With deadwood's inherent character as a spatially scattered habitat of plant tissue and transient in time, local assemblages living in deadwood should be affected not only by the dispersal ability of wood inhabiting taxa, but also by host identity, local environment and decay status. However, the relative contributions and interactions of these drivers are still unknown and are expected to vary among taxa. We exposed 40 logs of a conifer and 40 logs of a broadleaf tree in forest gaps and in closed stands to disentangle the importance of microclimate and host tree as drivers of decomposer communities during the early and mid-stage of decomposition. We sampled beetles, spiders, fungi and bacteria over 3 years, comprising 449, 160, 192 and 34,647 species/OTUs respectively. Variation partitioning showed host identity as most important for fungi, microclimate and succession stage for beetles and spiders, and succession stage for bacteria. Microclimate's overruling of the host identity in beetles provides a paradigm shift in insect dead-wood ecology, where it is widely believed that beetles are specialized to specific hosts. Moreover, the increase of host generalist beetles in logs exposed in gaps points out that macroecological findings of wider host niches in species adapted to harsh environment might be expanded to environments with harsher microclimate.

Projecting forest dynamics across Europe: potentials and pitfalls of empirical mortality algorithms

Timothy Thrippleton[1], Lisa Hülsmann[2], Maxime Cailleret[3,4], Harald Bugmann[1]

[1]Swiss Federal Institute of Technology (ETH Zurich), Forest Ecology, Zürich, CH, timothy.thrippleton@usys.ethz.ch
[2]University of Regensburg, Group for Theoretical Ecology, Regensburg, DE
[3]Swiss Federal Research Institute WSL, Ecophysiology (EPHY), Birmensdorf, CH
[4]IRSTEA, Ecosystèmes Méditerranéens et Risques, Aix-en-Provence, FR

Mortality is a key process of forest ecosystem dynamics and functioning strongly altering biomass stocks and carbon residence times. Dynamic vegetation models (DVMs) used to predict forest dynamics are typically based on simple, largely data-free ('theoretical') mortality algorithms (MAs). To improve DVM projections, the use of empirically-based MAs has been suggested, but little is known about their impact on DVM behavior. A systematic comparison of eight MAs (seven inventory-based, one 'theoretical') for the pan-European tree species *Pinus sylvestris* L. was carried out within the DVM ForClim for present and future climate scenarios at three contrasting sites across Europe. Model accuracy was furthermore evaluated with empirical data from young and old-growth forests. We found strongly diverging mortality patterns among the MAs for present climate. Based on their behavior, we identified two distinct empirical MA groups that were related to their structure (i.e., variables considered), but not to their geographic origin (i.e., the environmental conditions they were calibrated to). Under climate change, MAs based on a competition index produced ecologically inconsistent results, while MAs based on growth showed more plausible and less extreme behaviors. Furthermore, MAs based on growth reached a higher accuracy for projecting young and old-growth forest dynamics. Our results demonstrate that using empirical MAs in DVMs has a high potential to better predict forest dynamics, but also a risk of yielding implausible results if their structure is inadequate. For DVM applications across large spatiotemporal scales, we thus suggest using MAs based on growth, particularly under future no-analogue climates.

Session 21-O10 - Forest Ecology - methods and management strategies

Can an invasive species (*Hymenoscyphus fraxineus*) enhance spider and ground beetle diversity in commercial ash plantations? Not really!

Ondřej Košulič[1], Kamila Surovcová[1], Tomáš Hamřík[1], Jiří Rozsypálek[1], Radek Michalko[2]

[1]Department of Forest Protection and Wildlife Management, Faculty of Forestry and Wood Technology, Mendel University in Brno, Brno, CZ, ondra.kosulic@seznam.cz
[2]Department of Forest Ecology, Faculty of Forestry and Wood Technology, Mendel University in Brno, Brno, CZ

Invasive species often have a tendency to cause negative effects in ecosystems. However, in some cases the effects of invasive species is seemingly positive. Ash trees (*Fraxinus excelsior*) are one of the last smooth tree species that continue to grow in lowland floodplain forests. In the last decades, ashes have been attacked by the invasive fungus *Hymenoscyphus fraxineus*. Ash decline can cause significant changes in the stand structure, microhabitat conditions, and various biotic interactions. Our objective was to analyse the biodiversity of spiders and carabid beetles in commercial ash plantations along the gradient of *H. fraxineus* infestation. In particular, we studied the effect on species and functional diversity, activity density, conservation value, degree of rarity, and abundance of rare and endangered species. All studied indicators showed a hump-shaped relationship with increasing infestations except carabid species diversity that showed no particular relationship with infestation. In general, community of spiders and carabids was significantly more complex in ash stands under moderate infestation. Surprisingly, the results showed that the invasive organism can have a seemingly positive effect on the diversity of particular organisms in forests. However, the ultimate impact was still negative because a strong infestation of ash plantations greatly reduced the overall biodiversity.
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Session 21-O11 - Forest Ecology - methods and management strategies

Costs and benefits of active deadwood restoration: short-term effects on biodiversity and ecosystem functions in an experimental setup

Nadja K. Simons[1,2], Jonas Hagge[3,4], Claus Bässler[4], Roland Brandl[5], Axel Gruppe[3], Fabian Härtl[6], Stefan Hotes[5], Hubert Job[7], Thomas Knoke[6], Marius Mayer[8], Jörg Müller[4,9], Joachim Rathmann[7], Philipp Sacher[8], Wolfgang W. Weisser[1]

[1]Terrestrial Ecology Research Group, Technische Universität München, Freising, DE
[2]Ecological Networks, Technische Universität Darmstadt, Darmstadt, DE, simons@bio.tu-darmstadt.de
[3]Lehrstuhl für Zoologie - Entomologie, Technische Universität München, Freising, DE
[4]Nationalpark Bayerischer Wald, Sachgebiet Naturschutz und Forschung, Grafenau, DE
[5]Department of Ecology, Philipps-University Marburg, Marburg, DE
[6]Institute of Forest Management, Technische Universität München, Freising, DE
[7]Lehrstuhl für Geographie und Regionalforschung, Institut für Geographie und Geologie, Julius-Maximilians-Universität Würzburg, Würzburg, DE
[8]Juniorprofessur für Wirtschaftsgeographie und Tourismus, Institut für Geographie und Geologie, Universität Greifswald, Greifswald, DE
[9]Field Station Fabrikschleichach, Department of Animal Ecology and Tropical Biology, Biocenter, University of Würzburg, Rauhenebrach, DE

Increasing the amount of deadwood in unmanaged as well as managed forests is an important goal for nature conservation and part of different political and management strategies. While the positive effects of deadwood on the biodiversity of different taxa is unquestioned, economic implications and acceptance by different stakeholders are rarely evaluated. Those and other constraints within managed forests lead to very practical questions of how much, where and what type of deadwood can or should be established and maintained. In addition, active creation of deadwood might be needed to achieve large deadwood amounts within the desired timeframes. In a large-scale experimental approach, combinations of three different types of deadwood (stumps, lying logs and standing snags) and two spatial configurations (aggregated and distributed) were artificially created on 0,25 ha-plots within the Bavarian Forest. Within the first two years after the deadwood was created, different aspects of biodiversity and ecosystem functions were assessed at plot level as well as in relation to individual deadwood objects. As the data were collected shortly after the experimental disturbance, they describe the early response of the system rather than the long-term benefits of deadwood addition which might change distinctly at later stages. The observed effects on biodiversity and ecosystem functions were mostly related to changes in structural heterogeneity and microclimate. In addition to the ecological data, the economic costs, scenic beauty evaluations

and public acceptance of the different deadwood treatments were assessed and are discussed in relation to the benefits for biodiversity and ecosystem functioning.

Session 21-O12 - Forest Ecology - methods and management strategies

You cannot dance at two weddings: managing trade-offs in forest multifunctionality and multidiversity

Lionel Hertzog[1], Lander Baeten[1], Martijn Vandegehuchte[1], Dries Bonte[1], An Martel[1], Kris Verheyen[1], Luc Lens[1]

[1]University of Gent, Gent, BE, lionel.hertzog@ugent.be

Forest ecosystems provide multiple services and harbor a diverse set of communities, current forest management practices strive to maintain and promote both multifunctionality and multidiversity from multiple stakeholder perspectives. Different drivers may affect forest multifunctionality and multidiversity leading to potential trade-offs and synergies as a response to management actions such as the removal of an invasive species or changes in landscape-scale fragmentation levels. However, the identification of these trade-offs and synergies depending on different stakeholder perspectives but also their constraints in mature forests is lacking. We developed a research platform comprising 53 mature forest plots in 19 forest fragments in central Belgium with varying tree composition and varying levels of fragmentation. Ecosystem functions encompassing all ecosystem compartments were collected together with community data in 8 major groups. Here we show that different stakeholder perspectives leads to important variation in the multifunctionality and multidiversity changes following management actions. For instance, multifunctionality under a productivist perspective (high wood production), is maximized in beech monocultures with large amount of edges and close to large forest fragments. Whereas under a conservationist perspective (high vertebrate diversity) multidiversity is maximized in pedunculate oak mixtures in isolated fragments. Further analysis will reveal how these plot-level patterns scale up to the landscape. Together our results show that due to the presence of trade-offs no perfect plot and landscape-level management option exists that maximize all functions while having high diversity across trophic levels. Managers must therefore embrace the conflicting facets of forest multifunctionality and multidiversity and develop management strategies based on the relative importance given to multiple functions and diversity.

Session 21-O13 - Forest Ecology - methods and management strategies

Applicability of participatory forest management: Lessons from an East African biodiversity hotspot

Muthio Joslyn Nzau[1], Elizabeth Gosling[1], Halimu Shauri[2], Marco Rieckmann[3], Jan Christian Habel[4]

[1]Technical University of Munich, Freising, DE, muthio.nzau@tum.de
[2]Pwani University, Kilifi, KE
[3]University of Vechta, Vechta, DE
[4]University of Salzburg, Salzburg, AT

Participatory Forest Management (PFM) has been adopted as one approach towards reconciling biodiversity conservation goals and livelihood needs. PFM was implemented around the largest remaining forest block of the African coastal forest in Kenya two decades ago. While forest cover has remained stable, there is evidence for persistent selective logging, subsequent reduction of habitat quality, and a steady decline in biodiversity. Against this ecological backdrop, this study employed structured surveys and semi-structured expert interviews to investigate the efficiency and acceptance of PFM by examining local awareness based on indigenous and modern ecological knowledge, willingness to adopt good environmental practices and attitudes towards forest conservation. Our quantitative analysis revealed low awareness on endangered and endemic flora and fauna which was influenced by gender, education, indigenous knowledge and settlement time scale. Men, participants possessing higher formal education or indigenous knowledge, and long-term residents showed significantly higher awareness. Whereas 80% of participants perceived the forest as of high personal importance, only a minority expressed a sense of personal responsibility towards its protection which was influence by ethnicity. The Waata, a shrinking ethnic minority, showed significantly high scores on traditional ecological knowledge, willingness and personal responsibility towards forest conservation, in comparison to the ethnic majority, the Mijikenda. Qualitative analysis pointed to institutional gaps in the implementation of PFM and overlapping legitimacy claims on subsistence forest use and benefit sharing. Our results question the presumptions of PFM and recommend localized, adaptable and evidence-based conservation strategies.

Key words: Forest management, biodiversity hotspot, nature conservation, conservation attitudes

Session 21-O14 - Forest Ecology - methods and management strategies

Optimizing the management of Calabrian pine (*Pinus brutia* T.) stands in Syria based on individual-tree models

Tammam Suliman[1], Uta Berger[1], Marieke van der Maaten-Theunissen[1], Ernst van der Maaten[1], Wael Ali[2]

[1]TU Dresden, Dresden, DE, tammam.suliman@forst.tu-dresden.de
[2]Tishreen University, Latakia, SY

- **Context** *Pinus brutia* is the most widely planted conifer in the coastal region of Syria. Sustainable forest management of this valuable resource, however, is limited so far since knowledge is lacking about the annual growth hindering an accurate estimation of the optimal rotation length, the best suitable thinning regime, as well as an accurate prediction of stand development and forest dynamics.
- **Aims** The study presents the newly developed forest simulator PINUS-Syria IBM designed to simulate even-aged *Pinus brutia* stands based on real-time series in the coastal region of Syria in order to analyze the outcome of different management regimes.
- **Methods** PINUS-Syria IBM is a distance-independent, individual-based forest model implemented in the open source software NETLOGO, and is thus freely available for any forester interested in the topic. The particular advantage of this model is in its parametrization which bases on real-time series obtained in the Aleppo region. The latter includes, for example, the site index, stem diameter, height and crown ratios. Individual tree growth and mortality consider tree size, site characteristics, and competition.

- **Results** The model was evaluated well on the short-term and long-term. The mean annual volume increment with the optimal rotation length ranged between 2.9 m^3 ha^{-1} and 11.5 m^3 ha^{-1} on the poorest site depending on site quality. The rotation length was 35-45 years for the best site and 100-115 years for the poorest site. Our findings imply that moderate and heavy thinning remarkably improve the growth and reach within 10-40 years of the production period to the optimum age.

- **Conclusion** PINUS-Syria IBM is the first forest simulation model developed and parameterized for Syrian conditions. It simulates the stand development of even-aged forests. It is freely available for scientists and foresters alike pathing the way for a quantified. PINUS-Syria IBM allows predicting future yields and to compare alternative management schedules.

Session 21-O15 - Forest Ecology - methods and management strategies

Soil-atmosphere exchange of greenhouse gases following conventional selective logging and reduced-impact logging in a Congo Basin rainforest of Cameroon

Rodine Tchiofo Lontsi[1], Marife D. Corre[1], Oliver van Straaten[1], Edzo Veldkamp[1]

[1]Goettingen University, Goettingen, DE, rtchiof@gwdg.de

Undisturbed tropical forests are an important sink of greenhouse gases (GHG) from the atmosphere. Following selective logging that affects forest canopy, microclimate, soil physical conditions and biogeochemical cycling, tropical forests can turn to GHG source. Our study aimed to (1) assess the changes in soil CO_2, N_2O and CH_4 fluxes following conventional (repeated logging entries depending on timber demand), and reduced-impact (which requires a management plan with 30-year logging cycle) logging, and (2) determine their controlling factors. For each logging system, we investigated four disturbance strata (road, logging deck, skidding trail and felling gap) and an undisturbed reference area in four replicate plots. We used vented static chamber (11-L volume, 0.04-m^2 area) to measure soil CO_2, N_2O and CH_4 fluxes monthly from September 2016 to October 2017 (four chambers per stratum and replicate plot). Simultaneously, we measured soil (mineral N, water-filled pore space (WFPS), temperature) and climatic factors (air pressure and temperature) as well as soil biochemical characteristics, all known to control soil GHG fluxes.

Soil CO_2 emissions across a year of measurements ranged from 55.0 to 206.8 mg C m^{-2} h^{-1} and were 55% to 73% lower in road and logging deck compared to undisturbed area and felling gap ($P < 0.01$). Across strata and logging systems, soil CO_2 fluxes were controlled by soil temperature, bulk density and fertility indices. Soil N_2O emissions were highest in skidding trail (56.7 µg N m^{-2} h^{-1}, $P < 0.01$) and were correlated with WFPS. Undisturbed area and felling gap were CH_4 sink (-25.5 to -51.6 µg C m^{-2} h^{-1}) while skidding trail, logging deck and road emitted CH_4 (5.2 to 873.1 µg C m^{-2} h^{-1}, $P < 0.01$). Soil CH_4 fluxes were influenced by WFPS, C:N ratio and base and aluminum saturations. After the first logging event, soil GHG fluxes were generally comparable between conventional and reduced-impact logging.

Session 21-O16 - Forest Ecology - methods and management strategies

Surveying forest damage after extreme droughts

Tobias Mette[1]

[1]Landesanstalt für Wald und Forstwirtschaft, Freising, DE, tobias.mette@lwf.bayern.de

Climate change affects forest managers most sensibly through climatic extremes such as heat, drought, heavy rains, or thunderstorms. The necessity to respond to the consequences of such extremes increasingly charges the silvicultural working capacities and makes forest management according to plan difficult. Salvage cuttings flood the wood market and spoil the wood prices. For 2018, the estimated forest damage amounted up to 50 Mio m3 over an area of 114.000 ha in Germany – one third from windthrow, two thirds from drought. While the impact of storms is directly visible, the impact of severe droughts is more difficult to quantify. A clear concept how to capture the extent of damage and the affected sites is missing.

In 2016, Scots pine in the region of Nuremberg suffered a dieback ranging from individual trees to 30-50 % of entire stands. The dieback was concentrated in a region where drought in 2015 was most extreme. To quantify the damage and investigate the stands and sites affected, a study was carried out including remote sensing, intense investigation sites, tree ring analyses and a stratified crown condition survey. The results indicate that the fungus *Diplodia sapinea* responsible for pine tip blight led to an irreversible decline in vitality and mortality. The stratified crown condition survey revealed that less productive stands, forest edges and those on poorer soils were more likely to show higher crown damage. Yet, incidences were too little to estimate the regional forest damage.

In 2018, Germany suffered from a severe drought, in Bavaria mainly the northern part. Based on the results of 2016, a preliminary "risk map" was drawn to identify regions where Scots pine dieback is potentially elevated. Currently, different survey designs are simulated in order to improve the risk map and deliver robust estimates of the extent of forest damage. An optimized survey concept will strongly help understanding and responding to the impact of future extreme events.

Session 21-O17 - Forest Ecology - methods and management strategies

Diversity of saproxylic arthropod communities in tree hollows with regard to forest and landscape structure

Benjamin Henneberg[1,2], Heike Feldhaar[1], Elisabeth Obermaier[2]

[1]Tierökologie 1, Universität Bayreuth, Bayreuth, DE, ben_henneberg@web.de
[2]Ökologisch-Botanischer Garten, Universität Bayreuth, Bayreuth, DE, ben_henneberg@web.de

Tree hollows with wood mould are considered as key structures for a high biodiversity in forests. They offer a constant microclimate for many years and nutritional resources for many endangered saproxylic arthropod species. To analyze the effects of forest- and landscape structure on the diversity of saproxylic insects in tree hollows in managed forests, we examined 40 – 50 tree hollows in beech trees in each of three Bavarian state forestries using emergence traps. We utilized forest inventory data collected by the state forestries to analyze saproxylic diversity in tree hollows. During the first year of the study, we collected a total of 231 saproxylic beetle species in the state forestries Ebrach (Steigerwald) and Fichtelberg, 19% of which were on the Red List. Species composition differed a lot in the two forestries. 158 beetle species were exclusively found in the forestry Ebrach, 34 exclusively in the forestry Fichtelberg, and only 39 beetle species were detected in both forestries. In the forestry Ebrach, forest stand parameters like elevation, temperature, and exposition of the tree hollows had the strongest influence on diversity of saproxylic beetles, but also the degradation status of the wood mould. With regard to the effect of forest structure on saproxylic diversity on a landscape scale, the amount of deadwood that was calculated using forest inventory data had a positive effect on saproxylic diversity up to a radius of 300 m around the focal tree hollow. However, in the forestry Fichtelberg that was dominated by coniferous trees, only the portion of beech trees up to a radius of 100 m around the focal tree hollow had a positive effect on the diversity of saproxylic beetles. These preliminary results imply that forest inventory data could be a useful instrument for the prediction of saproxylic diversity in tree hollows in managed forests.

Session 21-P1 - Forest Ecology - methods and management strategies

Which shares of even-aged, uneven-aged and unmanaged forests best promote gamma-diversity in European beech forest landscapes?

Peter Schall[1], Martin Gossner[2], Steffi Heinrichs[1], Christian Ammer[1]

[1]Silviculture and Forest Ecology, University of Göttingen, Göttingen, DE, peter.schall@forst.uni-goettingen.de
[2]Swiss Federal Research Institute WSL, Birmensdorf, CH

The composition of forest landscapes in terms of tree age, developmental phases and the share of unmanaged forests is substantial for protecting biodiversity. Forest conservationists and policy advocate increasing the share of unmanaged and uneven-aged forests even though the effect of the regional forest structure on biodiversity is still under debate.
We studied the biodiversity of forest landscapes composed of even-aged, uneven-aged and 50 to 70 years unmanaged European beech forests for 14 organism groups sampled in the Hainich-Dün area, Germany. Hypothetical forest landscapes were generated by resampling plots of the three management systems so that all compositional combinations were represented in steps of 10%. We asked how differently composed forest landscapes affect α- and γ-diversity and multidiversity.
Beetles, spiders and vascular plants responded most strongly to differences in landscape composition with maximum γ-diversity in a pure even-aged (age-class) forest landscape and minimum values in a pure unmanaged forest landscape. The response is comparable to forest specialists. Birds benefited from even-aged forests in combination with a share of unmanaged forests of approximately 20%. Two groups had their γ-diversity maximum in unmanaged forests (deadwood fungi) or in uneven-aged plenter forests (bacteria). Gamma-multidiversity culminated in pure even-aged forest landscapes, harboring 97.5% of the total diversity across the 14 groups. Pure landscapes of even-aged forests (87.0%) or unmanaged forests (86.2%) reduced γ-diversity by more than 10%. The α-multidiversity showed a concurrent, but less pronounced response.
We conclude that biodiversity of most taxa is best preserved in even-aged forests. This indicates that a mosaic of different age-classes better promotes regional biodiversity than high within-stand heterogeneity and several decades of management abandonment in European beech forests.

Session 21-P2 - Forest Ecology - methods and management strategies

The dependence of abundance-based β-diversity metrics on γ-diversity

Ke Cao[1,4], Jens-Christian Svenning[3], Chuan Yan[2], Jintun Zhang[4], Xiangcheng Mi[1], Keping Ma[1]

[1]Institute of Botany, Chinese Academy of Sciences, Beijing, CN
[2]Institute of Zoology, Chinese Academy of Sciences, Beijing, CN
[3]Department of Bioscience, Aarhus University, Aarhus, DK
[4]College of Life Sciences, Beijing Normal University, Beijing, DK

Studying the spatial patterns of β-diversity allows ecologists to test hypotheses regarding the generation and maintenance of biodiversity. Most incidence-based β-metrics are strongly dependent on γ-diversity, causing artefacts in β-diversity and resulting in misleading inferences. However, whether these metrics depend on γ-diversity remains unclear. To better understand these relationships, we chose five widely-used β metrics and compare the effectiveness of two common approaches to removing γ-dependence using both simulated and empirical data.

We found that most abundance-based metrics were dependent on γ-diversity in varying degrees. One notable exception was the multi-site Shannon entropy index, which was relatively independent of γ-diversity when a correction for undersampling was applied. The Jaccard-Chao index was also relatively insensitive to γ-diversity when community size was large, because bias due to undersampling was corrected for by estimating the effect of undetected shared species. The null model adequately removed the γ-dependence of the Jaccard-Chao index, but partially reduced γ-diversity dependence of other metrics undersampling was left unaccounted for.

The multi-site Shannon entropy index and the β-deviation of Jaccard-Chao appear to be relatively independent of γ-diversity, except when sample size is small. This suggests that these metrics can be used as robust comparisons of β-diversity among regions. Importantly, null models can partially remove γ-diversity dependence of these metrics. The normalized divergence and Hellinger distance were also strongly dependent on γ-diversity. However, these two metrics offer several advantages and should be strongly considered after reliable bias correction methods for undersampling are applied.

Session 21-P3 - Forest Ecology - methods and management strategies

Mapping priority forest services at high spatial resolution using forest association models

Daniel Scherrer[1], Thomas Wohlgemuth[1]

[1]WSL Swiss Federal Research Institute, Birmensdorf, CH, daniel.scherrer@wsl.ch

Forests provide a multitude of different ecosystem services, among which wood production, biodiversity and protection against natural hazards are prevailing in Central Europe. However, the priority ecosystem service considerably depends on the forest plant community.-

Swiss forest plant communities have been regionally defined by using an old system of plant associations (n=71) and continuously extending it with new units and sub-units (n=270; NaiS site types). So far, a nationwide comprehensive fine resolution map of those forest types at any community level is lacking, making nationwide efforts to quantify and analyze the priority of ecosystem services difficult.

Here, to predict the site types at 25 m resolution across all forests, we used 6000 plots of the National Forest Inventory (Swiss NFI) with site definitions and performed machine learning techniques by addressing a large set of environmental predictors (biotic and abiotic). Model results were then linked to NFI-derived information on e.g. biodiversity, main ecosystem service, and wood volume. High-resolution maps will serve as a decision-support system to be adjusted depending on policy targets. In particular, the model will be used to define effects of changed abiotic (climate change) and/or management conditions on the forest community level and related shifts in priority services.

As the units of the applied forest model are forest types at the community level, priority forest services are easily compared in contrast to models based on single species distributions both under current and future conditions.

Session 21-P4 - Forest Ecology - methods and management strategies

Abiotic and biotic determinants of height growth of Picea abies regeneration in small forest gaps in the Swiss Alps

Ueli Schmid[1], Monika Frehner[1], Harald Bugmann[1], Christof Bigler[1]

[1]Forest Ecology, ETH Zürich, Zürich, CH, ueli.schmid@usys.ethz.ch

In forests protecting against gravitational natural hazards, the continuous presence of regeneration is of great importance since it is the main factor contributing to the system's resilience. Height growth of regeneration is decisive for the time needed until young trees can assume a protective function. A better understanding of this process is important for e.g. refining management interventions and detailed depiction of forest dynamics in growth models. However, there are hardly any data sets allowing for the analysis of height growth of regeneration covering a large span of heights and large environmental gradients. We conducted an extensive field campaign focusing on one of the most important tree species in European mountain forests, *Picea abies*.

We collected data in the upper montane and subalpine altitudinal belt across the Swiss Alps. In small forest gaps, we measured height growth of the dominant regeneration (10 cm height to 12 cm DBH). In the center of each gap, hemispherical photographs were taken and the surrounding stand was assessed (DBH and position of each tree). In total, approximately 300 trees in 120 gaps were measured.

We used linear mixed models to analyze the data and cross-validation for model selection. The resulting models are able to explain height growth over a large span of three height with considerable accuracy. The most important explanatory variables are tree height and a measure of competition by the surrounding stand. To describe competition, metrics based on basal area and light availability are almost equally well suited. Further explaining variables such as temperature and drought proxies and local topography add accuracy to the models but were usually not significant, except for local topography.

We thus conclude that it is possible to predict height growth of Norway spruce regeneration based on a surprisingly small set of predictor variables, with considerable implications for dynamic models of mountain protection forests.

Session 21-P5 - Forest Ecology - methods and management strategies

Regeneration dynamics in experimental canopy gaps in beech and oak dominated forests of the Rostocker Heide

Jan Wilkens[1], Sven Wagner[1]

[1]TU Dresden, Tharandt, DE, j.wilkens@gmx.net

Tree species diversification is a valid silvicultural strategy to prepare forests for the uncertainties of climate change and increasingly extreme weather patterns. Today, silviculture strives to mimic natural disturbance regimes. As a result, stem-wise forest management is now prevalent in central Europe. This management strategy - due to small-scale disturbances - excludes natural regeneration of pioneer tree species and maintains species-poor climax forests. Therefore, our aim here is to quantify the requirements of the different tree species necessary for natural regeneration in canopy gaps.

The study is carried out in 24 experimental canopy gaps (50 to 600 m²) in pure beech and mixed oak-beech old growth forests in the Rostocker Heide in north-eastern Germany. Annual inventories of natural regeneration include 9000 individuals observed in all canopy gaps. In addition, 2000 beeches were planted and 1200 oaks were sown in autumn and spring in 2017 and 2018 in all gaps. Measurements include survival, annual length growth, diameter increment, vitality and damages, as well as the stem foot coordinates of each individual. The effects of resource availability and competition on the regeneration dynamics of different tree species are studied in high spatial and temporal resolution. On 600 plots we measured direct and diffuse solar radiation with hemispherical photos and performed annual vegetation inventories. Lastly, using 200 soil samples, we analysed the below-ground competition around mature trees by modelling the spatial fine root biomass distribution.

The results show that survivability and height growth of planted beeches are strongly correlated with direct and indirect solar radiation, but also indicate the importance of belowground processes. Highest mortality and lowest growth rates were found in northern gap partitions, where high direct radiation combines with increased below-ground influence of nearby mature trees.

Session 21-P6 - Forest Ecology - methods and management strategies

Spatial analyses of natural sessile oak regeneration and ground cover types to improve silvicultural management strategies in Scots pine forests

Franka Huth[1,2,3], Alexandra Wehnert[1,2,3], Sven Wagner[1,2,3]

[1]Franka Huth, Institute of Silviculture and Forest Protection, Department of Forest Sciences Tharandt, TU Dresden, DE, f.huth@freenet.de
[2]Alexandra Wehnert, Institute of Silviculture and Forest Protection, Department of Forest Sciences Tharandt, TU Dresden, DE, f.huth@freenet.de
[3]Sven Wagner, Institute of Silviculture and Forest Protection, Department of Forest Sciences Tharandt, TU Dresden, DE, f.huth@freenet.de

The situation in Scots pine (*Pinus sylvestris* L.) forests in the northeastern German lowlands poses a challenge to silvicultural management, which aims to achieve near-natural stand structures and site-specific tree species mixtures, e.g. with sessile oak (*Quercus petraea* (Matt.) Liebl.). The proportions of vital and seed producing oak trees are small and the trees are irregularly distributed over large areas consisting of mono-layered Scots pine forests. These forests typically also exhibit other conditions unfavourable for the establishment of oak-pine mixtures by natural regeneration such as the presence of a closed ground vegetation layer dominated by grasses or shrubs. Environmental niches such as safe sites are necessary to provide the conditions for successful oak regeneration. Accordingly, the objectives of this study were to: (i) estimate distant-dependent oak seedling densities in relation to oak seed tree positions, (ii) provide small-scale spatial distribution analyses of oak seedlings and (iii) determine the influence of ground vegetation types to adapt silvicultural measures, for example, by preserving a sufficient density of mature oak trees. The positions of all oak seedlings and overstorey pine trees were measured along transects on three different pine forest sites with admixed old solitary oak trees. Maps of ground vegetation mosaics were generated by means of grid-based interpolations of empirically sampled vegetation groups. Using point pattern analyses and the replication of transects it was possible to derive generalised linear models. The results provide information on two different spatial scales. A site-specific decrease in seedling densities at increasing distances from seed producing oak trees could be proven. On a smaller scale, within distances of just a few meters, oak seedlings exhibited clumped distributions. Ground cover types dominated by grasses and shrubs were less favourable for oak seedlings than litter and lying deadwood.

Session 21-P7 - Forest Ecology - methods and management strategies

200 years of concepts for habitat tree protection

Andreas Mölder[1], Peter Meyer[1], Marcus Schmidt[1]

[1]Northwest German Forest Research Institute, Göttingen, DE, andreas.moelder@nw-fva.de

The protection and permanent provision of habitat trees are integral parts of modern forest nature conservation strategies such as retention forestry. Not only bats and cavity-nesting birds, but also a great variety of specialized saproxylic beetle species are dependent on hollow trees rich in microhabitats. Effective habitat tree schemes therefore make an important contribution to the sustained preservation of habitat continuity.
Already 200 years ago, initial ideas for habitat tree protection were developed by foresters and natural scientists. In the second half of the 19th century, the concept of habitat tree protection in forestry was generally known, though not under this name. At that time, a large number of advocates of utilitarian bird protection called for the preservation of hollow and woodpecker trees. As a result, the preservation of habitat trees was sometimes recommended by forestry institutions. The actual extent of habitat tree protection, however, was often dependent on the individual initiative of single foresters. Added to this was the protection of veteran trees for aesthetic reasons, which also fulfilled habitat tree functions. These measures can be assumed to have had a positive effect on the population of cavity-nesting birds, at least regionally. Habitat continuity, however, was widely interrupted due to increasingly efficiency-oriented forest management.
After 200 years, we are nowadays experiencing the implementation of a trend-setting idea of far-sighted 19th century foresters and natural scientists.

Session 21-P8 - Forest Ecology - methods and management strategies

Forest extent mitigates land-use intensification impacts on bird communities in the Dry Chaco landscapes of Argentina

Julieta Decarre[1], Leandro Macchi[2,3], Andrea Goijman[1], Matias Mastrangelo[2,4], Pedro Blendinger[2,3], Gregorio I. Gavier[1], Francisco Murray[5], Maria Piquer-Rodriguez[3], Asunción Semper-Pascual[6], Tobias Kuemmerle[6,7]

[1]National Institute of Agricultural Technology, IRB-CNIA, AR, decarre.julieta@inta.gob.ar
[2]CONICET, Buenos Aires, AR
[3]Institute of Regional Ecology (IER), Tucumán, AR
[4]National University of Mar del Plata, Mar del Plata, AR
[5]National Institute of Agricultural Technology, AER San Luis, AR
[6]Geography Department, Humboldt-Universität zu Berlin, Berlin, DE
[7]Integrative Research Institute on Transformations of Human-Environment Systems (IRI-THESys), Berlin, DE

Understanding how biodiversity responds to intensifying agriculture is critical for mitigating the ubiquitous strong trade-offs between both. We demonstrate that in dynamic landscapes, such as subtropical deforestation frontiers, the nature of these trade-offs changes as landscapes transform. Within a hierarchical Bayesian occupancy framework, we analyzed a large bird dataset from a biodiversity hotspot, the South American Chaco. We show that woodland extent consistently determined the response of the avian community, and strongly affected almost half of its species (n=85) not only as a simple feature in the landscape, but also in combination with agricultural intensification. Importantly, we found species that shifted their occupancy trend from declining to increasing, depending on the extent of the surrounding forest. Assessing strategies to best mitigate biodiversity-agriculture trade-offs must consider landscape context when evaluating the response of biodiversity. Conservation strategies based on snapshots of data are likely misleading and risk failing in dynamic landscapes.

Session 21-P09 - Forest Ecology - methods and management strategies

Alternative tree species under climate warming – estimating cultivation risk from European distribution data

Wolfgang Falk[1], Eric Andreas Thurm[1]

[1]Bavarian State Institute of Forestry (LWF), Freising, DE, wolfgang.falk@lwf.bayern.de

This study estimates the present and future distribution potential of 12 thermophilic and rare tree species for Europe based on climate-soil sensitive species distribution models (SDMs), and compares them to the two major temperate and boreal tree species (*Fagus sylvatica* and *Picea abies*). We used European national forest inventory data with 1.3 million plots to predict the distribution of the 12+2 tree species in Europe today and under future warming scenarios of +2.9 and +4.5 °C.
The SDMs that were used to calculate the distributions were in a first step only given climate variables for explanation. In a second step, deviations which could not be explained by the climate models were tested in an additional soil variable-based model. Site-index models were applied to the found species distribution to estimate the growth performance (site index) under the given climate. We found a strong northward shift (500 km to 700 km) for the thermophilic species over the regarded time period from 2060 to 2080 under warming scenarios (2.9 °C and 4.5 °C). Potential winners of climatic warming have their distribution centroid below 48°N. *Fagus sylvatica* and *Picea abies* will lose great parts of their potential distribution range (approx. 55 and 60%, respectively). An index of area gain and growth performance revealed *Ulmus laevis, Quercus rubra, Quercus cerris* and *Robinia pseudoacacia* as interesting alternatives in managed temperate forests currently dominated by *F. sylvatica* and *P. abies*. Area winners exhibited lower growth performances. So, forest conversion with these warm-adapted species goes hand in hand with loss of overall growth performance compared to current species composition.
Outcome of the distribution models are interpreted as cultivation risk and used within the Bavarian forest administration for the adaptation of private forests to climate change.

Session 21-P10 - Forest Ecology - methods and management strategies

The tree of heaven (*Ailanthus altissima*) - threat or opportunity for Central-European forestry?

Julia Isler[1], Harald Bugmann[1], Timothy Thrippleton[1]

[1]Swiss Federal Institute of Technology (ETH Zurich), Forest Ecology, Zürich, CH

Since its introduction to Europe, the tree of heaven (*Ailanthus altissima*) has become one of the most invasive tree species. Despite an increasing ecological knowledge at the individual tree level, relatively little is known on its behaviour at the stand level and potential impacts on stand structure, species composition and ecosystem functioning. To address these questions, *Ailanthus* was implemented in the dynamic forest model ForClim and simulation results evaluated via empirical data from four sites in southern Switzerland. Subsequently, the long-term dynamics of natural and managed forest stands in southern and northern Switzerland were projected under current climatic conditions as well as a future climate scenario (RCP8.5). The results show that the species was capable of gaining a considerable basal area fraction during the first 100 years of the simulations, but did not gain dominance on the long-term (>200 years) in any of the investigated scenarios. However, an increasing management intensity led to a rising share of *Ailanthus*. Simulations for future climate change showed that Ailanthus was less able to establish at sites with a higher tree species diversity, especially if these included species that were well-adapted for future climatic conditions. Overall, the results suggest that *Ailanthus* will increase locally in abundance and influence the tree species composition, particularly at managed sites, but is unlikely to dominant on the longer term. The results of this study furthermore emphasize the high potential of forest management to regulate the mixture proportion of *Ailanthus*.

SESSION 22

Global change experiments: from plants to ecosystems

Chairs: Matthias Arend, Nadine Ruehr, Jürgen Kreyling

Global change is a serious threat to terrestrial ecosystems, adversely affecting their ecological functions and socio-economical services. Rising levels of atmospheric CO2, anthropogenic nitrogen deposition, increasing temperatures and altered precipitation patterns interact on different temporal and spatial scales on plant physiology and biogeochemical cycles, which are tightly linked to ecological processes including competition, symbiotic networks and plant diversity. Effects of global change can be observed across all biomes and types of vegetation but less intensely managed ecosystems with limited potential for human-assisted adaptation, such as grasslands and forests, are particularly concerned. Global change experiments provide the information that is needed to gain process understanding and predict the direction and magnitude of future ecosystem changes. Manipulation of plants in research gardens, greenhouses or climate chambers is a frequently used approach to study effects of global change factors, separately or in combination, on plant-dependent processes and interpolate this understanding to future ecosystem responses. Manipulation of whole ecosystems in mesocosms, ecotrons or field plots is technically challenging but includes the effects of global change factors on biotic interactions and biogeochemical cycles, thus reflecting all fundamental processes of ecosystem functioning. Finally, field experiments provide high external validity but fewest control of environmental parameters. This session will cover both scientific and methodological aspects of global change experiments with plants, associated organisms and whole ecosystems. It will particular address the following topics: (1) responses of plants to global change factors including extreme events, (2) feedbacks of altered plant function on biogeochemical cycles and biotic interactions, and (3) effects on inter- and intraspecific competition and biodiversity.

Session 22-O1 - Global change experiments

End-of-season senescence in grassland species can be traced to leaf temperature during preceding extreme summer drought

Ivan Nijs[1], Sigi Berwaers[1], Hans J De Boeck[1]

[1]University of Antwerp, Wilrijk, BE, ivan.nijs@uantwerpen.be

In natural multi-species communities, drought extremes elicit complex, though seldom measured, ecophysiological responses triggered by divergent drought coping strategies and plant-plant interactions. This raises the question whether the whole-season impact of such events is in any way predictable in such systems from stress measurements during the drought. Here, we experimentally induce local variation in soil moisture in a humid, multi-species, temperate grassland in summer and test whether any of the stress indicators (stomatal conductance, net photosynthetic rate and midday leaf surface temperature) measured on the seven most abundant species is a good early warning signal of end-of-season senescence. We found that, across species, plants exposed to lower soil water content experienced similar elevation of leaf surface temperature, and that plants with warmer leaves during the drought extreme were consistently more senescent at the end of the growing season two months later, averaging 0.7% surplus leaf senescence with every additional 1 °C. We also observed links between lagged effects in the weeks after the drought, which were weakly negative on stomatal conductance, but strongly positive on photosynthesis in some species, and end-of-season senescence. Part of the damage might thus be ascribed to these drought legacies. To conclude, even in complex field settings, local leaf surface temperature measured at an early stage can be a powerful and species-specific indicator of the whole-season impact of drought extremes. This opens perspectives to estimate where in the landscape such events will be most detrimental.

Ecosystem processes show uniform sensitivity to winter soil temperature change across a continental gradient of temperate forests

Robert Weigel[1,2], Hugh A. L. Henry[3], Ilka Beil[2], Gerhard Gebauer[4], Gerald Jurasinski[5], Marcin Klisz[6], Ernst van der Maaten[7], Lena Muffler[1,2], Juergen Kreyling[2]

[1]Plant Ecology, Albrecht von Haller Institute for Plant Sciences, University of Goettingen, Goettingen, DE, robert.weigel@uni-goettingen.de
[2]Experimental Plant Ecology, Institute of Botany and Landscape Ecology, University of Greifswald, Greifswald, DE, robert.weigel@uni-goettingen.de
[3]Department of Biology, University of Western Ontario, London, CA
[4]BayCEER - Laboratory of Isotope Biogeochemistry, University of Bayreuth, Bayreuth, DE
[5]Landscape Ecology, University of Rostock, Rostock, DE
[6]Forest Research Institute, Department of Silviculture and Genetics of Forest Trees, Raszyn, PL
[7]Chair of Forest Growth and Woody Biomass Production, Institute of Forest Growth and Forest Computer Sciences, TU Dresden, Tharandt, DE

The magnitude and frequency of soil frost events are projected to increase in northern temperate regions due to reduced insulation caused by declining snow cover during climate warming. In temperate deciduous forests, increased soil frost severity can hamper tree growth and increase the mortality of fine roots, soil fauna and microorganisms, thus altering carbon and nutrient cycling. From single-site studies, however, it is unclear how the sensitivities of these responses to altered winter soil temperatures change along continental gradients from regions with low to high snowfall. We conducted a gradient-design snow cover and soil temperature manipulation experiment across a range of lowland beech (*Fagus sylvatica* L.) forest sites. We predicted i) decreased plant growth and altered biogeochemical cycling with soil cooling within sites and ii) highest sensitivity of response to altered soil temperatures in the coldest sites, where soils frequently are protected from frost by snow cover. While snow exclusion only induced mild and inconsistent soil frost, there were significant effects of manipulated soil temperatures on tree increment, germination, litter decomposition and the retention of added ^{15}N within sites. However, the sensitivity of response (treatment effect size per degree of warming or cooling) was not related to prevailing winter climate and snow cover conditions. Our results support that it may be valid to scale these responses to simulated winter climate change up from local studies to regional scales. This upscaling, however, needs to account for the fact that cold regions with historically high snowfall may experience increasingly harsh soil frost conditions, whereas in warmer regions, soil frost may diminish. Thus, despite the uniform biotic sensitivity of response, there may be opposing directions of winter climate change effects on temperate forests along continental temperature gradients due to different trends of winter soil temperature.

Session 22-O3 - Global change experiments

Does higher nutrient availability reduce drought resistance in grassland species? - Insights from a global change experiment

Carola Kiene[1], Leonor Álvarez-Cansino[1], Eunyoung Jung[1], Bettina Engelbrecht[1,2]

[1]Functional and Tropical Ecology, University of Bayreuth, Bayreuth, DE, Carola.Kiene@uni-bayreuth.de
[2]Smithsonian Tropical Research Institute, Panama, PA

Drought and nutrients, two of the main global change drivers, are important factors shaping community composition, diversity and ecosystem function in grasslands. Although it is suggested that communities in high nutrient sites are less drought resistant, interactions of nutrients and drought are complex and often contradictory, suggesting that the effect of nutrients on drought responses differs across species. Thus, our ability to predict consequences for grassland agriculture and natural grasslands under climate change remains severely limited. In this study we comparatively assessed the effect of different nutrient conditions on whole-plant drought responses of 14 common temperate grassland species. In a common garden experiment, species were grown under four different nutrient conditions (unfertilized control, nitrogen (N) or phosphorous (P) addition, and combined addition (N+ P)) in mesocosms. In the second growing season, half of the plants were exposed to an extreme drought. Species increased their biomass under nutrient addition, especially under the combined addition of N and P. Drought reduced growth in all species, but this reduction was parallel to the positive response of the species to fertilization (no drought-nutrient interaction). Thus, plants in the N+P treatment had the highest biomass even under drought. In general, drought mortality averaged around 10%, with small differences between nutrient conditions for most species. Accordingly, a wide range of common temperate grassland species possess high drought resistance, regardless of nutrient availability. However, especially forbs showed higher drought mortality than grasses and species associated with moist habitats (Ellenberg indicator values) were more drought sensitive. This response will likely lead to changes in community structure and may seriously affect the productivity (i.e. agricultural value) of grasslands with increasing drought under global change.

Session 22-O4 - Global change experiments

Effects of extreme weather events, competitive hierarchy, and propagule pressure on the invasion of *Solidago gigantea* in experimental grasslands

Sandra Liliana Rojas Botero[1], Johannes Kollmann[1], Leonardo H Teixeira[1]

[1]Technische Universität München, Freising, DE, sandra.rojas-botero@tum.de

Invasive alien species (IAS) are a challenge for restoration of degraded ecosystems, and thus it is important to improve the knowledge about how to design plant communities that could suppress IAS. We tested the effects of three drivers of invasion under climate change and based the study on theory of community assembly. A mesocosm experiment was used to test how the invasion resistance of plant communities is affected by competitive hierarchies, by extreme weather events related to climate change and by propagule pressure of the invasive alien *Solidago gigantea*. Two designed communities based on regional seed mixtures of five native grass species with different trait-based competitive abilities were established using contrasting abundances. The performance of the communities was investigated under three levels of IAS propagule pressure with interspersed heat waves and floods simulated in the climate chambers of TUMmesa. Heat waves had a negative effect on the aboveground biomass of the native species and might have indirectly enhanced the success of the IAS. However, when heat waves were followed by floods, there was a positive effect on the productivity of native species and a negative one on the IAS, implying that fluctuating resources allowed for a rapid recovery of the native community and thus, decreased invasibility. The community dominated by highly competitive species was more productive and had the strongest negative effect on *S. gigantea*, regardless of the abiotic conditions and the propagule pressure. A large propagule size introduced early in the assembly process produced the largest IAS biomass at all levels of the other two factors. Our results indicate that heat waves coupled with scarce precipitation may have deleterious impacts on grassland communities and increase invasions. Communities dominated by highly competitive species offset the effect of propagule pressure on invasion success.

Session 22-O5 - Global change experiments

Resistance and resilience of arable cropping systems in response to severe drought

Valentin H. Klaus[1], Yujie Liu[1], Qing Sun[1], Gicele Silva Duarte[1], Emily O. Hagen[2], Anna K. Gilgen[1], Raphaël Wittwer[2], Marcel van der Heijden[2,3], Nina Buchmann[1]

[1]ETH Zürich, Zürich, CH, valentin.klaus@usys.ethz.ch
[2]Agroscope, Reckenholz, CH
[3]University of Zürich, Zürich, CH

In line with projected reductions in summer precipitation, agricultural production systems will be subjected to more frequent and severe droughts. Subsequent drought effects on food production and ecosystem functions are likely to depend on the choice of a specific cropping system, such as organic versus conventional farming. Thus, there is an urgent need to better understand the performance of different cropping systems during and after periods of drought.
Within the project RELOAD (*Resilience of Organic and Conventional Production Systems to Drought*), we study four different arable cropping systems embedded in a large field experiment in Switzerland, the farming systems and tillage (FAST) experiment. The four cropping systems are organic versus conventional farming with either intensive tillage or conservation tillage, i.e. no tillage in conventional and reduced tillage in organic systems. Drought is induced by rainout shelters from late spring to early summer each year of the study. We assessed different aspects of ecosystem functioning related to plant water uptake, soil microbiology and ecosystem multifunctionality during and after drought to assess the resistance of ecosystem functions to drought and the recovery of the functions after drought (resilience).
During the first two years of the experiment, drought effects on production, nitrate availability and litter decomposition were strong but did not show interactions with cropping systems. Nitrate availability in soil was strongly restricted by drought, but overcompensated after shelter removal, creating a (theoretical) risk of nitrate leaching. Likewise, decomposition of standard litter was significantly slowed down by drought. Recovery of decomposition after drought was also unaffected by cropping systems. The results of the first years of this experiment indicate that it might not be possible to buffer against drought effects by choosing one out of the studied cropping systems.

Session 22-O6 - Global change experiments

Effects of combined long-term drought and warming on leaf metabolites of *Plantago lanceolata*

Rabea Schweiger[1], Colin M. Orians[2], Jeffrey S. Dukes[3,4,5], Eric R. Scott[2], Caroline Müller[1]

[1]Department of Chemical Ecology, Bielefeld University, Bielefeld, DE, rabea.schweiger@uni-bielefeld.de
[2]Department of Biology, Tufts University, Medford, US
[3]Department of Forestry and Natural Resources, Purdue University, West Lafayette, US
[4]Department of Biological Sciences, Purdue University, West Lafayette, US
[5]Department of Biology, University of Massachusetts Boston, Boston, US

In the context of global climate change, shifts in precipitation regimes are expected for many regions of the world. Often, these shifts are predicted to be accompanied by changes in air temperature. Drought and warming probably affect plant chemistry to some extent. Whereas the impacts of acute drought and warming stress were investigated in many studies, the long-term effects of these stressors in combination are less well known. In this study, *Plantago lanceolata* plants naturally occurring in the Boston Area Climate Experiment (BACE) were subjected to two precipitation (ambient, drought with 50 % less water than ambient) and four temperature (ambient, +0.8 °C, +2.4 °C, +4 °C above ambient) treatments for several years. Plant size was measured and leaf carbon and nitrogen as well as primary and specialized metabolites were analyzed. The number of leaves and length of the longest leaf did not differ between treatment groups. Lower foliar nitrogen concentrations and higher carbon-to-nitrogen ratios in drought-exposed plants indicate that the uptake of nitrogen was likely reduced under drought. Pronounced effects of drought as well as the precipitation x temperature interaction on the concentration of various leaf metabolites were found, whereby higher temperature levels reinforced the metabolic effects of drought. The specialized metabolite catalpol, an iridoid glycoside, showed reduced concentrations under drought. The metabolic changes found in the current study suggest that non-nitrogen-containing osmolytes were involved in the response of *P. lanceolata* to drought. The drought-induced changes in both primary and specialized metabolites probably modify plant interactions with antagonists; therefore, the results of this study are of high ecological relevance.

Session 22-O7 - Global change experiments

Belowground communities under climate change - the role of land use

Martin Schädler[1], Rui Yin[1], Julia Siebert[2], Iwona Gruss[3], Nico Eisenhauer[2]

[1]Helmholtz-Centre for Environmental Research - UFZ, Halle, DE, martin.schaedler@ufz.de
[2]German Centre for Integrative Biodiversity Research (iDiv), Leipzig, DE
[3]University of Wroclaw, Wroclaw, PL

Climate change and land use are amongst the two most important threats to global biodiversity and associated ecosystem functions. While both pressures have been usually studied in isolation, the interacting effects are less well investigated, especially for belowground systems. We used a large field experiment (Global Change Experimental Facility – GCEF) to investigate the consequences of a future climatic scenario on belowground biota and the decay of organic matter as an associated ecosystem function under five different land-use regimes ranging from conventional agriculture to extensively used grasslands. We found rather consistent climate effects on the community composition of soil fauna across the land-use regimes. Litter decomposition, faunal feeding activity and microbial activity, however, showed land-use dependent climate effects. These effects are especially evident for periods with reduced rainfall during the summer months. Moreover, land use and climate change showed divergent pathways of their effects on total biomass of soil mesofauna. We conclude that communities and ecosystem processes belowground are driven by interacting effects of climate and land-use type. We further discuss the suitability of land-use intensification as mitigation strategy for climate change effects.

Session 22-O8 - Global change experiments

Climate effects on biodiversity depend on spatial grain, local climate and magnitude of the experimental manipulation

Lotte Korell[1,2,3], Harald Auge[2,3], Jonathan Chase[1,2], Stan Harpole[2,3], Tiffany Knight[1,2,3]

[1]Martin-Luther-University Halle-Wittenberg, Halle (Saale), DE, lotte.korell@idiv.de
[2]German Centre for Integrative Biodiversity Science (iDiv), Halle - Jena - Leipzig, DE, lotte.korell@idiv.de
[3]Helmholtz Centre for Environmental Research (UFZ), Halle (Saale), DE, lotte.korell@idiv.de

Mitigation and adaptation to climate change requires an understanding of the magnitude by which climate change will influence biodiversity of plants across the world's biomes. Experiments that manipulate climate drivers to test plant community responses under projected conditions are a powerful approach to establish climate as a causal driver of biodiversity change. Although climate change experiments have been conducted for more than two decades in many different ecosystems, we still lack a synthetic understanding of how climate change alters biodiversity, because experiments may vary in the magnitude of the treatment applied as well as in the background climatic conditions. Biodiversity differences between control and treatment plots will also depend on both the spatial grain of the measurements, and how the treatments influence the total abundance, evenness and aggregation of plants, which are spatially-dependent. Finally, treatments may influence the plot to plot heterogeneity in the composition of plants, which would act to shift the magnitude and even direction of biodiversity effect sizes depending on the scale of measurement. Here we synthesized primary data from 38 climate change experiments and compared the effect of manipulated temperature and precipitation on different aspects of biodiversity, i.e. the species richness, evenness and abundance across different spatial scales. Species richness and evenness were affected by the magnitude of precipitation manipulation at the plot-scale and this effect depended on the background climatic conditions. The heterogeneity from plot to plot increased when precipitation was decreased and vice versa, and as a result the precipitation influenced species evenness at the plot but not scale of the whole experiment. With no discernable effects of warming on total abundance and evenness, we conclude that the negative effect of temperature on species richness at the plot-scale is likely due to the loss of rare species.

Session 22-O9 - Global change experiments

Stability of semi-natural ecosystems under drought – separating resistance and resilience mechanisms

Maximiliane Herberich[1], Nicola Lechner[1], Katja Tielbörger[1]

[1]University of Tübingen, Tübingen, DE, nicola.lechner@uni-tuebingen.de

Global alterations in climate pose a challenge to ecosystems worldwide. Due to ongoing climate change, temperatures will increase globally and precipitation patterns are going to change.
To test the response of temperate vegetation to decreasing summer precipitation we established field experiments in forests and grasslands along a gradient of natural water availability on the Swabian Alb. To simulate different drought scenarios and test for ecosystem resistance and resilience we established rain-out shelters which reduce precipitation by either 30% or 50%. We simulate permanent moderate drought, short-term extreme drought and long-term extreme drought in each experimental site. To control for the ecosystem response, vegetation response, which is plant biomass, diversity and community composition, is recorded every year.
We hypothesize that plant communities that are adapted to variability in water availability are slightly more resistant to moderate drought that non-adapted communities while adapted communities are highly more resilient to extreme drought than non-adapted communities. We further predict a change in species composition with ongoing drought.
After two years of rainfall manipulation, we found a significant change in diversity between years in different ecosystems. Nevertheless we did not see any differences between locations or treatments. Species communities are probably highly resistant to drought and differences between years are due to natural variation in precipitation. Aboveground biomass deceased slightly with stronger drought. But as changes often do not occur immediately, further investigations in the following years could show unexpected changes.

Session 22-P1 - Global change experiments

Germination and early phenology of salt marsh plants under different experimental warming treatments

Eva Ostertag[1], Kai Jensen[1], Simon Thomsen[1], Roy Rich[2], Stefanie Nolte[1]

[1]Universität Hamburg, Hamburg, DE, eva.ostertag@uni-hamburg.de
[2]Smithsonian Environmental Research Center, Edgewater, US

Salt marshes are of utmost importance when it comes to carbon sequestration and coastal protection. However, these vulnerable ecosystems are threatened by climate change and it is unclear if they will cope with increasing temperatures.
Therefore, a unique warming experiment has been established in the Wadden Sea in 2017 to study the salt marsh ecosystem response to increased temperatures (MERIT). Two climate scenarios (+1.5° and +3°) are simulated in the salt marsh. The experiment includes passive aboveground warming achieved by domes covered in greenhouse foil and active belowground heating with electrical cables. These treatments are applied in the three different salt marsh zones: pioneer zone, low marsh and high marsh, which are defined by their elevation with respect to sea-level and the resulting inundation frequency.
We studied the effect of warming on early phenology in salt marsh plants. Emergence, survival and growth (as well as developmental stage) were recorded weekly. We found most seedlings in the pioneer zone, where the annual plant *Salicornia europea* co-dominates the vegetation. The low marsh showed a diverse number of seedling species, while in the high marsh, there was hardly any germination occurring. The results will give insight in possible development of dominance shifts due to warming. This will help us to understand if salt marshes can withstand increasing temperatures and still provide important ecosystem services in the future.

Phenotypic plasticity in a major forest tree revealed by reciprocal transplantation across and beyond the species' distribution

Lena Muffler[1,2], Marcin Klisz[3], Jonas Schmeddes[1], Robert Weigel[2], Juergen Kreyling[1]

[1]Experimental Plant Ecology, Institute of Botany and Landscape Ecology, University of Greifswald, Greifswald, DE, lena.muffler@uni-greifswald.de
[2]Plant Ecology, Albrecht-von-Haller-Institute for Plant Sciences, University of Goettingen, Goettingen, DE, lena.muffler@uni-greifswald.de
[3]Forest Research Institute, Department of Silviculture and Genetics of Forest Trees, Raszyn, PL

European beech (*Fagus sylvatica* L.) is the dominant natural forest tree in Central Europe and is expected to suffer from climate change due to a high drought sensitivity and a low seed dispersal capacity. Phenotypic plasticity, however, is high and can be expected to buffer against climate change in situ. Local adaptation to different climates has been demonstrated in common garden experiments. However, potentials and limits of phenotypic plasticity and local adaptation in European beech are still unclear. Thus, we aim to quantify phenotypic plasticity and genetic adaptation at the recruitment stage of beech. For that purpose we conducted a fully reciprocal transplantation experiment with 9 sites across and 3 sites beyond the distribution range. These sites display strong climatic gradients of decreasing summer precipitation towards the south (Spain) and decreasing temperatures towards the north (Sweden) and east (Poland). We found that the fitness traits germination and establishment success were highly phenotypic plastic. Looking into detail, the rate of germination and establishment increased when provenances were transplanted to warmer sites. Although provenances responded differently, we hardly found evidence for local adaptation. The functional trait specific leaf area was also highly plastic. However, we additionally found indications for local adaptation in the climate transfer distance analyses. Differences in the performance trait height could not be explained by local adaptation, as we couldn't find any interaction between transplantation site and provenance origin. In conclusion, all measured traits were highly plastic, whereas local adaptation played a minor role. Thus, European beech seems to be able to cope with climate change without the necessity of assisted migration. However, the higher fitness towards warmer transplantation sites need to be considered in regard to the projected range shift of European beech towards the north.

Session 22-P3 - Global change experiments

Invertebrate decline affects plant species abundance and phenology

Josephine Ulrich[1], Solveig Franziska Bucher[1], Alban Gebler[2,3], Nico Eisenhauer[2,3], Anja Schmidt[2,3], Manfred Türke[2,3], Christine Römermann[1,2]

[1]Institute of Ecology and Evolution, Plant Biodiversity, Friedrich Schiller University, Jena, DE, josephine.ulrich@uni-jena.de
[2]German Centre for Integrative Biodiversity Research (iDiv) Halle-Jena-Leipzig, Leipzig, DE
[3]Institute of Biology, Leipzig University, Leipzig, DE

Land-use and climate change lead to phenological changes in both, plants and insects. Previous findings revealed that some plant species advance or prolong their flowering period, whereas other species do not respond and that insects are more responsive to changes in temperature than plants. This, in combination with the massive decline of insect biomass within the last decades, might result in mismatches of plant-insect interactions, with consequent losses of ecosystem functions, such as flower availability. The aim of this study was to identify the potential links between invertebrate density, plant phenology, and resultant effects on ecosystem functions. Using the 24 experimental units of the iDiv Ecotron, we assessed the effects of invertebrate decline on an artificial grassland community formed by 12 herbaceous species. Invertebrates from a meadow close to Halle, Germany were caught using Malaise traps and sweep nets with different catching efficacies corresponding to two different densities: 100% (no decline) and 25% (decline of 75%). Invertebrates were transferred into eight units, respectively. Another eight units received no fauna. Plant species abundance and flowering phenology was observed weekly over a period of 18 weeks. Our results showed that invertebrate densities affected the abundance and phenology of plant species. We observed a distinct species abundance, with respect to the invertebrate treatment – especially a reduction of the dominant species when invertebrates were present. Additionally, we showed that the species shifted their flowering phenology as a response to the different invertebrate densities. The peak flowering was more dispersed in time when invertebrates were present. We could demonstrate that besides abiotic drivers, there are also biotic components that drive phenological changes in plant communities. Strikingly, a 75% loss of invertebrates resulted in effects, which were similar to a complete loss of invertebrates. This study clearly suggests that invertebrate decline may contribute to already observed mismatches between plants and animals, with potential corresponding negative consequences for ecosystem services like fodder provision and pollination success. This deterioration of ecosystem functions could enhance the loss of insects and plant biodiversity.

Session 22-P4 - Global change experiments

Plant community changes in mountainous grasslands following three years of climate warming: A translocation experiment

Peter Wilfahrt[1], Bernd Berauer[1], Andreas von Hessberg[1], Max Schuchardt[1], Anke Jentsch[1]

[1]University of Bayreuth - Disturbance Ecology, Bayreuth, DE, peter.wilfahrt@uni-bayreuth.de

Climate change is likely to be more severe at higher elevation, leading to uncertainty for future biodiversity and productivity of montane grasslands. Increasing temperature may favor increased biomass by extending the growing season or increasing metabolic rates, but may also limit biomass production when it increases drought stress. These changes in biomass allocation patterns are also likely to change interspecific competition of species within communities. We examined yearly changes in productivity and diversity in grasslands exposed to warmer climates following permanent downslope translocation of plant-soil monoliths. We expected to see increasing temperature leading to i) increased aboveground biomass in sites where precipitation was similar to the home environment and ii) subsequent decreases in richness as competitive hierarchies shifted. We addressed these hypotheses by translocating 126 plant-soil monoliths of three different montane grasslands in the German Alps to lower sites with elevational changes ranging from 300 m - 1000 m, in order to simulate possible future climate scenarios. In 2017, following one year of exposure, plant communities in warmer areas increased aboveground biomass increases as long as precipitation regime was not severely altered. Changes relative to controls ranged from 52% increase to a -23% decrease where precipitation also decreased. Species richness declined consistently with warming, ranging from 13% to 46% species loss. Functional group composition shifted towards more graminoid dominated communities. In 2018, a severe drought occurred in Central Europe, leading to experiment wide decreases in biomass and species richness, with only richness being exacerbated at the most extreme translocation distance. Generally, we show at small spatial scales a loss of species in montane environments with future climate change, while changes in aboveground biomass were conditional on concurrent precipitation changes.

Session 22-P5 - Global change experiments

The MERIT Experiment – Assessing Marsh Ecosystem Response to Increased Temperature

Stefanie Nolte[1], Roy Rich[2], Simon Thomsen[1], Eva Ostertag[1], Salomé Gonçalves[1], Miriam Fuß[1], Hao Tang[1], Svenja Reents[1], Peter Mueller[1,3], Kai Jensen[1]

[1]Universität Hamburg, Hamburg, DE, stefanie.nolte@uni-hamburg.de
[2]Smithsonian Environmental Research Center, Edgewater, US
[3]Aarhus University, Aarhus, DK

Salt marshes are a vital habitat for many plant, bird and invertebrate species, including soil fauna, and therefore, they play an important role in the protection of biodiversity. In addition, salt marshes are recognized for their high potential for ecosystems services such as carbon sequestration and coastal protection. Ecological research in the Wadden Sea salt marshes has previously mainly focussed on effects of livestock grazing; yet, we also need to understand how the valuable and sensitive salt marshes are affected by the on-going global change. The aim of this project is therefore to assess the **M**arsh **E**cosystem's **R**esponse to **I**ncreased **T**emperatures (MERIT). To do so, a world-unique ecosystem warming experiment was installed at Hamburger Hallig including experimental passive aboveground and active belowground heating in three vegetation zones. In each zone nine plots are subjected to one of three warming treatments since summer 2018. The warming treatments include a +1.5°C and a +3.0°C experimental warming, as well as a control treatment with ambient temperature. An integrated feedback control system allows the heating system to be constantly adjusted to keep each plot at exactly the right temperature. We will study how plants and soil fauna, as well as their interactions, are affected by natural abiotic conditions and by experimental warming. Furthermore, we want to investigate how this interplay in turn affects critical ecosystem functions and services, especially in relation to carbon sequestration, coastal protection and greenhouse gas emissions. Overall, our results are expected to contribute to the development of sustainable management strategies for salt marshes in times of climate change.

Session 22-P6 - Global change experiments

N_2O emission in response to the rooted emergent macrophytes growing in wetlands sediments of Chaohu Lake in China

GU Xiaozhi[1], Chen Kaining[1]

[1]Nanjing Institute of Geography and Limnology, Chinese Academy of Science, Nanjing, CN, guxiaozhi@163.com

Denitrification has been found to play a significant role in the nitrogen (N) biogeochemical cycle of riparian wetland systems; however, there is little understanding of the role of emergent macrophytes in sediment denitrification. In this study, laboratory culture experiments were conducted to examine how *Phragmites australis* growth affected N_2O emissions. Additionally, preliminary investigations into the variability of carbon and available NO_3^--N fractions were conducted. The N_2O emission rate was quantified based on the high-resolution N_2O microprofiles in acetylene-inhibited sediment cores. Seasonal-dependence of N_2O emission was remarkable throughout incubation of both *P. australis* rooted sediments and control with no *P. australis*, and increased significantly with biomass steady accumulation ($p<0.05$), reaching a peak emission of 630±15 μmol $N_2O \cdot m^{-2}\ d^{-1}$ at day 180 (in late autumn) in the *P. australis* rhizosphere. Simultaneously, N_2O emissions were more highly influenced by fine-root biomass, belowground biomass and plant height than total biomass, root activity and relative growth rate in the Spearman rank correlation model. More specifically, based on the strong and significant ($p<0.01$) positive correlations between hot-water extractable carbon (HWC) and N_2O emission flux, the rapid transformation indicated that changes in the HWC (ranging from 720 to 3564 mg kg^{-1}) with plant growth could reflect a 14-fold variation in N_2O emissions during the growth stage, and that N_2O emissions were highly dependent on fine-root biomass and its delivery of organic carbon. The ion exchangeable form NO_3-N (IEF-NO_3-N) in sediments was found to be the predominant transferable form involved in denitrification, while the iron-manganese oxide form NO_3-N (IMOF-NO_3-N) can be considered as a potential source of nitrogen for denitrification. This study highlights that emergent macrophyte communities dominate riparian ecosystem denitrification and that the metabolic mechanisms of emergent macrophytes can have positive feedbacks on the HWC fraction and available NO_3-N combined with sediment components in rhizosphere sediments.

Session 22-P7 - Global change experiments

Bud burst phenology of clonal *Populus nigra italica* in a common garden experiment

Phillip Kaldewey[1], Bárbara Díez Rodríguez[1,2], Lars Opgenoorth[2,3], Katrin Heer[1]

[1]Department of Conservation Biology, Philipps-University Marburg, Marburg, DE, Kaldewey@students.uni-marburg.de
[2]Department of Ecology, Philipps-University Marburg, Marburg, DE
[3]Swiss Federal Research Institute WSL, Biodiversity and Conservation Biology, Ecological Genetics, Birmensdorf, CH

Bud phenology crucially determines the fitness of trees in their local environment and has shown to be highly heritable. Adjusted to seasons and sensitive to environmental cues, it determines the start of the growing season. However, under current climate change, genetic adaptation might be too slow to keep track with fast temperature changes. Current research suggests that epigenetic mechanisms might contribute to a fast plastic response of plants, but our knowledge about the importance of epigenetics in trees is still limited.
For studying epigenetic-based variation and inheritance of phenotypic plasticity, the Lombardy poplar (*Populus nigra* ´Italica´ Duroi) is an ideal model. The male clone line has been propagated vegetatively for almost three centuries and has been planted all over Europe. Here, we investigated bud burst phenology in ramets of Lombardy poplars. Ramets were collected at 12 sites across a large environmental gradient in Europe and were planted in a common garden in Central Germany. Bud burst was monitored for 374 individuals in spring 2019. Since their mother trees are supposed to hold local ecotypes, we expect variation in bud burst in the common environment. Mixed-effects models will be used to investigate correlations between timing of bud burst and geographic and climatic variables of the sampling. First results will be presented during the conference.

SESSION 23

Plant populations across space and time

Chairs: Solveig Franziska Bucher, Johannes F. (Niek) Scheepens,
Christian Lampei, Johannes Metz

Environmental factors, such as temperature, precipitation and land use, impose strong selective pressures on plant populations. Many environmental factors generally vary along spatial gradients, and/or due to temporal variation and environmental change. Species may change in abundance, exhibit trait plasticity and evolve phenological, physiological and morphological characters in response to such spatial and temporal variability. While these responses are often species-specific, they may alter properties of local plant communities and ecosystems and vice versa. Many such patterns and processes are only now being investigated. For example, will phenotypic plasticity hamper or promote local adaptation of plant populations in a changing world? Can we identify patterns and mechanisms behind species-specific responses? Can dispersal of adapted genotypes rescue populations from extinction? Does community composition affect evolution of the constituent species? A profound knowledge about ecological and evolutionary patterns and processes is strongly needed to forecast the fate of plant populations. This session offers a stage for scientists working on basic and applied questions in plant population ecology, evolutionary ecology and related disciplines, and we particularly encourage contributions addressing evolutionary ecological challenges posed by environmental change.

Session 23-O1 - Plant populations across space and time

Fire promotes shrub encroachment in Arctic tundra

Ramona J. Heim[1], Anna Bucharova[1], Daniel Rieker[1], Andrey Yurtaev[2], Johannes Kamp[1], Norbert Hölzel[1]

[1]Institute of Landscape Ecology, University of Münster, Münster, DE, ramona.heim@uni-muenster.de
[2]2 International Integrated Research Laboratory for Climate, Land Use and Biodiversity Study, University of Tyumen, Tyumen, RU

Wildfires are a naturally rare phenomenon in sub-arctic tundra ecosystems. Future climate shifts might lead to a significantly higher frequency and extent of fires in those regions. Fire has been shown to change ecosystem properties of the arctic tundra strongly. The loss of an insulating plant and litter cover, due to combustion, increases soil temperature during summer significantly. Higher soil temperatures lead to permafrost thaw and mobilize belowground resources, causing enhanced plant growth. However, long-term effects of fire on vegetation dynamics are still poorly understood and have been rarely in the focus of research so far.
Therefore we studied soil and vegetation patterns of three fire scars (>44, 28 and 12 years old), situated at the northern border of the forest tundra ecozone in Western Siberia within the Yamalo-Nenets Autonomous Okrug.
Negative long term fire effects were evident for lichen cover which was generally lower on burnt in comparison to unburnt plots. Positive effects were found for bryophyte and shrub cover. Lower lichen and higher bryophyte and shrub cover was still apparent more than four decades after a fire event. A clear winner of tundra fires was *Betula nana*, which showed enhanced growth of individual plants after burning: diameter and height of the shrubs as well as specific leaf area increased strongly with time since fire, indicating increased vitality and growth potential, due to modified ecosystem processes after fire. Fire led to higher soil temperatures and thus to a deeper active layer. While the active layer and soil temperatures returned to normal levels after a certain time, we found shrubs to grow further, which reveals a strong fire legacy effect with far reaching impacts on the whole ecosystem.

Session 23-O2 - Plant populations across space and time

Why is the Siberian treeline migration rate not keeping pace with climate warming? – insights from individual-based modelling and trait adaptation.

Stefan Kruse[1], Alexander Gerdes[1], Ulrike Herzschuh[1,2,3]

[1]Polar Terrestrial Environmental Systems Research Group, Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research, Potsdam, DE, stefan.kruse@awi.de
[2]Institute of Earth and Environmental Science, University of Potsdam, Potsdam, DE
[3]Institute of Biology and Biochemistry, University of Potsdam, Potsdam, DE

The Siberian latitudinal tundra taiga ecotone runs across thousands of kilometers and covers vast areas in the north of Eurasia. A northwards expansion of the temperature-limited treeline will likely happen under global warming and would cause an additional warming due to albedo decrease of transformed tundra. However, we identified that the current migration is slower than expected and strongly lagging behind the temperature increase. We consider this slow response can be partly explained by a historical adaptation of local populations to past cold climates.
At the southern Taimyr Peninsula, we found larch individuals with a creeping growth form, also known as krummholz, ahead of the treeline. Those are likely remnants from past forest expansion during the Holocene Thermal Maximum based on our results from a genotyping study. At these areas we identified still a high genetic diversity, but also largely asexual reproduction and growth in clonal groups, which is a strategy to lower the risk of extinction. The historical selection for cold-adapted genotypes helped to survive under unfavorable environments but could now hamper the response to current strong warming.
To track pathways of genetic information across the landscape we implemented wind-dependent pollination aside from seed dispersal into our individually based and spatial-explicit vegetation model LAVESI. New processes allowing traits to adapt to the environment and make it suitable to run simulation experiments. We will test the influence of local adaptation versus phenotypic plasticity on colonization speed, and the importance of krummholz course of treeline dynamics. We aim to forecast the treeline migration for the upcoming decades by forcing simulations with scenarios of different climate warming trajectories in combination with adaptation behavior. With this, we can address the timely question, 'What is the amount of additional warming the Siberian treeline migration would cause in the near future?'

Session 23-O3 - Plant populations across space and time

Spatial and temporal variation of leaf traits in populations *Betula pendula* and *B. pubescens* along the latitudinal climate gradient in central Northern Eurasia

Svetlana Migalina[1,2], Larissa Ivanova[1,2]

[1]Botanic Garden UB RAS, Ekaterinburg, RU, fterry@mail.ru
[2]Tyumen State University, Tyumen, RU, fterry@mail.ru

Birch species are important components of forest ecosystems over the entire northern hemisphere, typically occurring across large areas and different climatic zones. This is also true for two closely related birch species of northern Eurasia, *Betula pendula* and *B. pubescens,* both growing across a wide range of climates from forest-tundra to steppe, suggesting local adaptation in plant structure and functioning. We studied leaf functional traits in *Betula pendula* and *B. pubescens* from different geographical populations along a 1.600 km latitudinal gradient in east of the Ural Mountains in Western Siberia during three consecutive years. Latitudinal variation of birches ranged from the subcellular to the whole-leaf level. Notably, both species showed uniform clines of mesophyll traits, while whole-leaf traits tended to vary in a species-specific manner. Specifically, leaf thickness and mesophyll cell size linearly increased in both species along the climate gradient from steppe towards northern taiga and forest-tundra. Mesophyll cell number per unit leaf area decreased to the north and was strongly influenced by weather conditions in the current year. Whereas, in *B. pendula* leaf size increased from the central part of the transect to both, northern and southern populations while leaf mass per area (LMA) and venation density decreased. Conversely, in *B. pubescens* leaf size was lower and LMA and venation density were higher in the north and south. But also, stomata size and number were 20–30% higher in the northern populations of both species. Our findings indicate that both *Betula* species exhibit species-specific as well as universal physiological mechanisms of local adaptation to climate resulting in a distinct geographic differentiation.

Session 23-O4 - Plant populations across space and time

Epigenetic variation in *Populus nigra italica* clones along climatic and geographical gradients.

Bárbara Díez Rodríguez[1], Tabea Mackenbach[1], Lars Opgenoorth[1,2], Katrin Heer[1]

[1]Philipps-University Marburg, Marburg, DE, bardrdz@biologie.uni-marburg.de
[2]Swiss Federal Research Institute WSL, Birmensdorf, CH

Plant ecological epigenetics aims at understanding how epigenetic changes affect the ability of plants to adapt to the environment. This is important for predicting species responses to global change.
The Lombardy poplar *(Populus nigra* cv. 'Italica') is a unique system to study epigenetics in trees. It is a male clone that has been widely planted throughout Europe since the 18th century. As such the identical genotype covers a wide range of environments and allows to investigate the ecological priming inferred by these environmental conditions. In this project, *P. nigra* 'Italica' clones from twelve sites across European-scale geographic and climatological gradients will be investigated. Specifically, DNA methylation will be screened in order to characterize epigenetic structure, associate methylation variants with relevant ecological and climatic variables, and assess the contribution of environmental induction to epigenetic changes relative to stably inherited methylation patterns. Additionally, cuttings from the twelve sampling sites were planted in a common garden with a random block design to screen phenotypic differences. In 2018 and 2019, growth and phenology parameters were recorded in 375 trees. The date of winter bud set did not differ between sites and no correlation with climatic variables was found, but bud set date was positively correlated with height and diameter. Additional results from our phenotyping efforts will be presented during the conference.

Session 23-O5 - Plant populations across space and time

Once first always first: explaining the large variation in spring leaf phenology in one forest stand of *Fagus sylvatica.*

Andrey Malyshev[1], Dennis Maß[1], Aron Garthen[1], Ernst Van der Maaten[2], Matthias Schwabe[3], Juergen Kreyling[1]

[1]University of Greifswald, Greifswald, DE, andrey.malyshev@uni-greifswald.de
[2]Technische Universität Dresden, Dresden, DE
[3]Nationalparkamt Müritz, Serrahn, DE

Despite improved phenology models, a substantial amount of variation remains unexplained with respect to spring budburst dates within tree species. To better explain within-species variation, long-term monitoring of a large number of trees is required.
We recorded leaf bud burst dates of 153 neighbouring *Fagus sylvatica* trees in a forest stand over 12 years in the Müritz National Park, Germany. Landscape topography, tree height, trunk diameter, air temperature, air humidity and precipitation were recorded to explain the variation in spring phenology. Additionally, to test if spring phenology could be predicted via differences in bud dormancy depth, tree twig samples were collected once in January from six early and six late flushing trees. Days to budburst under optimal growing conditions in climate chambers were used as a proxy of dormancy depth.
Bud burst dates of individuals differed from the median by as much as 32 days, with a mean of 21 days. Consistent phenological ranking with respect to early and late flushing trees was observed, whereby only the spatial arrangement of the trees had a significant influence on the tree ranking. No other parameter could explain the clumping pattern of early and late flushing trees. Furthermore, winter bud dormancy depth of early bursting species was lower than the dormancy depth of late bursting species.
We conclude that the within-species differences in spring phenology are likely driven by tree-specific variation in bud dormancy development, potentially caused by genetic similarity of related trees. Tree relatedness is thus likely to be an important factor in studying bud dormancy and improving the accuracy of phenology models.

Session 23-O6 - Plant populations across space and time

Invasive *Impatiens glandulifera:* micro-habitat preferences and impact on native vegetation

Judith Bieberich[1,2], Heike Feldhaar[2], Marianne Lauerer[1]

[1]University of Bayreuth, Ecological Botanical Garden, Bayreuth Center of Ecology and Environmental Research (BayCEER), Bayreuth, DE, judith.bieberich@uni-bayreuth.de
[2]University of Bayreuth, Animal Ecology 1, Bayreuth Center of Ecology and Environmental Research (BayCEER), Bayreuth, DE, judith.bieberich@uni-bayreuth.de

Invasive species are considered to be one of the major threats to biodiversity, but in fact the impact of an invasion is often difficult to assess because of its dependency on several contexts. *Impatiens glandulifera* is an excellent model species to study context dependencies. For although *I. glandulifera* heavily invaded several habitats in Central Europe its impact on native plant communities is ambiguous. We hypothesize that environmental conditions, thus the micro-habitat, model the interdependence of *I. glandulifera* and the resident vegetation leading to that ambiguous results.
Within heterogeneous riverside habitats a vegetation survey was performed investigating how the cover of *I. glandulifera* depends on micro-habitat conditions and whether *I. glandulifera* alters plant diversity and plant communities.
We found though *I. glandulifera* had a broad environmental tolerance it was not equally distributed within the study sites but it occurred in patches with its cover depending on environmental conditions. *I. glandulifera* had not any impact on plant diversity but it had a negative impact on the cover of the native vegetation, especially of some dominant species and it changed the plant community depending on the micro-habitat.
Overall the impact of *I. glandulifera* on native vegetation can be regarded as low within the investigated riverside habitats. The micro-habitat dependence of *I. glandulifera* cover and impact may be a reason for this low impact but it may also indicate that the vegetation of other habitats could be much stronger affected.

Session 23-O7 - Plant populations across space and time

Inbreeding reduces phenotypic plasticity in the response to waterlogging in *Mimulus guttatus*

Florian Gerken[1], Diethart Matthies[1], Tobias Sandner[1]

[1]Plant Ecology, Faculty of Biology, Philipps-Universität Marburg, Marburg, DE, Gerken@students.uni-marburg.de

Inbreeding depression (ID) often differs between environments, but the underlying mechanisms are only poorly understood. In a previous experiment with *Mimulus guttatus* (Phrymaceae) ID did not generally increase under stress, but only under some types of stress, particularly under waterlogging. To understand the underlying mechanisms, we grew clonally replicated inbred and outbred offspring of *M. guttatus* under waterlogging and control conditions and measured chlorophyll fluorescence and a range of functional traits involved in plant response to waterlogging. After two weeks of stress outbred plants were able to maintain their fitness even under waterlogged conditions (fitness homeostasis), whereas that of inbred plants was reduced. As a response to waterlogging, *M. guttatus* produced longer stolons with floating adventitious roots. Plasticity of this adaptive trait was lower for inbred plants. The results suggest that a reduced plasticity in functional traits may be responsible for increased ID under some types of stress.

Session 23-O8 - Plant populations across space and time

Macrodemography - how large-scale demographic variation depends on functional traits and environmental conditions

Frank Schurr[1], Martina Treurnicht[1,2,3], Karen Esler[3], Jörn Pagel[1]

[1]University of Hohenheim, Stuttgart, DE, frank.schurr@uni-hohenheim.de
[2]South African Environmental Observation Network (SAEON), Claremont, ZA
[3]Stellenbosch University, Stellenbosch, ZA

The dynamics of populations and their fate under environmental change depends on demographic responses to environmental variation. These demographic responses thus determine which species will be winners and losers under global change. It is commonly assumed that interspecific differences in demographic responses depend on functional traits. So far, it is, however, poorly understood how large-scale demographic variation depends on environmental conditions and functional traits. Here, we examine these dependencies using data on variation in key demographic rates and functional traits across the global geographic ranges of 26 shrub species (Proteaceae endemic to the South African Cape Floristic Region). The fire-linked life history of these study species facilitates the collection of informative data on long-term fecundity, post-fire recruitment and fire mortality of adults. This enabled us to assemble >3,000 population-level records of these fundamental demographic rates. Combining these demographic data with measurements of commonly used plant functional traits, we address three questions: (1) to what extent can variation in demographic rates be explained by the physical environment (climate, soils and disturbance), functional traits and their interaction? (2) Are demographic responses to environmental variation better explained by population-level trait measurements than by species mean traits? (3) Which easily measurable traits best explain demographic responses to the environment? Answers to these questions are key to a better integration of population ecology with functional ecology and biogeography. Notably, they should help to understand how functional traits shape population dynamics, and how traits are distributed in geographical space. Finally, a trait-based understanding of demography-environment relationships should enable us to formulate general rules about which populations and species are at greatest risk from global change.

Session 23-O9 - Plant populations across space and time

How functional traits shape resource allocation and life histories of woody plants

Huw Cooksley[1,2], Karen Esler[2], Alexander Neu[3,4], Matthias Schleuning[3], Frank Schurr[1,5]

[1]Universität Hohenheim, Stuttgart, DE, huwcooksley@hotmail.com
[2]Stellenbosch University, Stellenbosch, ZA, huwcooksley@hotmail.com
[3]Senckenberg Biodiversity and Climate Research Centre, Frankfurt am Main, DE
[4]University of Frankfurt, Frankfurt am Main, DE
[5]CNRS/Université Montpellier 2, Montpellier, FR

A central aim of functional ecology is to predict demographic processes from functional traits. However, correlations between traits and demographic rates are often perplexingly weak. It has been argued that this is because simple trait-demography correlations ignore two important facts. First, individual demographic processes and the underlying life history components depend on multiple traits. Secondly, different life history components are linked via trade-offs mediated by resource allocation. Integrated analyses of how traits affects resource acquisition and resource allocation should thus foster a better understanding of life histories and demographic patterns. Here, we present such an integrated model that describes how functional traits shape resource allocation and life histories of woody plants. Using hierarchical Bayesian statistics, we fit this model to data on the life history schedules of ~700 individuals from 20 species of woody plants (members of the genus *Protea* from the South African Cape Floristic Region). The growth morphology of these species and the fact that they form canopy seedbanks enable us to reconstruct year-to-year variation in growth, reproduction, and maternal care for multiple years into the past. We show that the remarkable diversity of life-histories observed in the study species can be explained by traits measuring resource costs of growth, reproduction and maternal care, and that certain traits (notably measures of seed resources) mediate trade-offs among life history components. Our analysis thus yields novel insights into the demographic relevance of functional traits and into the constraints and trade-offs shaping life history evolution of woody plants.

Session 23-O10 - Plant populations across space and time

Long-term change in epiphyte populations and communities

Helena Einzmann[1], Tizian Weichgrebe[1], Gerhard Zotz[1,2]

[1]Carl von Ossietzky Universität, Oldenburg, DE, helena.einzmann@uol.de
[2]Smithsonian Tropical Research Institute, Panamá, PA

A key feature of most tropical floras are epiphytic plants. Despite their prominent role in tropical forest systems, we still know very little about the dynamics of epiphyte populations and communities. Despite their herbaceous habit, epiphytes resemble their long-lived hosts much more than terrestrial herbs in terms of longevity, slow growth and fecundity. However, because of the dependence on their hosts and their three dimensional distribution in space, the results of studies with trees can hardly be applied to epiphytes. Much of our progress in understanding tree communities results from long-term studies, and comparable studies for epiphytes should allow a similar advancement. The data of the present study are unique in spanning >20 years and three consecutive censuses of epiphytes growing on *Annona glabra* in the Gatun Lake in Panama. Total epiphyte abundance increased substantially during both intervals, resulting from positive population growth rates in most species. We also observed a steady increase in the percentage of inhabited trees. The most common taxa were the first to colonize empty trees and there was a strong positive relationship between regional occurrence (= number of occupied tree groups) and a species' average local abundance (= mean number of individuals in a tree group). The oldest *Annona glabra* host trees were established about 100 years ago. Nevertheless, they still offer open habitat patches and the epiphyte assemblage continues to expand. Our results are consistent with the results of the few other studies with epiphytes, although none is of comparable duration. We conclude that epiphyte assemblages are exceptional for plant communities, because - in contrast to other, soil-rooted plant assemblages - these systems show no sign of saturation.

Session 23-O11 - Plant populations across space and time

Reduced seed dispersal at range margins of an ant-dispersed plant

Itamar Giladi[1]

[1]The Mitrani Department of Desert Ecology Swiss Institute for Dryland Environmental and Energy Research The Jacob Blaustein Institutes for Desert Research Ben-Gurion University of the Negev, Midreshet Ben Gurion, IL, itushgi@bgu.ac.il

The evolution and maintenance of mutualistic animal-mediated seed dispersal involves the provision of a reward by the plant in return for an efficient seed dispersal service by the animal. While morphological and chemical adaptations are very common in nature, the extent to which the mutual benefits associated with such an interaction are maintained across space and time is less clear. Especially, the maintenance of the interaction's benefits may be impaired at species range margins. We used the concept of seed dispersal effectiveness to test whether dispersal of an ant-dispersed perennial plant (*Sternbergia clusiana*), is quantitatively and/or qualitatively reduced toward a non-expanding range margin. We evaluated plant investment in dispersal structures (elaiosome), seed removal rates, and the relative abundance, activity and behavior of seed dispersing ants across a sharp climatic gradient. In a set of cafeteria and bating experiments, we found that overall seed removal rates, the contribution of high-quality dispersers, maximum dispersal distance and dispersal-conducive ant behavior decreased towards the species southern range margin. Range margin plant populations invested less in the reward, as indicated by a lower elaiosome/seed ratio, but not by variation in the reward chemistry. The variation in ant-seed interactions could be mostly attributed to reduced presence and activity of the more efficient seed-dispersing ants in the marginal populations. Specifically, we found a local-scale mismatch between the distribution of potentially effective seed dispersers, and that of the plant. Interestingly, although the observed variation in the outcome of ant-seed interactions supported the prediction of reduced dispersal at non-expanding range margins with small and isolated populations, the underlying mechanisms seems to be incidental difference in ant community rather than a plant-mediated response to selection.

Session 23-O12 - Plant populations across space and time

Trait means or coefficients of variation - what determines species local and regional abundance in dry grasslands?

Klarissa Kober[1]

[1]Leibniz-Zentrum für Agrarlandschaftsforschung (ZALF), Müncheberg, DE, klarissa.lipowski@yahoo.de

It is of strong interest to identify mechanisms that determine the abundance of species. Even though intraspecific trait variability (ITV) is recognized to play an important role for community assembly and dynamics, it is mostly neglected in trait-abundance research so far. As variability allows species to adapt to and cope with biotic and abiotic conditions, it possibly alters the chance of a species to survive in an environment and therefore might enable its abundance.

To assess the role of ITV, I measured five functional traits (leaf area, specific leaf area, leaf dry matter content, plant height and plant above-ground biomass) of 43 plant species at 21 dry grassland plots in the Uckermark region (Brandenburg, Germany). I related the trait means as well as the coefficients of variation to species abundance at the local and regional scale (per plot and over all plots). Additionally, I tested the impact of the plant type, i.e. grass or forb, and considered the possible influence of plot productivity at the local scale.

The determinants of species abundance were scale-dependent. At the local scale, exclusively the plant type had an impact on the abundance with grasses being slightly more abundant than forbs. The model containing this trait explained 30 % of the variance. At the regional scale, mean plant height and variation in leaf area and LDMC had a positive effect on species abundance while variation in plant height had a negative effect, all together explaining 20 % of the variance.

These results suggest that ITV is more important at the regional than at the local scale and of traits related to environmental stress. The measured traits are not very strong predictors which implies that others, particularly regarding dispersal, should be included in future studies. It is a strength of this study to have integrated both trait means and their variation. Furthermore, the present study underlines that it is fundamental to consider at which scale abundance is assessed.

Session 23-O13 - Plant populations across space and time

Trait plasticity in a Mediterranean annual grass decreases with rising rainfall variability but increases with environmental productivity

Laura Josephin Hartmann[1], Anne Kremser[2], Johannes Metz[1]

[1]University of Hildesheim, Hildesheim, DE, hartmannl@uni-hildesheim
[2]University of Potsdam, Potsdam, DE
[3]University of Hildesheim, Hildesheim, DE

Understanding plasticity in plants is of increasing importance as plastic responses might improve ecosystem resilience towards a changing climate.
However, little is known about how plasticity differs among populations and along environmental gradients.
It was hypothesized, that plasticity is favored by increased environmental heterogeneity.
Here, we tested this hypothesis by examining the degree of traits' plasticity along a large scale aridity resp. precipitation variability gradient in *Brachypodium hybridum*, a widely distributed, Mediterranean annual grass.
We assumed, that populations from more arid environments (i.e. with higher rainfall heterogeneity), had greater trait plasticity than those from more mesic sites.

F2 offspring from 139 mother plants originating from 14 different sites along a steep aridity gradient in Israel had been grown in a glasshouse under six different irrigation and competition treatments.
Plasticity was measured in ten traits as coefficient of variation across these treatments and tested for relationships with precipitation heterogeneity at the sites of origin.

In general, plasticity was lowest in flowering time and seed mass and highest in traits related to fitness and growth. Furthermore, plasticity differed strongly *within* each of the populations.
In contrast to our hypothesis, with higher rainfall variability (i.e. higher aridity) trait plasticity was mostly smaller (*height and number of leaves before flowering, canopy height, reproductive biomass and allocation, seed mass*) or similar (*flowering time*, *seed number, maximum height, vegetative biomass*) in comparison to more mesic environments.

The findings suggest that extreme, arid environments selected for specialized phenotypes with low plasticity, possibly decreasing the resilience to climate change. Whereas in mesic, more competitive environments greater plasticity may improve the ability to use suitable microsites.

Session 23-O14 - Plant populations across space and time

Plasticity is not enough: escaping from drought requires evolution

Christian Lampei[1], Katja Tielbörger[2]

[1]University of Münster, Münster, DE, christian.lampei@uni-muenster.de
[2]University of Tübingen, Tübingen, DE

In recent years extreme weather events like heat spells and drought periods increased in frequency. For plants, surviving these events requires either strong plasticity or adaptation. But how do plants respond to drought? And which traits are favored by drought selection? First insights can be gained by comparing populations from environments that differ in precipitation. While such substitutions are useful, they do confound the identity and history of populations with the selecting environment. To conduct a rigorous test requires the estimation of selection and plasticity under artificial drought. Here we present a case study that combined both approaches, using the generalizing power of a diverse set of 18 annual plant species on the one hand and the high precision of an automated irrigation system with 12 watering levels on the other hand. We found that on average plants have faster phenology when they stem from dryer sites, which corresponds to earlier observations. Two of those plants, *Biscutella didyma* und *Bromus fasciculatus,* were reared under the irrigation gradient. They showed strong plasticity, with plant size and biomass showing a non-linear decrease with increasing drought and a linear delay of flowering. The timing of flowering was also the only trait under selection in this experiment. Notably, earlier flowering was favored under drought, but not when water was not limiting. Furthermore, selection for earlier flowering was stronger in the plants from humid sites, than in plants from the desert in *Biscutella didyma*. We, therefore, conclude that the widely observed earlier flowering of plants from dryer sites reflects past and ongoing selection. Managing projects of species that are potentially threatened by an increase of extreme droughts should focus their efforts on monitoring and optimizing the diversity of phenology genotypes to support survival through adaptation.

Session 23-O15 - Plant populations across space and time

Rapid adaptive evolution in a large-scale climate change experiment

Johannes Metz[1], Christian Lampei[2], Katja Tielbörger[3]

[1]University of Hildesheim, Hildesheim, DE, metzjo@uni-hildesheim.de
[2]University of Münster, Münster, DE
[3]University of Tübingen, Tübingen, DE

Rapid evolution is considered an important pathway for plants to adapt to ongoing climate change. However, empirical evidence for it under natural conditions is hard to obtain and limited. Few studies are available, and for potentially observed responses it is difficult to judge adaptivity.
To overcome these problems, we combined for the first time in rapid evolution studies long-term *in situ* climate manipulations with a corresponding natural climatic gradient. Trait patterns along the natural gradient provided clear hypotheses about expected trait evolution under experimental climate change to judge adaptivity. Adaptivity was further assessed by selection analyses.
Namely, we utilized a multi-site rainfall manipulation experiment located along a natural rainfall gradient in Israel, where two sites received rainfall manipulations (+30%, control, -30%) and another two sites extended the span of the natural rainfall gradient. After ten years of manipulations, offspring of an annual Brassicaceae (Biscutella didyma L.) were raised in the greenhouse under five irrigation levels to assess phenotypic divergence in eight traits.
In both sites, plants in dry-manipulated plots had evolved c. 4% earlier flowering with c. 13% fewer leaves and, moreover, 10-15% higher reproductive allocation than plants from control and wet manipulated plots. These responses conformed with trait patterns observed along the natural rainfall gradient. Selection analyses further corroborated that earlier flowering and higher reproductive allocation was favored under low irrigation.
Our results show consistent rapid evolution in two sites within merely ten years. The combination with selection analyses and the natural climatic gradient provides compelling evidence for their adaptivity. Thus, plants may adapt to changing climate within ten generations. Whether this will be fast enough to keep up with ongoing rates of change, especially for long-lived species, remains an open question.

Session 23-O16 - Plant populations across space and time

How does biodiversity loss affect the response of plant species to global change?

Peter Dietrich[1,2], Nico Eisenhauer[2,3], Simone Cesarz[2,3], Christiane Roscher[1,2]

[1]Helmholtz-Centre for Environmental Research - UFZ, Physiological Diversity, Leipzig, DE, peter.dietrich@idiv.de
[2]German Centre for Integrative Biodiversity Research (iDiv), Physiological Diversity, Leipzig, DE, peter.dietrich@idiv.de
[3]Leipzig University, Institute of Biology, Experimental Interaction Ecology, Leipzig, DE

Grasslands are among the most important ecosystems worldwide hosting a huge number of species. However, diversity in grasslands is dramatically decreasing due global change (GC). Loss of diversity can alter the selective environment that plants experience, so that persisting species must adapt to novel biotic interactions, especially to changes in the composition of mutualistic and antagonistic soil biota. However, little is known about how fast the remaining species adapt to the novel biotic conditions and whether such micro-evolutionary processes affect the response of these species to GC. To address this knowledge gap, we performed a common garden experiment using plant and soil material from a long-running biodiversity experiment (Jena Experiment). We collected seeds of four grass species and took samples of soil biota, which both were selected for 15 years either in a species-rich or species-poor environment (communities with 2 or 6 species). We studied the performance of the offspring, which was transplanted either in pots inoculated with their own soil biota (home) or with different soil biota (away) and which were either non-treated (control) or exposed to drought, increased nitrogen input or a combination of both in a full factorial design. Across all species, plant individuals in home soil produced more biomass than individuals in away soil after four months of growth. Moreover, plants in home soil benefited more from fertilization than individuals in away soil, while both groups responded similarly to drought and to the combination of drought and fertilization. Our study shows that individuals of the same species took different evolutionary pathways depending on the plant species diversity of neighborhood and resulting specificity of soil biota. We also showed that these micro-evolutionary changes may impact species responses to GC drivers, which might be important to understand the mechanisms how ecosystems respond to the ongoing process of global change.

Session 23-O17 - Plant populations across space and time

Predicting evolutionary dynamics of plant species in response to climate change

Anna-Maria Madaj[1,2], Stefan G. Michalski[1]

[1]Helmholtz-Centre for Environmental Research - UfZ, Halle (Saale), DE, anna-maria.madaj@ufz.de
[2]Martin-Luther-Universität Halle-Wittenberg, Halle (Saale), DE, anna-maria.madaj@ufz.de

Anthropogenic induced environmental changes, e.g. climate change, are counted among the major threats to biodiversity. They alter global and local environmental conditions in unprecedented dimensions. Hence, the investigation of the ability of species and communities to cope with rapidly changing environmental conditions as well as the comprehensive understanding of possible adaptation processes is urgently needed. Using methods of quantitative population genetics, we quantified fundamental predictors of evolutionary dynamics in multiple plant species. For this we established a common garden experiment with two different environments (i.e. control and drought) for a total of over 100 open pollinated seed families per species. Heritability, selection differentials and the response to selection of functional, vegetative, morphological and physiological traits and their variation in response to drought were estimated. So far, we found differential amounts of heritable phenotypic variance among traits as well as trait specific responses to drought which gives us fundamental knowledge about genetic diversity in quantitative traits. However, the detection and quantification of genetic diversity and selection differentials in functional traits has often been limited to controlled environmental conditions whereas an evidence for a significant role of adaptation to climate change in natural communities is rare. Hence, we will additionally assess evolutionary predictors for the study species in near-natural meadows and pastures of the Global Change Experimental Facilty (GCEF) and compare these predictors with the estimates obtained in the common garden. This knowledge will help us to understand the evolutionary potential and response of plant species to predicted climate change and to formulate future scenarios about ecological consequences and resulting population dynamics.

Session 23-P1 - Plant populations across space and time

Assessing spatial and temporal genetic population structure using pooled samples

Walter Durka[1,2]

[1]Helmholtz-Centre for Environmental Research, Halle, DE, walter.durka@ufz.de
[2]iDiv, Deutsches Zentrum für integrative Biodiversitätsforschung Halle-Jena-Leipzig, Leipzig, DE, walter.durka@ufz.de

In large-scale projects, genotyping of SNP markers in multiple populations non-model species using next-generation-sequencing methods may become prohibitively expensive. Pooling individuals into population pools may be an alternative. Here I present examples from different projects that used pooled plant samples, ddRAD genotyping of various species and spatial and temporal scales.

Session 23-P2 - Plant populations across space and time

Genetic diversity of ex-situ collections of *Gentianella campestris* (L.) Börner

Philipp Mann[1], Sascha Liepelt[1]

[1]Philipps-Universität, Marburg, DE, mannph@students.uni-marburg.de

Persistent habitat fragmentation has led to a continuous decline of wild plant species. This poses major problems, especially for species with small populations, as the exchange of genetic information is made more difficult. The consequences are mostly genetic impoverishment and reduced adaptability. To preserve the remaining genetic diversity, plants from threatened populations are often cultivated in ex-situ collections. In our study, newly developed microsatellite markers are used to investigate the genetic diversity of ex-situ collections of the endangered species *Gentianella campestris* (L.) Börner. In a first study nine of these microsatellite-markers were applied to 80 sampled individual plants from nine populations. Five of these populations belong to the species *G. campestris*, two populations belong to the related species *Gentianella praecox* ssp. *bohemica* (Skalický) Holub and two to *Gentianella lutescens* (Velen.) Holub. Five of the nine microsatellite markers exhibited clear signal peaks and polymorphisms and were therefore included in the analysis. For the two related species, four of the markers provided polymorphic signals. Basic genetic diversity indices were calculated and the genetic structure of was evaluated by Bayesian cluster analyses and PCoA. In most *G. campestris* populations a heterozygous surplus was found. The proportion of heterozygous individuals within the *G. campestris* populations was very high. The number of individuals with identical genotypes is also strikingly high, which might possibly be explained by apomixis. The five investigated *G. campestris* populations were divided into three genetic clusters resulting in a geographically consistent pattern. Due to the small number of microsatellite markers used and individuals studied, our results have to be interpreted carefully. More comprehensive investigations are necessary for reliable statements on genetic diversity and to investigate the hypothesis of apomixis in depth.

Session 23-P3 - Plant populations across space and time

Population genetic patterns of the endangered *Arnica montana* as a basis for restoration measures

Eva Mosner[1], Verena Hollmann[1], Ilona Leyer[1], Sascha Liepelt[1]

[1]University of Geisenheim, Department of Applied Ecology, Geisenheim, DE, eva.mosner@hs-gm.de
[2]Philipps-Universität Marburg, Marburg, DE

The endangerment of species is often not merely a problem of degraded habitats. Even more, species that are negatively affected by strong declines experience also population genetic threats such as loss of genetic diversity or inbreeding depressions. Hence, where translocations of individuals act as last resort measures for the conservation or restoration of populations, knowledge of population genetic patterns as well as the underlying processes is necessary to succeed.
Arnica montana, a species of national responsibility in Germany, is an endangered species of nutrient poor, acidic grasslands in Central Europe. Especially during the last decades, strong decreases in population numbers and sizes have been recorded in many countries. Besides habitat-specific problems, also population genetic issues are thought to be responsible since the species reproduces not only generatively but also vegetatively. Additionally, it is considered self-incompatible.
In our study, we investigated clonal as well as genetic diversity patterns of 37 *Arnica* populations throughout Hesse, Germany, using 14 microsatellites. We focused on the one hand on the regional population structure to assess whether genetic differentiation between the populations occurs. On the other hand, the extant of clonal structures within stands were evaluated targeting the local population structure. Considering the regional scale of Hesse, stands displayed two clusters, one in the north-west, the other one in the south-east. Analyses at the local scale revealed a positive relation between rosette numbers and genetic diversity. Moreover, a considerable number of multi-ramet-genotypes could be observed within the different populations. Our results allow to identify the genetically strongly endangered populations and also potential donor populations from which seed material can be used for restoration measures.

Session 23-P4 - Plant populations across space and time

Signatures of local adaptation in *Arnica montana* (Asteraceae): a multi-disciplinary approach

Loris Capria[1], Eva Mosner[1], Ilona Leyer[1], Klaus Eimert[1], Sascha Liepelt[3]

[1]University of Geisenheim, Geisenheim, DE, loris.capria@hs-gm.de
[3]Philipps-Universität Marburg, Marburg, DE

Last-resort measures, such as assisted gene flow, become necessary when genetically pauperised populations of declining species cannot recover without human intervention. In order to succeed, considering local adaptation is a fundamental prerequisite. Besides abiotic parameters (e.g. temperature), also biotic factors (e.g. herbivory) are addressed as important drivers of local adaptation. In plants, secondary metabolites play a decisive role in herbivory resistance and chemotype patterns can be expected to vary between populations in relation to herbivory intensity. The extent to which such traits are genetically fixed and contribute to local adaptation remains unclear though. In order to put into practice the information about local adaptation patterns in reintroduction and conservation actions, wide range studies are necessary to cover environmental gradients properly. We will present a multi-disciplinary approach that combines traditional common garden with metabolomics, transcriptomics, and genomics in order to identify patterns of local adaptation in the highly endangered species *Arnica montana*. Firstly, plant material from *A. montana* populations throughout Europe will be grown in a common garden and tested for secondary metabolites to identify adaptive chemotypic variation. Transcriptome analysis will then be used to identify candidate genes and therein a panel of SNPs associated with secondary metabolites as well as environmental variation. Finally, on the basis of these SNPs, range-wide surveys will be conducted to identify genotype-environment associations to detect patterns of neutral and adaptive genetic variation throughout the distribution range. With this study, we aim at defining patterns of local adaptation and population structure in *A. montana* for the development of effective restoration measures.

Session 23-P5 - Plant populations across space and time

Contrasting patterns of intra-specific trait variability between native and non-native plant species along an elevational gradient on Tenerife, Canary Islands

Paul Kühn[1], Amanda Ratier Backes[1,2], Christine Römermann[2,3], Helge Bruelheide[1,2], Sylvia Haider[1,2]

[1]Institute of Biology/Geobotany and Botanical Garden, Martin Luther University Halle-Wittenberg, Halle (Saale), DE, paul.kuehn@student.uni-halle.de
[2]German Centre for Integrative Biodiversity Research (iDiv) Halle-Jena-Leipzig, Leipzig, DE
[3]Institute of Ecology and Evolution with Herbarium Haussknecht and Botanical Garden, Friedrich Schiller University Jena, Jena, DE

Non-native plant species have often been recorded at high elevations. Here we investigate, if range expansions of such species along elevational gradients are related to high intra-specific variability in functional traits. Intra-specific specific leaf area (SLA) and leaf nutrients are expected to decrease and leaf C:N ratios to increase with elevation. Because non-native species tend to be introduced in lowland areas and then have to pass environmental filters when expanding upwards, intra-specific trait variation of non-native species, as expressed by functional diversity (FD) of a particular trait, is expected to decrease with increasing elevation. To test these assumptions, 8 individuals of 6 native and 5 non-native forb species from 5-10 populations were sampled along an elevational gradient ranging from 55 to 1925 m a.s.l. on Tenerife, Canary Islands, resulting in a total of 664 samples. Various traits regarding leaf structure and nutrient concentrations were measured in the field and laboratory. Functional diversity for these traits was calculated on a plot-per-species level. Along the elevational gradient, no significant changes were found in SLA and leaf P, but the leaf C:N ratio increased for native species. As hypothesized, FD for SLA, P and C:N ratio decreased with elevation for non-native species, but we found no changes in natives. While FD of non-natives decreased along the gradient, they unexpectedly displayed low levels of trait variability. This implies that environmental filtering selects for intermediate trait values that meet the requirements of a variety of conditions. However, the directional trait changes with elevation of native species combined with no or positive changes in FD, point to adaptations to local environmental conditions. This study indicates that functional diversity is not as important for the expansion of non-native species into mountains as the expression of certain trait values that are advantageous along the whole gradient.

Session 23-P6 - Plant populations across space and time

Persistence and phenotypic characteristics of typical heathland species along a succession gradient

Vincent Aljes[1], Gert Rosenthal[1]

[1]Universität Kassel - Landschafts- u. Vegetationsökologie, Kassel, DE, v.aljes@asl.uni-kassel.de

Progressive succession from open heathland and dry grassland to forest ecosystems results in far-reaching changes in habitat conditions (especially light and temperature) and plant species composition. To analyse the response of characteristic heathland/dry grassland species we used the space-for-time-substitution approach. We analysed the persistence, the regeneration potential and the morphological plasticity of populations of seven heathland species in different succession stages from open heathland/dry grassland to forest. Furthermore, to examine the regenerative capacity of the species the soil seedbank was analysed. The study was conducted in the DBU Natural Heritage Site "Oranienbaumer Heide" (Sachsen-Anhalt, Germany), an abandoned military training area with base-rich sandy grassland and heather ecosystems, partly overgrown by early and later successional stages of pine and birch.
First results show that many of the heather and dry grassland species disappear with the appearance of dominant grass species. For the selected species a trade-off between vegetative and reproductive characteristics could be observed in response to changes in the surrounding vegetation structure. This becomes especially clear for plant height and number of flowers. The density of the local population within the successional stages was related to a high adult longevity, the ability for vegetative reproduction and a long persistent seedbank.
Our conclusion is that functional traits and fitness parameters of plants could be a promising tool to better predict extinction risks for species. For instance, the decline of reproductive organs could indicate local extinction in a very early stage of succession.

Session 23-P7 - Plant populations across space and time

How land-use intensity affect the species-area relationship in grasslands and forests in Germany?

Ralph Bolliger[1], Daniel Prati[1], Markus Fischer[1]

[1]University Bern - Institut of Plant Sciences, Bern, CH, ralph.bolliger@ips.unibe.ch

It has already been shown that land use affects species richness of grassland and forest communities. However, how exactly the land-use intensity changes the species-area relationships, i.e. the increase of species richness with increasing plot size, has not been investigated thoroughly. In the context of the Biodiversity Exploratory Project in Germany, we surveyed the vegetation in 150 grassland plots and 150 forest plots that differed in management intensities in three different regions. In these plots, we established nested survey areas of three different sizes, which allowed us to calculate the slope of the species-area relationship. Fist results in grassland confirm that land-use intensity, in particular the intensity of mowing, reduced the slope of the species-area relationship, i.e. homogenized the vegetation. In forest, first analyses show a positive effect of the stand density on the species-area relationship, i.e. older forests become more homogenous. We will present further analyses using structural equation models, detailing how species-areas relationships are affected by the land-use intensity.

Session 23-P8 - Plant populations across space and time

The impact of tundra fires on annual tree ring growth of *Betula nana L.* in the north of Western Siberia.

Nina Reimann[1], Ramona Heim[1], Norbert Hölzel[1], Stefan Kruse[2]

[1]Institute of Landscape Ecology, University of Münster, Heisenbergstraße 2, 48149 Münster, DE, nina.reimann@uni-muenster.de
[2]Polar Terrestrial Environmental Systems Research Group, Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research, Telegrafenberg A43, 14473 Potsdam, DE

The Arctic is particularly vulnerable to climate change, as an increase in temperature is predicted to be most pronounced in high-latitude areas. Fires are expected to increase in frequency and expand throughout arctic regions in the course of climate change. Tundra fires have a big impact on ecosystem properties in the Arctic. Burning of vegetation and organic layers often results in higher soil temperatures and can lead to permafrost thaw. Through the acceleration of nutrient cycling fires may also lead to significant changes in the performance and composition of vegetation. An increased shrub cover might be caused, resulting in increasing plant productivity, changed surface albedo and microclimate. Fire events may therefore further enhance shrub encroachment in the lower tundra.
However, long-term fire effects on arctic shrub growth are poorly studied and not well understood so far. In this study the long-term effects of tundra fires on the growth performance of the abundant shrub species *Betula nana L.* was studied by the analyses of annual ring width at three locations with a different fire disturbance history (>44, 28 and 12 years old) and neighbouring control sites at the northern edge of the forest tundra in Western Siberia.
Due to higher soil temperatures, lowered permafrost depth and enhanced nutrient cycling in the soils caused by the wildfires, we expect increasing tree ring width of *Betula nana* at burned sites. Due to improved site conditions and lowered completion on burned sites the influence of regional weather conditions (especially cold summers) on shrub growth, should be less pronounced. In addition, the variability between different shrub individuals should be smaller.

Session 23-P9 - Plant populations across space and time

Survival and growth of two birch species from a West Siberian 1700 km latitudinal transect in a common-garden at mid-latitude

Ann-Kathrin Köther[2], Svetlana Migalina[3,4], Leonid Ivanov[3,4], Dina Ronzhina[3,4], Polina Yudina[3], Alexej Evstyugin[3], Larissa Ivanova[3,4], Norbert Hölzel[2], Christian Lampei[2]

[2]Institue of Landscape Ecology, Münster, DE, annkathrinkoether@gmail.com
[3]Botanical Garden, Ural Devision, Russian Academy of Science, Yekaterinburg, RU
[4]Tyumen State University, Tyumen, RU

Due to the ongoing climate change many species will face different environmental conditions in the future. Field studies all over the world increase our knowledge about plant adaptation and the effects of climatic change on plant populations. In Russia a unique experiment was started 50 years ago to study a wide variety of Betula trees growing out of their origin habitat under common-garden conditions. From a 1700 km latitudinal transect east and west of the Ural Mountains in Russia seeds from *Betula pendula* and *Betula pubescens* originating from 5 and 6 populations, respectively, were planted in a common garden at mid-latitude near Yekaterinburg. After 50 years we now have data of the survival rates of more than 2800 trees. Furthermore, we measured the timber volume of a subset of five *B. pendula* and six *B. pubescens* populations along the latitudinal gradient as an indicator of tree growth. Survival and growth present two central parameters of plant fitness that are often traded off against each other. Preliminary results show strong differences between the populations of *B. pendula*. The survival of trees was negatively correlated with the latitudinal distance from the common garden. However, relative to the southern populations, trees of the northern populations showed a higher survival. For growth, there was less variation among populations, but surviving trees of southern populations tended to be larger than trees of northern origin. Results for *B. pubescence* are still outstanding. Our results suggest that populations of *B. pendula* are locally adapted and therefore may require adaptation to changing environmental conditions. The trade-off between survival and growth along latitude may be of central importance for this adaptation.

Session 23-P10 - Plant populations across space and time

Patterns of phenotypic plasticity of *Fagus sylvatica* L. in a reciprocal transplantation experiment across Europe.

Jonas Schmeddes[1], Lena Muffler[1], Jürgen Kreyling[1]

[1]Experimental Plant Ecology, Institute of Botany and Landscape Ecology, University of Greifswald, Greifswald, DE, jonas.schmeddes@uni-greifswald.de

Fagus sylvatica L. (European Beech) is the dominant tree species over large areas of Western and Central Europe. Yet, due to its drought susceptibility and low seed dispersal capability, it is expected to suffer from future climatic changes. Across its large distribution range, *F. sylvatica* shows only low genetic adaptation to its local environments. Implications of its high phenotypic plasticity for species persistence in the face of future climatic changes, however, are not fully understood yet. We conducted a fully reciprocal transplantation experiment across a Europe-wide gradient, reaching from the dry (Spain) to the cold distribution edge (Sweden, Poland) of the species. At 12 different sites inside and outside of the natural distribution range, we planted in total over 12.800 beechnuts collected from known mother trees. We sampled morphological, fitness- and stress-related traits during the year of establishment and in the subsequent year. Here, we compare different potential sources of phenotypic plasticity in *F. sylvatica*, namely within single mother trees, within single stands or provenances, and across different provenances under the contrasting climates of the translocation sites. Our working hypothesis is that the source of the high phenotypic plasticity in *F. sylvatica* is located already at the level of single mother trees. This hypothesis will be tested before the conference and the results will be presented. Support for our working hypothesis would imply a high potential for adaptation to climate change in *F. sylvatica*.

Session 23-P11 - Plant populations across space and time

Using heterogeneous forest inventory data to study regeneration patterns in European forests: potentials and challenges

Yannek Käber[1], Christof Bigler[1], Harald Bugmann[1]

[1]Chair of Forest Ecology, Swiss Federal Institute of Technology, Zurich, CH

Forests will be affected strongly by human-induced climate change, mediated by changes of growth, mortality, and regeneration of trees. Models are needed to assess the interplay of these processes and to project future forest dynamics, but models cannot be better than the underlying data and knowledge. There is a wealth of data on the impacts of climate change on tree growth, and knowledge on mortality has augmented a lot over the past 10+ years. However, regeneration and its quantification towards inclusion in forest models have received much less attention, partly because regeneration is a very "noisy" process that is hard to study. Thus, it remains unclear under what conditions forest dynamics are prone to recruitment limitation, and what this implies for their future development. Based on a wealth of novel data from widely different sources and new data analysis techniques such as hierarchical statistical modeling and Approximate Bayesian Computation, we assess tree regeneration to quantify recruitment rates of a wide range of European tree species. We analyze heterogeneous data sets from multiple data sources such as European National Forest Inventories, Swiss Forest Reserves Network combined with large datasets on regeneration after windthrow, regeneration experiments and large-scale browsing surveys. This enables us to evaluate the nature and extent of species-specific recruitment limitation along an extended environmental gradient in European forests. Particular attention is placed on the description of differences in regeneration patterns between natural and managed forests. The rigorous analysis of highly heterogeneous and "noisy" data to quantify recruitment rates offers new possibilities to evaluate existing regeneration models and to use previously inaccessible information for the development of new such models.

Session 23-P12 - Plant populations across space and time

The fluctuation of macrophytes in Lake Taihu, China

Wei Huang[1], Kaining Chen[1]

[1]Nanjing Institute of Geography and Limnology, Chinese Academy of Science, Nanjing, CN, whuang@niglas.ac.cn

Lake Taihu is situated in the Changjiang (Yangtze) delta, the most industrialized area in China. Lake Taihu is the third largest freshwater lake in China and is located between 30°55’- 31°32’N and 119°52’-120°36’E. Lake length is 68.5 km and widths 56 km. Mean depth is 1.9 m, and maximum depth is 2.6 m corresponding to an elevation of 3.0 m above sea level. Since 1980, however, economic development has resulted in pollutants being produced and discharged into rivers and the lake. With the deterioration of water quality, eutrophication and algal blooms *(Microcystis* spp.) have occurred. Recently, the algal bloom has extended its coverage and persists throughout the summer. Macrophytes play an important role in ecosystem structural and water quality improvement in shallow lake, which is also the target of many ecological restoration projects. In order to assess the state of the plant, we surveyed macrophyte in Lake Taihu in May and September from 2016 to 2019. 45 transects were set around the lake, and each transects contains 5-7 sampling points. Statistical analysis reveals that extreme high water level in summer of 2016 caused great damage to macrophyte structural. Although low water level in 2017 and 2018, the recovery process is unusually slow, and macrophyte richness remained a low level.

Session 23-P13 - Plant populations across space and time

Plant-invertebrate interactions across a strong environmental gradient

Anne Kempel[1], Eric Allan[1], Martin Gossner[3], David Wardle[2]

[1]University of Bern, Bern, CH, kempel@ips.unibe.ch
[2]Swedish University of Agricultural Sciences, Umea, SE
[3]Eidg. Forschungsanstalt für Wald, Schnee und Landschaft WSL, Birmensdorf, CH

Over the past few decades the relationship between variation in soil fertility and biodiversity has become a major research topic. This is because soil fertility is strongly affected by nitrogen and phosphorus enrichment, two major global change drivers which induce changes in productivity and soil chemistry and cause substantial loss of plant diversity. While we have considerable knowledge on how plants respond to variation in soil fertility, we still know very little about the consequences of nutrient enrichment for invertebrate herbivores and their impact on plants. This is surprising given the strong effects that invertebrate herbivores are well known to exert on ecosystem processes such as plant production and nutrient cycling. Using an island chronosequence in northern Sweden where islands vary considerably in productivity and soil fertility owing to differences in fire history, we investigated whether invertebrate herbivore diversity and biomass, as well as their impact on plants, show coordinated responses to variation in soil fertility. Moreover, we disentangle the relative effects of plant diversity, productivity and predation on herbivore diversity, biomass and impact.

Session 23-P14 - Plant populations across space and time

How do Janzen-Connel hypothesis and predation affect early secondary succession in the temperate zone?

Marketa Tahadlova[1,2], Katerina Sam[1,2]

[1]Faculthy of Science, University of South Bohemia, Ceske Budejovice, CZ, m.tahadlova@gmail.com
[2]Entomology Institute, Czech Academy of Science, v.v.i., Ceske Budejovice, CZ

Succession is one of the essential topics in ecology and has been in the scope of scientists for over a century. Yet, the processes shaping successional trajectories remain unknown. There exist several theories which including neutral theory or niche theory try to explain stochastic and deterministic processes in shaping plant communities. Plant succession trajectories are affected not only by abiotic conditions or plant interactions themselves, but also by higher trophic levels such as plant natural enemies and their consumers. These multitrophic interactions may shift plant composition, diversity and productivity. The Janzen-Connell hypothesis postulates that the mortality of seeds and seedlings, caused by insect herbivores and/or fungal pathogens maintains high diversity of tropical rainforest vegetation as it produces negatively density-dependent population dynamics that favours rare plant species. Temperate forests are far from such high plant species diversity. Such a difference generates the questions: (1) Are the diversity differences caused strictly by abiotic conditions shaping the temperate plant communities? And if not, (2) do those biotic interactions affect temperate plant communities the same way? The study presented is the first one compiling multitrophic experimental approach on the early successional dynamics in temperate conditions. We compared secondary succession on 45 vegetation plots (2.5 x 2.5 m), organized in nine blocks and containing control plots, experimentally excluded insects (insecticides), fungal pathogens (fungicides), vertebrate herbivores (metal fence) and vertebrate + ant predators (exclosure cages). We will present the effect of our treatments on very early succession, accumulated over the course of two years.

SESSION 24

Assessment of biodiversity and species interactions with molecular tools

Chairs: Julia Tiede, Alexander Keller, Bernhard Eitzinger

Metabarcoding and other recent DNA-based approaches are increasingly used in ecological research, paleobiology, biomonitoring and conservation. The applications range from the molecular detection of rare species in environmental samples, over complete biodiversity assessments from bulk samples (e.g., trap-catches) to identification of interspecific interactions. These tools however also come with challenges and limitations to be carefully considered to ensure reliable results. This includes, amongst other things, sample collection, laboratory approaches, bioinformatics, databases and data interpretation. In this session, we will discuss results, opportunities, challenges and solutions in this rapidly developing field and thus invite technical contributions that critically review and enhance current methodologies. We further also explicitly invite presentations about applied projects that made use of these methods to answer ecological questions and such setting them into context with other types of data.

Session 24-O1/2 - Molecular biodiversity & interaction assessment

Molecular methods in Biodiversity monitoring: An overview

Sarah Bourlat[1]

[1]Zoological Research Museum Alexander Koenig (ZFMK), Adenauerallee 160, 53113 Bonn, DE, s.bourlat@leibniz-zfmk.de

In this talk, I will provide an overview of existing molecular methods and their suitability for different biomonitoring applications. I will discuss the use of targeted approaches (species specific detection) versus community-based approaches (multiple species detection). Metabarcoding library preparation and bioinformatic steps will be described in detail as well as several case studies from my own research. These case studies include the detection of prey species from the stomach contents of fish and the benchmarking of metabarcoding methods for bulk samples of insects from malaise traps using mock community experiments. Multiple parameters can affect efficient and reliable analysis of malaise trap samples such as primer bias, biomass bias, sample complexity, PCR replicate number, clustering and denoising methods and sequencing depth. We show how to benchmark factors affecting taxonomic coverage in the metabarcoding of malaise trap samples using mock communities assembled from the GBOL reference library.

Session 24-O3 - Molecular biodiversity & interaction assessment

Seasonal diversity patterns in aquatic macroinvertebrate communities analysed through metabarcoding and the impact on biomonitoring aspects

Vera Zizka[1], Matthias Geiger[2], Florian Leese[1]

[1]University of Duisburg-Essen, Aquatic Ecosystem Research, Essen, DE, vera.zizka@uni-due.de
[2]Zoologisches Forschungsmuseum Alexander Koenig (ZFMK), Bonn, DE

Background: Recurrent freshwater bio-assessments are important to monitor trends of ecological status and biodiversity and validate the efficiency of conservation and restoration measures. The diversity and abundance of macroinvertebrates is a widely-used indicator in such assessments world-wide and especially in the EU Water Framework Directive (WFD). In the present study, we applied DNA-metabarcoding to stream bulk macroinvertebrates on two stream systems in Western Germany (Emscher and Sieg) with different stressor impacts and levels of restoration. The aim was to assess levels of natural seasonal fluctuations in macroinvertebrate communities and investigate the impact on assessment results.

Results: Macroinvertebrates were biannually (two years, spring/autumn) sampled at six locations of two German streams (river Emscher and Sieg). Metabarcoding revealed moderate seasonal fluctuations in community composition and read numbers for the investigated taxonomic groups. For macroinvertebrates, this had minor influence on the determined ecological status, which was largely congruent with estimations based on morphological identifications.

Significance: This study validates again the potential of metabarcoding to reliably infer community composition of macroinvertebrates. Furthermore, it indicates that, even if moderate seasonal fluctuations of taxonomic groups within macroinvertebrates are visible, the ecological quality status does not depend on sampling season, yet showing a high congruence for macroinvertebrates between traditional and molecular methods. This finding is encouraging given the comparability of DNA-based and classical approaches in the context of national and international assessments such as in the context of the WFD.

Session 24-O4 - Molecular biodiversity & interaction assessment

Drivers of structure and dynamics of communities in natural microcosms

Rachel Korn[1], Gerhard G. Thallinger[2], Sarah M. Gray[1], Louis-Félix Bersier[1]

[1]University of Fribourg, Department of Biology–Ecology and Evolution, Fribourg, CH
[2]Graz University of Technology, Institute of Computational Biotechnology, Graz, AT

Via metabarcoding the 16S- and 18S rRNA gene of the microbiome sampled from the pitcher-shaped leaves of *Sarracenia purpurea* phytotelmata and adjacent *Sphagnum* mosses, we aimed at unraveling community structure and the drivers that shaped it. Hereby, we accounted for step-wise constraints on the extant communities with a structural equation modeling approach: (i) colonization of the pitchers is hypothesized to be driven by biogeographical factors reflecting spatial organization on a landscape level, (ii) environmental filters act on a macro- and microhabitat level and (iii) multilevel trophic interactions drive the structure within each realized community at an early and late successional stage. First results showed that microbial diversity was distinctly higher and different in the mosses than in the pitchers, suggesting a stringent filtering in the pitchers. Further, community composition was partitioned on the macrohabitat level; thus, indicating that factors as temperature and geographic position are important drivers of community composition.

Session 24-O5 - Molecular biodiversity & interaction assessment

Optimizing work- and dataflow for microarray hybridization and high-throughput amplicon sequencing to detect phytopathogenic fungi in orchards using internal transcribed spacer sequences

Janno Harjes[1], Gerhard Rambold[1]

[1]Department of Mycology, University of Bayreuth, Bayreuth, DE, jann0.harjes@uni-bayreuth.de

Host specificity is a major determinant of the composition and distribution of epiphytic and endophytic fungal communities on leaves of fruit trees. Additionally, temporal changes influence the diversity of these fungal communities and their survival on tree species. A short-termed sampling campaign was carried out in an orchard hosting fruit trees of the family Rosaceae, to monitor intraseasonal shifts of epiphytic and endophytic fungal leaf community composition as well as potential proliferation of plant pathogenic fungi.
Leaf samples for DNA and RNA isolation, were collected and flash frozen until final storage. An ITS amplicon library was created and sequenced on an Illumina MiSeq 3000 platform (Biocenter, LMU Munich). Reads were pre-processed using QIIME pipeline and data analyses conducted applying PRIMER-7 software. Additionally, custom-made microarray (Agilent) hybridization experiments applying ITS-based probes in the 8x15K format, were performed with the aim to deliver supportive data for quantification and detection of phytopathogenic fungi.
Fungal community compositions, based on relative OTU abundances are strongly influenced by the host tree species, allowing detectable separation between the host species. Host-tree specificity also proved to reflect phylogenetic relations between the hosts up to the tribe level, and indication of shifts in the community composition over time become detectable. Comparing microarray hybridization results to metabarcoding data from the same specimens serves the purpose of cross-validating the species/OTU detection and quantification. Microarray signal detection was calibrated using log2-scaled dilution series. Threshold level settings for both workflows were evaluated, in order to optimize pathogen detection at low abundances.

Session 24-O6 - Molecular biodiversity & interaction assessment

Epichloë endophytes in cool season grass species in Germany

Veronika Vikuk[1], Jochen Krauss[1]

[1]University of Würzburg, Department of Animal Ecology and Tropical Biology, Würzburg, DE, veronika.vikuk@uni-wuerzburg.de

Cool season grass species can be infected with different systemic *Epichloë* endophytes. The endophyte is able to produce different alkaloids which can be toxic for vertebrates and/or invertebrates. These alkaloids can lead to severe intoxications in grazing animals, which are known from overseas, but hardly from Europe. Little is known about infection rates and alkaloid production of *Epichloë* endophytes in European grass species. In this study we report for the first time a combination of genetic and analytical methods to determine the endophyte diversity in grasslands.
We sampled 13 grass species on 150 plots in three regions in Germany, along a landuse intensity gradient in the Biodiversity Exploratories, and detected infection rates of the grasses with *Epichloë* spp., as well as genotypes and chemotypes of the associated *Epichloë* spp.
We detected infections with *Epichloë* spp. in five grass species. Two species had infection rates of 73-81 % (*Festuca pratensis*, *Festuca ovina* agg.), whereas *Lolium perenne*, *Festuca rubra* and *Dactylis glomerata* had infection rates of 8-15 %. By determining genotypic diversity with multiplex-PCR, we also predicted chemotypic diversity of the *Epichloë* species, which were confirmed with HPLC and GC analyses. We detected vertebrate and insect toxic alkaloids in the grass samples. We also showed that the biosynthesis starting gene for the vertebrate toxic ergovaline was absent in *Epichloë* sp. in *L. perenne* and that the endproduct was indeed missing.
Increasing cultivation of grass monocultures dominated with *Epichloë* infected species, may result in greater numbers of intoxicated livestock. We showed that PCR screens provide a robust way of testing the endophyte status of pasture grasses and could be used for regular monitoring. We suggest to maintain heterogenous grasslands in Germany to avoid threats for livestock.

Session 24-O7 - Molecular biodiversity & interaction assessment

Of plants and nematodes: How plant and soil diversity alter plant chemistry and therefore herbivory

Christian Ristok[1,2], Alexander Weinhold[1,2], Marcel Ciobanu[3], Yvonne Poeschl[1,4], Fredd Vergara[1,2], Nico Eisenhauer[1,5], Nicole van Dam[1,2]

[1]Deutsches Zentrum für Integrative Biodiversitätsforschung (iDiv) Halle-Jena-Leipzig, Leipzig, DE, christian.ristok@idiv.de
[2]Friedrich Schiller Universität Jena, Jena, DE, christian.ristok@idiv.de
[3]Branch of the National Institute of Research and Development for Biological Sciences, Cluj-Napoca, RO
[4]Martin-Luther-Universität Halle-Wittenberg, Halle, DE
[5]Universität Leipzig, Leipzig, DE

Plants produce many metabolites, together called the metabolome, to cope with biotic interactions. Plant metabolomes are dynamic and respond to interactions with other organisms. Hence, we hypothesize that different plant and soil communities alter the plant's metabolome. We further expect that these changes feed back to ecosystem functions, such as herbivore resistance.

We used the "Jena Experiment" to study plant metabolomes of seven common grassland plant species, which grew in plots that differed in plant diversity. We analyzed metabolomes in shoots of individual plants using liquid chromatography and high resolution mass spectrometry, and assessed herbivore damage on all plants. In addition, we assessed variations in soil biota as represented by soil nematode and microbial communities.

We show that differences in plant diversity altered the metabolome in several plant species. In particular, the metabolomes of plants grown in more diverse plant communities differed from those grown in monocultures. We further show that community-weighted mean functional traits, such as leaf area or rooting depth, drive the chemical diversity of individual plants, with opposing effects on grass and herb metabolomes. Finally, we show that across all species, plant diversity is indirectly linked to herbivory *via* the soil nematode community and the individual plant metabolome.

We conclude that differences in soil community composition due to plant diversity level affect the plant's metabolome and thereby the interaction with aboveground herbivores. In addition, we suggest that biodiversity-ecosystem functioning research will benefit from integrating metabolomes of interacting organisms to elucidate mechanisms underlying species interactions and ecosystem functioning.

Session 24-O8 - Molecular biodiversity & interaction assessment

Genetic traits affect the occurrence and speed of island radiations - insights from an individual-based model

Ludwig Leidinger[1], Juliano Sarmento Cabral[1]

[1]Center for Computational and Theoretical Biology, Universität Würzburg, Würzburg, DE, ludwig.leidinger@uni-wuerzburg.de

In molecular biodiversity assessment, genetic traits are usually interpreted morphological. But genetic traits may hold important functional information. Here we address the question why, on oceanic islands, particular lineages diversify, while others remain monospecific. The increasing availability of genetic data presents a new opportunity to shed light on this matter. Combined with ecological traits (e.g. body mass, dispersal abilities), this can reveal interactions between genetic and functional divergences. However, large scale sampling of fine scale genetic and functional data is difficult across islands and taxa for any useful generalization.
To overcome this limitation, we use a genomically-explicit individual-based model for insular floras to assess the interaction between genetic and functional traits on lineage differentiation. We analyze diversification patterns of colonising lineages taking into account several genetic and genetically-coded ecological traits.
While lineages with a low degree of genetic linkage differentiate quickly into specialized subpopulations, lineages with a high degree of genetic linkage remain initially species poor. After a certain period of accumulating mutations, those latter lineages experience a radiation burst, eventually surpassing species numbers of low-linkage-lineages. These findings suggest a two-phase-pattern for island diversification: an initial phase dominated by differentiation of lineages with low linkage level and a late phase dominated by differentiation of lineages with high degree of linkage.
Our results provide insights as to what combinations of genetic and ecological traits distinguish species poor from species rich lineages.
Additionally, our model can be used to benchmark molecular analyses and to compare diversification patterns with empirical data.

Session 24-O9 - Molecular biodiversity & interaction assessment

Intensified land-use correlates with loss of pollen diversity and nutritional quality of larval provisions in solitary bees

Birte Peters[1], Alexander Keller[2], Sara Diana Leonhardt[1]

[1]University of Würzburg; Department of Animal Ecology and Tropical Biology, Würzburg, DE, birte.peters@uni-wuerzburg.de
[2]University of Würzburg; Department of Bioinformatics; Center for Computational and Theoretical Biology, Würzburg, DE

Biodiversity loss, as found in intensively managed agricultural landscapes, correlates with reduced ecosystem functioning, such as pollination provided by plant-insect interactions. High land-use intensity often results in altered plant community composition, as well as reduced floral diversity and abundance, which can negatively affect pollinators (e.g. bees).
We investigated the influence of land-use intensity on the diversity of trap nesting solitary bees along land-use gradients in three regions in Germany. Further, we addressed the structure and complexity of plant-bee networks using ITS2 metabarcoding and nutritional analyses of collected pollen. We found that bee species diversity and composition differed between regions and further that pollen/plant diversity decreased and floral composition changed with increasing land-use intensity.
To investigate if differences and changes in plant diversity and community compositions also affects pollen nutritional quality, we analyzed free amino acid (by ion exchange chromatography), sugar content and lipid content and composition (by gas chromatography) of pollen of trap nesting bee larvae. We found that the protein (i.e. total amino acid) and fat (i.e. total fatty acid) content, as well as concentrations of several fatty acids in larval food decreased with increasing land-use intensity. Concluding, we found strong influences of land-use intensity on diversity and quality of foraged diets for solitary bee species that also are likely to impact health of bee populations.

Session 24-10 - Molecular biodiversity & interaction assessment

Metabarcoding of gut content indicates which factors shape predator-prey interactions along environmental gradients

Bernhard Eitzinger[1,2,3], Nerea Abrego[2], Dominique Gravel[4], Tea Huotari[2], Eero Vesterinen[2], Eoin O Gorman[5], Tomas Roslin[2]

[1]University of Freiburg, Freiburg, DE, bernhard.eitzinger@biologie.uni-marburg.de
[2]University of Helsinki, Helsinki, FI
[3]University of Marburg, Marburg, DE, bernhard.eitzinger@biologie.uni-marburg.de
[4]Université de Sherbrooke, Sherbrooke, CA
[5]University of Essex, Essex, UK

Analyzing the structure and dynamics of biotic interaction networks and the processes shaping them is currently one of the key fields in ecology. How changes in environment affect these interaction networks is of particular interest to understand the consequences of climate change on species and their distribution. We here investigate prey choice and trophic niche space of an abundant generalist arthropod predator – wolf spiders – along two environmental gradients in the Arctic. We specifically ask how environmental and biological traits are shaping trophic interactions with increasing altitude and soil temperature respectively, thereby deriving a new perspective on community structure and its response to environment. We used metabarcoding of spider gut content to characterize consumed prey community and compared it with available prey community identified by pitfall trapping and vacuum sampling. While we found that available prey community changes along the gradients, environmental variables had only a small effect on the prey community found in the spider's gut. These observations indicate that wolf spiders exert selective feeding on particular taxa irrespective of environmental constraints. Interestingly, the realized trophic niche of co-existing wolf spider species is getting smaller with increasing soil temperature, minimizing overlap in prey use. By directly modelling the probability of predation based on gut content data, we found that neither trait matching in terms of predator and prey body size nor phylogenetic or environmental constraints modified interaction probability. Our results indicate that taxonomic identity may be more important for predator-prey interactions than environmental constraints or prey traits. The impact of environmental change on predator-prey interactions thus appears to be indirect and mediated by its imprint on the community of available prey.

Session 24-O11 - Molecular biodiversity & interaction assessment

Species specific identification of weed seed food of carabids in cereal fields

Yasemin Guenay[1,2], Britta Frei[1], Michael Traugott[2], David Bohan[3], Sandrine Petite[3], Corinna Wallinger[1]

[1]Mountain Agriculture Research Unit, Institute of Ecology, University of Innsbruck, Innsbruck, AT
[2]Institute of Interdisciplinary Mountain Research, IGF, Austrian Academy of Sciences, Innsbruck, AT
[3]INRA Centre Dijon, Dijon, FR

Trophic interactions of species in agroecosystems provide key regulation ecosystem services, such as pest control and pollination, and therefore also determine the dynamics, robustness and resilience of service provision. For achieving international goals of reducing application of pesticides without compromising crop yield, recent research attaches importance to the biological control potential of carabid beetles. Apart from feeding on animals including insect pests carabids also consume substantial amounts of weed seeds. However, the different trophic-functional groups in ground beetles that would enable us to describe the specific associations between particular prey species are not yet well defined. This basic gap of knowledge limits our ability to utilise carabids in agricultural situations.
In the present project, we sampled carabid beetles in cereal fields in three different regions in Austria and France. Regurgitates of over 2000 representatives of the 19 most common carabid species present, were molecularly screened via next generation sequencing employing a nested-PCR approach. With this metabarcoding approach we identified the seeds consumed on a species specific level. The outcomes of these analyses will contribute to a better prediction of weed control ecosystem services provided by these carabid species and their specific role in the functioning of agroecosystems.

Session 24-O12 - Molecular biodiversity & interaction assessment

The interplay of plant life-history traits and foraging behavior of tamarins affect seed dispersal distances and spatial genetic structure in two Neotropical tree species

Tiziana A. Gelmi-Candusso[2], Daria Slana[2], Eckhard W. Heymann[2], Katrin Heer[1]

[1]Conservation Biology, Philipps University Marburg, Marburg, DE, katrin.heer@uni-marburg.de
[2]Verhaltensökologie & Soziobiologie, Deutsches Primatenzentrum, Göttingen, DE

Foraging behavior of animal seed dispersers impacts seed dispersal distances (SDD), and as a consequence, the spatial distribution of plant genotypes. Yet, few studies consider both, the animals´ behavior and the resulting seed dispersal patterns and whether these differ among plant species with the same dispersers. Here, we investigated how plant-life-history traits affect the foraging behavior of seed dispersers, and whether this results in differences in SDD and spatial genetic structure (SGS). For our study, we focused on two primate-dispersed tree species with different life-history traits in the Peruvian Amazon. At our study site, seeds of *Leonia cymosa* (Violaceae) and *Parkia panurensis* (Fabaceae) are exclusively dispersed by two tamarin species, *Saguinus mystax* and *Leontocebus nigrifrons*. Behavioral observations of the tamarins were used to derive movement patters and foraging behavior, and allowed collecting seeds from fecal samples. Dispersed seeds, seedlings, saplings and adults of both tree species were genotyped with microsatellite markers. Genetic and observational data were used to estimate SDD with different approaches, and SGS was determined for both tree species across life stages. We found that fewer individuals fed simultaneously in crops of *Leonia* and time and distance between the feeding site and the next resting site were longer compared to *Parkia.* Further, we found that SDD was longer in *Leonia* than in *Parkia* and SGS was less pronounced in seedlings and adults, but not in sapling of *Leonia*. By relating our results to the respective life history of each plant species, we show that reproductive traits and plant population density impact foraging behavior, which is in turn reflected in SDD and the SGS of the plant populations.

Session 24-P1 - Molecular biodiversity & interaction assessment

Effect of mulching on grassland mycobiota, a case study of CHEGD fungi in a Slovak pasture

Miroslav Caboň[1], Dobromil Galvánek[1], Gareth W. Griffith[2], Slavomír Adamčík[1]

[1]Plant Science and Biodiversity Centre SAS, Bratislava, SK, miroslav.cabon@gmail.com
[2]Aberystwyth University, Aberystwyth, UK

Mulching is used as a low-cost method for maintenance of abandoned grasslands, however it may cause a decrease of species diversity. This management treatment often induces changes in above-ground species composition, which are rapidly reflected by changes in soil mycobiota. Unlike plants, restoration of original mycobiota composition on disturbed places lasts for decades or centuries. Group of grassland macrofungi of Clavariaceae, *Hygrocybe*, *Entoloma*, Geoglossaceae and *Dermoloma*, collectively named as CHEGD, are frequently referred as indicators of natural value of European semi-natural grasslands. The evaluation scoring for grasslands is estimated based on counting CHEGD species during fructification, making this system inaccurate and weather or season depended. In this study we tested use of amplicon sequencing as a tool for estimation of CHEGD diversity in grasslands. We hypothesised that mulching negatively affects CHEGD fungal species composition because of available plant dead material for saprophytic fungi which may interact with other soil organisms and influence the soil ecosystem indirectly by rapid increasing of available organic material resulting from the decomposition. To specify impact of mulching on soil mycobiota, we compared different grasslands managements on sub-mountain oligotrophic *Nardus* grasslands in the Central Slovakia: mulching in spring, mulching in autumn, mulching in autumn combined with grazing, grazing, mowing combined with grazing and no management controls (4 replicates for each). The diversity of soil fungi was assessed by analysis of amplicon sequencing of two separate runs for ITS1 and ITS2 regions of nrDNA performed by Ilumina MiSeq . We compared the number of CHEGD MOTUs and its proportion to total fungal diversity. Our results suggest that the impact of mulching depends on season when the grassland is mulched and its negative impact might be decreased by combination with other management treatments.

Session 24-P2 - Molecular biodiversity & interaction assessment

Temperature shapes the temporal succession of the photosynthetic picoeukaryote community in Lake Chaohu, a highly eutrophic shallow lake

Xiaoli Shi[1], Xiaoli Shi[1]

[1]Nanjing Institute of Geography and Limnology, Chinese Academy of Sciences, Nanjing, CN

The monthly composition of Photosynthetic picoeukaryotes (PPEs) in Lake Chaohu were investigated using a combination of flow cytometry sorting and high throughput sequencing. Results indicated that temperature is the most important factor shaping PPE community structure. The PPE community can be categorized into three groups that are dominant at different temperature ranges: high temperature (> 21.8 °C), intermediate temperature (between 9.8 °C and 21.8 °C) and low temperature (< 9.8 °C). At the supergroup level, Cryptophyta was dominant at the intermediate temperature level, and Bacillariophyta was prevalent at low temperatures. In comparison, Chlorophyta PPEs were sensitive to temperature at the order level. Molecular network analysis using 18S rDNA sequencing results from sorted samples revealed that the Operational Taxonomic Units (OTUs) of PPE from the same taxonomic groups were predominantly positive, implying that they were occupying similar niches. The cooccurrence patterns between PPEs and fungi were mostly negative. In particular, OTU101, which was associated with Chytridiomycota, was negatively related to many OTUs belonging to Chlorophyta and Diatom, indicating that their potential parasitic associations are not species-specific. OTUs which might be important functional groups, were all present in relatively low abundances.

Discrimination of spatial distribution of aquatic organisms in a coastal ecosystem based on eDNA approach

Hyunbin Jo[1], Dong-Kyun Kim[1], Kiyun Park[1], Ihn-Sil Kwak[1,2]

[1]Fisheries Science Institute, Chonnam National University, Yeosu 59626, Republic of Korea, prozeva@chonnam.ac.kr
[2]Division of Fisheries and Ocean Science, Chonnam National University, Yeosu 59626, Republic of Korea

The nonlinearity and complexity of coastal ecosystems often cause difficulties when analyzing spatial and temporal patterns of ecological traits. Environmental DNA (eDNA) monitoring has provided an alternative to overcoming the aforementioned issues associated with classical monitoring. We determined aquatic community taxonomic composition using eDNA based on a meta-barcoding approach that characterizes the general ecological features in Gwangyang Bay coastal ecosystem. We selected the V9 region of the 18S rDNA gene (18S V9), primarily because of its broad range among eukaryotes. Our results produced more detailed spatial patterns in the study area previously categorized (inner Bay, main channel of the Bay and outer Bay) by Kim et al. (2019). Specifically, the outer Bay zone was clearly identified by CCA using genus-level identification of aquatic organisms based on meta-barcoding data. We also found significant relationships between environmental factors. Therefore, eDNA monitoring based on meta-barcoding approach holds great potential as a complemental monitoring tool to identify spatial taxonomic distribution patterns in coastal areas.

Session 24-P4 - Molecular biodiversity & interaction assessment

Comparison between environmental DNA meta-barcoding and conventional microscopic examination on water samples

Ihn-Sil Kwak[1,2], Hyunbin Jo[1], Kiyun Park[1], Dong-Kyun Kim[1]

[1]Fisheries Science Institute, Chonnam National University, Yeosu 59626, KOR, inkwak@hotmail.com
[2]Division of Fisheries and Ocean Science, Chonnam National University, Yeosu 59626, KOR

We examine the applicability of eDNA metabarcoding for effective monitoring and assessment of community composition, compared with conventional observation using microscopic identification in a coastal ecosystem, Gwangynag Bay in South Korea. Our analysis is based primarily on two surveys at a total of 15 study sites in early and late summer (June and September) of the year 2018. The results of our study demonstrate the similarity and dissimilarity of biological communities in composition, richness and diversity between eDNA metabarcoding and conventional microscopic identification. It is found that, overall, eDNA metabarcoding appears to provide a wider variety of species composition, while conventional microscopic identification depicts more distinct plankton communities in sites. Finally, we suggest that eDNA metabarcoding is a practically useful method and can be potentially considered as a valuable alternative for biological monitoring and diversity assessments.

Session 24-P5 - Molecular biodiversity & interaction assessment

Using environmental DNA to monitor the reintroduction success of the Rhine sculpin (*Cottus rhenanus*) in a restored stream

Christopher Hempel[1,2], Bianca Peinert[2], Arne Beermann[2], Vasco Elbrecht[1], Jan-Niklas Macher[2,3], Till-Hendrik Macher[2], Gunnar Jacobs[4], Florian Leese[2,5]

[1]University of Guelph, Department of Integrative Biology, Guelph, DE, vera.zizka@uni-due.de
[2]University of Duisburg-Essen, Aquatic Ecosystem Research, Essen, DE, vera.zizka@uni-due.de
[3]Naturalis Biodiversity Center, Marine Biodiversity, Leiden, NL
[4]Emschergenossenschaft-Lippeverband, Essen, DE
[5]University of Duisburg-Essen, Centre for Water and Environmental Research, Essen, DE

As a consequence of the strong human impact on freshwater ecosystems, restoration measures are increasingly applied to restore and maintain their good ecological status. The ecological status of freshwaters can be inferred by assessing the presence of indicator species, such as the Rhine sculpin (*Cottus rhenanus*). However, traditional methods of monitoring fish, such as electrofishing, are often challenging and invasive. To augment or even replace the traditional fish monitoring approach, the analysis of environmental DNA (eDNA) has recently been proposed as an alternative, sensitive approach. The present study employed this modern approach to monitor the Rhine sculpin, a species that has been reintroduced into a recently restored stream within the Emscher catchment in Germany, in order to validate the success of the restorations.
We monitored the dispersal of the Rhine sculpin using replicated 12S end-point PCR eDNA surveillance at a fine spatial and temporal scale to investigate the applicability of analyzing eDNA for freshwater ecosystem monitoring. We also performed traditional electrofishing in one instance to compare visual and eDNA-based assessments.
We could track the dispersal of the Rhine sculpin and showed a higher dispersal potential of the species than we assumed. Furthermore, the eDNA analysis showed higher sensitivity for detecting the species than traditional electrofishing, although false negative results occurred at early reintroduction stages. Our results show that analyzing eDNA is capable of validating and tracking ecological reintroductions and contribute to the assessment and modelling of ecological status of streams.

Session 24-P6 - Molecular biodiversity & interaction assessment

Resource intake of stingless bee colonies along a disturbance gradient in a tropical ecosystem in Ecuador

Gemma N. Villagómez[1], Alexander Keller[2], Claus Rasmussen[3], Sara D. Leonhardt[1]

[1]University of Würzburg, Department of Animal Ecology and Tropical Biology, Würzburg, DE, gemma.villagomez@uni-wuerzburg.de
[2]University of Würzburg, CCTB - Center for Computational and Theoretical Biology, Molecular Ecology Group, Würzburg, DE
[3]Aarhus University, Department of Bioscience, Aquatic Biology, Aarhus, DK

Tropical forests are important pools of global biodiversity. Nowadays, they are experiencing extreme land-use changes (e.g. fragmentation and deforestation), which can lead to rapid biodiversity loss, changes in ecosystems structures and interactions, and with-it the loss of important ecosystem functions. One important tropical pollinator group are stingless bees (Apidae: Meliponini). Although stingless bees have a global (sub)tropical distribution, are very species rich, and pollinate a large spectrum of tropical plant species, we often know little about their foraging behavior and resource intake. However, a better understanding of habitat-, species- and colony-specific differences in resource intake is essential for unraveling their role in tropical plant-pollinator interaction networks, their responses to habitat alterations and to finally improve conservation programs aimed at supporting these pollinators in altered ecosystems.
We here present site-, colony- and species-specific differences in foraging activity, resource intake (pollen, nectar, and resin), and richness of visited floral sources (obtained from collected pollen via DNA-metabarcoding) of eleven stingless bee colonies (from six different genera, seven species) located at different forest types (i.e. from mature to disturbed to restored rain forests) in two nature reserves in the Esmeralda Province, Ecuador.

Session 24-P7 - Molecular biodiversity & interaction assessment

Seasonal changes in the dietary diversity and composition of the serotine bat (*Eptesicus serotinus*) detected by DNA metabarcoding

Julia Tiede[1], Melanie Diepenbruck[1], Jürgen Gadau[1], Bernd Wemheuer[2,3], Christoph Scherber[1]

[1]University of Münster, Münster, DE
[2]University of Göttingen, Göttingen, DE
[3]UNSW Sydney, Sydney, AU

Insectivorous bat populations are in decline due to a variety of factors including the loss of foraging habitat and diminishing food supply. Knowledge of foraging strategies and hunting areas are key to understanding the ecology of threatened bat species and optimizing conservation strategies.
Here, we investigated seasonal variation in the diet of two nursery colonies of the serotine bat *Eptesicus serotinus* located in an intensively farmed agricultural landscape in north-west Germany. DNA of food remains in bat droppings were amplified with standard COI barcoding primers for arthropods, sequenced with Illumina MiSeq and identified to species or higher taxonomic level using BOLD.
We found that the dietary diversity increased from May to June and plateaued in July. This pattern reflects the increasing insect activity with progressing season and indicates that the feeding strategy of *E. serotinus* is highly generalistic and somewhat opportunistic even when prey is abundant. The diet composition largely varied according to seasonal conditions. Dipteran species and spiders were mostly consumed in the early season when other taxa are still scarce, whereas in June and July the frequency of Lepidopteran and Coleopteran species increased. The ecology of prey taxa can be used as an indicator for the hunting areas of *E. serotinus*: e.g. Calliphoridae (Diptera) and Siliphidae (Coleroptera) colonize excrements of livestock and Tortricidae and Geometridae (Lepidoptera) can be found predominantly along border structures such as hedgerows, forest edges, or orchards.

Session 24-P8 - Molecular biodiversity & interaction assessment

Automated reference database creation for any marker and taxonomic group

Alexander Keller[1], Sonja Hohlfeld[1], Andreas Kolter[2], Jörg Schultz[1], Birgit Gemeinholzer[2], Markus J. Ankenbrand[1]

[1]University of Würzburg, Würzburg, DE, alexander.keller@uni-wuerzburg.de
[2]University of Giessen, Giessen, DE

An up to date and high quality reference database is essential for DNA barcoding and metabarcoding. Given the variety of markers, formatting requirements for classifiers and constant growth of primary databases, suitable reference databases are however limited to few markers. Other common problems are lack of standardization or documentation, and outdated data. We developed a software pipeline with a web and command line interface to generate reference databases on-the-fly for any applicable marker. It gathers current available data from primary databases and allows for optional filtering, formatting and restriction options specific for (meta-)barcoding purposes. Generated databases optionally receive a DOI, making them well documented with meta-data, publicly sharable and citable. The BCdatabaser enables researchers to quickly build standardized reference databases for arbitrary markers and custom taxonomic groups. It helps capitalize on new data while maintaining quality and reproducibility. Availability: https://www.github.com/molbiodiv/bcdatabaser (code), https://bcdatabaser.molecular.eco (webservice)

Session 24-P9 - Molecular biodiversity & interaction assessment

A complete time-calibrated multi-gene phylogeny of the European butterflies

Martin Wiemers[1,2], Nicolas Chazot[3,4,5], Oliver Schweiger[1], Christopher W. Wheat[6], Niklas Wahlberg[3]

[1]Helmholtz Centre for Environmental Research - UFZ, Halle, DE, martin.wiemers@ufz.de
[2]Senckenberg Deutsches Entomologisches Institut, Müncheberg, DE, martin.wiemers@ufz.de
[3]Lund University, Lund, SE
[4]University of Gothenburg, Gothenburg, SE
[5]Gothenburg Global Biodiversity Centre, Gothenburg, SE
[6]Stockholm University, Stockholm, SE

With the aim of supporting ecological analyses in butterflies, the third most species-rich superfamily of Lepidoptera, we present the first time-calibrated phylogeny of all 496 extant butterfly species in Europe, including 18 narrow endemics for which no public DNA sequences had been available previously. It is based on a concatenated alignment of the mitochondrial gene COI and up to 11 nuclear gene fragments, using Bayesian inference of phylogeny. To avoid region-specific sampling bias the European tree is grafted on a global genus-level backbone butterfly phylogeny. In addition to the consensus tree which is shown here, we will provide the posterior distribution of trees and the full concatenated alignment in an upcoming publication for further analyses.

SESSION 25

Multitrophic interactions

Chairs: David Ott, Malte Jochum

Unraveling the nature and underlying drivers of interactions between individuals, populations, functional and trophic groups lies at the heart of understanding the complexity of ecosystems and the processes therein.
In this session, we will cover direct and indirect, non-trophic and trophic interactions between organisms at different trophic levels and across different spatial and temporal scales from microbe-plant interactions in alpine moraines to succession in dung-associated communities, bird communities on Papua New Guinea and epiphyte litter decomposition in subtropical forests.
Comprising a mixture of talks and posters, this session will provide a broad overview over traditional concepts and recent highlights of multitrophic community ecology in the Anthropocene.
The contributions will highlight how anthropogenic induced stressors, such as heat waves, exotic species invasion, insect pests and ship-induced waves can alter species interactions in terrestrial and aquatic systems and across above and below-ground compartments.

Session 25-O1 - Multitrophic interactions

Microbe-assisted vegetation cover to reduce erosion in alpine environments – concept and first results

Lisa-Maria Ohler[1], Sabine Kraushaar[2], Stefan Haselberger[2], Jan-Christoph Otto[3], Robert R. Junker[1]

[1]University of Salzburg, Department of Biosciences, Salzburg, AT, lisa-maria.ohler@sbg.ac.at
[2]University of Vienna, Department of Geography and Regional Research, Vienna, AT
[3]University of Salzburg, Department of Geography and Geology, Salzburg, AT

Glaciers are facing ongoing and fast retreat due to global warming. The receding ice leaves unvegetated surfaces covered by unconsolidated deposits of sediment, so-called moraines. Sediments remobilised during extreme precipitation and flooding events may have negative effects on natural and anthropogenic structures downstream. It has been shown that high vegetation cover serves as effective protection against erosion, which is also supported by our findings. Apart from cover, our results indicate that plant communities with higher community weighted means in specific functional traits such as root mass and leaf area are more effective in slope protection than plant communities with other functional compositions. Studies on crop species demonstrated the growth-promoting abilities of microbes and also their ability to alter plant traits. We adopted this approach in order to exploit beneficial plant-microbe interactions to reduce sediment remobilisation. Therefore, we tested the effects of naturally occurring microbes on plant growth and trait expressions of the naturally occurring alpine plant species *Campanula barbata* (Campanulaceae) in order to enhance slope protecting abilities of this plant species. A screening of native bacteria collected in the test site identified those that significantly affected seed germination as well as functional trait characteristics in *C. barbata*. In the next steps, we will apply the microbe-assisted seed mixture to the field sites and monitor erosion from experimental plots in the Kaunertal Valley, Austria. Our results provide new insights into plant-microbe interactions in natural ecosystems with implications for a nature-based solution to reduce sediment erosion in high mountain areas.

Different startegies for hummingbirds and plants in hummingbird-plant interactions

Catherine Graham[1], Ben Weinstein[2], Holgar Beck[3], John Clark[4], Mathieu Perret[5]

[1]Swiss Federal Research Institute (WSL), Birmensdorf, CH, catherine.graham@wsl.ch
[2]University of Florida, Gainesville, US
[3]Santa Lucia Research Station, Santa Lucia, EC
[4]The Lawrenceville School, Lawrence, US
[5]Conservatoire et Jardin Botaniques de la Ville de Genève, Chambésy, CH

Species interactions, such as a pollinator visiting a given plant species, form the architecture of biodiversity, yet we lack a unifying theory of why and how they vary. Many studies in network ecology identify emergent patterns using measures of network structure. However, this approach may not detect the ecological processes that result in these emergent patterns. Here we explore how hummingbird-plant interactions vary across 6 sites and 4-6 years in the Ecuadorian Andes. We find that hummingbirds preferentially visit plants with a corolla length similar to their bill length, indicative of niche partitioning. In contrast, species in the family Gesneriaceae, a species rich family common in hummingbird's diet, flower concurrently and attract similar hummingbird visitors. These result suggest that facilitation may be an important mechanism shaping flower communities in tropical hummingbird visited assemblages. Combined our results indicate that different mechanisms might influence hummingbird versus plants in hummingbird–plant resulting in complex spatial and temporal interaction patterns.

Session 25-O3 - Multitrophic interactions

The food choice of the marine herbivorous gastropod *Conomurex persicus* (Swainson 1821) stays consistent during an experimental heat wave

Laura Argens[1], Lisa Gassen[4], Gil Rilov[3], Mark Lenz[2]

[1]Technische Universität München, München, DE, laura.argens@tum.de
[2]Helmholtz-Zentrum für Ozeanforschung Kiel, Kiel, DE
[3]National Institute of Oceanography, Haifa, IL
[4]Universität Rostock, Rostock, DE

One consequence of climate change are more frequent and intense temperature extremes. Several studies suggest that changes in temperature regimes influence trophic interactions between producers and primary consumers. In marine ecosystems, elevated temperatures affect macroalgae-grazer-interactions. An increase in temperature can change the energy demand of the grazer (direct effect) or the attractiveness of the algae (indirect effect), or both. However, it remains unclear how the combination of direct and indirect effects shapes grazer food preference under changing temperatures. This study used multiple choice feeding assays to test whether heat waves in the eastern Mediterranean Sea affect the food preference of the marine snail *Conomurex persicus.* Prior to the assays, we acclimated 3 brown algae and 2 red algae as well as the snail individuals to five target temperatures between 25°C and 33°C (in 2°C steps). At all temperatures, the snails showed a clear preference for *Galaxaura rugosa*. Although, total grazer consumption rates increased with increasing temperatures, the preference of *C. persicus* for *G. rugosa* prevailed independent of which component (snails or snails and algae) was acclimated. Furthermore, the algae species which were preferred at 25°C were even more consumed at higher temperatures. While the snails consumed the same biomass of *Dictyota sp.* (the least preferred species) at 25°C and 33°C, consumption rates of *G. rugosa* doubled at 33°C in comparison to 25°C. The more pronounced preference of *C. persicus* for *G. rugosa* presumably goes back to the effect that the temperature increase had on the snails, because acclimating the snails led to the same results as acclimating the snails and the algae. It can be explained by the higher energy demands of the snails at the elevated temperatures. In coming decades an increase in total consumption for marine macroalgae-grazer-interactions will presumably be more common than a switch in food preference.

Session 25-O4 - Multitrophic interactions

Predator-predator naïveté between native ants and the invasive ladybeetle *Harmonia axyridis* in Europe

Roman Bucher[1], Laura M. Japke[1,3], Ayse Gül Ünlü[1], Florian Menzel[2]

[1]Philipps-Universität Marburg, Marburg, DE, bucher@uni-marburg.de
[2]Johannes Gutenberg-Universität Mainz, Mainz, DE
[3]Westfälische Wilhelms-Universität Münster, Münster, DE

Several hypotheses have been proposed to explain the invasion success of species spreading beyond their natural ranges. The predator-predator naïveté hypothesis suggests that non-native predators benefit from being unknown to native predators, resulting in reduced intraguild interference with native predators. This novelty advantage should depend on the ability of native predators to recognize chemical cues of non-native predators.
Here, we compared ant aggression and ladybeetle response among four native European ladybeetle species and the invasive Asian ladybeetle species *H. axyridis*. In addition, we manipulated cuticular hydrocarbons on the elytra of ladybeetles to test, whether these chemical cues are involved in species recognition. For this, we conducted behavioral assays in the laboratory confronting two common ant species with living ladybeetles but also with ladybeetle elytra bearing or lacking the chemical cues of the respective ladybeetle species.
Consistent with the predator-predator naïveté hypothesis, our behavioral experiments revealed weaker aggression of ants towards the invasive ladybeetle *H. axyridis* compared to most native ladybeetle species. The removal of cuticular hydrocarbons from ladybeetle elytra greatly reduced aggression by ants. If cues of respective ladybeetle species were added on cue-free elytra, natural levels of ant aggression could be restored for most ladybeetle species. This experiment demonstrates that chemical cues on the surface of ladybeetles are important determinants of intraguild interactions. Reduced ant aggression towards *H. axyridis* is likely to improve their ability to deplete aphid populations in the field and thus to outcompete native ladybeetles.

Session 25-O5 - Multitrophic interactions

Responses of forest soil fauna communities to invasion of exotic earthworms

Malte Jochum[1,2], Olga Ferlian[1,2], Madhav Thakur[1,2,3], Jörg Salamon[4], Nico Eisenhauer[1,2]

[1]German Centre for Integrative Biodiversity Research (iDiv) Halle-Jena-Leipzig, Leipzig, DE, malte.jochum@idiv.de
[2]Leipzig University, Institute of Biology, Leipzig, DE, malte.jochum@idiv.de
[3]Department of Terrestrial Ecology, Netherlands Institute of Ecology (NIOO-KNAW), Wageningen, NL
[4]Institut für Zoologie, Department für Integrative Biologie und Biodiversitätsforschung, Universität für Bodenkultur Wien, Wien, AT

Invasion of exotic earthworms is a global phenomenon, which can alter the biodiversity of plants, animals, and microbes in the invaded ecosystems. For the last approximately 12,000 years, earthworms have been naturally absent from wide parts of North America but have been intentionally and accidentally re-introduced over the past ~400 years with dramatic consequences for the native flora and fauna. Soil-fauna responses to earthworm invasion are often studied by focusing on single taxa, functional groups or components of the affected ecosystem. Here, we present results from a comprehensive analysis of four different northern North American forests (three in Canada, one in the US) sampled for soil fauna between 2016 and 2018. We calculated species richness, density, biomass, and average body mass of soil macro-, meso-, and microfauna and assessed their community composition in invaded and non-invaded parts of the forests. Additionally, we assessed which functional groups and size classes are most heavily affected by earthworm invasion and if these effects were positive or negative. While earthworm invasion had significant effects on all of these groups, magnitude and direction of effects differed between size-, functional, and taxonomic groups. Our results show that while invasive earthworms do represent a strong environmental filter for native communities that have developed without these ecosystem engineers for thousands of years, there are winners and losers of these invasions among the soil fauna and the long-term consequences of this globally important invasion will depend on which roles these soil fauna groups play in their native ecosystems.

Session 25-P1 - Multitrophic interactions

Ecology of bird communities along an elevational tropical gradient in Papua New Guinea

Katerina Sam[1], Bonny Koane[1]

[1]Biology Centre CAS, Ceske Budejovice, CZ, katerina.sam.cz@gmail.com

Elevational gradients continue to provide an attractive setting for biodiversity studies and serve as a heuristic tool and natural experiment in the study of community ecology. Here we present robust quantitative data on bird communities along a complete *undisturbed* rainforest elevational gradient. Our aim was to describe bird communities in detail and inspect various aspects of their ecology and patterns along the gradient. Mt Wilhelm gradient is located in the Central Cordillera of Papua New Guinea, spanning from the lowland floodplains of the Ramu river (200m) to the tree line (3700m). We collected bird community data at eight sites (500m elevational increment) during five independent surveys – in dry, wet seasons and extremely dry seasons (El Nino event). We used point counts, mist-netting and random walks throughout the area to survey birds. We divided all recorded birds (more than 40,000 individuals comprising 248 species) into five feeding guilds. We examined patterns of species richness, density, range size and distribution of birds. We further describe patterns in functional diversity and seasonal movements of birds. Data indicate that species richness and abundance of birds is highest at the lowest elevations and decreases steeply for all birds together and for frugivores. However, the diversity and abundances of insectivores remains constant until 1700 m a.s.l. and then decreases with increasing elevation. The patterns in frugivore-insectivores and insectivore-nectarivores are more similar to those of insectivores rather than frugivores. We observe overall highest species turn-over at mid-elevations (between 1200-1700m), and highest abundances of insectivorous birds at 700–1700m. Extreme droughts during of El Nino even in 2015 had significant effect on bird communities, especially on frugivorous birds at lower elevations. Finally, we discuss malaria parasitemia in birds along the elevational gradient, and their elevational migrations.

Session 25-P2 - Multitrophic interactions

Ship-induced waves reduce the reproduction success of *Daphnia magna* and *Daphnia pulex*

Ulrike Moser[1], Friederike Gabel[1]

[1]Institute of Landscape Ecology, Münster, DE, ulrike.moser@uni-muenster.de

Negative effects of ship-induced waves, e.g. reduced growth rates and fitness as well as increased mortality, have been demonstrated for plants, benthic invertebrates and fish. However, direct effects of ship-induced waves on zooplankton have not been investigated yet. Zooplankton, especially water fleas, are an important compartment of aquatic food webs. Hence, impacts or reduced planctonic abundances may be far-reaching.
We investigated the direct effects of simulated ship-induced waves on *Daphnia magna* and *D. pulex*. We hypothesized that the individuals get attached to the water surface and that wave disturbance may lead to a reduced reproduction success. Furthermore, we hypothesized that the effects may be more pronounced to *D. pulex* than to *D. magna*, as it's lower surface-to-volume ratio may induce a higher sensitivity to hydraulic forces and adhesive power. The experiments were conducted in a wave flume to analyze short-term effects and effects on reproduction success for a six-week period. We could reveal that wave disturbance significantly decreases the reproduction success of both daphnids. Furthermore, *D. pulex* was significantly more often attached to the surface of the water than *D. magna*.
This may be relevant especially in areas with high ship traffic or near shore areas where the wave becomes more pronounced and leads to reduced abundances of water flea. This in turn may affect higher trophic levels due to reduced prey availability, too.

Session 25-P3 - Multitrophic interactions

Litter decomposition on epiphytes and forest floor of subtropical floodplain forests

Tomohiro Yoshida[1], Koichiro Shimizu[1]

[1]Tokyo University of Agriculture and Technology, Tokyo, JP, yoshitom@cc.tuat.ac.jp

Litter decomposition is a fundamental ecological process in forest ecosystems and occur not only on the forest floor but also on trees. Accumulated litter patches on epiphytes are important habitats for litter macroinvertebrates such as isopods and cockroaches, and would serve as refuges especially in floodplain forests. We investigated litter macroinvertebrate assemblages and leaf-litter decomposition on epiphytes (bird's nest ferns) and the forest floor of subtropical floodplain forests. We used two types of litter bags with and without macroinvertebrates to clarify the effect of macroinvertebrates on litter decomposition on the two habitats. We also examined the relationships between fern size and litter decomposition on trees. Community composition of macroinvertebrates differed between the epiphytes and the forest floor. Leaf-litter decomposition was faster on the epiphytes than on the forest floor. The effect of macroinvertebrates on litter decomposition differed between the two habitats. Leaf-litter decomposition in the litterbags without macroinvertebrates was positively correlated with fern size, whereas greater litter decomposition in the litterbags with macroinvertebrates even on the smaller ferns. We concluded that the relative contribution of macroinvertebrates to litter decomposition was higher on the smaller epiphytes than the larger epiphytes and the forest floor of subtropical floodplain forests.

SESSION 26

Remote Sensing for ecological research and application

Chairs: Hannes Feilhauer, Daniel Doktor

Earth observation data are increasingly used in spatial ecology and nature conservation. Depending on the sensor system, remote sensing data provide useful insights in the spatio-temporal distribution and composition of leaf and canopy functional traits, species, communities, structural properties of vegetation stands, habitat characteristics, phenological trends, ecosystem services or land-use intensity. To take full advantage of this rich information content, advanced analysis techniques such as machine learning algorithms, time series analysis, multi-sensor data fusion, multi-scale analyses and the combination of remote sensing data with process-based models are helpful. This session will give an overview on recent ecological applications of various remote sensing approaches and aims to foster the discussion of these topics among interested users. We kindly invite all contributions that rely on remote sensing for spatio-temporal analyses in ecological science and practice.

Session 26-O1 - Remote Sensing

Remote sensing of an N-fixing invasive shrub species: Early indicators of high impact

André Große-Stoltenberg[1], Christine Hellmann[4], Jan Thiele[2], Christiane Werner[4], Jens Oldeland[3]

[1]Landscape Ecology and Landscape Planning, Justus-Liebig-Universität Gießen, Gießen, DE, andre.grosse-stoltenberg@umwelt.uni-giessen.de
[2]Johann Heinrich von Thünen Institute, Braunschweig, DE
[3]Biodiversity, Ecology and Evolution of Plants, Biocentre Klein Flottbek and Botanical Garden, University of Hamburg, Hamburg, DE
[4]Ecosystem Physiology, University of Freiburg, Freiburg, DE

High impact invaders, such as the N-fixing *Acacia longifolia*, are a major threat to ecosystems worldwide. They can built persistent and monospecific stands with a clear decrease in native biodiversity. While local impact of *A. longifolia* on ecosystem structure and functioning in biodiverse Mediterranean dune ecosystems is well understood, there is a lack of methods for early detection of its impact across scales.
First, we show that *A. longifolia* can be mapped at landscape level by integrating high resolution airborne hyperspectral images and laserscanning (LiDAR) data. We then simulated satellite imagery, and a clear increase of productivity was detected at early stages of invasion when Acacia cover was below 10%. Thus, there is high potential to retrieve early indicators of high impact using freely available satellite data.
Second, we traced the impact of the invader on N cycling at the stand scale by joining a functional tracer of N-fixation, the stable isotopic composition of nitrogen $\delta\ ^{15}N$, with airborne laserscanning (LiDAR) data. Foliar $\delta^{15}N$ of the non-fixing, native shrub *Corema album* increased in vicinity (5-8m) of invader stands over and above the influence of environmental heterogeneity derived from LiDAR. Thus, the uptake of N previously fixed by the invader could be mapped, which gives mechanistic insights into the invasion process.
Third, we demonstrate at leaf and canopy scale that the invader differs in its biochemical and biophysical traits from the native species of the same growth form, particularly regarding leaf N content. This dissimilarity may provide an indicator for invaders with a high impact on N cycling. It can be retrieved from hyperspectral data, which emphasizes potential for mapping.
Thus, early indicators of high impact can be retrieved using sensor-based techniques, which offers promising possibilities for monitoring invasions of ecosystem engineers in sensitive and biodiverse ecosystems.

Session 26-O2 - Remote Sensing

A closer view from the sky: Use of an Unmanned Aerial Vehicle for monitoring invasion of *Impatiens glandulifera*

Lionel Sujay Vailshery[1], Thomas Köllner[2], Cyrus Samimi[3], Heike Feldhaar[1]

[1]Department of Animal Ecology I, Bayreuth Center for Ecology and Environmental Research (BayCEER), University of Bayreuth, Universitätsstraße 30, 95444, Bayreuth, DE, lionelsujay@gmail.com
[2]Professorship of Ecological Services, Faculty of Biology, Chemistry and Earth Sciences, Bayreuth Center for Ecology and Environmental Research (BayCEER), University of Bayreuth, Universitätsstraße 30, 95444, Bayreuth, DE
[3]Department of Geography, Bayreuth Center for Ecology and Environmental Research (BayCEER), University of Bayreuth, Universitätsstraße 30, 95444, Bayreuth, DE

Impatiens glandulifera, an invasive plant species spreading rapidly throughout Europe, especially along riparian habitats poses a risk to native ecosystems. Hence, it is essential to establish cost-effective methods that enable easy monitoring of this plant. We are developing a methodology for semi-automated, close-range remote sensing using Unmanned Aerial Vehicle (UAV) for the acquisition of high-resolution imagery, to investigate the population dynamics and effects of *I. glandulifera* on ecosystem services. The study areas are located within ~25kms from Bayreuth, in riparian areas with known existence of *I. glandulifera*. A 3DR-SOLO UAV suitable for the terrain we were flying over, combined with a Parrot Sequoia multiband sensor onboard was used for imaging. At first, a pixel-based approach used for classification of the image and did not yield needed accuracy (67%-70% overall accuracy) for distinguishing the invasive plant from the native vegetation. Therefore, we are currently developing rule sets for object-based approach, experimenting with scale, shape and compactness of a multi-resolution segmentation algorithm to produce image objects at the best possible scale in eCognition. Based on its morphology *I. glandulifera* is easily distinguishable from the native vegetation in its mature stage as it grows taller than the other herbaceous plants and has very conspicuous pink flowers. We have achieved 87% overall accuracy in classifying *I. glandulifera* using this workflow for very high-resolution images acquired from UAV.

Session 26-O3 - Remote Sensing

Drone-based assessment of grass vitality reveals emergent pattern formation of Australian fairy circles

Stephan Getzin[1,2], Todd E. Erickson[3,4], Hezi Yizhaq[5], Miriam Muñoz-Rojas[3,4,6], Andreas Huth[2], Kerstin Wiegand[1]

[1]University of Goettingen, Goettingen, DE, stephan.getzin@uni-goettingen.de
[2]Helmholtz Centre for Environmental Research – UFZ, Leipzig, DE, stephan.getzin@uni-goettingen.de
[3]The University of Western Australia, Crawley, AU
[4]Kings Park Science, Department of Biodiversity, Perth, AU
[5]Ben-Gurion University of the Negev, Sede Boqer, IL
[6]The University of New South Wales, Kensington, AU

The so-called fairy circles (FCs) are one of Nature's greatest mysteries and they are subject to a lively debate about their origin. They comprise a spectacular, extremely regular, landscape pattern in arid grasslands with mean gap diameters ranging from 4 - 6 m. So far, FCs are only known from the grassland-desert transition along the Namib in southern Africa, and few years ago they have been also discovered in the remote outback of Western Australia. The Australian FCs are an ideal model ecosystem for studying self-organized vegetation-pattern formation in arid environments because it is dominated by only one *Triodia* grass species that forms highly plastic growth patterns to cope with water stress. Furthermore, a termite origin of this gap pattern has been recently rejected based on systematic soil excavations.
Here, we are reporting results from a drone survey and field campaign that was conducted in 2017 in Western Australia near the town of Newman. Using a *Microdrone md4-1000* quadcopter, we mapped five large FC plots of different post-fire age with the photo camera *Sony Nex-7* and the multispectral camera *Tetracam Mini-MCA 6*. Based on this multispectral sensor, we calculated the Normalized Difference Vegetation Index and differentiated between bare soil, low and high vitality grasses, as well as shrubs and trees. Using spatially explicit statistics such as the Berman test and classic landscape metrics, we analyzed the scale-dependent relationship of low- and high-vitality grasses to the surrounding large FCs and small individual bare-soil spots.
Our results show that vital grasses are consistently more strongly associated with the large FCs than non-vital grasses while at the same time an opposite relationship is true for the small bare-soil spots. These empirical results are supporting model predictions of pattern-formation theory where positive biomass-water feedbacks are causing the fairy circles as an emergent vegetation pattern at the landscape scale.

Session 26-O4 - Remote Sensing

Modeling tropical montane biodiversity: potential and limitations of multispectral data

Christine I.B. Wallis[2], Jörg Bendix[2], Roland Brandl[3], Nina Farwig[4]

[2]LCRS, University of Marburg, Marburg, DE, christine.wallis@staff.uni-marburg.de
[3]Ecology, University of Marburg, Marburg, DE
[4]Conservation Ecology, University of Marburg, Marburg, DE

The development of spatially explicit indicators is of particular interest for the monitoring of biodiversity in remote and topographically complex regions. Here, the potential of multispectral remote sensing data to model taxonomic and functional aspects of biodiversity in a tropical mountain rainforest in southern Ecuador was analyzed. In particular, vegetation indices from multispectral reflectance and their textural information were used. For this purpose (i) different taxonomic groups and diversity measures (e.g. alpha/beta diversity) were investigated, (ii) a comparison to topographic metrics was made, and (iii) sensor data with high and moderate spatial resolution were considered. The results of three closely related approaches showed that the potential of multispectral remote sensing is associated with the environmental filters of the respective biodiversity measures, which are responsible for spatial patterns of taxonomic and functional diversity.

Session 26-O5 - Remote Sensing

Remote Sensing based estimation of land-use intensity in grasslands

Maximilian Lange[1], Daniel Doktor[1], Sebastian Preidl[1]

[1]Helmholtz-Centre for Environmental Research - UFZ, Department Computational Landscape Ecology, Leipzig, DE, maximilian.lange@ufz.de

Information on land-use is crucial for earth system science and environmental monitoring to support decision making and reporting of climate-relevant processes. Land-use intensities in particular are linked to numerous environmental processes and indicators, such as biodiversity, primary production, nitrogen deposition and resilience to climate extremes, and are thus increasingly used in ecological studies. However, there are still large knowledge gaps in the understanding of the relationship between land-use intensity and the environment. Thus, the quantification and analysis of land-use intensity of grasslands is a timely endevour. New satellite generations, such as ESA Sentinel-2, enable the detection of the mainly subtle changes induced by land-use intensification by their fine spatial and temporal resolution. We developed a methodology mapping land-use intensity of grassland areas in Germany using Sentinel-2 satellite data with 20m spatial resolution. Grassland areas were classified into low, intermediate and high land-use intensity areas depending on livestock density, mowing frequency and fertiliser amount. A supervised classification with the random-forest algorithm was compared to an unsupervised approach using clustering algorithms. Land-management data from German farmer cooperatives and science initatives served as training and validation data. Here, we present our methodology and first upscaling results.

Session 26-O6 - Remote Sensing

The return of the fuzzy – ups and downs of remote sensing based mapping approaches for natural vegetation

Hannes Feilhauer[1], Adam Kania[2], András Zlinszky[3]

[1]FU Berlin, Berlin, DE, hannes.feilhauer@fu-berlin.de
[2]definity, Wroclaw, PL
[3]Hungarian Academy of Sciences, Balaton Limnological Institute, HU

Natural vegetation forms fuzzy patterns that can be mapped with remote sensing using three different approaches: crisp classification, fuzzy classification, and gradient mapping.
Crisp classification assigns each pixel unambiguously to a class. While this enables area statistics, ecotones are not well represented. Further, for mixed image pixels, a loss of information is inevitable.
Gradient mapping aims to preserve gradual transitions. Using an ordination of vegetation records, each pixel is assigned a position in the ordination space that indicates the species composition. Ecotones and mixed pixels are well represented and the definition of 'typical' classes is not necessary. However, an *a priori* definition of the gradients is hardly feasible and area statistics are not possible.
Fuzzy mapping preserves the best of both worlds. The mapped units are hard classes, but the resulting map shows their cover fractions per pixel. This enables area statistics but preserves the fuzziness. It is, however, challenging to represent all class distributions in a single map.
Here, we systematically compare the three approaches. Using a case study of raised bogs, poor fens, transitional mires and *Molinia* grasslands, we discuss their advantages and issues of data requirements, interpretability, as well as opportunities for monitoring.

Session 26-O7 - Remote Sensing

When soils thaw: Determining the active layer depth in interior Alaska by applying floristic gradient mapping

Veronika Döpper[1,2], Santosh Panda[3], Hannes Feilhauer[1]

[1]FAU Erlangen-Nürnberg, Erlangen, DE
[2]TU Berlin, Berlin, DE, v.doepper@tu-berlin.de
[3]University of Alaska Fairbanks, Fairbanks, US

Permafrost soil properties are closely linked to structural and compositional properties of the arctic vegetation. Nevertheless, data on such soil properties are limited to the point scale. Large scale model approaches still have high uncertainties particularly in the discontinuous permafrost zone. Remote sensing approaches for permafrost soil monitoring are based on vegetation indicators, thereby exploiting the strong interaction between vegetation and permafrost. Until now, the use of discrete vegetation maps is common practice in permafrost prediction, hampering the observation of gradual changes in vegetation and soil properties.

This study examines the added value of a continuous floristic gradient mapping for permafrost estimation in a boreal setting using multi-seasonal satellite imagery.
Therefore, plant species data are subjected to an ordination algorithm to extract two floristic gradients. The ordination scores are then extrapolated using the spectral data.
As the relation between vegetation associations and permafrost properties could be confirmed in this study, the spatial distribution of ordination scores is then applied to map the soil properties over the same area.
The accuracy of the prediction is at the same range of previous analyses but uses a lower number of predictors, underlining the potential of this approach.

Session 26-O8 - Remote Sensing

Emerging near-surface remote sensing methods for the assessment of the phenology of thousands of individual trees

David Basler[1], Andrew D. Richardson[2]

[1]Harvard University, Cambridge MA, US, david.j.basler@gmail.com
[2]Northern Arizona University, Flagstaff AZ, US

The length of the period of vegetation activity is a significant driver of the global carbon cycle. Thus, the observation of plant phenology and seasonal vegetation dynamics has become an essential tool to quantify the impact of climate change on ecosystems. Satellite-based remote sensing time series has proved to be an invaluable resource for observing landscape phenology and vegetation dynamics across regions or even continents. However, the data derived from such platforms often lack the spatial and/or temporal resolution to resolve the responses on the species level or to even reveal intraspecific patterns across the landscape. Quantifying and understanding these specific responses and the underlying biological processes is crucial when making predictions using process-based models. Near-surface remote sensing methods, such as the established use of stationary cameras (PhenoCams) and recently developed methods using UAVs take an intermediate position between the satellite observation and observation of individual trees by a human observer.
Based on multiple datasets collected in New England during the last two growing seasons, we showcase the potential of UAV-based near-surface remote sensing to assess phenological responses and use this data to address ecological questions. The datasets we have assembled cover well over 16’000 individual trees and a multitude of tree species, across 90ha in an urban arboretum, and 35ha in a natural forest. Further, deep-learning based image segmentation allowed for accurate tracking of tree phenology using a car-mounted camera over a nearly 100 km transect, covering an elevation- and urbanization gradient and tens of thousands of trees. Efficient collection of such high-resolution spatiotemporal data provides an excellent opportunity to quantify variation in tree phenology at the level of individual organisms, across landscape and regional scales.

Session 26-P1 - Remote Sensing

Multi-method approach to capture aboveground biomass stocks at the tundra-taiga transition zone in northeastern Siberia, Russia

Stefan Kruse[1], Frederic Brieger[1,2], Lutz Bünseler[1,2], Iuliia Shevtsova[1,2], Evgenii Zakharov[4,5], Luidmila Pestryakova[4], Birgit Heim[1], Ulrike Herzschuh[1,2,3]

[1]Polar Terrestrial Environmental Systems Research Group, Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research, Potsdam, DE, stefan.kruse@awi.de
[2]Institute of Earth and Environmental Science, University of Potsdam, Potsdam, DE
[3]Institute of Biology and Biochemistry, University of Potsdam, Potsdam, DE
[4]Institute of Natural Sciences, North-Eastern Federal University of Yakutsk, Yaktusk, RU
[5]Institute for Biological Problems of Cryolithozone, Siberian Branch of Russian Academy of Sciences, Yaktusk, RU

Ecosystem changes driven by climate changes and disturbances can dramatically alter ecosystem services. Of particular interest is the tundra-taiga ecotone covering Siberian permafrost landscapes that is experiencing a strong warming. It is unknown, whether this leads to an increase of carbon sequestration or to a release, if additional human-caused disturbances destabilize natural boreal forest trajectories. To assess the consequences, field data for such remote regions is rare and often focusses on single aspects rather than complete ecosystems. We aim to forecast the impact of climate change on carbon stocks in the tundra-taiga transition zone.
Therefore, we visited 64 vegetation plots along a large bioclimatic gradients and disturbance regimes. The transect starts in the tundra in northeastern Chukotka, includes northern summer-green taiga forests, and ends in evergreen boreal forests of central Yakutia. For each plot, we will analyse the complete carbon stocks based on soil and above ground biomass samples taken following standard sampling procedures. This is complemented by vegetation composition and projective cover assessment, and forest inventories at the plot level. To acquire detailed spatial variability we use very high-resolution near UAV-based imagery to build 3D-point clouds. With these, we can detect and analyse single trees and shrub individuals as well as the surface vegetation cover. In addition, we can train statistical-models for upscaling the retrieved data to larger regions. With our time-for-space sampling location design, we can thus evaluate biomass changes that we have to expect for these ecosystems in a changing environment. In addition, the results will be used to parameterize the individual-based spatially explicit vegetation model LAVESI developed for Siberian larch forest dynamics. Finally, forcing this model with future climate scenarios, it can help to estimate carbon stock development and to highlight regions of high sensitivity.

Session 26-P2 - Remote Sensing

Automatic identification of land use type using Conditional Adversarial Networks for historical topographical maps

Tomohiro Ichinose[1], Ikuko Imoto[1], Akihiro Oba[2]

[1]Keio University, Fujisawa, JP, tomohiro@sfc.keio.ac.jp
[2]Chuo University, Tokyo, JP

Landscape changes, ex. habitat fragmentation and isolation should affect the distribution of organisms. The vast number of studies have been conducted related to land use changes using many types of geographic information. Old topographic maps have been used for long-term land use changes in the world. However, we have to digitize each land use or habitat type manually on the map, and it takes a long period of time. Recently, there are many methods to image-to-image translation. For instance, an old black and white photograph can be colored by such methods. We applied a technique to automatic identification of land use type, which is called Conditional Adversarial Networks "pix2pix" (Isola et al. 2017), which is the improved version of Generative Adversarial Networks (GAN) (Goodfellow at el. 2014, Denton at el. 2015), whose model is a type of neural networks.

Our study site was Shikoku Island, west part of Japan. We selected 1/25,000 old topographical maps issued in 1891, which was the oldest in this area. At first, we identified nine land use types, namely forest, bamboo forest, grassland, wetland, dry field, paddy field, sand, water body, and urban land use, from the map and digitized five maps manually. Then, we exported each map scaled to 1/200,000 with 1000 dpi (7875×7875 pixels), and divided nine maps with 2625×2625 pixels for training and testing on pix2pix. We trained pix2pix for 1000 epochs with a batch size of 1 on 2048×2048 at one GPU NVIDIA Tesla T4 15GB (Google Colaboratory, https://colab.research.google.com). After training a generator on 64×64 images, we tested it on 3072×3072 images.

We will show the land use maps analyzed by the pix2pix software comparing to training ones on a poster and the identification rate.

Session 26-P3 - Remote Sensing

Remote sensing and machine learning for spatial ecological predictions: Relevance of considering spatial data characteristics towards reliable models

Hanna Meyer[1], Marc Dragunski[1]

[1]University of Münster, Münster, DE, hanna.meyer@uni-muenster.de

A major task in environmental science is to obtain spatially (or spatio-temporally) comprehensive data from limited field samples (e.g. climate stations, vegetation records, species occurrence). In this context machine learning algorithms find frequent application to learn nonlinear and complex relationships between field observations and remotely sensed predictor variables (e.g. from satellites).
The number of applications in the field of ecology and remote sensing is increasing. However, the characteristics of ecological spatial data are widely ignored in the modelling process. We hypothesize that this is problematic and results in models that can reproduce training data but are unable to make reliable spatial predictions beyond the locations of the training samples.
One difficulty caused by the spatial dependencies of the data is an adequate error assessment. It is reported by an increasing number of studies that common validation strategies that do not consider the spatial dependencies lead to highly overoptimistic performance estimates. In this presentation we systematically test different spatial validation strategies to reliably estimate the error of spatial prediction models. We simulate different sampling designs to test how the different validation strategies affect the estimated model performance for differently sampled data.
Spatial validation for assessing the model performance is crucial, but we argue that it is not sufficient. Spatial validation provides reliable error estimates but it does not improve the model itself. Since it has been shown that spatial prediction models often suffer from a low spatial performance and high overfitting, new modelling frameworks are needed. To improve models, we test how spatial validation can be used in the context of model tuning and variable selection (basically during all steps of model building) to develop remote sensing based models that are optimized to reliably map ecological variables in space (and time).

Session 26-P4 - Remote Sensing

Mapping structure of the coastal forests and micro landforms by airborne Lidar.

Ikuko Imoto[1,2], Tomohiro Ichinose[3], Ryuichi Sekoguchi[4]

[1]Keio Research Institute at SFC, Fujisawa, Kanagawa, JP, imotoi@ga2.so-net.ne.jp
[2]NPO The Geoecological Conservation Network, Shinjuku, Tokyo, JP, imotoi@ga2.so-net.ne.jp
[3]Faculty of Environment and Information Studies, Fujisawa, Kanagawa, JP
[4]Aero Asahi Corp. Spatial Infomation Divison, Kawagoe, Saitama, JP

The coastal forest has been planted, maintained, and conserved by government and local community since more than a hundred years ago in Japan. The function of the coastal forests was considered mostly to prevent strong sea wind and sand movement from coast to inland fields and paddy fields.
On the other hand, since the tsunami, which caused by the 2011 Great East Japan Earthquake, disaster mitigation function of the coastal forests is re-recognized as an important Eco-DRR (Ecosystem-based Disaster Risk Reduction) method. And, the maintenance and management of the coastal forest have been an urgent task for government and local communities.
We investigated two types of coastal forest, using airborne Lidar (Light Detection and Ranging) data to analyze the vegetation structure and micro landform. One is a typical planted coastal forest dominated by evergreen conifer tree *Pinus thunbergii* and the other is a natural forest composed of many evergreen broadleaf tree species, such as *Machilus thunbergii*, *Daphniphyllum teijsmannii*, and *Cinnamomum camphora*. It was established by natural succession from *Pinus thunbergii* forest in these 50 to 80 years. These coastal forests are located in the southern part of Shikoku Island, west Japan, where a massive earthquake and tsunami is projected within 30 years.
The Laser Profiler in the 0.5m grid shows clearly the micro landform, and also the height and density of the trees. Those are useful information for the evaluation of the forest community, planning forest management and maintenance, and also analyze Eco-DRR.
We will show the 3D maps of the two type of coastal forest made by Lidar data.

Session 26-P5 - Remote Sensing

Toward high resolution species distribution models of the Antarctic Dry Valleys: Downscaling land surface temperature time series via machine learning

Maite Lezama Valdes[1], Marwan Katurji[2], Hanna Meyer[1]

[1]Institute for Geoinformatics, University of Münster, Münster, DE, maite.lezama@uni-muenster.de
[2]Department of Geography, University of Canterbury, Christchurch, NZ

The McMurdo Dry Valleys (MDV) are one of Antarctica's biodiversity hotspots, whose local ecosystem properties are threatened to be altered by climate change. To monitor and predict those developments, spatially continuous data on abiotic variables are needed.
Land Surface Temperature (LST) is a key driver for the MDV ecosystem and can be sensed via satellite-based systems such as MODIS (Terra/Aqua satellites). However, the spatial resolution provided (1000m) is too coarse to model habitat properties of the prevailing organisms. As the area is difficult to access for direct measurements, a higher resolution LST product needs to be developed based on such satellite data. Landsat data provide a much higher resolution than MODIS (30m), but its temporal resolution (~16 days) is very coarse. Thus, the aim of this study is to take advantage of both sensors and statistically downscale LST from the resolution of the MODIS product to the higher resolution of 30m as provided by Landsat 8. The downscaling is performed via a machine learning approach: MODIS LST as well as terrain and shading information derived from a high resolution DEM, as well as the land cover serve as predictor variables in a Random Forest model that uses Landsat 8 derived LST data as a reference. The approach delivers a high temporal and high spatial resolution LST product (30m, sub-daily). The model is validated via blockwise spatial cross-validation and the relative importance of predictor variables is assessed via spatial forward feature selection.
The MDV-wide LST product will serve as an important dataset towards species distribution modelling and monitoring of habitat characteristics in this area. The presented workflow will also be adapted to provide further high resolution abiotic variables such as soil moisture.

Session 26-P6 - Remote Sensing

Indicative optical traits from multispectral imaging obtained from UAV and satellite data for a structural differentiation of species rich grassland on former military area

Anne Schindhelm[1], Carsten Neumann[1], Gabriele Weiß[2], Jörg Müller[3]

[1]Helmholtz Centre Potsdam, GFZ, Potsdam, DE, annesch@gfz-potsdam.de
[2]ecostrat GmbH, Berlin, DE
[3]Heinz Sielmann Stiftung, Wustermark, DE

The Kyritz-Ruppiner Heide in the northwest of the federal state of Brandenburg was formerly used by military for training purposes. Now it is considered as the largest unfragmented heathland area in Europe and is designated as a Site of Community Importance by the European Natura 2000 network. Due to decades of soil disturbance, tree cutting and fire regimes an open sandy landscape was established on acidic, nutrient-poor soils, mostly covered by European dry heaths, but also by species rich fresh meadows and sandy grasslands.
In practice, terrestrial mapping of biotope types and its respective plant communities highly depends on a priori set terrestrial classification schemes. Classification is thereby based on the occurrence of few indicative, significant plant species, what furthermore is defined for each federal state of Germany slightly differently.
In open grasslands, recent high resolution multispectral imaging systems can provide spectral signatures as well as structural traits such as the distribution of open soils, vegetation heights or successional gradients on the scale of plant communities and even plant species. We thus enhance the spectral feature space through the detection of structural aspects of an area in order to improve the classification of biotope types and introduce a novel mapping algorithm.
For that purpose, we recorded plant species composition of 135 plots on ground, measured their specific spectral reflectance signatures and recorded images with a commercial drone camera (DJI Phantom 4 Pro). A multi-scale approach (2 cm and 2m pixel size), that incorporates a multi-sensor fusion (drone and WorldView satellite) and time-series analyses, was implemented. We used scale-specific optical and structural traits to discriminate species rich grassland biotope types and their respective phytosociological units e.g. *Corynephorus canescens* communities and *Armeria maritima*/*Festuca brevipila* communities.

SESSION 27

Organismal movement in ecology and conservation

Chairs: Ulrike Schlägel, Johannes Signer

Movement of organisms is an omnipresent process and is relevant for many fields in ecology and nature conservation. For example, movement processes can have critical roles in disease dynamics, ecosystem functioning (e.g. seed dispersal, pollination, or trophic interactions), community and metacommunity dynamics, as well as the spread of alien species. In addition, movement capacities but also movement requirements determine whether populations, and ultimately species, can persist in human-modified landscapes and adjust to shifting climatic conditions. New technological devices enable researchers to record the movement of animals, plants, and propagules, often in great detail at unprecedented spatial and temporal resolution. In addition, animal movement data can be aligned with various auxiliary information on the state of an individual (e.g. via accelerometers) and the external conditions it experiences (e.g. via external sensors on the animal or remote sensing). We can use such data to study questions like: When, where and why do organisms move? How do actively moving animals react to permanent and dynamic features of the landscape; and how does the landscape affect passively moving organisms? How do animals coordinate their movements among each other? Which impact do these movements have for other transported organisms? These and many more questions can now be addressed. Correspondingly there is a steady development of new statistical and computational tools to manage, visualize, and analyze these data. The aim of this session is to look at movement ecology from many different fields of ecology. We invite contributions from movement ecologists about how their findings can help to understand and solve problems in ecology and nature conservation, including the challenges that organisms face in human-altered landscapes and under changing environmental conditions. We also welcome researchers from other fields in ecology to talk about perspectives how movement ecology can contribute to a better understanding in their field.

Session 27-O1 - Movement ecology

Movement of Afrotropical birds across a habitat mosaic: functional traits explain responses to land-use change better than species identity

Christina Fischer[1], Jan Christian Habel[2]

[1]Restoration Ecology, Technische Universität München, Freising, DE, christina.fischer@tum.de
[2]Evolutionary Zoology Group, University of Salzburg, Salzburg, AT

Effects of anthropogenic habitat change on ecological communities are complex and vary across species depending on their ecological traits. Movement ecology may provide important insight into species´ responses to habitat change. We investigated how movement behaviour across a human-modified landscape depends on species traits, with particular focus on habitat specialisation, feeding preference and dispersal ability. We tracked nine Afrotropical bird species over three years, and then investigated whether species functional traits predicted their habitat use and movement behaviour across a habitat-agriculture mosaic in an anthropogenic riparian landscape of East Africa. We found that omnivorous generalists have larger home ranges than frugivorous and insectivorous generalists and omnivorous and insectivorous specialists. Habitat generalists travelled with roughly equal movement speed throughout the day and moved faster through riparian thickets than habitat specialists, which showed diurnal movement peaks. These coherences are not confirmed by dispersal ability, as well as species identity. Our results reveal that functional traits provide better insight into the responses of organisms to habitat changes than species identity, and highlight the potential role of movement patterns in explaining widely reported impacts, including local extinction in species with high specialisation.

Session 27-O2 - Movement ecology

Individual differences in movement strategies of free-living Red Knots

Selin Ersoy[1], Pratik Gupte[1,2], Allert Bijleveld[1]

[1]NIOZ Royal Netherlands Institute for Sea Research, Den Hoorn, NL
[2]University of Groningen, Groningen, NL

Individuals differ consistently in their behaviour, so-called animal personalities. Personality traits are generally quantified under controlled conditions in artificial setups, and it's important to study the consequences of between-individual variation in the wild. The consequences of personalities in the wild are, however, understudied. In captivity, Red Knots (*Calidris canutus*) have been shown to differ consistently in their exploratory behaviour. In this study, we investigate whether individual differences in exploratory behaviour link to differences in habitat use in the wild, the Dutch Wadden Sea. First, we present a field method to quantify exploratory behaviour within 24 h after catching. Second, we quantify habitat use of 137 Knots with novel tracking technology. We found that while knots with a greater body mass had larger residence patches, a higher exploratory score was associated with slightly smaller residence patches on average. Our results show that Knots have different movement strategies in the wild that affect habitat use, which have the potential to drive fluctuations in local population sizes.

Session 27-O3 - Movement ecology

The importance of Southern Ocean frontal systems for the improvement of body condition in southern elephant seals

Samantha A Gordine[1], Mike Fedak[1], Lars Boehme[1]

[1]University of St Andrews, St Andrews, UK, sagordine@gmail.com

It has been suggested that southern elephant seals (SES) serve as sentinels of ecosystem status to inform ecosystem management and conservation. This is because SES annually undertake two large-scale foraging migrations for 2-3 and 7-8 months to replenish resources after fasting during breeding and moulting. For this, SES often rely on dynamic macroscale latitudinal fronts to provide favourable foraging conditions through aggregating prey. Yet, it is largely unknown whether SES respond to changes in frontal systems, whether their foraging success shifts to specific frontal systems, and how flexible SES populations are to behaviourally adapt to any such changes. This study examines how the resource acquisition of 64 SES relates to the water masses and frontal systems between the Subtropical Frontal Zone and the Southern Boundary of the Antarctic Circumpolar Current. During 4 post-moult and 3 post-breeding migrations between 2005 and 2010 SES associated more frequently with more southerly, higher latitude fronts/zones. It follows that body condition improvements related to a given frontal system or water mass vary strongly according to year, season, month and sex. The variability in body condition improvements is higher in some frontal systems than in others, likely due to shifts in the Subantarctic and Polar Front. During a migration, some individuals stay within ≤3 frontal systems, whilst others change between several frontal systems and primarily improve their body condition in upper ocean waters. SES do not trace particular water masses across different frontal systems and both surface and deep foraging strategies are used. This suggests that SES do not target particular water masses, but adjust foraging and movement strategies to exploit boundary areas at which mixing and prey aggregation is high. The large behaviour plasticity towards the spatio-temporal variability in the encountered oceanographic regions could indicate resilience against environmental changes.

Session 27-O4 - Movement ecology

Visitation of jaguars to seasonal ponds during dry season in a Tropical forest

Carlos A. Gaitán[1], Vivian R. González[1], Gerber D. Gumán-Flores[1], Manolo J. García[1]

[1]Centro De Estudios Conservacionistas Cecon/Usac, Guatemala City, GT, gaitan.carlos@usac.edu.gt

Jaguars are the largest cats in the Neotropic. For jaguars, water availability is determinant during dry periods along wetlands such as seasonal ponds that could be a determining factor to delimit home ranges since they are influenced by the grouped distribution of prey around them. The aim of this study was to describe the visitation of jaguars to seasonal ponds in a Tropical forest during dry season and their activity patterns. Along dry seasons 2014-2017 camera-traps were installed in seven ponds in Dos Lagunas Biotopo to record jaguar presence and identify individuals. We described daily activity patterns and capture histories for individuals and ponds. We recorded 60 visit events. Jaguars are with greater daytime activity. Most events occurred during daytime and twilight. Both sexes differ in their activity after dawn in the measure in which males show greater activity, females decrease theirs, suggesting different habitat use. Females, in spite of being represented in smaller quantity in comparison with males, have more visit events in ponds. Home ranges of female jaguars overlap in one of all the ponds we sampled. During dry season, a pond can be visited more than once by the same jaguar in the same day, and at the same time be visited by at least two jaguars in a single day in the course of 1 hour. A pond is visited by a jaguar in an average of 14 days; and a jaguar visits the same pond in an average of 4 days, while can visit a different pond in an average of 22 days. Constant visitation of jaguars confirms seasonal ponds are important for their populations during dry season. We suggest to increase research in seasonal ponds in dry and rainy season to better understand the use of this resource by wildlife.

Session 27-O5 - Movement ecology

How range residency and long-range perception change encounter rates

Justin Calabrese[1,3], Ricardo Martinez-Garcia[2]

[1]Smithsonian Institution, Front Royal, US, CalabreseJ@si.edu
[2]Princeton University, Princeton, US
[3]University of Maryland, College Park, US, CalabreseJ@si.edu

Encounter rates link movement strategies to intra- and inter-specific interactions, and therefore translate individual movement behavior into higher-level ecological processes. Indeed, a large body of interacting population theory rests on the law of mass action, which can be derived from assumptions of Brownian motion in an enclosed container with exclusively local perception. These assumptions imply completely uniform space use, individual home ranges equivalent to the population range, and encounter dependent on movement paths actually crossing. Mounting empirical evidence, however, suggests that animals use space non-uniformly, occupy home ranges substantially smaller than the population range, and are often capable of nonlocal perception. Here, we explore how these empirically supported behaviors change pairwise encounter rates. Specifically, we derive novel analytical expressions for encounter rates under Ornstein-Uhlenbeck motion, which features non-uniform space use and allows individual home ranges to differ from the population range. We compare OU-based encounter predictions to those of Reflected Brownian Motion, from which the law of mass action can be derived. For both models, we further explore how the interplay between the scale of perception and home range size affects encounter rates. We find that neglecting realistic movement and perceptual behaviors can systematically bias encounter rate predictions.

Session 27-O6 - Movement ecology

Investigating space use of animals: A simulation-based approach

Johannes Signer[1], Björn Reineking[2], Laura Richter[1], Niko Balkenhol[1], Tal Avgar[3], John Fieberg[4]

[1]Faculty of Forest Sciences and Forest Ecology University of Goettingen, Goettingen, DE, johannes.signer@forst.uni-goettingen.de
[2]Irstea, Grenoble, FR
[3]Utah State University, Utah, US
[4]University of Minnesota, Minnesota, US

An understanding of how animals use space is critical for making informed wildlife management decisions. Locations of animals (e.g., from wildlife telemetry studies) are typically summarized using utilization distributions (UDs), two-dimensional relative frequency distributions in space, or estimates of home-range size derived from the UD (e.g., based on its outer 95% contour). These traditional approaches have significant limitations. First, they neglect the importance of the underlying biological processes that give rise to these patterns, including movement constraints (can individuals reach a certain point in space?) and habitat selection (are there certain resources preferred over others?). Second, because these summaries are devoid of any mechanism, they do not provide a means of predicting animal space use in novel areas or under changed environmental conditions.
Integrated Step-Selection Functions (iSSFs) allow researchers to simultaneously model habitat selection and movement processes, and therefore offer an attractive alternative method for summarizing animal location data. Model-based estimates of UDs can be derived by simulating movements under both current and novel environments. In addition, simulated short-term trajectories can provide insights into landscape connectivity. Lastly, rigorous tests of the underlying model can be conducted by comparing simulated movements in novel environments to location data collected in these landscapes from animals not used to fit the model.

Session 27-O7 - Movement ecology

The secret life of wild animals revealed by accelerometer data: How landscape diversity and seasonality influence the behaviour of European hares

Wiebke Ullmann[1], Christina Fischer[2], Stephanie Kramer-Schadt[3,5], Karin Pirhofer-Walzl[4], Jana Eccard[1], Philipp Wevers[1], Angelique Hardert[1], Katharina Sliwinski[1], Michael Glemnitz[4], Niels Blaum[1]

[1]University of Potsdam, Potsdam, DE, wiebke.ullmann@uni-potsdam.de
[2]TUM, Munich, DE
[3]IZW, Berlin, DE
[4]ZALF, Müncheberg, DE
[5]Technical University, Berlin, DE

Movement is a key process for animals to deal with alterations in their habitat, home range formation e.g. is related to changes in landscape diversity. However, the underlying behavioural mechanisms for this relationship have remained largely unexplored, because it is nearly impossible to observe free-ranging animals continuously. Modern biologging devices, like tri-axial accelerometers can provide the opportunity to record data on animals' behaviours at very high temporal resolutions.
We investigated the hidden behaviours of animals in agricultural landscapes and related daily movement behaviours to landscape diversity. We show how behavioural mechanisms shape home range formation and how the relationship between landscape diversity and animal behaviour is influenced by sex-specific dependent seasonality.
We used accelerometer data from European hares to classify animal behaviours into five categories: resting, foraging, moving, grooming and vigilance behaviour and tested whether the amount of conducted behaviours in each behavioural category differed with landscape diversity and season. We conducted the study in two structurally contrasting landscapes (a simple versus a complex landscape).
Hares in diverse landscapes rested more, moved less and spend less time searching for resources. This effect was especially pronounced during the peak breeding season from April to July. Furthermore, the behaviour of male hares was strongly influenced by the reproductive cycle, as they moved significantly more during the mating season.
For animals in agricultural landscapes, high landscape diversity is important, especially during the breeding season. As only then, animals can allocate their energy into reproduction and guarantee species persistence in human altered habitats. Our study highlights that accelerometers are excellent tools to detect underlying behavioural adaptations of wildlife to ongoing changes in landscape diversity caused by increasing land use pressure.

Session 27-O8 - Movement ecology

Mammal body acceleration and epizoochory - what can we learn from wildlife collar data?

Carsten M. Buchmann[1], Lukas Dreyling[1], Frank M. Schurr[1]

[1]University of Hohenheim, Stuttgart, DE, carsten.buchmann@uni-hohenheim.de

Epizoochorous seed dispersal is a key mechanism for plant populations, also for plant species that do not appear to be particularly adapted to this dispersal type. Moreover, this animal mediated dispersal mode has a particularly great potential for long distance seed dispersal which can be crucial for plant survival in heterogeneous and changing environments. Dispersal distance depends on animal movement distance and speed but also on the seed retention time on the animal body. This retention time again depends to some extent on animal movement, specifically on the shaking forces/accelerations as well as the number of such strokes which the seed experiences on the animal body while the animal moves. A great number of wildlife studies collect, for various reasons, data on animal body acceleration (ACC) with collars mounted on animal necks, however, most seeds are attached to the body or the legs of the animals. In order to find the explanatory power of ACC data recorded around the neck for the situation at other parts of the animal body we synchronously measured 3-dimensional ACC at the neck, the breast and the upper hind leg of 41 moving individuals of nine mammal species from 27.5 to 867 kg. We calculated the variance, 95%-quantile and frequency of peaks in the ACC data as they describe the strength and number of strokes which could potentially shake seeds out of the fur. Analyses using LMERs with animal individual nested in species as random factors show that neck ACC can explain up to 84 % of the variation in breast ACC and 62% in leg ACC, relationships are partially non-linear and depend on animal body mass. This demonstrates that available ACC data from animals' necks can be used to infer ACC at other body parts, considering animal body mass. These findings will not only help to inform research on seed dispersal, involving generalizations from studies on seed detachment force from fur, but can also be relevant for the study of a/detachment of ectoparasites.

Session 27-O9 - Movement ecology

Movement on an empty stomach: Aerial dispersal as a threshold response in the two spotted spider mite (*Tetranychus urticae*) and the consequences for competition.

Steven Goossens[1], Nicky Wybouw[1], Thomas Van Leeuwen[1], Dries Bonte[1]

[1]Ghent University, Ghent, BE, stevenf.goossens@ugent.be

Habitat fragmentation imposes strong constraints on metapopulation dynamics and gene flow. Therefore, survival of populations largely depends on the capacity of individuals to move (over long distances) between patches. However not all individuals of a species have the same movement capacity. These individual differences in movement are well known for flying insects and the idea that a flight-fecundity tradeoff underlies the life history of insects has been widely accepted. This does not imply that migration and reproduction are alternate physiological states for all arthropods and movement types. Many arthropods are known to effectively emigrate large distances by wind despite the absence of wings. Examples include ballooning spiders, instars of Lepidoptera, small mites and scale insects. All arthropods from the previous example have clear behavioral traits that facilitate aerial dispersal. Individual differences in the behaviors and life history traits of these wingless arthropods and the causes and consequences for metapopulation dynamics are largely understudied.
In this talk, I will present the first result of a study on individual differences in aerial dispersal behavior in spider mites (*Tetranychus urticae*). We tested the influence of maternal effects and resource depletion on the dispersal behavior and separated disperses from philopatric individuals. These individuals were further investigated for differences in life history traits, competition and gene expression. Our results indicate that there is an individual threshold for recourse depletion that underlies the aerial dispersal behavior and other correlated traits.

Session 27-P1 - Movement ecology

The feedback between large herbivore movement and natural vegetation under different wildlife-based land use options in Namibia

Robert Hering[1], Morgan Hauptfleisch[2], Niels Blaum[1]

[1]University of Potsdam | Plant Ecology and Nature Conservation, Potsdam, DE, robert.hering@uni-potsdam.de
[2]Namibia University of Science and Technology, Windhoek, NA

In Southern Africa endemic large herbivores such as antelopes are a promising alternative land use option to livestock. Endemic antelopes are highly adapted to drought conditions and their economical usage is manifold, ranging from meat production to tourism. Thus, land users change from livestock to wildlife-based land use. For this to be sustainable, however, a deep understanding of the feedback between these herbivores, the vegetation and related ecosystem services is essential.
Especially in semi-arid ecosystems, where resources are loosely distributed, large herbivores influence the environment on a large spatial scale through their movement and on a long temporal scale through their specific seasonal feeding habits. Vice versa, spatio-temporal variation in vegetation impacts herbivore movement crucially. In our project we will disentangle the complex herbivore-vegetation feedback by combing high resolution GPS based movement data, accelerometer based behavioral data, ground-truthed satellite vegetation data and biodiversity assessments. In order to clarify how body size, herd structure and feeding type and different approaches to use large herbivores influence that feedback we will compare three different endemic and economically important antelope species (springbok, kudu, eland) under three different wildlife-based land use options (photo safari, hunting, community-based conservancies).
Our results on the feedback between herbivores and vegetation on a landscape scale will provide important implications for nature conservation on economically used areas, especially in terms of biodiversity conservation and the preservation of ecosystem services.
The GfÖ poster will provide a deeper insight into this recently started study containing first, preliminary results of springbok movement in relation to large-scale vegetation. Furthermore, the German-Namibian ORYCS research project as part of the BMBF funded SPACES program will be introduced.

Session 27-P2 - Movement ecology

Gaining knowledge of carabid movement using new approaches in statistics

Alexandra Wehnert[1,2,3], Sven Wagner[1,2,3], Franka Huth[1,2,3]

[1]Alexandra Wehnert, Institute of Silviculture and Forest Protection, Department of Forest Sciences Tharandt, TU Dresden, DE, alexandra.wehnert@freenet.de
[2]Sven Wagner, Institute of Silviculture and Forest Protection, Department of Forest Sciences Tharandt, TU Dresden, DE, alexandra.wehnert@freenet.de
[3]Franka Huth, Institute of Silviculture and Forest Protection, Department of Forest Sciences Tharandt, TU Dresden, DE, alexandra.wehnert@freenet.de

Extensive basic information exists in relation to the habitat requirements and life cycles of Carabus species but specific knowledge of small-scale habitat preferences and the factors driving movement between different habitat structures is lacking. In most studies the preferred habitat structures are described only in general terms, in particular in forest ecosystems. Spatial information about specific structural elements in forest ecosystems, linked with spatially adapted sampling designs, can increase the information content of studies of species-specific Carabus movement. Comprehensive spatial statistics options can also be used to better understand the movement of different Carabus species. The study was carried out in a homogenous Scots pine forest with solitary admixed oak trees. The samples focussed on four Carabus species (*C. coriaceus*, *C. violaceus*, *C. hortensis*, *C. arvensis*). Field sampling employed the capture-recapture method within an area of approximately three hectares. The positions of all trees were recorded and related to the positions of the pitfall traps. Two statistical approaches were applied to link oak tree positions and movement of Carabus species: (i) spatial point pattern analyses and (ii) geostatistical models. The results of the spatial point pattern analyses showed species- and gender-specific distributions of individuals. Females and larvae of *C. coriaceus* and *C. hortensis* demonstrated a high affinity to oak trees, whereas *C. violaceus* was collected more frequently in pure pine areas. *C. arvensis* exhibited uniform movement over the whole forest area, without a specific preference for either tree species. The geostatistical models underlined these results, and served to prove the statistical significance of these spatial habitat preferences. Practical restoration measures and silvicultural management should, therefore, aim to preserve admixed solitary oaks in order to increase the diversity of environmental niches for Carabus species.

Session 27-P3 - Movement ecology

Ground beetles as mobile links for phytopathogenic fungi

Nadja Heitmann[1], Marina Müller[1], Michael Glemnitz[1]

[1]Leibniz-Centre for Agricultural Landscape Research (ZALF), Müncheberg, DE, Nadja.heitmann@zalf.de

Arthropods are known as switching between different habitats. Thus, they might act as mobile links, transporting genetic material or microorganisms, like fungal spores from one habitat to another. In the case of a phytopathogenic fungi like Fusarium, transportation means supporting the spread of a plant disease. With fungi infected host plants are likely to interact on agricultural fields and neighboring kettle holes with ground beetles that may substantially affect plant diseases by influencing fungi spread. Numerous ground beetles are potential vectors for Fusarium spores, but the effectiveness might depend on species specific traits, like diet, morphology and habitat. Therefore, identification of potential vector species and the understanding of their movement behavior can help to estimate the influence of ground beetles on disease spread mechanisms.
In my PhD Thesis, I investigate the movement behavior of ground beetles around kettle holes, semi-natural pond-like habitats in crop fields, whose moist conditions benefit many fungi species. 40 directional-pit-fall traps are placed close to the grass verge of 5 kettle holes and 5 m away from it in transects and used with brine to determine spill-over or refugee-habitat effects. The number and composition of leaving and entering beetles will be analyzed. Same traps are used for catching living beetles in order to isolate the fungal spores on the beetles' surface. Genetic and culturing technics are applied to identify the fungal species associated with beetles and traits promoting this connection.
The PhD project builds upon extensive previous work on carabid species occurrence and habitat use as well as on fungal disease occurrence and spatial spread, which until now have been analyzed separately from each other.

Session 27-P4 - Movement ecology

Movement of pioneer tree species from forest into storm-felled areas by seed dispersal

Katharina Tiebel[1], Franka Huth[1], Sven Wagner[1]

[1]Technische Universität Dresden, Tharandt, DE, Katharina.Tiebel@forst.tu-dresden.de

As a result of strong storm events of the past decades, the interest in early successional colonists - such as pioneer tree species (*Betula pendula*, *Salix caprea*, *Sorbus aucuparia*) - is increasing in practical forestry. Particularly climate change is associated with more frequent and intense disturbances. Therefore, knowledge about speed of colonization and seed dispersal distances becomes more important for the successful establishment of natural regeneration.
However, little is known about anemochorous and endozoochorous seed dispersal mechanisms and distances of pioneer tree species. The seed dispersal into disturbed forest areas is influenced by: (i) the size of storm-felled open areas and the distances to open areas, (ii) the influence of relief inclination and directionality (anemochory) and (iii) the impact of structural elements at storm-felled sites (endozoochory). The study was established on 5 windthrown forest sites with sizes of 4-13 ha at high altitudes in the spruce-dominated Thuringian Forest, Germany. The results show that seed densities of silver birch and goat willow decreased rapidly with increasing distance from the seed source. Maximum seed densities occurred within 40–50 m distance to birch seed trees, whereas highest seed numbers for willow occurred close to the base of seed trees. Inverse models showed mean dispersal distances for silver birch between 86-97 m uphill and 367-380 m downhill. Willow seeds are dispersed farther than 350 m independently of the relief inclination, according to the results of our phenomenological model. Directionality in seed dispersal could not be confirmed by model results for both anemochorous pioneer tree species.
Dispersal distances and spatial distribution patterns of endozoochorously dispersed seeds on open areas depend on the presence of structural elements, which were used by frugivorous birds as perches to defecate. Birds most often rested on dead parts of trees with at least one meter perch height and horizontal structures.

Session 27-P5 - Movement ecology

Resting behaviour and energy management of mesopredators in human-dominated landscapes - a movement network approach

Carolin Scholz[1]

[1]Leibniz Institute for Zoo and Wildlife Research, Berlin, DE, scholz@izw-berlin.de

We live in a time in which our environment is subject to constant anthropogenic change. This change has direct and indirect effects on wildlife. However, certain species like the red fox (*Vulpes vulpes*) or even the (in our latitudes invasive) raccoon (*Procyon lotor*) have adapted to these in some extent unnatural and human-dominated habitats very well.
Energy management plays a key role in the evolution of animals, as it is vital, influences body condition and thus reproductive success and fitness benefits. Therefore, a careful dealing of energy resources can be advantageously.
A recent method to estimate energy expenditure uses the overall dynamic body acceleration (ODBA) as a proxy, since the most variable factor in modulating energy expenditure in many vertebrates is movement. ODBA can be easily measured by external attachment of a tri-axial acceleration (ACC) logger. Therefore, we supplied red foxes and raccoons with GPS-ACC collars. Afterwards, we performed a recurse analysis of animal trajectory data to identify hot spots of habitat use. These can represent ecological relevant places such as denning sites or important resource locations. The hot spots are also nodes of a movement network. Consequently, investigating the energy expenditure by ODBA of the hot spots in comparison to the edges (movement between the nodes) can reveal important behavioural strategies for living and surviving in an anthropogenic world.

Session 27-P6 - Movement ecology

Taking it personal - implications of intraspecific variation in movement behaviour for species coexistence

Alexander Milles[1], Melanie Dammhahn[1], Volker Grimm[2]

[1]University of Potsdam, Potsdam, DE, alexander.milles@ufz.de
[2]Helmholtz Centre for Environmental Research - UFZ, Leipzig, DE

Movement is a key element of life as it determines various patterns of inter- and intraspecific interactions. Recent studies highlighted animal personalities, i.e. consistent among-individual differences, as an important determinant of home-ranging behaviour and spatial interactions for small rodents. However, the implications of these new insights for individual fitness and species coexistence remain unknown.
To approach this knowledge gap, we resort to individual-based modelling of species communities with spatially explicit movement. As a framework, we couple memory-based movement and behavioural reaction norms as two well-established concepts of movement ecology and animal behaviour. Pattern-oriented modelling allows us to analyse the consequences of the observable personality-dependent variation in movement metrics on species interactions and coexistence. We analyse simulated movement tracks and foraging efficiency which is a proxy for fitness. Our findings suggest that intraspecific variation in movement behaviour matters on the community level, as it reduces interspecific differences in foraging efficiency and buffers the effect of competition. Thereby, fitness differences are reduced, which increases the likelihood of coexistence. Although many questions remain, these findings already link the growing research fields of movement ecology and animal personality with the pressing matter of global biodiversity loss.

Session 27-P7 - Movement ecology

The 4th dimension in animal movement: the effect of temporal resolution in habitat selection analyses

Ulrike Schlägel[1], Johannes Signer[2], Viktoriia Radchuk[3], Cédric Scherer[3], Carolin Scholz[3], Stephanie Kramer-Schadt[3,4]

[1]University of Potsdam, Potsdam, DE, ulrike.schlaegel@uni-potsdam.de
[2]University of Göttingen, Göttingen, DE
[3]Leibniz Institute for Zoo and Wildlife Research, Berlin, DE
[4]Technische Universität Berlin, Berlin, DE

Understanding habitat selection of animals is important in ecology and conservation, allowing us, for example, to predict space-use of animals, to evaluate reasons for human-wildlife conflicts, and to design appropriate conservation measures such as movement corridors. Common tools for assessing habitat selection are resource selection analysis (RSA) and step selection analysis (SSA). Typically, these approaches use location data that are obtained from animal-borne automatic devices programmed to a certain sampling scheme, and the space-use models underlying RSA and SSA mirror the discrete nature of the data. However, inference based on discrete-time movement models (i.e. random walks) is usually not robust to changes in the time discretization. Here, we evaluate the sensitivity of RSA and SSA to temporal resolution of movement data, comparing spatially explicit resource-selection functions, step-selection functions, and a 1-step fitting procedure of a step-selection movement model. We use both simulated and empirical data with different temporal resolutions to test to the ability of the methods to correctly estimate animal habitat selection.

Session 27-P8 - Movement ecology

Visual tracking of terrestrial animals meets ecological practice

Lars Haalck[1], Benjamin Risse[1]

[1] Computer Vision & Machine Learning Systems, Faculty of Mathematics and Computer Science, University of Münster, Münster, DE, lars.haalck@uni-muenster.de

The ability to move is a fundamental characteristic of life. Behavioural quantifications enable the study of causes, patterns, mechanisms and consequences of organismal movement in the context of anthropogenic land-use, changing climate, habitat fragmentation, and the introduction of exotic species. A better understanding of animal movement is therefore crucial to manage and restore degraded landscapes, control the spread of pests and invasive species, toxins, allergens and infectious diseases, and to understand the dynamics of ecosystems functioning such as seed dispersal and pollination. On the level of terrestrial individuals, behavioural quantifications are usually facilitated by using external sensors such as antennas, GPS or accelerometers. Since these sensors need to be attached on the animals and only provide limited information about the surroundings, camera-based tracking is highly beneficial for a variety of circumstances. Due to the intrinsic complexity and dynamics of natural environments, there is, however, no visual tracking system for field experiments which meet the need of ecologists in terms of flexibility and usability.

Here, we present our current progress of such a marker-free visual tracking system for arbitrary environments and terrestrial animals. The ecologist can utilise a freely moving camera to record the animal. From these continuous videos, our system automatically extracts the positions of potentially tiny animals in the individual frames, generates a globally optimal panorama from the video stream and projects the animal trajectory into this panorama. Our system requires almost no user-input, facilitates automatic initialisation and automatically recovers detections after ambiguous situations such as occlusions. On our poster, we will present tracking results for a variety of different animals and environments, including desert ants recorded using a hand-held mobile phone and gazelles recorded using a consumer drone.

SESSION 28

Dynamic ecosystems in a changing world

Chairs: Dr. Sabine Fink, Dr. Kristin Ludewig

Dynamic ecosystems, such as floodplains, coastal areas, storm water ponds and fire-prone habitats are frequently endangered. Past and contemporary alterations aiming at reducing the frequency of extreme events (e.g. floods, fires) resulted in ecosystem changes or habitat losses. Climate change may further accelerate this decrease as some extreme events, i.e. heavy rain or prolonged drought periods may not benefit the vulnerable dynamic ecosystems. While many global and national guidelines designate dynamic ecosystems as conservation priorities, it is difficult to meet the ecological challenges linked to dynamics. Our knowledge on rare and adapted species as well as complex communities or interactions on ecosystem level are still limited. Additionally, reference systems for natural processes in dynamic zones without effects of human alterations are restricted. Many strategies for conservation are not applicable to dynamic ecosystems due to periodic and stochastic frequency of dynamic events. According to the knowledge gaps outlined above, this session aims at (i) better understanding the functioning of dynamic ecosystems, (ii) developing conservation strategies for dynamic ecosystems, and (iii) contributing to strategies applying the results of scientific studies in practical conservation work in a changing world. The contributions are not limited to the above-mentioned ecosystems and might include results of more or less successful conservation projects in dynamic ecosystems.

Session 28-O1 - Dynamic ecosystems

Impact of open-cast lignite mining products in the Lusatian area on the spatial biogeochemical patterns of sediments along the river Spree (Germany)

Giulia Friedland[1,2], Björn Grüneberg[2], Michael Hupfer[1]

[1]IGB Berlin, Berlin, DE, friedland@igb-berlin.de
[2]BTU Cottbus-Senftenberg, Cottbus, DE, friedland@igb-berlin.de

As a result of the open-cast lignite mining in Lusatia (Eastern Germany), large quantities of iron (Fe) and sulphur (S) are fed into small streams discharging into the Spree river system with interconnected lakes. The study tests the hypothesis whether the Fe and S immission as a typical mining disturbance leads to longitudinal gradients in the riverine sediments downstream the mining region in terms of element composition and mineral formations.
We sampled the surface (upper 0-3, 3-6 cm) sediment using a gravity corer at 15 sites stretching 150 km between Spreewald and Lake Müggelsee (Berlin). Sediments were analysed for total C, N and S using an element analyser, for various elements (incl. Fe, Mn, Al, P) by ICP-OES after digestion with hot aqua regia and for minerals by semi-quantitative XRD analysis. A sequential Fe-extraction (modified after Tangalos et al. 2010) from fresh sediments was performed to differentiate solid iron forms.
We discovered a decreasing sedimentary Fe content with the flow direction from 130 mg g^{-1} close to the mining region down to 50 mg g^{-1} at lake Müggelsee, and at the same time an increasing S content from 5 to 20 mg g^{-1}. This results in an in increasing molar S:Fe ratios (from 0.05 to 0.4) and also decreasing Fe:P ratios (from 25 to 10) ratios. Furthermore, the Fe binding shifts from more lightly bound Fe to more strongly bound Fe. We were able to prove that the sedimentary element composition and especially the Fe mineral characteristics are influenced by mining activities at least 90 km downstream the Spree river system, probably affecting the P availability and carbon turnover.

Session 28-O2 - Dynamic ecosystems

Reintroduction of an alpine river specialist under altered river dynamics – the role of habitat reachability

Romy Wöllner[1], Johannes Kollmann[1,2], Thomas C. Wagner[1]

[1]Technical University Munich, Freising, DE, romy.woellner@tum.de
[2]Norwegian Institute of Bioeconomy Research, Ås, NO

Alpine rivers and their floodplains are highly dynamic ecosystems with a constantly changing mosaic of habitats. They host a variety of specialist plant and animal species that are today threatened or even extinct, presumably as a result of altered river dynamics due to flood protection measures and hydrological engineering. Hence, conservation and restoration of adequate habitats and viable populations is imperative. Assessing, planning and monitoring of the respective measures in such a dynamic environment represents a particular challenge, as frequent and detailed monitoring is necessary to capture sudden changes in habitat configuration on a landscape scale.
As a model system we assessed the potential for the reintroduction of the pioneer species *Chondrilla chondrilloides* at the Upper Isar river. On the basis of two extant populations, we characterize the species habitat requirements for successful rejuvenation. For that, we mapped all individuals and acquired relevant environmental parameters using a UAV. With these data, we created a habitat suitability model and applied it to the study reach to identify suitable habitats. We related the spatio-temporal configuration of these habitats to the dispersal characteristics of the model species in order to assess the extent to which it is capable of establishing self-sustaining meta-populations.
The results confirmed a high abundance of suitable habitats for both the natural and the reintroduction sites, and minimal changes in the habitat configuration over the years. However, under the current (less) dynamic situation, we find reachability of suitable habitats to be more important than sheer abundance. This is crucial for the reintroduction of the species, since leaving habitat distances unconsidered will impede the establishment and survival of a viable meta-population.

Session 28-O3 - Dynamic ecosystems

No evidence for the diversity-stability hypothesis in restored grasslands on river dikes under fluctuating climatic conditions

Jakob Huber[1], Frank Schuster[2], Johannes Kollmann[1]

[1]Technical University of Munich, Freising, DE, jakob.k.huber@tum.de
[2]RMD Wasserstraßen GmbH, Munich, DE

Manipulative experiments show that more diverse grassland communities have reduced variation in biodiversity and ecosystem functions, and there are some field studies that investigate the diversity-stability hypothesis in restored communities. River dikes are relatively dry and nutrient-poor habitats, supporting species-rich grassland communities. For the construction of new dikes, environmental offset planning requires the establishment of certain types of grassland with high levels of community stability. To monitor the development of sown dike grasslands, we conducted vegetation surveys on 1–15 years old dikes. Repeated records of 70 plots in three years between 2017 and 2019 enabled us to investigate the persistence of these communities under contrasting weather conditions based on Bray-Curtis dissimilarities and functional traits.

In the exceptionally dry summer 2018, the distribution of plant species evenness across communities was narrow, indicating that monodominant species were to a certain degree repressed, while more evenly composed grasslands exhibited an increased dominance of certain profiting species. Fluctuations in species abundances were more pronounced in species-rich meadows regardless of evenness. This relationship was confirmed when accounting for character species of mesophilic oat grass meadows as opposed to those of semi-dry calcareous grasslands. When basing dissimilarity between years on abundance-weighted community mean functional traits, it was not significantly explained, neither by biodiversity, evenness nor phytosociological affiliation. Those shifts in communities with a high number of mesophytic plants coincided with differing rainfall between years, suggesting a climatic driver, even without a directional response in functional mean traits.

The results may be caused by a more diverse pool that will produce a more complex interaction network, meaning that more interspecific interactions can be modified by random or deterministic influences. This may lead to alternating vegetation structures, particularly if a certain driving force coincides with maladapted species. Thus, the aim of restoring species-rich grasslands on dikes has to incorporate community fluctuations among years, while also complying with strictly defined legal target vegetation types.

Session 28-O4 - Dynamic ecosystems

Effect of climate change on the water birds dynamics: study case of Garaet Hadj Tahar (Algeria, occidental Numidia).

BARA Mouslim[1]

[1]BEE Lab., SNV-STU Faculty, University of Guelma, PB 401, 24000, Guelma, DZ, mouslim.bara@gmail.com

Water birds have traditionally been used as ecological indicators to monitor natural habitats and wetland changes. Climate is widely recognized as a major predictor of bird abundance and richness along large scale environmental gradients, but mechanisms by which climate influences the bird abundance are still unknown. We analyzed seasonal variations on the bird community structure of Rallidae and Anatidae families in the northeastern Algerian Garaet Hadj Tahar for three consecutive years (September 2012 to August 2015). We studied the effect of air temperature and water depth on bird abundance and two ecological diversity indices (Shannon and Shannon E). Significant inter-annual fluctuations in bird abundance were recorded. Maximum values were always recorded during autumn. Water depth correlated positively with bird abundance and Shannon index. Field samplings indicated that bird abundance was frequently higher than 1000 individuals, which suggests that this site is an important refuge of water birds in the Guerbes-Sanhadja wetlands complex. Two key conservation species were observed regularly in the Garaet: near threatened Ferruginous Duck (*Aythya nyroca*) and endangered White-headed Duck (*Oxyura leucocephala*). The variance of Shannon index values changed between years, but did not change for the Shannon *E* index. Water depth correlated positively with Shannon index ($r = 0.31$, p-value = 0.01), but negatively with Shannon *E* index ($r = -0.37$, p-value = 0.001). Also, number of birds was significantly different between 2012/13 and 2014/15 and between 2013/14 and 2014/15, but not within 2012/13 and 2013/14. As mean daily air temperature and water depth were strongly correlated, for analysis purpose we only used water depth. Bird abundance was positively influenced by water depth. Our results highlight the importance of preserving the Garaet Hadj Tahar as a water bird refuge.

Session 28-O5 - Dynamic ecosystems

Long-term vegetation changes due to loss of tidal influence at the Dove Elbe River in Hamburg (Germany)

Nikola Lenzewski[1], Mareike Asdonk[1], Luca A. Schebesch[1], Kai Jensen[1], Kristin Ludewig[1]

[1]Universität Hamburg, Hamburg, DE, nikola.lenzewski@uni-hamburg.de

Estuarine floodplains are highly dynamic ecosystems due to their tidal hydrological regime. They harbour plant species, which are adapted to these dynamic conditions and which are often rare and threatened in Central Europe. River shore obstructions and river training as well as land-use intensification have caused a drastic decline of natural floodplain ecosystems since the mid-20th century. Nevertheless, long-term studies on changes of vegetation due to ceased or altered tidal influence as well as land-use intensification are scarce.
We studied how plant biodiversity and species composition changed along the Dove Elbe River in Hamburg (Germany) from the 1950s until today. The Dove Elbe River is an anabranch of the upper Elbe Estuary and was disconnected from the tidal influence in 1951 by the installation of a sluice. In 2016, we conducted a resampling study of the vegetation along the Dove Elbe River using a dataset by Meyer (1954), who surveyed the vegetation of the floodplain on 98 plots in 1951 before the sluice was build. Furthermore, we compared the herbaceous vegetation of former tidal softwood forest along the Dove Elbe River with tidal softwood forests along the Elbe River in Hamburg in 2018, which still underlie tidal influence.
Our resampling study showed a complete loss of semi-aquatic vegetation types, such as *Limosella aquatic* communities, along the Dove Elbe River, and a decrease in species richness per plot as well as the loss of some threatened species. Softwood forests with no tidal influence along the Dove Elbe River had lower species richness per plot and a more homogeneous species composition in comparison to tidal softwood forests along the Elbe River. For both studies, the hydrologic conditions in the soil seem to be one of the main factors affecting species composition.
Our results reinforce the argument to restore the tidal influence along the Dove Elbe River, which should be based on an (at least partial) opening of the sluice.

Session 28-O6 - Dynamic ecosystems

A perfect Storm – Effects of extreme hydrodynamic forcing on tidal marsh vegetation

Stefanie Nolte[1], Svenja Reents[1], Elizabeth Christie[2], Tjeerd Bouma[3], Helen Brooks[2], Ben Evans[2], Kai Jensen[1], Matthias Kudella[4], Maike Paul[5,6], Ken Schoutens[7], Stijn Temmerman[7], Iris Möller[2]

[1]Universität Hamburg, Hamburg, DE, stefanie.nolte@uni-hamburg.de
[2]University of Cambridge, Cambridge, UK
[3]NIOZ, Yerseke, NL
[4]Forschungszentrum Küste, Hannover, DE
[5]Leibniz Universität Hannover, Hannover, DE
[6]TU Braunschweig, Braunschweig, DE
[7]Universiteit Antwerpen, Antwerpen, BE

Tidal marshes are highly dynamic ecosystems, which are found along coastlines and in estuaries, and play a crucial role in both climate change mitigation and adaptation. They act as important buffers against sea level rise (by sediment accretion and increasing surface elevation) and extreme storms (by wave and surge attenuation). However, the risk of erosion of coastal wetland surfaces and dislocation of vegetation under extreme storms is poorly understood. Therefore novel insights are needed on the stability of marsh vegetation and soil surfaces when exposed to varying hydrodynamic forces. Furthermore, assessing what types of plant species and protective measures are most effective in reducing erosion will help identify which coastal management interventions are likely to be most successful in preventing the loss of these valuable natural buffers in the face of climate change. Until we have such knowledge, it will not be possible to predict the way in which the future morphology of these systems, and thus the degree of natural coastal protection that they will provide, will alter with sea level rise and climate change. These issues are particularly critical in the early stages of marsh establishment and growth. This project thus aimed to quantify: (1) how extreme wave-forcing affects vegetation (both seedling survival of pioneer species and damage of mature marsh plants); (2) how (and to what extent) vegetation in the tidal marsh pioneer zone affects erosion under extreme forcing conditions; and (3) how vegetated salt marsh soils exposed in cliffs respond to high energy wave conditions. We set up five separate experimental treatment zones, including individual seedlings, tussocks and dense canopies, in the large wave flume (Grosser Wellenkanal, GWK), Hannover, Germany. These were exposed to varying wave conditions and we observed significant differences between species and growth stages with regard to bed level and the vegetation damage.

Session 28-O7 - Dynamic ecosystems

Growth-competition model of newly established forest patches

Dominique Lamonica[1], Joern Pagel[1], Didier Bert[2], Elena Valdés-Correcher[2], Frank Schurr[1]

[1]Hohenheim University, Stuttgart, DE, dominique.lamonica@uni-hohenheim.de
[2]INRA, Bordeaux-Pierroton, FR

Europe has experienced a steady growth of forest area over the recent decades. Abundance of new forests increased in many European regions, partly due to the reduction in farmlands and livestock. Forests that result from natural regeneration on former farmlands are typically small but numerous, and often not or little managed. Together with remnants of ancient and semi-natural managed forests, they form a network of more or less connected patches of habitats that can act as stepping stones for biodiversity conservation and associated ecosystem functions and services. Nearly 30% of the EU territory is moderately to very highly fragmented. In this context, there is little doubt that spontaneous forest establishment can represent a very cost-efficient tool for creating or reinforcing a green infrastructure across many rural landscapes in Europe.
Extricating the full potential of newly established forest patches in landscape management requires a thorough understanding of forest establishment and its underlying ecological mechanisms within the landscape context. For that, we are developing a demo-genetic model for newly established forest patches to answer the two following questions : i) how do new forest patches establish within fragmented landscapes and ii) which consequences does the establishment process have for the genetic and phenotypic diversity of new forest patches.
The first step of the demo-genetic model consisted in describing growth and neighbourhood competition processes. We developed a spatially explicit individual growth model. Exhaustive sampling of dendrochronology data was conducted in 15 newly established forest patches of oak trees (*Quercus robur*) in the Bordeaux region (South West of France). We used those data to estimate growth and competition parameters, as well as individual and year to year random effects on growth rate, within the Bayesian framework. We also investigated inter patch variability.

Session 28-P1 - Dynamic ecosystems

The importance of Southern Ocean frontal systems for the improvement of body condition in southern elephant seals

Samantha A Gordine[1], Mike Fedak[1], Lars Boehme[1]

[1]University of St Andrews, St Andrews, UK, sagordine@gmail.com

It has been suggested that southern elephant seals (SES) serve as sentinels of ecosystem status to inform ecosystem management and conservation. This is because SES annually undertake two large-scale foraging migrations for 2-3 and 7-8 months to replenish resources after fasting during breeding and moulting. For this, SES often rely on dynamic macroscale latitudinal fronts to provide favourable foraging conditions through aggregating prey. Yet, it is largely unknown whether SES respond to changes in frontal systems, whether their foraging success shifts to specific frontal systems, and how flexible SES populations are to behaviourally adapt to any such changes. This study examines how the resource acquisition of 64 SES relates to the water masses and frontal systems between the Subtropical Frontal Zone and the Southern Boundary of the Antarctic Circumpolar Current. During 4 post-moult and 3 post-breeding migrations between 2005 and 2010 SES associated more frequently with more southerly, higher latitude fronts/zones. It follows that body condition improvements related to a given frontal system or water mass vary strongly according to year, season, month and sex. The variability in body condition improvements is higher in some frontal systems than in others, likely due to shifts in the Subantarctic and Polar Front. During a migration, some individuals stay within ≤3 frontal systems, whilst others change between several frontal systems and primarily improve their body condition in upper ocean waters. SES do not trace particular water masses across different frontal systems and both surface and deep foraging strategies are used. This suggests that SES do not target particular water masses, but adjust foraging and movement strategies to exploit boundary areas at which mixing and prey aggregation is high. The large behaviour plasticity towards the spatio-temporal variability in the encountered oceanographic regions could indicate resilience against environmental changes.

SESSION 29

Citizen Science in Ecology:
Data quality concerns, methods and solutions

Chairs: Daniel Dörler, Florian Heigl

The reliability and quality of data is an important aspect of every scientific project. Based on data collected in a project, scientists make models, analyses and interpretations, that can have an impact on both policy decisions and scientific progress. Therefore, thorough quality and management systems need to be in place from the beginning of any project to avoid false assumptions based on flawed data. There are numerous methods available to ensure data quality for all kinds of research questions in any given project, that have been tested and approved of by researchers worldwide.

In citizen science projects, where volunteers are involved in at least one step of the scientific process, such quality control mechanisms are extremely important, especially when we think about mass participation projects, where thousands of participants collect data. In our session we invite oral presentations and posters which answer among others the following questions revolving around data quality in citizen science projects: How can we ensure that these data have been collected in a proper scientific way? What best practices for data quality management are available in ecological citizen science projects? What are the prerequisites and constraints for data quality in citizen science projects?

Session 29-O1 - Citizen Science in Ecology

Occupancy-Detection Models for Opportunistic Citizen Science: an example with German Dragonflies and simulation experiments

Diana Bowler[1], sMon Project Team at idiv[1]

[1]iDiv, Leipzig, DE, diana.bowler@idiv.de

Occupancy-detection models are increasingly being used to analyze opportunistic (presence-only) citizen science data and assess species' population trends. These models aim to account for the various sources of sampling biases arising from how citizen scientists report species' observations. Here, we show an application of these models to dragonfly data collected by natural history enthusiasts across Germany. Consistent with reports from other countries, our analysis suggests that most dragonfly species have stable or increasing population trends, especially warm-adapted species. The wider applicability of occupancy-detection models to citizen science depends on their robustness to different types of observation processes (i.e., the sampling behavior of citizen scientists). Hence, we further present simulation experiments in which we explored how well different types of behavior could be accommodated by the models. Overall, we find that occupancy-detection models are valuable tools for citizen science.

Session 29-O2 - Citizen Science in Ecology

Combining citizen science and tracking data to reveal the migration routes of Eastern Palaearctic songbirds

Wieland Heim[1], Ilka Beermann[1], Yury Gerasimov[2], Ramona J. Heim[1], Pavel Ktitorov[2], Kiyoaki Ozaki[3], Ilya Panov[4], Martha Maria Sander[5], Sissel Sjöberg[6], Sergei M. Smirenski[7], Alexander Thomas[1], Ivan Tyunov[2], Mikkel Willemoes[6], Anders Tottrup[6], Thorup Kasper[6], Norbert Hölzel[1], Johannes Kamp[1,8]

[1]University of Münster, Münster, DE, wieland.heim@uni-muenster.de
[2]Russian Academy of Science, RU
[3]Yamashina Institute for Ornithology, Tokyo, JP
[4]Moscow Bird Ringing Centre, Moscow, RU
[5]University of Turin, Turin, IT
[6]University of Copenhagen, Copenhagen, DK
[7]Muraviovka Park for Sustainable Land Use, Blagoveshchensk, RU
[8]Dachverband Deutscher Avifaunisten e.V., Münster, DE

Species-distribution models (SDMs) are widely used to model the spatio-temporal occurrence of birds. Observations from citizen scientists have become a commonly utilized data source for SDMs, but their usefulness for this purpose remains controversial. Here we use eBird observation data and a maximum entropy modelling approach to predict the distribution of eight songbird species that migrate in the East Asian flyway. Separate models were built to predict the main spring and autumn stopover sites, and wintering areas. We then used recoveries from the Russian and Japanese ringing schemes to test, how the model-predicted occurrence at a given period of the annual cycle matched known areas of presence. Additionally, we used geolocator tracking data to validate the predicted areas of occurrence and – for the first time – plot the migration routes of a set of East Asian songbird species with contrasting life histories.
We found that the overlap between areas predicted as suitable from the eBird data and areas that had records from ringing and tracking was highest in winter, and lower for the migration periods. On average, only 44% of the geolocator points fell onto areas that were predicted as suitable during autumn migration. During winter, almost 100% of the geolocator points coincided with the modelled distribution. We conclude that combining different data sources has great potential to gain a better understanding of the non-breeding distribution of Eastern Palearctic songbirds.

Session 29-O3 - Citizen Science in Ecology

Teaching ecology in times of global crises

Moira S. McKee[1], Juliane Filser[1]

[1]UFT, University of Bremen, Bremen, DE, moira.mckee@uni-bremen.de

Currently our planet faces major threats such as climate change and severe loss of biodiversity. Training ecologists who can help tackle these global issues should therefore be a priority. Sparking interest and enthusiasm for the manifold topics in ecology through exciting courses that have connections to current topics is the first step. Raising awareness for the ecological footprint of science in practice – from extensive collections to online research and international conferences – seems appropriate in view of dramatically declining resources. This is most obvious in biodiversity hotspots, where sustainability training at universities is urgently needed. However, not all ecology students will eventually find jobs conducting environmental research in field or lab and additional competencies will be needed. These include application oriented skills such as nature conservation management, ecological risk assessment and legal knowledge. Our goal should therefore not only be to give future generations of ecologists a solid scientific training, but to also prepare them for the job market outside of academia in times of urgent need for experts in environmental sustainability. For this, new modes of teaching and corporations between research fields and institutions as well as laymen (citizen science) will be needed. We will show examples of innovative teaching methods and invite the audience to join a discussion on how to successfully teach ecology.

Session 29-O4 - Citizen Science in Ecology

Flora Capture - A Citizen Science Approach to Collect Plant Picture Data

Alice Deggelmann[1], Jana Wäldchen[1], Michael Rzanny[1], David Boho[2], Marco Seeland[2], Hans Christian Wittich[2], Patrick Mäder[2]

[1]Max Planck Institute for Biogeochemistry, Jena, DE, adeggel@bgc.jena.mpg.de
[2]Technische Universität Ilmenau, Ilmenau, DE

The Flora Incognita project aims to develop a smartphone app for reliable plant identification. To make picture-based plant identification work, a large amount of picture data is required. As a method to collect unambiguously identified plant pictures, we present Flora Capture, an app that provides a tool to capture plant pictures in situ from defined perspectives. With this easily accessible app, we are able to gather plant data with high spatial and temporal variability. This data helps to improve our plant identification process, but can also be used for scientific studies concerning plant monitoring, phenological or morphological analyses. To reach and motivate as many interested citizens as possible, we utilize various channels of communication and media. In our presentation, we will focus on the functionality of Flora Capture and the manual review process, which ensures the quality of the collected data. We will also go into the amount and variety of the data already collected with the Flora Capture App and our experiences as a citizen science project.

Session 29-O5 - Citizen Science in Ecology

MetaData can be easy!

Rainer M. Krug[1], Owen L. Petchey[1]

[1]Department of Evolutionary Biology and Environmental Studies, University of Zurich, Zürich, CH, Rainer.Krug@uzh.ch

The data generated in and for research increases dramatically not only in size but also in the number of data sets. For (later) re-use of data (by the creator of the data as well as by others), the metadata associated with data sets is as important as the data itself. But when 'normal' researchers are asked to provide metadata, the enthusiasm is severely dampened due to the complexities of most metadata schemes.
It is generally easy to provide general ("bibliographic") metadata, but this type of metadata is often not very useful when trying to find the data one is looking for.
Going further, the definitions of metadata schemes are often so complex, that only somebody very familiar with these (and preferably fluent in reading and writing of xml) is able to use them to their full potential.
Consequently, metadata remains the poor stepchild of data sets.
I will present an approach which tries to overcome this weakness by

1. defining a domain specific metadata scheme which is being driven by scientists in a specific domain and their needs to find other data sets which can be used in their research
2. use an R package to define the metadata scheme
3. use a spreadsheet to enter the metadata per experiment and not per dataset
4. validate the metadata and creating a user friendly report
5. export the metadata to xml format for further usage and
6. bundling functionality as well as scheme definition into one convenient R package.

It is planned to wrap the whole workflow into a shiny application, so that users do not need any knowledge of R to use these metadata schemes.

Session 29-P1 - Citizen Science in Ecology

The frog in the drop of water – a citizen science approach for eDNA-monitoring of amphibians

Corinna Wallinger[1], Daniela Sint[2], Dominik Kirschner[3], Martina Nindl[2], Michael Traugott[2]

[1]Institute of Interdisciplinary Mountain Research, IGF, Austrian Academy of Sciences, Technikerstraße 21a, 6020 Innsbruck, Austria1Institute of Interdisciplinary Mountain Research, IGF, Austrian Academy of Sciences, Innsbruck, AT, Corinna.Wallinger@uibk.ac.at
[2]Mountain Agriculture Research Unit, Institute of Ecology, University of Innsbruck, Innsbruck, AT
[3]Ssinsoma GmbH, Voels, AT

Amphibians have become under particular threat over the past decades. This can be mainly ascribed to the global warming, soil sealing and drainage of wetlands as well as habitat fragmentation. For completing their life cycle they require both aquatic and terrestrial habitat types. Natural and semi-natural small water bodies can represent important areas of retreat which may help to ensure their survival. So far, a comprehensive amphibian monitoring of small runlets and ponds has been impossible due to the high costs and personnel expenses. Molecular tools allow for rapid and reliable species identification via the analysis of environmental DNA (eDNA), which is emitted by all aquatic and semi-aquatic organisms in the surrounding water. The citizen science approach provides the possibility of the direct participation of the general public. On the basis of water samples taken by themselves in their private ponds or waterbodies participants are interested in, we can characterize the species composition of amphibians. Moreover, we can identify whether the water is infested with the advancing invasive pathogen *Batrachochytrium dendrobatidis* (Bd), a fungus that has caused mass extinctions of amphibians in many cases. Using this cutting-edge molecular method we are – for the first time – able to comprehensively monitor the distribution of amphibians in Austria and to raise the public awareness with regard to the critical situation of this group of animals.

SESSION 30

Atmospheric interfaces of terrestrial biota – ecological functions, modifications, fluxes

Chairs: Jürgen Burkhardt, Anita Roth-Nebelsick

Terrestrial organisms have interfaces with the atmosphere that participate in - or even control - the fluxes of gases, fluids, particulate matter, and energy with the atmosphere. The interface microstructures seem particularly important and their high diversity might indicate their adaptive value to the abiotic and biotic environment. Within the last few decades, progress has been made in describing and understanding interface microstructures, and their physical and chemical properties, and in some cases to make technical use of them. It has also been recognized that environmental modifications like air pollution or climate change may affect the functionality of these interfaces. But a more general systematics is still missing. The session aims to bring together basic and applied approaches to - Describe interface microstructures and modifications (e.g., by leaf wetting or air pollution), - Understand effects of microstructures and modifications on environmental fluxes (e.g., benefits of wet leaves) - Make use of interface microstructures (e.g. optimization of green walls for air pollution cleaning; biomimetic approaches to reduce chemical treatments or to save energy) The session aims to improve the understanding of possible selective advantages and ecological relevance of microstructures, their modifications and their effects across the kingdoms (e.g., dragonfly wings showing the "Lotus effect"). Ideally, the session will identify ways to include microstructures (and environmental impacts like "wax degradation") into large databases of e.g., leaf traits.

Session 30-O1 - Atmospheric interfaces of terrestrial biota

New insights into isotope uptake and allocation processes from a multi-isotope labeling study in a Swiss dry pine forest

Marco M. Lehmann[1], Ao Wang[1], Rolf T.W. Siegwolf[1], Jobin Joseph[1], Mai-He Li[1], Marcus Schaub[1], Arthur Gessler[1], Matthias Saurer[1], Andreas Rigling[1]

[1]Forest Dynamics, WSL Birmensdorf, Birmensdorf, Zürich, CH, marco.lehmann@wsl.ch

The isotope and thus the information transfer of climatic signals from photosynthetic active leaves towards potential sinks such as tree-rings under different environmental and hydrological conditions is still not fully understood. To further explore this topic, we performed a multi-isotope branch labeling experiment in a pine (*Pinus sylvestris*) forest in Switzerland (Pfynwald, Valais), where a long-term irrigation experiment is conducted since 15 years. One branch per tree (ca. 1 m length) of three control (natural dry) and three irrigated pine trees were labeled for 4 h with $^{13}CO_2$ and with a newly developed ^{18}O-labeling technique via leaf wetting and water vapour at high relative humidity. Pine needle and twig tissues, as well as mistletoe leaves (as a side aspect) were sampled several times over 192 h (8 days) for isotope and concentration analysis of water and photosynthetic assimilates. The ^{13}C-label uptake into needle and twig assimilates was higher in irrigated trees than in control trees. However, neither the ^{18}O-label uptake into water and assimilates of needle and twig tissues nor the non-structural carbohydrate concentration was influenced by the soil moisture conditions. Our observation suggests differences in processes controlling the C and O-signal uptake and allocation in plants. Further, we will compare the ^{13}C- and ^{18}O-label uptake between the parasitic mistletoes and the host trees. Our study gives therefore new insights into carbon and oxygen isotope uptake and allocation processes in trees under changing climatic conditions.

Session 30-O2 - Atmospheric interfaces of terrestrial biota

Bidirectional fog droplet fluxes

Bettina Breuer[1], Otto Klemm[1], Yen-Jen Lai[2], Po-Hsiung Lin[3], Heta Meyer[1], Felix Nieberding[4], Qing-Hai Song[5], Yi-Ping Zhang[5]

[1]Climatology Research Group, University of Muenster, Muenster, DE, bettina.breuer@uni-muenster.de
[2]Experimental Forest, National Taiwan University, Nantou, TW
[3]Department of Atmospheric Sciences, National Taiwan University, Taipei, TW
[4]Institut für Geosysteme und Bioindikation, Technische Universität Braunschweig, Braunschweig, DE
[5]Key Lab of Tropical Forest Ecology, Xishuangbanna Tropical Botanical Garden, Chinese Academy of Sciences, Mengla, CN

It is a challenge to study microphysical processes in fog under natural conditions. Energy fluxes, production and dissipation of turbulence, as well as droplet microphysical processes merge into complex regimes with large spatial and temporal heterogeneity. The Köhler theory helps to understand the formation and growth of cloud condensation nuclei at conditions near 100 % relative humidity. At the same time, turbulent transport leads to highly variable microphysical conditions in fog layers very close to the surface. Former studies showed bidirectional fluxes of fog droplets, but the exact conditions to lead to such fluxes still need to be described.
The scope of our investigation is to further analyze physical and chemical processes in fog in conjunction with turbulent processes. This research studies the temporal variability of the fog droplet size distribution and the coincident size-resolved fog droplet fluxes. What are sources and sinks of small droplets? What causes bidirectional fluxes of fog droplets? Where exactly is the tipping point of flux direction? Is this tipping point dependent on air pollution or other boundary layer conditions?
We employed the eddy covariance method at two meteorological masts in SW China (Ailaoshan, January to March 2016) and Taiwan (Xitou, March 2017) to quantify turbulent fog droplet fluxes. Both studies sites are located in evergreen subtropical forests and mountainous terrain.
Preliminary results indicate that fluxes of smaller droplet can turn upwards to the atmosphere. Turbulent fluxes of larger droplet are always orientated downwards to the surface. Therefore, the total droplet number flux is frequently oriented upwards while the liquid water flux is oriented downwards all time. The tipping point between upwards and downwards flux direction is similar at both study sites, near 10 μm diameters.

Session 30-O3 - Atmospheric interfaces of terrestrial biota

The velamen radicum of epiphytic orchids: structure and water absorption

Anita Roth-Nebelsick[1], Frank Hauber[2], Mike Thiv[3], Arnd Heyer[4]

[1]Staatliches Museum für Naturkunde Stuttgart, Abteilung Paläontologie, Stuttgart DE
[2]Universität Tübingen, Fachbereich Geowissenschaften, Tübingen, DE
[3]Staatliches Museum für Naturkunde Stuttgart, Abteilung Botanik, Stuttgart, DE
[4]Universität Stuttgart, Institut für Biomaterialien und biomolekulare Systeme, Stuttgart, DE

The velamen radicum (VR) of aerial roots of epiphytic orchids is an important element for water and nutrient absorption. In this contribution, some relationships between VR structure and water absorption are presented for various taxa. As demonstrated by MRI (Magnetic Resonance Imaging), the VR is usually completely drained in less than two hours after wetting. Interspecific differences in drainage time can be explained at least partially by differences in thickness and structure of the considered taxa: dehydration time of an aerial root increases with increasing thickness of the VR. Drainage behavior is, however, not completely dependent on thickness alone. Also porosity of the VR walls and the size of the single pores are of relevance

Session 30-O4 - Atmospheric interfaces of terrestrial biota

The global worming: do earthworms increase greenhouse gas emissions?

Alexandru Milcu[1]

[1]CNRS Ecotron, Montferrier-sur-Lez, FR, alex.milcu@cnrs.fr

One of the main aims of the Paris Climate Agreement (COP 21, 2015) is to reduce the emissions of greenhouse gases (GHG) in a manner that does not threaten food production. In an agricultural context, lumbricid earthworms (family Lumbricidae) have always been considered indicators of soil fertility and productivity. However, a couple of recent meta-analyses suggested that earthworms enhance the emissions of soil GHG (CO_2 and N_2O) and can reduce soil carbon storage. These findings have been received with reservation by a part of the scientific community arguing that they may stem from unrealistic microcosm experiments with punctual measurements of GHG. To address these knowledge uncertainties, we started a large experiment using the 12 Macrocosms with lysimeters (5m2, 1.5 m deep and weighting 13 tons each) at the CNRS Ecotron facility (www.ecotron.cnrs.fr), and established treatments with and without different earthworm functional groups (none, anecic and endogeic). Our overarching hypothesis is that, in contrast to the methodologically biased meta-analyses using predominantly data from unrealistic microcosm experiments, under realistic field conditions including plants, earthworms reduce greenhouse gas emissions and increase soil carbon stabilization and sequestration. In line with our hypothesis, we found that the presence of earthworms did not increase the GHG emissions. Mechanisms and potential explanations are discussed.

Session 30-O5 - Atmospheric interfaces of terrestrial biota

Does the succession of dung-emitted volatile compounds structure the succession of dung-inhabiting beetles and flies?

Frantisek Xaver Sladecek[1,2], Stefan Dötterl[3], Irmgard Schäffler[3], Simon Segar[4], Martin Konvicka[1,2]

[1]Biology Centre of the Czech Academy of Sciences, Institute of Entomology, Ceske Budejovice, CZ, franzsladecek@gmail.com
[2]Faculty of Science, University of South Bohemia, Department of Zoology, Ceske Budejovice, CZ, franzsladecek@gmail.com
[3]Department of Biosciences, Plant Ecology, University of Salzburg, Salzburg, AT
[4]Department of Crop and Environment Sciences, Harper Adams University, Edgmond, Newport, UK

Underlying mechanisms of community assembly of decomposer communities are still largely understudied, in comparison to communities of plants and herbivores, with strong bias to predicting the exclusive role of niche differentiation. However, new evidence emphasises the potential importance of environmental filtering, particularly for species succession within decomposing habitats. In this study, we focused on succession of dung-inhabiting insects and investigated whether insect succession is influenced by dung-emitted volatile organic compounds (VOC). Using gas chromatography/mass spectrometry (GC-MS) we identified the spectrum and total amounts of volatile compounds released from cow dung of 1 hour, 1, 2, 3, 5 and 7 days old. We then used those VOC data in analyses of successional patterns of dung-inhabiting beetle and fly species. We detected 54 VOCs, forming two large successional groups with chemical turnover peaking in 48 hours old dung. The early successional group consisted primarily of aliphatic alcohols and phenols, the late one consisted of aliphatic esters, nitrogen- and sulphur-compounds. Insect species reacted primarily to the early successional group of VOC; the vast majority of fly species were positively correlated with those early VOCs, while the vast majority of beetle species were negatively correlated with those early VOCs. Such associations suggest that insects use the early successional VOCs as evidence for suitability (flies; e.g. lower risk of egg predation) or unsuitability (beetles: e.g. high and lethal dung moisture) of dung pats for their colonization. Nevertheless, this relationship between insects and VOCs supports the idea that habitat filtering drives community assembly of decomposers, here dung-inhabiting insects, on ageing habitats.

Session 30-P1 - Atmospheric interfaces of terrestrial biota

From hydrophobic to hydrophilic and hygroscopic – air pollution affects biological surfaces

Daniel Zinsmeister[1], Shyam Pariyar[1], David A. Grantz[2], Mark A. Sutton[4], Sonja Vidic[3], Jürgen Burkhardt[1]

[1]University of Bonn, Bonn, DE, s7dazins@uni-bonn.de
[2]University of California at Riverside, Parlier, US
[3]Meteorological and Hydrological Service, Zagreb, HR
[4]Centre of Ecology and Hydrology, Edinburgh, UK

Pristine biological surfaces are often hydrophobic (lotus leaves, dragonfly wings), which has several benefits and might thus be interpreted as adaptation to the environment: Comprehensible examples are the leaves of the Taiwanese fog forest species *Chamaecyparis obtusa* var. *formosana*, where the arrangement and hydrophobicity of stomatal areas prevent the coverage from the perpetual fog droplets, or the 'lotus effect' that avoids surface wetting and reduces the establishment of microorganisms.
The deposition of atmospheric aerosols decreases the hydrophobicity of surfaces, makes them more reactive and more susceptible to biological attack. Most atmospheric aerosols are hygroscopic, as known from their role in the formation of cloud droplets. Whereas short-term effects of trace gases (e. g. O_3 and SO_2) on plants have been intensively studied, long-term effects by deposited hygroscopic particles are less well explained.
A comparison of *Pinus sylvestris* and *Fagus sylvatica* trees growing in greenhouses ventilated with either ambient air or filtered air (about 98% reduction of airborne particulate matter) revealed a higher minimum epidermal conductance (g_{min}, a parameter describing the permeability of leaves at maximum closed stomata) of those plants exposed to more polluted air indicating a reduced drought tolerance. Furthermore, deposited particles were shown to uncouple leaf conductance from stomatal aperture of *Vicia faba*, resulting in reduced water use efficiency.
Hygroscopic parts of the global atmospheric aerosol can reduce the drought tolerance of plants, by „creeping" into the stomata and inducing a pathway for liquid water loss that is not under stomatal control. This **H**ydraulic **A**ctivation of **S**tomata (HAS-effect) creates a link between air pollution and decreasing drought tolerance of plants and thus likely contributes to tree mortality and forest decline. Particulate air pollution could have broader, cumulative effects on organisms that rely on hydrophobic surfaces.

SESSION 31

Traits, networks, and ecosystem functioning: linking theory and practice

Chairs: Marco Moretti, Catherine Graham, Matthias Dehling

Functional traits and interaction networks are commonly used to study the relationship between the diversity and composition of species communities and ecosystem processes and services. They are also increasingly used to model the impact of global changes on species and communities and, consequently, ecological processes. In this session we address current challenges and future directions in trait and network ecology with the aim to advance our understanding of (i) the mechanism underlying biotic interactions, (ii) the relationship between diversity and ecosystem functioning, and (iii) the consequences of global changes on species communities and ecological processes. We welcome talks on topics at the forefront and intersection of trait-based community ecology, network ecology, and biodiversity-ecosystem function research, including the use of traits to predict biotic interactions and ecosystem functions; the role of intraspecific variation in species interactions; the role of species interactions for species distributions; how to measure ecosystem functioning; the effect of altered species composition on ecological processes.

Session 31-O1 - Traits, networks, and ecosystem functioning

Reward regulation in plant-frugivore interactions: the role of fruit and bird traits

Nina Farwig[1], Jonas Hagge[3], Dana Schabo[1], Martin Schaefer[4], Jörg Albrecht[2]

[1]University of Marburg, Marburg, DE, farwig@uni-marburg.de
[2]Senckenberg Biodiversity and Climate Research Centre, Frankfurt, DE
[3]Technical University of Munich, Munich, DE
[4]Fundación Jocotoco, Quito, EC

Theory assumes that fair trade among mutualists requires highly reliable communication. In plant–animal mutualisms the reliability of cues that indicate reward quality is often low. Therefore, it is controversial whether communication allows animal mutualists to regulate their reward intake. Here we show that even loose relationships between fruit brightness and nutritional rewards (**r**2 = 0.11–0.35) allow birds to regulate their nutrient intake across distinct European plant–frugivore networks. Resident, over-wintering generalist frugivores that interact with diverse plant species select bright, lipid-rich fruits, whereas migratory birds select dark, sugar- and antioxidant-rich fruits. Both nutritional strategies are consistent with previous physiological experiments suggesting that over-wintering generalists aim to maximize their energy intake, whereas migrants aim to enhance the build-up of body fat, their immune response and oxidative status during migration. Our results suggest that animal mutualists require only weak cues to regulate their reward intake according to specific nutritional strategies.

Session 31-O2 - Traits, networks, and ecosystem functioning

How adaptive is adaptive foraging?

Léo Ledru[1,2], Jimmy Garnier[1,3], Erwan Faou[4,5], Sébastien Ibanez[1,2]

[1]Université Savoie Mont Blanc, Le Bourget-du-Lac, FR, ledru.leo@hotmail.fr
[2]Laboratoire Ecologie Alpine, Le Bourget-du-Lac, FR, ledru.leo@hotmail.fr
[3]Laboratoire de Mathématiques, Le Bourget-du-Lac, FR
[4]Université de Rennes 1, Rennes, FR
[5]Institut de recherche mathématique de Rennes, Rennes, FR

Adaptive Foraging (AF) occurs when consumers adjust their foraging behaviour according to resource abundances and their preferences. AF may result in modifications at the ecosystem scale, for instance by promoting stability. However, little is known about the conditions that favor its evolution. On the one hand AF increases the quality of resource consumption, and on the other hand it lengthens prospecting time.
We investigate under which conditions AF can evolve with an eco-evolutionary model in which interactions between consumers and resources are ruled by a uni-dimensional pair of traits. Resources diversification depends on the distance to the niche optimal trait and also to the consumers' trait. The consumers evolve according to the available resources by foraging either randomly over resources (random foraging) or by adapting their foraging behaviour to the more suitable and abundant resources (AF). A consumer may experiment both foraging strategies with a proportion that can evolve through time. The handling time increases with the use of AF, which induces a trade-off.
Depending on the ecological conditions, our model leads to three different consumer communities: AF only, random foraging only, a coexistence of consumers with mixed foraging strategies. We investigate how these three outcomes depend on the effect of the shape and intensity of the trade-off, the width of the niche of the resources, and the intrinsic ability of consumers to use different types of resources. In addition, we explore the consequences of the evolution of AF on ecosystem functioning and stability.

Session 31-O3 - Traits, networks, and ecosystem functioning

A global synthesis of Hymenoptera trap nest studies: how host-parasitoid food webs change with plant diversity

Jochen Fründ[1,2], Alexandra-Maria Klein[2], Trapnest Synthesis Consortium[3]

[1]Albert-Ludwigs-Universität, Biometry and Environmental System Analysis, Freiburg, DE, jochen.fruend@biom.uni-freiburg.de
[2]Albert-Ludwigs-Universität, Nature Conservation and Landscape Ecology, Freiburg, DE, jochen.fruend@biom.uni-freiburg.de
[3]A group of >40 international collaborators, German and international affiliations, DE

The functional consequences of plant diversity have been highlighted by many experiments. Animal consumers and food webs have been shown to respond to changing plant diversity in experiments. However, we don't know how general these patterns are. A better understanding how animal diversity and interaction networks vary in relation to plant diversity would help to reveal mechanisms of biodiversity-ecosystem functioning relationships.
Here, we compiled a large food web dataset from 35 studies from across the world using a standardized method: trap nests that detect cavity-nesting Hymenoptera (hosts) and the interactions with their natural enemies (for simplicity: parasitoids). In total, the dataset represents the fate of 600 thousand brood cells of 500 host species from 1550 locations. We compiled a corresponding dataset of plant diversity representing experimental and observational gradients, and analysed how trap nest communities and food webs change with plant diversity in each study.
Overall, species richness of hosts as well as parasitoids increased with plant diversity, but these relationships were not found in all studies. Parasitism rate was generally unrelated to plant diversity. Diversity of parasitoids increased strongly and consistently with host diversity. The close relationship between parasitoid and host diversity resonates well with the high degree of specialization we detected in most of the food webs. Network specialization tended to decrease with plant diversity, possibly conferring greater stability to food webs based on diverse plant communities. In further analyses, we will separate the different guilds of hosts (bees, herbivore-hunting wasps, predator-hunting wasps) and enemies (true parasitoids, cleptoparasites, etc.) to get closer to the underlying mechanisms. Although our study confirms that plant diversity on average benefits higher trophic levels and makes interactions more generalized, this may depend on the system and guild considered.

Session 31-O4 - Traits, networks, and ecosystem functioning

Resource availability shapes the spatiotemporal dynamics of plant-pollinator interaction networks

Alexander Neu[1,2,3], Huw Cooksley[2,4], Janina Heinen[1,3], Karen Esler[2], Anton Pauw[2], Francois Roets[2], Frank Schurr[4], Matthias Schleuning[1]

[1]Senckenberg Biodiversität und Klima Forschungszentrum (SBiK-F), Frankfurt am Main, DE, alexander.neu@senckenberg.de
[2]Stellenbosch University, Stellenbosch, ZA, alexander.neu@senckenberg.de
[3]Goethe University Frankfurt, Frankfurt am Main, DE, alexander.neu@senckenberg.de
[4]University of Hohenheim, Stuttgart, DE

Ecological communities form complex interaction networks between plants and animals. Little is known about the mechanisms of spatiotemporal variation in these networks, in terms of their interaction diversity and degree of specialization. One potentially crucial driver of this variation is resource availability and the metabolic response of animal consumers to spatiotemporal resource variation. Our aim is to understand how plant-pollinator interaction networks assemble in space and time and how the spatiotemporal dynamics of plant resources drives these dynamics. We hypothesize that the build-up of floral resources leads to an establishment of an increasingly diverse pollinator community and an increase in interaction diversity.
Here, we investigated the effects of floral resource availability (nectar, pollen) of 21 *Protea* species (Proteaceae) on the pollinator abundance of bird, mammal and insect pollinators in Fynbos vegetation in the Western Cape, South Africa. Using direct observations and camera traps, we recorded visitation rates of birds, rodents and insects on *Protea* inflorescences at 21 sites that differed in their post-fire age and plant density in two consecutive years. For all sampled pollinators, we additionally recorded trait data on their morphology and body size.
We test how changes in floral resources influence visitation rates of pollinators and, specifically, whether plant-specific and site-specific variation in floral resources can predict visitations of different types of pollinators. A trait-based understanding of pollinator visits to plant resources would facilitate a mechanistic understanding of how plant-pollinator networks respond to spatiotemporal variability in floral resources and how ecological communities assemble in space and time.

Session 31-O5 - Traits, networks, and ecosystem functioning

Exotic garden plants substitute native plants as resources for pollinators when native plants become seasonally scarce without altering functional network structure

Maria Helena Pereira-Peixoto[1,2], Michael Staab[1,3], Alexandra-Maria Klein[1]

[1]Albert-Ludwigs-University of Freiburg, Freiburg, DE, maria.pereira-peixoto@nature.uni-freiburg.de
[2]CAPES Foundation, Ministry of Education of Brazil, Brasília/DF, BR, maria.pereira-peixoto@nature.uni-freiburg.de
[3]2University of Freiburg, Freiburg Institute of Advanced Studies (FRIAS), Freiburg, DE

Urban green spaces such as gardens in cities often consist of native and exotic plant species, which provide pollen and nectar resources and attract flower-visiting insects. Although some exotic plants are as attractive or even more attractive as their native relatives, it is unknown at which time of the season exotic plants complement native plants to support pollinator diversity. To investigate if seasonal changes in the availability of native vs. exotic flowering species affect flower visits, pollinator diversity and plant-pollinator interaction networks, we studied flowering plant-pollinator interactions every month over a whole vegetation season in 20 urban residential gardens in Freiburg, Germany. Higher proportions of flowers from exotic plants increased pollinator species richness with the progression of the season. Visits to native but not exotic plants decreased and the proportion of flower visits to exotic plants increased as season progresses. Plant-pollinator interaction networks per garden and month were moderately specialized and indicated more complex interactions in high summer. Our study indicates that exotic garden plants can complement flower resources for pollinators. This pattern was especially pronounced later in the season, when native blooming plants are rarely available. Gardens frequently contain exotic plants, which are deliberately planted to complement native flowering plants and to keep the garden on bloom over the entire season. If appropriately managed so that the risk of naturalisation is minimized, these exotic garden plants play an important role to support pollinator diversity in highly modified habitats such as cities and other settlements.

Session 31-O6 - Traits, networks, and ecosystem functioning

The reforestation type alters predator-prey interactions in understories of tropical forests

Radek Michalko[1], Ondrej Kosulic[1], Prasit Wongprom[2], Chaowalit Songsangchote[2], Venus Saksongmuang[3], Yongyut Trisurat[2]

[1]Mendel University in Brno, Brno, CZ, radar.mi@seznam.cz
[2]Kasetsart University, Bangkok, TH
[3]Prince of Songkla University, Songkhla, TH

Immense efforts have been devoted to mitigate the negative effects of deforestation, one of the main factors causing human-induced global change. However, the reforestation success has been evaluated mostly by means of various diversity measures that may not fully mirror the restoration of ecosystem function as a predator-prey interaction. We studied predator-prey interactions in forest understories using web-building spiders in four forest types representing a natural control and three 20-30 years old reforestations: dry evergreen forest, secondary forest, monoculture reforestation dominated by *Eucalyptus camaldulensis*, and mixture reforestation dominated by *Acacia mangium* and *Eucalyptus*. We collected spiders with their prey and measured the availability of potential prey. We also measured trait of spiders (web type, body size) that can affect the predator prey interactions. The prey composition caught by the web-building spiders differed among all four forest types but it did not simply mirror the differences in prey availability. The forest type influenced the predator-prey interactions in a complex way interactively affecting spider density and their prey-specific capture efficacy. The forest type also influenced the web-type and body-size distributions of spiders. Surprisingly, the prey composition was connected only to the web-type but not to the spider mean body size. We show that no studied reforestation restored yet the natural predator-prey interactions between the web-building spiders and their prey. The prey composition was driven mostly by the spider web type but not by the spider body size. This indicates that food-web models need to incorporate not only body sizes but also hunting strategies of predators to improve their predictive abilities.

Session 31-O7 - Traits, networks, and ecosystem functioning

Plant-herbivore interaction networks change along land-use intensity gradients in forest and grassland systems

Felix Neff[1,2], Martin Brändle[3], Loïc Pellissier[2,4], Martin M. Gossner[1]

[1]Forest Entomology, Swiss Federal Research Institute WSL, Birmensdorf, CH, felix.neff@wsl.ch
[2]Landscape Ecology, Institute of Terrestrial Ecosystems, ETH Zürich, Zürich, CH, felix.neff@wsl.ch
[3]Division of Animal Ecology, Department of Ecology, Philipps-Universität Marburg, Marburg, DE
[4]Landscape Ecology, Swiss Federal Research Institute WSL, Birmensdorf, CH

Land-use change and intensification are major drivers of ongoing biodiversity loss. While land use has been shown to affect abundance and richness of both plants and insects, the consequences for ecosystem functions are still under-studied. An important ecosystem function in terrestrial ecosystems is insect herbivory, which depends on the interactions within multi-trophic communities of plants and insects. Network approaches and particularly the study of networks along environmental gradients are promising tools to study the effects of land-use intensification on plant-insect interactions. We hypothesized that high land-use intensity homogenizes networks and excludes modules of sensitive and highly specialized herbivores.
To test these hypotheses, we focused on two of the most abundant terrestrial ecosystems in Central Europe, forests and grasslands, and monitored plants and herbivorous insects in a total of 300 plots along land-use intensity gradients over several years. We used a literature-based interaction data base and abundance data from both insect and plant communities to construct potential insect-plant herbivory networks. From this data, we constructed bipartite networks and characterized them by a set of well-established networks metrics.
We found contrasting effects in the two studied ecosystems. In grasslands, high land-use intensity reduced network modularity but increased nestedness, indicating the homogenizing effect of regular perturbations, in particular by intensive grazing. In forests, higher management intensity increased network modularity and reduced nestedness, which was driven by the introduction of non-native coniferous tree species that added new modules to the system. Thus, this study shows that land-use intensification causes profound but system-specific changes in network architecture. These results will help to better understand land-use effects on ecosystem processes involving multi-trophic communities.

Session 31-O8 - Traits, networks, and ecosystem functioning

The functional roles of species in metacommunities, as revealed by metanetwork analyses of bird-seed dispersal networks

Hai-Dong Li[1,2,3], Linfang Tang[1], Chenxi Jia[1], Marcel Holyoak[4], Jochen Fründ[3], Xiao-qun Huang[1], Zhishu Xiao[1,2]

[1]Institute of Zoology, Chinese Academy of Sciences, Beijing, CN, lihd@ioz.ac.cn
[2]University of Chinese Academy of Sciences, Beijing, CN, lihd@ioz.ac.cn
[3]Biometry and Environmental Systems Analysis, University of Freiburg, Freiburg, DE, lihd@ioz.ac.cn
[4]Department of Environmental Science and Policy, University of California, Davis, US

Understanding and predicting how networks of species interactions vary across environmental gradients is one major issue in ecology and biogeography. Because communities share species and their interactions, integrating metacommunity and metanetwork perspectives may help to illuminate the structure, stability, and functioning of complex networks in fragmented landscapes. In particular, published studies have been criticized for ignoring the roles of different species in metacommunity structure and dynamics. We performed a metanetwork of bird-plant interactions among 13 forest patches based on extensive sampling data of bird-plant interactions by direct observation and camera trapping in a subtropical forest in Southwest China. The metanetworks displayed a nested pattern. Bird-plant interactions involving on-the-tree birds and involving birds feeding on fruit either on- or under-the-tree had a higher centrality and contributed more to nestedness than those only involving under-the-tree birds. This indicates that on-the-tree birds have more regional impacts whereas under-the-tree birds are involved in more local processes. Moreover, the bird-plant interactions associated with larger fruited plants disproportionately contributed to nestedness and centrality. Our study highlights that disentangling spatial metanetworks are critical for better illustrating how ecological processes scale-up from local to regional level, and understanding the role of different species in metacommunities. We suggested that spatial metanetwork may help to guide conservation planning for restoring and conserving ecosystem functioning and interaction-based ecosystem services in a fragmented world.

Session 31-O9 - Traits, networks, and ecosystem functioning

Linking species-level network metrics to flower traits and plant fitness

Amparo Lázaro[1], Carmelo Gómez-Martínez[1], David Alomar[1], Miguel A. González-Estévez[1], Anna Traveset[1]

[1]Mediterranean Institute for Advanced Studies (IMEDEA; UIB-CSIC), Esporles, Balearic Islands, ES

Theoretical models indicate that the structure of plant-pollinator networks has important implications for community persistence against perturbations. However, we are still far from being able to predict the functional consequences of species' structural positions in such networks. From the plants' perspective, species position and roles in pollination networks might be related to traits describing flower attractiveness, availability, and dependence on pollinators. In turn, both, network metrics and species traits might influence plant fitness. During two field seasons, we collected data for 23 plant species from a rich coastal community in order to evaluate the association between population and floral traits, species-level network metrics. More abundant species and with larger flowers showed higher linkage levels, whereas longer flowering periods were negatively related to *d'* and positively related to centrality and important roles in the network. Plants more dependent on pollinators occupied more central positions in the network. Furthermore, species' centrality in the networks was significantly associated with plant fitness. Specifically, central species in the network produced more and heavier seeds than the others. The relationships found between network metrics and plant reproduction indicate, for the first time, the functional implications of these structural positions at the inter-specific level of community assembly.

The matching-centrality decomposition and network forecasting

Louis-Félix Bersier[1], Rudolf P. Rohr[1], Russel E. Naisbit[1], Christian Mazza[1]

[1]University of Fribourg, Fribourg, CH, louis-felix.bersier@unifr.ch

We will present how the structure of a network (e.g. food-web, plant-pollinator, social interaction) can naturally be decomposed into matching and centrality components. The decomposition is made at the node level (species, individuals) by the quantification of so-called latent traits of matching and of centrality. Then, we will explain how these latent traits can be used to gain a better understanding of potential factors underlying the structure of the network. This is achieved by relating the latent traits to independent information describing the nodes (e.g. species body size, phylogenetic status). Finally, we will show how this approach can be used to "reconstruct" partially observed networks, as well as to forecast the links that a novel node would create when joining an existing network.

Session 31-O11 - Traits, networks, and ecosystem functioning

Machine learning can infer trait matching and predict species interactions in ecological networks

Maximilian Pichler[1], Virginie Boreux[2], Alexandra-Maria Klein[2], Matthias Schleuning[3], Florian Hartig[1]

[1]Theoretical Ecology, University of Regensburg, Regensburg, DE, Maximilian.Pichler@biologie.uni-regensburg.de
[2]Nature Conservation and Landscape Ecology, University of Freiburg, Freiburg, DE
[3]Senckenberg Biodiversity and Climate Research Centre (SBiK-F), Senckenberganlage, Frankfurt (Main), DE

Ecologists have long suspected that species are more likely to interact if their traits match in a particular way. Signals of trait matching, however, strongly vary among different types of ecological networks. Here, we show that inconsistent signals of trait matching may have arisen at least in parts from methodological limitations. Using simulations, we demonstrate that advanced Machine Learning (ML) models outperform conventional regressions both for predicting species interactions based on traits, and for inferring causal trait combinations create an interaction (> 80% accuracy). In two case studies, we find that the best ML models can successfully predict species interactions in plant-pollinator networks (< 0.93 AUC) and infer ecologically plausible trait-matching rules for a plant-hummingbird network. Our results highlight the potential of machine learning and artificial intelligence for inference beyond standard tasks such as pattern recognition and for detecting trait matching and predicting species interactions in ecological networks.

Session 31-O12 - Traits, networks, and ecosystem functioning

How a mechanistic approach can predict the temperature increases effect on the biodiversity-ecosystem functioning relationship

Rudolf P. Rohr[1], Elodie C. Parain[1], Sarah M. Gray[1], Louis-Félix Bersier[1]

[1]University of Fribourg, Fribourg, CH, rudolf.rohr@unifr.ch

We will show how a model for the biodiversity ecosystem-functioning (BEF) relationship can be derived from the dynamics of a community. This mechanistic approach provides a BEF model with parameters that have a clear biological interpretation, contrary to standard statistical approach. Then, we will explain how this mechanistic model can be extended to study the effect of temperature on the BEF relationship. The theoretical results show that, in general, increased temperature will disrupt the BEF relationship. Finally, we will present the results of an experiment that uphold this prediction.

Session 31-O13 - Traits, networks, and ecosystem functioning

A Bayesian network approach to trophic metacommunities: habitat loss accelarates top species extinction rates in fragmented landscapes

Johanna Häussler[1,2], György Barabás[3], Anna Eklöf[3]

[1]iDiv Halle-Leipzig-Jena, Leipzig, DE, johanna.haeussler@idiv.de
[2]FSU Jena, Jena, DE, johanna.haeussler@idiv.de
[3]IFM Theoretical Biology, Linköping University, Linköping, SE

How does habitat loss affect food webs? Despite its relevance this question is still largely unresolved. Here, we develop a novel approach to trophic metacommunities which is rooted in single-species metapopulation models on fragmented landscapes (Ovaskainen & Hanski 2003, Theoretical Population Biology). The crux of our approach is that species' extinction rates are calculated from a Bayesian network representation of the food web (Eklöf et al. 2013, Methods in Ecology & Evolution). We then apply different habitat loss scenarios, which vary in the order, in which habitat patches are removed from the landscape. We explore whether these scenarios differ in their effect on food web persistence and how species' extinction rates scale with trophic level. Our results show that progressing habitat loss strongly decreases food web persistence at the landscape scale with top predators being the most vulnerable. The extent of this decrease significantly varies across the habitat loss scenarios we tested, emphasizing that there is strong variation in the contribution to long-term species persistence among habitat patches. Summarising tractability and computational efficiency, our model provides a complementary method to other spatial food web models and can be readily applied to empirical food webs.

Session 31-O14 - Traits, networks, and ecosystem functioning

Structure and dynamic of plant-pollinator networks depend on the temporal scale of data aggregation

Benjamin Schwarz[1], Gita Benadi[1], Paul CaraDonna[2,3], Carsten Dormann[1], Jochen Fründ[1], Benoit Gauzens[4,5], Tiffany Knight[4,6,7], Elena Motivans[4,7], Julian Resasco[8], Diego Vázquez[9,10]

[1]Biometry and Environmental System Analysis, University of Freiburg, Freiburg, DE, benjamin.schwarz@biom.uni-freiburg.de
[2]Chicago Botanic Garden, Glencoe, Illinois, US
[3]Rocky Mountain Biological Laboratory, Crested Butte, Colorado, US
[4]German Centre for Integrative Biodiversity Research (iDiv), Halle-Jena-Leipzig, Leipzig, DE
[5]Institute of Biodiversity, Friedrich Schiller University Jena, Jena, DE
[6]Institute of Biology, Martin Luther University Halle-Wittenberg, Halle, DE
[7]Department Community Ecology, Helmholtz Centre for Environmental Research – UFZ, Halle, DE
[8]Department of Ecology & Evolutionary Biology, University of Colorado, Boulder, US
[9]Argentine Institute for Dryland Research, CONICET, Mendoza, AR
[10]Faculty of Exact and Natural Sciences, National University of Cuyo, Mendoza, AR

Studying mutualistic networks has led to many valuable insights into the structure, function, and evolution of ecological systems. However, as ecological and evolutionary processes happen at different temporal scales, it is critical to understand how the temporal scale of data aggregation influences network interaction patterns and conclusions we derive from them. Every study on ecological networks is aggregating data to some extent, often motivated by the quest to achieve greater sampling completeness. Also due to high temporal turnover of plant and pollinator species and rewiring of their interactions over time, temporal data aggregation is likely to increase numbers of both species and links per species, with possibly large consequences for network structure.
Here we made use of 33 data sets of plant-pollinator networks that allow aggregating data from the scale of one day to several years. We tested whether temporal data aggregation affects sampling completeness and six metrics commonly used to describe network structure. We also assessed whether potential scale-dependencies can be explained by sampling intensity, species turnover and interaction rewiring.
We found that temporal data aggregation does not increase sampling completeness and that at least four of six network metrics were sensitive to temporal aggregation. For five of them sampling intensity, species turnover and rewiring in combination were better predictors than aggregation alone. When controlling for species richness in the analysis, networks became more generalized with increasing sampling intensity and rewiring and more specialized with increasing species turnover. Thus, the dynamic nature of plant-pollinator networks may both hamper sampling completeness and explain the scale-dependency of network metrics. This scale-dependency has to be considered for planning network studies and particularly for comparisons of networks that were sampled and ana-

lyzed at different temporal scales.

Session 31-O15 - Traits, networks, and ecosystem functioning

Relationship between habitat availability, insect trait-composition and leaf decomposition in water-filled tree holes

Martin M. Gossner[1], Mykola Y. Yaremchuk[6], Vasil O. Chumak[6], Laurent Larrieu[2,3], Michel Goulard[2], Benoit Courbaud[4], Thibault Lachat[1,5]

[1]Forest Entomology, Swiss Federal Research Institute WSL, Birmensdorf, CH, martin.gossner@wsl.ch
[2]DYNAFOR, Université de Toulouse, INRA, Castanet-Tolosan, FR
[3]CRPF-Occitanie, Tarbes, FR
[4]LESSEM, University Grenoble Alpes, Irstea, Grenoble, FR
[5]Bern University of Applied Sciences, Bern, CH
[6]Uzhhorod National University, Uzhhorod, UA

Habitat availability is assumed to be a major driver of organismic diversity and related ecosystem processes. A Tree related Microhabitat (TreM) is a distinct, well-delineated morphological singularity occurring on living or standing dead trees. It constitutes a crucial substrate or life site for species. Communities associated with TreMs are predicted to be organised in metacommunities. However, it is not well understood if small scale differences in habitat availability affect the diversity and composition of these specialised communities and related processes in TreMs due to e.g. dispersal limitations within metacommunities. We mapped all water-filled tree holes on a 10 ha plot in the primeval beech forest of Uholka, Ukraine, and a managed beech-dominated forest nearby. We installed in each forest 27 artificial water-filled containers with 2 g dried beech leaves each on a regular grid in both forest to assess the spatial distribution of insect functional community composition as well as leaf decomposition rates in the artificial containers. We did a spatial correlation analyses to test whether communities in these TreMs are affected by the spatial distribution in habitat availability and whether this translates into a change in leaf decomposition. We found substantial small-scale variability in habitat availability in the primeval as well as managed forest and this was a strong driver of the functional composition of TreM associated communities and leaf decomposition rates. This suggest that dispersal limitations might affect the colonization of habitats within metacommunities already at a very small scale and that this translates into a change in ecosystem processes.

Session 31-O16 - Traits, networks, and ecosystem functioning

Trait-based interactions across trophic levels drive leaf litter decomposition

Simone Fontana[1], Sergio Rasmann[2], Yumi Bieri[1], Marco Moretti[1]

[1]Swiss Federal Research Institute WSL, Birmensdorf, CH, simone.fontana@wsl.ch
[2]University of Neuchâtel, Neuchâtel, CH

Functional traits determine interactions among organisms and therefore influence ecosystem processes. While trait-based studies have mostly focused on patterns within single trophic levels (especially primary producers), mechanisms driving biotic interactions across trophic levels have so far remained largely elusive. Soil invertebrates contribute crucially to the fundamental processes of leaf litter decomposition and nutrient recycling. Here we tested experimentally the effect of soil macrodetritivore's identity on the decomposition of two common leaf litter species, both in litter monocultures and in their mixture. We used nine different macrodetritivore species from three taxomic groups (isopods, snails, earthworms), which are characterized by distinct traits related to feeding mode, and arguably occupy different ecological niches. Our results reveal that macrodetritivore's identity (and thus traits) influences the relative consumption rates of the two leaf litter species when they are mixed, pointing towards the existence of (partially) separate feeding niches. Furthermore, leaf litter decomposition patterns seem to be strongly influenced by the trait-based interaction between macrodetritivores and microbial community. Possible implications of these results, as well as ongoing follow-up experiments and future plans will also be presented. These include the combination of several macrodetritivore species with contrasting traits to investigate niche partitioning and possible cascading effects through changes in soil chemistry, subsequent plant germination and growth rate, plant-herbivore interactions (i.e. resistance against herbivores), and nutrient recycling.

Session 31-O17 - Traits, networks, and ecosystem functioning

Do specialists contribute more to functional diversity and ecological processes?

Matthias Dehling[1]

[1]Albert-Ludwigs-Universität Freiburg, Freiburg, DE, matthias.dehling@canterbury.ac.nz

Specialist species are supposed to fulfil specialized functional roles and are therefore often considered particularly important for ecological communities.
However, whether specialists contribute more to functional diversity and to ecological processes has never been tested. I present results from a recent collaboration in which we used a recently published method for describing species' functional roles based on their niches to investigate the relationship between the specialization of frugivorous birds and their contribution to functional diversity in eight frugivory networks across South America. For each bird species in a local network, we measured the degree of specialization by its niche size and by two measures for the specialization of its niche position. We then compared them to the species' contribution to functional-role diversity and to the diversity of the local seed-dispersal process. Species' contribution to the functional-role diversity and to the diversity of the seed-dispersal process increased with increasing niche size of species. However, a while a higher specialization of a species' niche position also lead to a higher contribution to functional-role diversity, it tended to result in a lower contribution to the ecological process. Different measures for specialization provide differing, partly complementary, information about species' contribution to, and, hence, their potential importance for, ecological processes.

Session 31-O18 - Traits, networks, and ecosystem functioning

A network perspective on biodiversity effects in real-world farming systems

Christoph Scherber[1]

[1]University of Muenster, Muenster, DE, Christoph.Scherber@uni-muenster.de

Biodiversity-ecosystem function experiments have shown that increasing primary producer diversity can affect higher trophic levels and vice versa. Over the last decade, it has become increasingly clear that a network perspective for biodiversity-ecosystem functioning research is needed. However, network perspectives have only rarely been applied in the management of agroecosystems. For example, it is still common practice to "control" only a particular target pest species, while actually a whole network of interacting organisms is often affected by agricultural management practices. In this talk, I will show results from biodiversity experiments in grassland and from cropping system experiments and provide evidence that a network perspective will greatly enhance our understanding of these systems, including linkages between biodiversity at multiple trophic levels, and agricultural productivity.

Session 31-P1 - Traits, networks, and ecosystem functioning

Effects of climate and land-use intensity on multiple animal-mediated ecosystem processes

Didem Ambarlı[1,2], Nadja Simons[1,3], Katja Wehner[3], Wiebke Kämper[3,4], Martin Gossner[5], Thomas Nauss[6], Felix Neff[5,7], Sebastian Seibold[1,8], Wolfgang Weisser[1], Nico Blüthgen[3]

[1]Terrestrial Ecology Research Group, Department for Ecology and Ecosystem Management, Technical University of Munich, Freising, DE, didem.ambarli@tum.de
[2]Department of Agricultural Biotechnology, Faculty of Agricultural and Natural Sciences, Düzce University, Düzce, TR, didem.ambarli@tum.de
[3]Ecological Networks, Technische Universität Darmstadt, Darmstadt, DE
[4]Genecology Research Centre, University of the Sunshine Coast, Maroochydore DC, AU
[5]Forest Entomology, Swiss Federal Research Institute WSL, Birmensdorf, CH
[6]Department of Geography, Environmental Informatics Unit, University of Marburg, Marburg, DE
[7]Landscape Ecology, ETH Zürich, Zürich, CH
[8]Field Station Fabrikschleichach, Department of Animal Ecology and Tropical Biology, Biocenter, University of Würzburg, Rauhenebrach, DE

Animal-mediated ecosystem processes are fundamental for important ecosystem functions and services. Global change impacts on biodiversity are likely to translate into reduced ecosystem functioning. We asked two questions: i) What are the short- and medium-term effects of climate and land use, two drivers of global change, on rates of animal-mediated ecosystem processes? ii) How stable are the rates with respect to land use intensity at different spatial scales? We quantified dung removal, seed removal, predation and foliar herbivory by arthropods at subplot level in 283 grassland and forest sites in three regions in Germany. We found significant regional differences in process rates and higher rates of all processes in forests than in grasslands. The coefficient of variation in process rates was pronounced both within each site (20% –178%) and across sites (24%–306%). The variation was higher in grasslands and was correlated to land-use intensity. Each climate and land-use variable affected the rate of at least one process. Medium-term climate conditions often had higher effect sizes on process rates than short-term conditions. While the mean effects of climate were higher compared to land-use intensity for seed removal and total herbivory in grasslands, contrasting effects were found in forests.

Session 31-P2 - Traits, networks, and ecosystem functioning

Intraspecific comparison of microclimate conditions and functional traits among epiphytic and terrestrial individuals of accidental epiphytes

Vincent Hoeber[1], Gerhard Zotz[1]

[1]University of Oldenburg, Oldenburg, DE, vincent.hoeber@gmail.com

Vascular epiphytes are commonly associated with the tropics. However, occasional epiphytic occurrences of terrestrial plants are common in many forest ecosystems around the globe. Such “accidental epiphytes” may be evolutionary trials towards true epiphytism, representing the first steps from terrestrial to epiphytic growth. To assess this evolutionary potential, we compared abiotic growth conditions in trees and on the ground and referred effects of these conditions to functional traits of epiphytic and terrestrial conspecifics. Samples were taken in the Harz Mountains, a Central European low mountain range, rich in accidental epiphytes. We measured photosynthetic active radiation (PAR), minimum winter temperature, soil moisture, soil C, N, P and K content and soil pH at pairs of epiphytic individuals growing in crotches with accumulated arboreal soil and conspecific terrestrials. Water content, SLA, LDMC, relative chlorophyll content, root/shoot ratio and N, P, K, Ca, Mg and Na content were taken as functional traits for each plant individual. In both microhabitats, PAR was similar. Minimum winter temperature was lower in crotches. Apart from that, growth conditions were even better in crotches, as substrate moisture was as high or even higher than on the ground and nutrient contents were >4 times higher in crotches. These differences affect plant functional traits. Epiphytic individuals had higher water content, higher SLA and consequently lower LDMC. Relative chlorophyll content was lower, while root/shoot ratio did not differ from terrestrial individuals. N, P, K and Mg content were higher in epiphytic individuals. Without further studies, we assume that these differences arise from phenotypic plasticity rather than from genetic differences. However, these results illustrate the evolutionary potential of epiphytic individuals of accidental epiphytes even in the temperate zone, provided that gene flow is restricted between epiphytic and terrestrial conspecifics.

Choosy grazers: Dependence of forage selection by three cattle breeds on plant traits

Caren M. Pauler[1,2,4], Johannes Isselstein[2], Joël Bérard[3], Thomas Braunbeck[4], Manuel K. Schneider[1]

[1]Forage Production and Grassland Systems, Agroscope, 8046 Zurich, CH, caren.pauler@gmx.de
[2]Department of Crop Sciences, Georg-August-University, 37075 Goettingen, DE, caren.pauler@gmx.de
[3]AgroVet-Strickhof, 8315 Lindau, CH
[4]Centre for Organismal Studies, Ruprecht-Karls-University, 69120 Heidelberg, DE, caren.pauler@gmx.de

Forage selection by herbivores is a major driver of diversity in pasture vegetation. Yet, we know relatively little on how plant traits influence herbivores' decisions to prefer or to avoid a certain plant species on pasture. We therefore quantified the impact of the traits N, C and P contents, specific leaf area (SLA) and physical defence mechanisms on plant species selection and how this is affected by three cattle breeds. The breeds were (1) high-yielding Angus x Holstein crossbreeds, (2) Original Braunvieh, a dual-purpose breed, and (3) Highland cattle, an undemanding robust breed. The cattle grazed a series of adjacent paddocks in different alpine pastures. All animals had high-elevation grazing experience. Plant species selection of the cattle was quantified by assessing biomass proportions of all plant species in 66 vegetation subplots before and after pasturing. Plant traits and indicator values were extracted from the TRY database. Data on 152 plant species were analysed using a multivariate hierarchical regression model estimated in a Bayesian framework.
Plant traits had a clear impact on forage behaviour. Plants with high SLA, N and P contents were significantly preferred, whereas plants with high C content (e.g. woody plants) and defence mechanisms (e.g. thistles) were generally avoided. Species selection was also well represented by forage quality indicators (as defined by Briemle et al., 2002). In addition to these well-known drivers of herbivore's selection, significant differences between cattle breeds were detected. Selection by low-productive Highland cattle was much less influenced by plant traits than for the two higher-yielding breeds. Our results indicate a breed-specific response of grazing to vegetation composition. Highland cattle (and possibly other robust breeds) graze less selectively and, thereby, impose less selective exclusion on sensitive plant species. This may sustain or even increase the diversity of species-rich pastures.

Session 31-P4 - Traits, networks, and ecosystem functioning

Including dynamics in the equation: tree growth rates and the host specificity of vascular epiphytes

Katrin Wagner[1], Gerhard Zotz[1,2]

[1]Carl von Ossietzky Universität Oldenburg, Oldenburg, DE, ka.wagner@uni-oldenburg.de
[2]Smithsonian Tropical Research Institute, Ciudad de Panamá, PA

The forest canopy is home to a rich biota. One salient feature of this habitat is the dynamics of its basic modules (trees), which are growing and eventually vanishing. Tree growth rates, final size and longevity are strongly varying among tree species. Nevertheless, these inherent dynamics have been a blind spot in studies on host specificity of vascular epiphytes (vascular plants dwelling on trees without parasitizing them) – not least because tree growth rates and longevity are usually unknown in highly diverse tropical forests. The present study aims at tackling this blind spot. We compared epiphyte abundances (> 23.000 individuals) among four focal tree species (285 individuals) in a lowland moist forest in Panama. Data on repeated dbh censuses provided by the Center of Tropical Forest Science (which runs a permanent tree plot at the study site) gave us the unique opportunity to estimate the age of our sampled trees. To compare the relative importance of age vs. host tree characteristics for host biases, we quantified a number of tree traits (microclimate and bark acidity, rugosity and stability) of our focal tree species. Our findings indicate that the studied tree species differ in host quality and that epiphyte species partly differ in host preferences. We further demonstrate that conclusions concerning relative host tree quality depend hugely on whether or not different tree growth rates are considered. Comparing these conclusions allows interesting insights into the role of tree longevity in shaping epiphyte communities. Relating tree trait differences to the observed distributions of epiphytes among the focal tree species show how the simultaneous action of various tree characteristics causes host biases. Our findings highlight the substantial but, up to now, hidden role of differential substrate dynamics for host tree specificity.

Session 31-P5 - Traits, networks, and ecosystem functioning

An analysis of global trait spaces of birds on islands

Ana María Bastidas Urrutia[1], Christian Hof[1]

[1]Biodiversity and Global Change Lab, Terrestrial Ecology Research Group, Technical University of Munich, Freising, DE, anamaria.bastidas-urrutia@tum.de

The equilibrium theory of island biogeography (ETIB) predicts island species richness patterns based on immigration and extinction processes, which are influenced by island characteristics (isolation and area). Recently, the rise of trait-based approaches has been influencing the field of biogeography, including the ETIB. For example, trophic characteristics and dispersal traits should influence the likelihood of species to disperse to and colonize islands. Here, we present an analytical framework (preliminary results) that integrates various traits in a multi-dimensional trait space and links them to the predictions of ETIB, using the bird communities of the world's islands as a study system.
With 7.650 species of birds, distributed in 85.124 islands around the world, we hypothesize that island isolation should influence colonization whereas island area should affect the trophic structure of the island communities. We expect that (a) the occurrence of species on isolated islands is mainly limited by dispersal traits (e.g., wing characteristics or body size) and that (b) the occurrence of species on small islands is mainly limited to species from low trophic levels (e.g., frugivorous and herbivores).
Eco-morphological traits as surrogates for resource acquisition and dispersal characteristics will be obtained from museum specimens, public databases, and literature. Information on species distribution data and geophysical island characteristics will be compiled from published databases. The data are analysed using multivariate regression and ordination techniques, in a spatial context and accounting for potentially confounding factors like climatic conditions, elevation, age, and geological origin.
The results of the analytical framework presented here provide general insights into the determinants of the variation of trait spaces among different island bird communities and thus to a better understanding of the variation of functional diversity on islands in general.

Session 31-P6 - Traits, networks, and ecosystem functioning

Functional traits of tree fine roots along an elevational gradient in Ecuadorian montane rainforests

Kerstin Pierick[1], Jürgen Homeier[1], Christoph Leuschner[1]

[1]Plant ecology and ecosystem research, University of Göttingen, Göttingen, DE, kerstin.pierick@uni-goettingen.de

Fine roots, although being the place of nutrient and water uptake as well as interactions with the soil biosphere, are severely understudied compared with other parts of plants. Especially *in situ* studies of fine roots of adult trees are difficult to conduct and therefore rare. However, functional traits of fine roots can be important predictors for the plant's resource economics strategy. We want to find out if there is a shift of average tree fine root traits along an elevational gradient and if fine root traits are linked to wood and leaf traits along this gradient, indicating that communities at different elevations adopted on average different resource economics strategies. Furthermore, we want to investigate to what degree fine root traits are phylogenetically conserved.
We conducted our study in one of the most species-rich biodiversity hotspots on earth, the montane rainforests of the eastern slopes of the Andes in South Ecuador. At 5 study sites ranging from 1000m to 3000m a.s.l., hence covering an extreme climatic and edaphic gradient, we randomly selected around 60 trees per site, which led to a data set of >140 tree species. We measured root diameter, specific root length, root tissue density, root branching intensity, nitrogen and phosphorus concentration. Then we tested if these traits changed along the elevational gradient, were linked to wood and leaf traits, and were explained by phylogenetic relationships between the tree species.

Session 31-P7 - Traits, networks, and ecosystem functioning

The 'fast-slow' plant economics spectrum in annual species: Independence between leaf-root dimension, growth rate and distribution

Susanne Kurze[1], Mark C. Bilton[2,3], Katja Tielbörger[3], Bettina Engelbrecht[1,4], Leonor Álvarez-Cansino[1]

[1]University of Bayreuth, Functional and Tropical Plant Ecology, Bayreuth Center of Ecology and Environmental Research (BayCEER), Bayreuth, DE, Susanne.Kurze@uni-bayreuth.de
[2]Namibia University of Science and Technology (NUST), Department of Agriculture and Natural Resources Sciences, Windhoek, NA
[3]University of Tübingen, Plant Ecology, Institute of Evolution and Ecology, Tübingen, DE
[4]Smithsonian Tropical Research Institute, Panama, PA

The 'fast-slow' plant economics spectrum assumes tight coordinations among traits involved in resource acquisition and transport. These traits are hypothesized to form one dimension of variation, determine species' growth rate and habitat affinity: fast-growing species with an acquisitive resource-use strategy should occur in resource-rich habitats, whereas slow-growing species with a conservative resource-use strategy predominate in resource-poor habitats. Tests of the plant economics spectrum have been restricted to perennial species, while the applicability of this scheme to annuals is unknown. Annuals though exhibit a substantially different life history strategy than perennials, and therefore may face other constraints and trade-offs.
We comparatively assessed nine resource-use related leaf and root traits considered in the plant economics spectrum, as well as the growth rate of 30 winter annual species from the Eastern Mediterranean Basin. The species differ in their distribution along a steep rainfall gradient in this region.
As expected from the plant economics spectrum, leaf and root traits formed one dimension of variation. However, contrary to the expectation, this dimension was independent from the growth rate, i.e. annuals with similar growth rates possessed a range of leaf and root trait combinations. Furthermore, neither the leaf-root trait dimension nor the growth rate was related to the distribution of the annual species along the rainfall gradient.
In conclusion, this first test of the plant economics spectrum in annual species undermines key assumptions of this scheme, and challenges its general applicability to different life-history strategies.

Session 31-P8 - Traits, networks, and ecosystem functioning

The impact of fire on the performance of bryophytes and lichens in the tundra of northern West Siberia

Daniel Rieker[1], Ramona J. Heim[1], Christian Lampei[1], Norbert Hölzel[1]

[1]Westfälische Wilhelms-Universität Münster, Münster, DE, daniel.rieker@gmx.net

With ongoing Global Change tundra ecosystems are exposed to an increased fire frequency, causing fundamental changes in soil thermal and hydrological dynamics, as well as in vegetation patterns. Surprisingly, earlier studies in this field largely ignored cryptogams, despite covering most of the surface and playing a crucial role for community assemblage. Considering that post-fire changes in growth related traits were observed for vascular plants, there may be changes in cryptogam traits as well. Due to their high importance for the ecosystem, any changes in their recovery could have a great impact on the resilience of the tundra ecosystem. We studied changes in growth related traits of two common bryophyte and lichen species on a fire scar, 28 years after combustion, with paired control plots in the unburnt surrounding area. Furthermore, we analysed nutrient levels and isotope ratios of these species on burnt and unburnt sites. We found bryophytes on burnt sites to attain similar trait values as specimen on unburnt sites, with no influence of fire. Whereas lichen, which spread and grow much slower, still display smaller height and diameter values on the burnt sites. Yet other traits, like thallus thickness or specific thallus mass remained unchanged by fire. Our findings suggest, that repopulation of burnt areas is mainly controlled by the loss of thick lichen mats, favouring fast growing bryophytes and vascular plants. Further, our results do not indicate evolutionary or plastic changes in bryophytes and lichens in burnt sites. Possibly, due to the fast life cycles of bryophytes, only early generations may have been directly affected. Contrarily, lichens colonize burnt sites only after the regeneration of soil properties and are therefore not exposed to alternated conditions.

Session 31-P9 - Traits, networks, and ecosystem functioning

Landscape structure is a major driver of plant and arthropod diversity in natural European forest fragments

Robert Galle[1], Csaba Tölgyesi[2], Zoltan Batori[2], Nikolett Galle-Szpisjak[1], Attila Torma[2], Peter Batary[1]

[1]Hungarian Academy of Sciences, Landscape and Conservation Ecology, Vacratot, HU
[2]University of Szeged, Department of Ecology, Szeged, HU

Disentangling the effects of different landscape and local attributes on the biota of habitat patches is often challenging. In forest-steppe ecosystems the high number of forest patches and the relatively homogenous matrix between them offer the opportunity to identify the effects of habitat size and landscape structure on biodiversity. We studied the biota of forest patches and hypothesized that the above variables and their interactions have different effect on forest specialist and open habitat plant, spider and carabid species. We selected 40 landscapes, including 20 landscapes in extensive, dry, sandy forest-steppe region and 20 landscapes in a mesic forest-steppe region of Hungary. Increasing forest patch size, forest habitat amount (landscape composition) and forest edge length (landscape configuration) had positive effects on forest species, but negative on open habitat species varying a bit among the studied taxa. However, effects of patch size were sometimes moderated by both landscape composition and landscape configuration, as well as habitat affinity of species. Thus patch size effect was more pronounced in landscapes with low forest habitat amount with positive effects on forest spiders and negative effects on open habitat plants. An effective conservation strategy should take into account not only the presence of forest patches in the forest-steppe landscape but also the size, amount and configuration of the forest patches to maximize diversity benefits.

Session 31-P10 - Traits, networks, and ecosystem functioning

Land-use intensification alters the structure of biodiversity-functioning-services networks

María Felipe-Lucia[1,2,3], Eric Allan[3]

[1]UFZ – Helmholtz Centre for Environmental Research, Leipzig, DE, maria.felipe-lucia@idiv.de
[2]German Centre for Integrative Biodiversity Research (iDiv), Leipzig, DE, maria.felipe-lucia@idiv.de
[3]University of Bern, Bern, CH, maria.felipe-lucia@idiv.de

The relationships between biodiversity, ecosystem functioning and ecosystem services are complex because different trophic groups affect ecosystem functions in distinct ways and several functions can combine to supply a number of ecosystem services. Despite the complexity of analysing these relationships, understanding the linkages between these three aspects of ecosystems rather than just looking at their effects on isolated pairs can provide critical information on the consequences of biodiversity change for the functioning of ecosystems and ultimately human wellbeing. One way to tackle this complexity is using correlation networks, that is, considering each trophic group, ecosystem function and service as a node and using the correlation coefficient between each pair of elements (i.e., species richness of a given trophic group, the level of a particular ecosystem function or an ecosystem service), as the link or edge. We exemplify this approach by using a unique dataset including 300 plots distributed along a land use intensity gradient in forests and grasslands with extensive data collection including species richness of 21 trophic groups, 10 ecosystem functions and 14 ecosystem services. In particular, we analysed the effect of increasing land use intensification on i) network structure (density, modularity and evenness); ii) the composition of modules of highly correlated nodes, and iii) the identity of the hubs. We found that land use intensification affects ecosystem structure by altering all metrics studied and also the identity of the hubs in both habitats, markedly in forests. Our work has implications for ecosystem stability and resilience and can inform policy makers about the ecological consequences of different land use intensity levels.

Session 31-P11 - Traits, networks, and ecosystem functioning

Inference of species interactions and prediction in changing environments

Anubhav Gupta[1], Owen Petchey[1]

[1]University of Zurich, Zurich, CH, anubhaviiser@gmail.com

Knowing the food web structure is crucial in understanding its dynamics and response to environmental changes. Various sources of information have been used for food web prediction. We would like to address the following questions: A. How can diverse sources of information such as gut contents, stable isotope composition of tissues and direct observations be used simultaneously to infer the structure of an ecological network (food web)? B. What increase in the precision and accuracy of network inference is gained from using multiple sources of information? C. Which sources of information are valuable, and which are redundant? D. What are the implications for predicting network responses (e.g. structure and stability) to changing environments across spatial and temporal scales? To answer Question A, we will use network model selection and parameterisation via approximate Bayesian computation (ABC). We have implemented the rejection algorithm in ABC to parameterise a food web model which is Allometric Diet Breadth Model (ADBM). Along with the model parameters, ABC also quantifies the underlying uncertainties. Questions B and C will be addressed in silico by simulating networks (food webs) so that the true parameter values are known. Inferred parameter values will be compared to true ones, and inferred network structure will be compared to true network structure. Variation in the types of information used for inference will be compared to variation in accuracy and precision of the parameter estimates and network structure. Question D will be addressed in silico by making predictions of changing network structure that include parameter uncertainty with appropriate propagation of uncertainty. Prediction of changing network structure will be useful depending on the size of the effect of environmental change relative to the uncertainty in that effect size. An important goal of the project is that the questions are addressed in case studies of real ecological communities and not just in silico.

Session 31-P12 - Traits, networks, and ecosystem functioning

Specific rhizosphere microorganisms improve wheat (*Triticum aestivum* L.) growth under drought conditions

Magdalena Szechyńska-Hebda[1], Natalia Hordyńska[1], Edyta Derkowska[2], Mateusz Frąc[2], Sławomir Głuszek[2], Anna Lisek[2], Michał Przybył[2], Lidia Sas-Paszt[2], Beata Sumorok[2], Paweł Trzciński[2], Krzysztof Weszczak[2]

[1]The F. Górski Institute of Plant Physiology Polish Academy of Sciences, Krakow, PL, szechynska@wp.pl
[2]Research Institute of Horticulture, Skierniewice, PL

Nowadays, soil degradation is particularly severe, due to intensive cultivation of monocultures, industrial pollution (heavy metals), salinity, acidification, and climate change that all together cause increasingly soil drought problems. The studies show that the negative impact of climate change and soil degradation on crops can be alleviated by the artificial introduction of specific microorganisms into the soil. The microorganisms may change physical and chemical properties of the soil by the production of biofilms or polysaccharides, thus maintain the water in the upper level of the soil more efficiently, and finally improve plants' growth and yield during drought. In this study, different microorganism consortia were tested for their utilisation in the culture of the spring wheat genotypes, of which one genotype was tolerant, and one sensitive to drought conditions. The drought was set at 50% of optimal soil moisture, whereas approximately 80% of moisture was maintained for control plants. After 8 and 13 weeks of plant development, different physiological and morphological parameters were measured. All tested microorganism consortia led to the increase of plant yield, however, significant differences in their influence on the plants were observed among consortia with different composition. The results indicate that usage of rhizosphere microorganisms can help to increase yield and biomass of wheat plants during spring drought. Utilization of this method could become a future strategy to overcome adverse climatic changes that reduce crops' yield.

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Session 31-P13 - Traits, networks, and ecosystem functioning

Plant genotype can determine the interaction with soil microorganisms during drought

Natalia Hordyńska[1], Maciej Grzesiak[1], Stanisław Grzesiak[1], Magdalena Szechyńska-Hebda[1]

[1]F. Górski Institute of Plant Physiology, Polish Academy of Sciences, Krakow, PL, hordynska.natalia@gmail.com

Drought is one of the factors limiting crop production. Due to climate change, drought conditions are predicted to occur more often, become longer, and the more extended area is exposed to its negative impact. Breeders are forced to develop new more drought-tolerant cultivars or improve tolerance of ones already existing to avoid crop yield loss in the future. Bread wheat (*Triticum aestivum* L.), provides a substantial percentage of the world's food energy intake, however, is exposed to spring heat waves and droughts, which decreases its yield every year. In this study, application of microorganism consortiums was tested for six spring wheat genotypes varying in drought stress tolerance (tolerant vs susceptible genotypes). The aim was to test, if genotypes can respond differentially to microorganisms' application, and which plant traits are involved in yield improvement under abiotic stress conditions. The plants grew in horticulture tent. After they reached the third leaf stadium of development, watering was limited to 35% to impose drought, while soil moisture of control was maintained at 70%. The different physiological and morphological parameters were measured for the plants. All tested genotypes had improved growth and yield; however, some significant differences were observed among genotypes with different tolerance to drought. The results indicate that usage of rhizosphere microorganisms can help to increase yield and biomass of wheat plants during spring drought, but plant genotype can be a crucial factor determining microorganism's effectiveness. Utilization of this method could become a future strategy to overcome adverse climatic changes that reduce crops' yield.

The authors are grateful to the Ministry of Agriculture and Rural Development for financial support within HOR.hn.802.1.2019(103) project, and grateful to DANKO Plant Breeders Ltd; and Smolice Plant Breeders Ltd IHAR for wheat genotypes.

Session 31-P14 - Traits, networks, and ecosystem functioning

Who gains the upper hand over the wheat ear?

Annika Hoffmann[1], Thomas Müller[1], Peter Lentzsch[1], Marina Müller[1]

[1]Leibniz Centre for Agricultural Landscape Research (ZALF), Müncheberg, DE, annika.hoffmann@zalf.de

The phyllosphere of wheat is full of microorganisms, especially fungi and bacteria. Of great importance are the fungi belonging to the genera *Alternaria* spp. and *Fusarium* spp., since they cause several economically relevant wheat diseases. Furthermore, the fungi produce mycotoxins that are potentially harmful for human health when ingested. A successful colonization depends on the aggressiveness of the fungi and how well it outcompetes the bacteria and fungi that are already present at the wheat ears. Especially the bacteria *Pseudomonas*, which is also commonly found on wheat, is known to have an antagonistic effect on the mentioned phytopathogenic fungi. Therefore, the hypothesis is that some strains of fluorescent *Pseudomonas* might strongly influence the presence of phytopathogenic fungi in an environment, functioning as a regulatory mechanism and therefore actively shaping species composition living on wheat ears. To confirm this, a climate chamber experiment was performed to assess how the appearance of *Pseudomonas* or other phytopathogenic fungi affect the probability of a successful infection by fungal spores. To gain a better understanding in the fungal infection dynamics in cereal crops, 210 flowering wheat ears were inoculated by either *Pseudomonas*, *Alternaria*, *Fusarium* or none as control. After one and two weeks respectively, an antagonist was applied to the same ears, to investigate the fitness of the second player in an already colonized area. At each inoculation point, ears were sampled for each treatment. After three weeks, all remaining ears were harvested and prepared for further analysis. Via qPCR, the temporal development of the infection process can be tracked. We hypothesize that on *Pseudomonas* inoculated plants the development of *Fusarium* or *Alternaria* is inhibited. First results show that *Fusarium* inoculated ears were infected more quickly and thickly and seemed to be less susceptible for the following antagonists.

SESSION 32

Plant - pollinator communities: a European perspective

Chairs: Demetra Rakosy, Amibeth Thompson

During the last century there have been dramatic changes in land-use practices and intensity across Europe (Kuemmerle et al., 2016). The mosaic of semi-natural and traditionally managed landscapes which maintain most of Europe's biodiversity has been thus lost throughout vast parts of the continent (Plieninger et al., 2014). This has led not only to a decline of individual species, but also affected entire communities. It is feared that the disassembly of animal and plant communities might have proceeded so far as to be close to a tipping point beyond which they cannot recover (Dakos and Bascompte, 2014; Lever et al., 2014). Plant-pollinator communities appear thereby to be amongst the most affected (Burkle et al., 2013; Burkle and Alarcón, 2011; Potts et al., 2010). Synthetizing our knowledge about how plant-pollinator communities are structured and how their structure may affect their resilience to anthropogenic environmental change is thus an imperative. The aim of this session is therefore to provide a platform for incorporating studies across Europe in order to address the following general issues: 1) What are the factors shaping the assembly of plant-pollinator communities? 2) What is the current state of plant-pollinator communities occurring in natural and semi-natural habitats across Europe? 3) How is the structure of plant-pollinator communities responding to anthropogenic environmental change and are there regional differences across Europe? 4) How can the methodology used for studying plant-pollinator communities be standardized to facilitate the synthesis of multiple datasets? 5) Can the structure of plant-pollinator communities be restored to ensure their resilience? We hope that this session will provide an opportunity to integrate past and ongoing empirical research into an effective strategy for plant-pollinator community conservation and restoration and to contribute towards a productive discussion of the future of plant-pollinator communities in Europe.

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Session 32-O1 - European plant-pollinator communities

Influence of spatio-temporal variability of nectar rewards on plant-pollinator networks in Central European wet meadows

Robert Tropek[1,2], Jan Filip[1], Stepan Janecek[1], Yannick Klomberg[1], Pavel Potocky[2], Sylvain Delabye[2,3], Petra Janeckova[1,3,8], Vincent Maicher[2,3], Eliska Chmelova[1,2], Jakub Straka[1], Michal Perlik[2,3], Paolo Biella[4], Martin Stary[5], Jana Jersakova[3], Jan Hornik[6,7], Michael Bartos[8]

[1]Faculty of Science, Charles University, Prague, CZ, robert.tropek@gmail.com
[2]Institute of Entomology, Biology Centre of the Czech Academy of Sciences, Budweiss, CZ, robert.tropek@gmail.com
[3]Faculty of Science, University of South Bohemia, Budweiss, CZ
[4]Biotechnology and Biosciences Department, University of Milano Bicocca, Milano, IT
[5]Faculty of Science, Masaryk University, Brno, CZ
[6]Nature Conservation Agency of the Czech Republic, Pardubice, CZ
[7]NGO Centaurea–Society for Landscape Monitoring and Management, Stolany, CZ
[8]Institute of Botany, Czech Academy of Sciences, Trebon, CZ

Interactions among flowering plants and their pollinators are a crucial part of biodiversity in most terrestrial ecosystems, including species-rich European meadows. However, our knowledge on their spatio-temporal dynamics is still highly limited, even in the otherwise well-studied temperate Europe. To partly fill this gap, we have sampled plant-pollinator networks in piedmont wet meadows of the Zelezne hory Mts., Czech Republic. In 2016 and 2017, we have repeatedly sampled 13 meadows with different level of isolation. Within each meadow, 20 plots (1x4 m) were established to sample visitors of all flowering plants three times in each study year. Besides reconstruction of the plant-pollinator networks for each transect and sampling period, we have also quantified flowering plants within each transect, as well as within each sampled meadow. Moreover, we measured production of nectar (quantified as the sugar weight produced per day) of individual flowering plant species per transect and per meadow. In this contribution, we will present how amount and diversity of nectar rewards influence structure of plant-pollinator networks in both studied scales, i.e. per transect and per meadow. The interannual dynamics of these patterns will be discussed as well.

Session 32-O2 - European plant-pollinator communities

Pollinator communities and flower-visitation networks in a traditional low-intensity agricultural system and their vulnerability to honeybee loss

Anikó Kovács-Hostyánszki[1,2], Ferenc Jordán[2,3], Rita Földesi[4], Anett Endrédi[3], András Báldi[1]

[1]Lendület Ecosystem Services Research Group, Institute of Ecology and Botany, MTA Centre for Ecological Research, Vácrátót, HU, kovacs.aniko@okologia.mta.hu
[2]GINOP Evolutionary Systems Research Group, MTA Centre for Ecological Research, Tihany, HU, kovacs.aniko@okologia.mta.hu
[3]Danube Research Institute, MTA Centre for Ecological Research, Budapest, HU
[4]University of Bonn, Institute of Crop Science and Resource Conservation, Agroecology/Organic Farming, Bonn, DE

Declining populations of wild bee species and honeybees worldwide poses major threats to agriculture and raises conservation issues. We studied pollinator communities and conducted the first large scale field study of flower visitation networks between bees and wild plants in a low-intensity (no agrochemicals on grasslands, low-intensive cropfields) farming system in Transylvania, Romania. We analysed the pollinator communities in the function of local and landscape scale characteristics, and the interaction networks between wild bees and the visited plant species. We were interested, how the structure of such networks in different habitat types may influence the vulnerability of pollinator communities to the potential loss of honeybees. The data were collected in 38 arable fields and 38 grasslands, which varied along different crop and/or management types. Both arable fields and grasslands hold abundant flower resources, thus both were important in sustaining pollinator communities. While honey bee was the most abundant species that contributed almost one-third of flower visitations, it visited less than half of the plant species. Whereas 63% of flower visitation was delivered by wild bees. The dominant species (relative abundance > 5%) visited the highest number of plant species (highest connectedness) and had the richest interaction structure and the strongest community effects (highest centrality). Rare species (relative abundance < 1%) were among the species of highest keystoneness, and visited one-sixth of the plant species exclusively. Using a topological index (distance-based fragmentation) we found that in general an intermediate plant/pollinator ratio was associated with high vulnerability in the absence of honeybees. We suggest that increased plant species richness can ensure more stable plant-pollinator networks without honeybee, where flower-visitation can rely more on wild bees. Abundant and rare species are equally important for network stability.

Session 32-O3 - European plant-pollinator communities

Game meadows – a forgotten habitat for pollinator communities? Early mulching impairs hoverflies as key flower visitors on game meadows of the Black Forest

Maria Georgi[1,2,3,4]

[1]Alexandra-Maria Klein, Freiburg, DE, maria.georgi@posteo.de
[2]Stefanie Gärtner, Kniebis, DE, maria.georgi@posteo.de
[3]Marc Förschler, Kniebis, DE, maria.georgi@posteo.de
[4]Axel Ssymank, Bonn, DE, maria.georgi@posteo.de
[5]Yvonne Oelmann, Tübingen, DE

Management is important for the conservation of grasslands rich in plant and insect species. The effects of low-intensity management on plants has been studied for decades. Some results show, that management might affect plant and insect species conversely. That makes management recommendations from a plant-focused perspective debatable. Furthermore, the effects of low-intensity management on insects are rarely studied for grazing grounds of wild animals (game meadows).
In our study we aim to understand how different mulching times and intensities of game meadows influence plant-flower-visitor interactions. We carried out different mulching treatments with (i) mulching in June, (ii) mulching in September, (iii) mulching in June and September, and (iv) no mulching (control) to observe plant-flower-visiting interactions on 24 game meadows located in the Northern Black Forest in south-west Germany.
One year after setting up the experiment, our results show that the abundance and species richness of all insects and flowering plants did not differ among management treatments. The networks between plants and flower-visiting insects were dominated by hoverflies (Diptera, Syrphidae) irrespective of mulching time. However, their abundance was significantly reduced when mulching took place in June. Furthermore, hoverflies suffered most from early mulching since richness and Shannon diversity of hoverflies peaked in early summer and the non-mulched control plots maximized the number of plant-insect interactions at this time of the year. We additionally found no difference in the plant-insect networks between the control and late mulching treatment.
Overall, we recommend late mulching (after June) as suitable game meadow management targeting the conservation of pollinator diversity.

Session 32-O4 - European plant-pollinator communities

Heterogeneous habitats promote diverse plant-pollinator interactions in Estonia

Elena Motivans[1,2,3], Lena Neuenkamp[4], Valentin Stefan[2,3], Esther Sossai[2,3], Tiffany Knight[1,2,3]

[1]Helmholtz Zentrum für Umweltforschung-- UFZ, Leipzig, DE, elena.motivans@ufz.de
[2]Martin-Luther-Universität Halle-Wittenberg, Halle, DE, elena.motivans@ufz.de
[3]Deutsches Zentrum für integrative Biodiversitätsforschung (iDiv), Leipzig, DE, elena.motivans@ufz.de
[4]Universität Bern, Bern, CH

The management of many traditional meadows and pastures has been abandoned in the past decades; in the Baltics, the area of active grassland management dropped by about 50% between 2003 and 2010, according to EU Agricultural Surveys. In order to preserve species diversity and pollinator communities in these grasslands, there is a strong interest to restore abandoned areas. We surveyed plant-pollinator networks in two types of traditionally managed grassland in Estonia to determine if the management type fosters different species and different structures of plant-pollinator networks. Specifically, we compared mowed wooded meadows, which have more heterogeneous light conditions, to grazed alvar pastures, which have more uniform light conditions. We find a higher abundance of pollinating insects in wooded meadows, which results in higher pollinator diversity compared to alvar pastures. Further, alvar pastures contain proportionately more hymenopterans whereas lepidopterans and dipterans are more proportionately present in wooded meadows. Rarefied network comparisons between the habitat types revealed that both habitats have similar nestedness and links per species, but wooded meadows have higher connectance and network level specialization (H2). Our results also demonstrate that the roles of individual plant and pollinator species in the network shift between the habitat types. Therefore, restoring the wooded meadows supports more individuals and interactions, but restoring both habitat types supports diverse interactions and network structures across the broader landscape.

Session 32-O5 - European plant-pollinator communities

The influence of management practices on plant-pollinator interactions in Central Europe - a case study

Demetra Rakosy[1,3], Arkadiusz Nowak[4], Valentin Stefan[1], Sebastian Swierszcz[5], Elena Motivans[1,3], Reinart Feldmann[1], Tiffany Knight[1,2,3]

[1]Department Community Ecology, Helmholtz Centre for Environmental Research – UFZ, Halle, DE, demetra.rakosy@ufz.de
[2]Institute of Biology, Martin Luther University Halle-Wittenberg, Halle, DE
[3]German Centre for Integrative Biodiversity Research (iDiv), Halle-Jena-Leipzig, Leipzig, DE, demetra.rakosy@ufz.de
[4]Department of Biosystematics, Opole University, Opole, PL
[5]Botanical Garden Centre for Biological Diversity Conservation in Powsin, Polish Academy of Science, Warsaw, PL

Grasslands represent one of Europe's most dominant and biodiverse ecosystems. They own their existence mainly to traditional agricultural practices such as grazing and mowing, which have consequences for plant and insect abundance and diversity, and the structure of plant-pollinator networks. As these grasslands are going through a renewed period of change, driven mostly by land-use change and intensification, it is crucial to understand the consequences for plant-pollinator interactions. We quantified how different management practices influence patterns of abundance, species richness, functional diversity and network structure in six Central European (Poland and Czech Republic) plant-pollinator communities. We find that grazed pastures have lower abundance and diversity of plants and flower visiting insects compared to mowed meadows. Pastures are also more dominated by Hymenopteran, whereas mowed meadow have proportionately more Lepidopteran and Dipteran flower visitors. We further examine the consequences for network structure and the role in the network of species with different functional traits. Our results show that intense grazing has negative consequences for the structure of plant-pollinator interactions.

Session 32-P1 - European plant-pollinator communities

The attractiveness of oilseed rape in a plant-pollinator network

Amibeth Thompson[1,2], Till Groth[1], Tiffany Knight[1,2,3]

[1]Martin-Luther-Universität Halle-Wittenberg, Halle (Saale), DE, amibeth.thompson@idiv.de
[2]German Centre for Integrative Biodiversity Research (iDiv) Halle-Jena-Leipzig, Leipzig, DE, amibeth.thompson@idiv.de
[3]Helmholtz Centre for Environmental Research- UFZ, Halle (Saale), DE

Mass flowering crops, such as Oilseed Rape (OSR), provide a large quantity of resources for pollinators, but for only a limited time. We know that OSR benefits from pollination services with increased seed set and that semi-natural habitats are important for maintaining species diversity. We do not know, however, how the attractiveness of OSR affects the pollinator interactions with native plants in these semi-natural habitats. The objective of the study was to determine, which pollinators are attracted to OSR and what native plants the identified pollinators have in common. We collected flower visitors of OSR and native plants along field margins and neighboring meadows of OSR across six different sites in Sachsen-Anhalt, Germany that are a part of the Terrestrial Environmental Observatories network (TERENO). From the data collected, we created a plant-pollinator network and found that four common plants share 20%-40% of their pollinators with OSR. We then created a null-model to determine if these plants share more pollinators with OSR than they would by chance. We also checked if there was site-to-site variation and found that there no difference between the six sites. The pollinators shared between OSR and the four native plants are generalist pollinators, providing service to several flowers in the community. Despite being highly attractive in the network, based on the pollinators that it shares with native plants, OSR does not negatively affect the pollination services of these plants.

SESSION 33

Causes and consequences of microbiome changes

Chairs: Stefan Geisen, Madhav Thakur

Microorganisms are the most abundant and diverse organisms on earth and drive major ecosystem functions. However, compared with macroscopic plants and animals, we know little about the vast diversity of microbial life that includes bacteria, archaea, fungi, protists as well as viruses. We are still in the phase of describing spatio-temporal patterns of microbial diversity aiming at identifying the main determinants of diverse microbiomes, while the functional importance of microbial taxa remains known only of specific taxa. In this session we aim at providing a cumulative overview on the current knowledge on microbiomes in different systems and how those are structured. We emphasise that abiotic parameters, such as pH or moisture, are key determinants of microbiomes. Therefore, the importance of global climate change in shaping microbiomes becomes evident. However, we also include biotic components, such as hosts as well as predators of microorganisms, as key elements that structure microbiomes. Furthermore, abiotic and biotic drivers of microbiome structures lead to plastic but also evolutionary imprinted changes that needs to be considered. The goal of this session is to first provide an overview of microbiome components in different systems, such as soils, marine, freshwater as well as diverse plant and animal hosts. We want to shed light on major abiotic and biotic parameters that shape those communities over space and time. We then aim at linking these community compositions to their functional importance ranging from food-web interactions to ecosystem processes. Overall, we hope to cover a broad spectrum of microbial diversity across Earth's systems and target a wide audience in virtually all fields of ecology.

Session 33-O1 - Predictors of microbiomes

Microbiomes: State-of-the-art and future challenges

Stefan Geisen[1], Madhav Thakur[1]

[1]Netherlands Institute for Ecology, Wageningen, NL, s.geisen@nioo.knaw.nl

The most abundant and diverse organisms on the planet are microorganisms – the drivers of several ecosystem services. We yet have at the best only scratched the surface of understanding their diversity, community assembly at virtually all systems on earth, even within our bodies.
Here I will give an overview of our current knowledge on microbiomes across systems, thereby introducing the main contributors of our session. Starting from this overview on microbiomes, I will provide an overview of the future challenges in microbiome research that will help opening the black-box of microbiome research across space, time and within diverse systems. Thereby, I will highlight the need of continuous microbiome research which will be furthered by the other speakers in our session.

Session 33-O2 - Predictors of microbiomes

Groundwater ecosystem functioning in a central European floodplain

Jürgen Marxsen[2,4], Nora Rütz[2], Susanne Schmidt[3]

[2]Institute of Animal Ecology, Justus Liebig University, Giessen, DE
[3]Institute for Hydrobiology of the Czech Academy for Sciences, České Budějovice, CZ, susanne.schmidt@hbu.cas.cz
[4]Limnological River Station of the Max Planck Institute for Limnology, Schlitz, DE

Within a 3 km^2 floodplain area of the River Fulda, where groundwater is used for drinking water production, four different groundwater situations were characterized based on their physical and chemical properties and their variability over time. The river-near wells were highly influenced by exchange with surface water, leading to the highest prokaryotic and faunal biomass in the floodplain. Two more situations were an organic carbon plume and its fringe zone, with high prokaryotic abundances and production, decreasing from the plume centre to the plume fringes. Prokaryote cells proved to be smallest within the carbon plume, perhaps because here groundwater-adapted specialists dominated, while in other zones, particularly those undergoing intense exchange with the surface, opportunistic generalists, related to larger surface water prokaryotes, were probably more important.
Wells at the foot of the hill bounding the floodplain proved to be influenced by nutrients from agricultural production. While none of the prokaryotic characteristics were prominent here, faunal biomass, taxa, and individual numbers were as high as in the wells close to the river at the other side of the floodplain. This might mean that what was measured was the net production of prokaryotes and a considerable part of the production was grazed upon by the fauna. In contrast, fauna did not seem to favour the carbon plume despite the high microbial productivity, which can be attributed to the low oxygen concentrations and/or the organic carbon source being toxic to fauna.
Although 40 years old, this data set which is now analysed for the first time in full (>20 wells measured every other month for up to 4 years; chemical, physical, prokaryote and fauna characteristics) provides complex insights that largely remain unequalled in groundwater ecological studies until today, even though the methodology has advanced since.

Session 33-O3 - Predictors of microbiomes

Floral microbiomes are species specific, but also influenced by land-use intensity

Paul Gaube[1], Alexander Keller[1], Robert R. Junker[2]

[1]University of Würzburg, Department of Bioinformatics, Würzburg, DE, paul.gaube@uni-wuerzburg.de
[2]University of Salzburg, Department of Biosciences, Salzburg, AT

Floral microbiomes are crucial for plant health, plant fitness and may interfere with pollination. Their composition may be shaped by environmental factors and sources such as soil bacterial communities, but also by functional plant traits such as availability of carbon and nitrogen, composition of secondary metabolites or phenology and morphological plasticity of flowers. We investigated the organismal α-, β- and γ- diversity of floral microbiomes of *Ranunculus acris* and *Trifolium pratense* using metabarcoding of 16S ribosomal DNA in order to address the composition of bacterial communities along a land-use gradient. For direct comparison, we also examined the microbiota associated with leaves of both plant species. The analysis of taxonomic data revealed a high organismal diversity of flower and leaf microbiomes. We found that typical flower and leaf associated bacterial genera are ubiquitous and very abundant among all samples of the two different plant species and plant organs. Pollinator related bacteria were found solely in flower samples, while bacterial members associated with the Rhizosphere were only present in high abundances on leaves. Our study revealed that land-use intensity has only minor effects on the bacterial community composition. However, we found indicator taxa for regularly disturbed environments. Furthermore, we found out that the structures of bacterial communities do not differ between geographically distinct regions, but between plant species. The floral bacterial community of *R. acris* showed a high variability in comparison to *T. pratense*, which may be explained by the heterogeneity of functional plant traits. Additionally, there is a high beta-diversity within each plot of each plant species that could also be affected rather by individual functional plant traits than by environmental factors.

Session 33-O4 - Predictors of microbiomes

Legacy of an extreme climatic event persists for multi-generations in microbial communities

Madhav Thakur[1], Stefan Geisen[1]

[1]Netherlands Institute of Ecology, Wageningen, NL, m.thakur@nioo.knaw.nl

Extreme climatic events can restructure ecological communities by differentially affecting community members, yet, we know little on how communities recover after such events. Here, using several combinations of predator-prey experimental interactions (with protists as predators and bacteria as their prey), we show that an extreme heat event reduced prey community biomass with negligible effects on predators. Further, predators consistently lowered prey resilience indicating destabilizing effects of predators on prey communities after an extreme heat event. Our results also show that bacterial biomass did not recover back to pre-extreme event levels for several generations post-extreme event. Our results thus highlight the importance of trophic regulations in predicting community recovery and signature of irreversible changes in microbial communities even when recovery periods last for several generations.

Session 33-O5 - Predictors of microbiomes

Studying interactions between fauna and microorganisms to understand soil functioning

Anton Potapov[1]

[1]J.F. Blumenbach Institute of Zoology and Anthropology, University of Göttingen, Göttingen, DE, potapov.msu@gmail.com

Although the direct contribution of soil fauna to carbon mineralization is moderate, they can affect significantly microbial communities via trophic interactions and alterations of the environment, which feeds back on the ecosystem functioning. Soil fauna are acting as (1) biological regulators, shaping microbial community composition via trophic interactions, (2) dispersal agents, shaping microbial community assembly via transferring propagules in their guts and on their bodies, (3) energy and nutrient transfer agents, creating hot spots of microbial activity via horizontal and vertical material allocation and chemical modification, (4) ecosystem engineers, forming the structure and spatial heterogeneity of soil via borrowing, grazing and casting activities. Animals with different traits (for example, body mass), perform these four main functions differently and thus different animal communities affect microbiome in different ways. However, the mechanistic links here are yet to be established. Despite the functions of soil fauna are widely recognized, they are not always easy to study. In recent years, a number of methods were developed to study trophic interactions between soil fauna and microorganisms. Stable isotope and fatty acid analyses can reveal the major energy pathways through, and roles of different animal groups in, soil food webs. Isotopic labelling allows to track flows of elements between ecosystem pools and study nutrient and energy cycling *in situ*. Molecular gut content analysis and next generation sequencing is increasingly used to establish species-specific interactions. Selective feeding of soil fauna may define competitive interactions between mycorrhizal and saprotrophic fungi or between fungi and bacteria across forests and agricultural ecosystems, respectively. Including fauna in carbon models will be a major step towards mechanistic understanding of element cycling in ecosystems.

Session 33-P1 - Predictors of microbiomes

Understanding host-microbiome interactions, Daphnia as a model organisms

Siddiq Akbar[1], Zhou Yang[1]

[1]Nanjing Normal University, Nanjing, CN, siddiqakbar@qq.com

In the last couple decades, the importance of microbes associated with hosts in shaping their physiology, immunity and evolutionary adaptations have been progressively recognized. Due to this, the number of studies on host-associated microbes have tremendously increased as of late, and have revealed the substantial effects of microbes on different aspects of host. Host-microbe interactions are omnipresent and have an essential role in host speciation and success. However, many underlying mechanisms behind these ecological and evolutionary changes remain unclear. To this end, we need model organisms to understand these interactions. Daphnia have been used for many years as model organisms due to their wide range of polyphenism including morphological and behavioural alternation, plasticity to different predators, and tolerance to toxic prey. Though, studies on Daphnia-microbiome are just recently beginning, but their early findings clearly show distinct microbiome from the environment and other organisms. Daphnia associated microbes provide beneficial effects which are necessary for their fitness and survival, and it is important to understand: how Daphnia maintains microbiota, and what adaptive traits allow stable microbiome in changing environments. Studies about adaptation and co-evolution between microbiota and Daphnia and their underlying molecular mechanisms to understand ecological interactions and their evolutionary outcomes in host-microbiome represent future areas of research, for which Daphnia will be a promising model organism.

SESSION 34

Biodiversity monitoring schemes - challenges and feasibilities

Chairs: Jens Dauber, Petra Dieker, Eva Knop

"The loss of biodiversity is worldwide progressing at an alarming rate. There is a growing awareness of the serious consequences of biodiversity loss not only for nature conservation but also for human well-being and economy, e.g. through the loss of ecosystem services. Recent data on the massive loss of insect biomass resulted in a strong debate about the causes and consequences of this decline not only in science but also in the media and the public. What became obvious in this debate was that there is generally a lack of sound data to quantify the decline of biodiversity and its underlying causes and consequences. This has opened widely a political window for the financing, promotion and development of monitoring initiatives from local to European level. These circumstances offer consequently the opportunity to establish sound biodiversity monitoring schemes and networks for evidence-based assessments of biodiversity trends and causes and consequences of it. Ideally these schemes would include different spatial scales and socio-economic settings. Current discussions, however, reveal that there is no common understanding developed about the aspects of biodiversity that a monitoring should encompass and how a monitoring should be designed to ensure both scientific standards and feasibility. The symposium aims at presenting and discussing the recent developments and approaches in theory and practice for designing and establishing biodiversity monitoring schemes and methodological innovations (e.g. digital data acquisition, remote sensing and new analytical approaches, meta-barcoding, capacity building). The symposium will end with a panel discussion. "

Session 34-O1 - Biodiversity monitoring schemes

Mapping forest biodiversity of tiny organisms from space is not a vision any more

Soyeon Bae[1], Shaun Levick[2,3], Lea Heidrich[1], Paul Magdon[4], Benjamin Leutner[5], Stephan Wöllauer[6], Alla Serebryanyk[7], Thomas Nauss[6], Peter Krzystek[7], Martin Gossner[8], Peter Schall[4], Christoph Heibl[9], Claus Bässler[9], Dörfler Inken[10,11], Ernst-Detlef Schulze[12], Franz-Sebastian Krah[9,10], Heike Culmsee[13], Kirsten Jung[14], Marco Heurich[9,15], Markus Fischer[16,18], Sebastian Seibold[1,10], Simon Thorn[1], Tobias Gerlach[19], Torsten Hothorn[17], Wolfgang Weisser[10], Jörg Müller[1,9]

[1]University of Würzburg, Würzburg, DE, baelovejx@gmail.com
[2]CSIRO Land and Water, Darwin, AU
[3]Charles Darwin University, Darwin, AU
[4]University of Göttingen, Göttingen, DE
[5]German Aerospace Center (DLR), Weßling, DE
[6]Philipps-University Marburg, Marburg, DE
[7]Munich University of Applied Sciences, Munich, DE
[8]Swiss Federal Research Institute WSL, Birmensdorf, CH
[9]Bavarian Forest National Park, Grafenau, DE
[10]Technical University of Munich, Freising, DE
[11]University of Oldenburg, Oldenburg, DE
[12]Max Planck Institute for Biogeochemistry, Jena, DE
[13]German Federal Foundation for the Environment, Osnabrück, DE
[14]University Ulm, Ulm, DE
[15]University of Freiburg, Freiburg, DE
[16]Senckenberg Biodiversity and Climate Research Centre (SBiK-F), Frankfurt, DE
[17]University of Zurich, Zurich, CH
[18]University of Bern, Bern, CH
[19]UNESCO-Biosphere Reserve Rhön, Oberelsbach, DE

Habitat loss is the primary cause of global species decline, but conservation still lacks open access information over large spatial-temporal scales. Therefore, progress in remote sensing evokes hope for monitoring essential indicators of biodiversity. We tested the potential for newly launched spaceborne radar (Sentinel-1) to map the biodiversity of twelve taxa across five temperate forest regions. We show that radar is sensitive to similar habitat structure as airborne laser scanning (ALS) – the current gold standard in measurements of forest structure. Modelling different facets of biodiversity revealed that radar performed as well as ALS. External validation of radar models for species composition of birds and saproxylic beetles still revealed promising predictive ability. These findings show that open access remote sensing is ready for large scale biodiversity monitoring. To progress this field even further, we need to match these radar data with stratified local observational biodiversity data for upscaling to countries.

Session 34-O2 - Biodiversity monitoring schemes

Advanced sampling strategy for monitoring agricultural species and habitats in Switzerland

Klaus Ecker[1], Eliane Meier[2], Gisela Lüscher[2], Yves Tillé[3]

[1]WSL, Birmensdorf, CH, klaus.ecker@wsl.ch
[2]Agroscope, Zürich, CH
[3]University of Neuchatel, Neuchatel, CH

Farmland biodiversity plays an important role in the functioning of the agro-ecosystem by providing ecosystem services such as pollination, pest control and soil protection. However, classical biodiversity monitoring of farmland at the national scale is restricted to view taxa such as birds and butterflies which are surveyed at the landscape level based on systematic sampling. The simple sampling concept fails when it comes to monitor plot level items such as plants or habitats. Existing programs based on such designs miss the majority of plant species and habitats as these items are typically rare or spatially clustered and, even more serious, previously unknown in the sampling frame. Techniques such as cluster sampling, stratification or model based sampling slightly increase the variety of items in the sample but still suffer from high data redundancy and unrealistic costs to capture the actual spectrum of interest. Here we describe the advanced sampling strategy of the long-term monitoring program of agricultural species and habitats in Switzerland (ALL-EMA) which introduces an extra two-stage sampling procedure to first obtain a large systematic sample of habitats which is then specifically subsampled for the costly survey of plant species. Sample efficiency is further improved by sample techniques such as stratified sampling, unequal probability cluster sampling, balancing and spatial spreading. The whole sampling scheme is applied twice, for the total farmland area and for the small areas with funded biodiversity management. The efficiency of balancing, spreading and sample size allocation is demonstrated in simulation studies. A power analysis suggests that changes of 5 – 10% can be statistically detected for a majority of the target habitats. First results show a positive effect of funded biodiversity management on predefined priority species and habitats.

Session 34-O3 - Biodiversity monitoring schemes

Establishing a Germany-wide monitoring scheme of habitat types

Daniel Fuchs[1], Werner Ackermann[1], Wiebke Züghart[2]

[1]PAN Planungsbüro für angewandten Naturschutz GmbH, München, DE, Daniel.Fuchs@pan-gmbh.com
[2]Bundesamt für Naturschutz, Bonn, DE

In times with continuing and growing pressures on the landcape generally and on natural resources specifically there is an urgent need for detailed and reliable data on the frequency, distribution, extent, condition and changes of the land cover. In Germany, nationwide data on habitat types are however lacking, especially with regard to areas not protected under conservation legislation. To address this problem the German Federal Agency for Nature Protection in 2016 launched an R&D project titled "Ecosystem monitoring on federally representative sample plots". Its aim is to enable statements on the effects of influencing factors such as land use change, increasing pressure, intensification of agriculture or climate change on land cover and vegetation as important components of biological diversity. Taking two successful and long-running federal programmes – the common breeding bird monitoring and the high nature value farmland monitoring – as a model the same sample of 1,000 plots of 1 km² is used for field mapping. After developing a habitat key and a field manual, complete surveys of 40 plots were undertaken in 2017 and of further 199 plots in 2018. Some 30,000 area features were mapped in the field, covering 231 different habitat types. Together with specific key characteristics for each habitat type plant species were recorded on transects for most of these habitat types, resulting in more than 115,000 records of 1,766 species. On 20 plots mapping was conducted independently by two different teams as part of a quality assurance procedure. The results of two years of field surveys show that a valid method to monitor the changes in habitat types and their area and quality has been developed. In a next step, the monitoring scheme is to be further improved and applied to a larger contiguous region of Germany.

DNA metabarcoding - Genetic identification of species and its implications for a biodiversity monitoring 2.0 in the digital age

Susanne Butschkau[1]

[1]Jerome Moriniere, Munich, DE, info@aimethods-lab.com

In times of global species extinction, climate change and habitat loss, the need for a fast and reliable method of species identification has never been more important than today. Within biomonitoring projects, correct identification of target species is crucial to provide decision-makers with the necessary information on which ecological measures must be used. Modern techniques, such as DNA metabarcoding, support classical methods beyond their capabilities and can identify all individuals of a species regardless of the life stage, the gender, or whether only small body parts are available for analysis. DNA metabarcoding is ready to be used for species determination beyond the taxonomic and regional delimitations and can be used to capture biodiversity in its entirety – not only focus groups. The reference libraries are ready for the application of metabarcoding, which allows the analysis of bulk samples derived from, Malaise traps, soil samples, fecal samples, gut contents, water bodies, processed foods, among many others. Hundreds of samples can be processed in one single analysis. Comprehensive biodiversity compositions of samples can be recorded, analyzed and then visualized using bioinformatic pipelines. DNA barcoding allows a biomonitoring 2.0 to be cost-effective and time efficient. With a fraction of the budget, and a significantly lower expenditure of time and personnel, a high percentage of the organisms in a sample can be identified.
Using our specialized lab routines and bioinformatic pipelines over the last years, we were able to support more than one hundred projects. We will present use cases from classical biomonitoring, pest species detection, pollinator analysis, as well as feces and gut content studies, which include animal, fungal and partly plant DNA analysis.

Session 34-O5 - Biodiversity monitoring schemes

Monitoring scheme to study wild bee diversity in the project BienABest

Hannah Burger[1], Ulrich Neumüller[1], Sabrina Krausch[1], Manfred Ayasse[1]

[1]Ulm University, Ulm, DE, hannah.burger@uni-ulm.de

As there is growing evidence for ongoing wild bee decline during the last centuries, wide ecological and economical interest evolved to preserve wild bees and their pollination service. The project BienABest (funded within the Federal Program for Biological Diversity) aims to increase wild bee populations in the agricultural landscape and to develop methods for standardized long term monitoring of bees. We established wild bee pastures and ground-nesting opportunities for wild bees on arable land closely located to flower-rich natural grassland areas at 20 selected locations in Germany. In order to study the diversity and abundance of wild bees and to evaluate the procedures of preservation, a systematic monitoring of wild bees is performed during the entire run time of the project until April 2023. The monitoring is following standardized methods to allow a comparative study between different locations, habitat types and different years. Sampling is performed by experienced wild be taxonomists using variable transect walks in 180 selected sampling plots. The landscape composition of the surrounding area was mapped in order investigate how wild bee populations are affected by landscape attributes and how far these effects are mediated by the local habitat type. In our contribution, we will introduce the project and our monitoring procedures and present the results of the first year of data acquisition in which we recorded more than 25,000 interactions between wild bees and flowers. The abundance and diversity of wild bees was affected by the composition of the surrounding landscape and differed depending on the studied habitat types. We are confident that our results will contribute to the conservation of wild bees. Above that, the standardized methods can be applied independently of the project BienABest and can be used as a basis for a systematic long-term monitoring of bees with a minimum sampling-impact on existing wild bee populations.

Session 34-O6 - Biodiversity monitoring schemes

Community completeness – a promising aspect of biodiversity used for monitoring

Gisela Lüscher[1]

[1]Agroscope, Zürich, CH, gisela.luescher@gmail.com

Farmland biodiversity is still declining. While measures related to species numbers and abundances are useful for monitoring trends within individual habitats, they are less suited to compare trends between habitats. A possibility for such comparisons are measurements that consider species communities. We therefore applied a community completeness index, which accounts for species composition and allows comparing trends in different habitats.
To do so, we used plant data from the Swiss biodiversity monitoring programme focusing on agricultural landscapes (ALL-EMA). We relied on around 3000 vegetation surveys sampled in 136 km^2 squares along altitudinal and land use gradients across Switzerland. We grouped the vegetation surveys to a number of distinct habitat types. For each habitat type, the corresponding species pool was estimated. Secondly, the community completeness index was calculated as ln(species observed/dark diversity), whereas 'dark diversity' represents the difference between the corresponding species pool and the observed species. Then, we analysed the performance of the community completeness index under potential scenarios of biodiversity change in comparison to classical measures such as species richness.
Results revealed a higher differentiation between habitats of the community completeness index than the species richness to the applied scenarios.
This study highlights the benefit of including several complementary aspects of biodiversity in evaluating monitoring data to detect relevant developments.

Session 34-O7 - Biodiversity monitoring schemes

Effective biodiversity monitoring needs integration

Hjalmar Kühl[1,2], Diana Bowler[1,3,4,4], Aletta Bonn[1,3,4]

[1]German Centre for Integrative Biodiversity Research (iDiv), Leipzig, DE, aletta.bonn@idiv.de
[2]Max Planck Institute for Evolutionary Anthropology, Leipzig, DE
[3]Friedrich Schiller University Jena, Jena, DE, aletta.bonn@idiv.de
[4]Helmholtz-Center for Environmental Research – UFZ, Leipzig, DE, aletta.bonn@idiv.de

Despite increased efforts, most national biodiversity monitoring programs still fall short of providing coherent output to inform national and international policy. Often, finding solutions is approached from a solely data-centric perspective to find an idealised, unified, top-down monitoring scheme, not taking into account that the biodiversity monitoring landscape consists of a network of stakeholders, each differing in motivation and expertise. Here, we argue for a stronger integration among different monitoring approaches and efforts - between people, stakeholders and data types – to establish a comprehensive biodiversity monitoring schemes. Large-scale standardized monitoring schemes are essential for robust inference on the state of biodiversity, and should provide the backbone of national biodiversity monitoring. Nonetheless, they tend to be restricted in time, space and taxa. In addition, a wealth of data collection schemes is driven by various monitoring stakeholders in society, covering different locations, time scales, species, and types of data and sampling protocols. Alignment and integration of these activities together with standardised centralised monitoring schemes can help to form a powerful monitoring network providing data to assess large-scale and cross-taxon biodiversity change. Ignoring these valuable efforts would also mean foregoing valuable expertise and neglecting opportunities for considerable buy-in. Recent major statistical advances for data integration allow for different data types, collected with different sampling protocols, to now be robustly aligned to provide coherent output. We suggest that systematic efforts for the capacity building of stakeholder networks and valuing and enhancing distributed expertise is as relevant for ensuring effective long-term biodiversity monitoring as centrally managed monitoring schemes. We present the benefits of integration for policy, society and science, assess the factors currently impeding integration and identify stakeholder specific incentives to overcome them.

Session 34-O9 - Biodiversity monitoring schemes

Challenges of settings and financial constraints for biodiversity monitoring schemes in farmland

Kathrin Pascher[1], Bärbel Pachinger[2], Christa Hainz-Renetzeder[3], Leopold Sachslehner[4], Thomas Frank[1]

[1]University of Natural Resources and Life Sciences Vienna (BOKU), Institute of Zoology, VIENNA, AT, kathrin.pascher@boku.ac.at
[2]University of Natural Resources and Life Sciences Vienna (BOKU), Institute of Integrative Nature Conservation Research, VIENNA, AT
[3]University of Natural Resources and Life Sciences Vienna (BOKU), Institute of Landscape Development, Recreation and Conservation Planning, VIENNA, AT
[4]Büro für Naturschutzpraxis und Forschung, VIENNA, AT

In order to quantify biodiversity decline in protected areas as well as in farmland in an accurate and realistic way, comparable detailed data sets must be available. The challenge is that - in addition to population fluctuations which occur naturally - actually occurring population declines and species loss have to be filtered out. In addition, climatic conditions of the respective survey year also play a major role for the data sets.
Originally, the Austrian program BINATS (Biodiversity-Nature-Safety) was implemented in 2006 as a baseline for identifying potential effects of genetically modified organisms and was then adopted in order to take the first step towards an Austrian biodiversity monitoring scheme with the starting point in the farmland. Juggling financial bottlenecks habitats, vascular plants, butterflies, and grasshoppers were chosen as indicators. In the 100 selected BINATS test areas (625x625 m) using a random sampling approach, habitats were mapped area-wide in 2007/2008. Presence/absence data were collected for vascular plants and animals in ten test circles (r=20m) within each test area. Additionally, for the animal indicators their abundance was measured. A fifth indicator - wild bees - was incorporated into the survey design in the first repetition in BINATS II (2017/2018). Here, we recorded 932 species (BINATS I: 908) of vascular plants, 55 (41) of butterflies, 54 (55) of grasshoppers, and 245 of wild bees in total for all 100 test areas. Because of access prohibitions to arable land, data analyses must now be carried out in two ways, direct comparison of the same sampling plots and comparison according to the same habitat categories due to required local shifting of plots.
In order to create a constant framework for effective monitoring schemes, prerequisites should be facilitated by politics and adequate funding should be provided in order to create data sets of high quality required for quantifying species loss.

Session 34-O10 - Biodiversity monitoring schemes

Successful long-term engagement in a Citizen Science project - lessons from 14 years of the German Butterfly Monitoring Scheme

Elisabeth Kühn[1], Martin Wiemers[1,5], Anett Richter[2,4], Reinart Feldmann[2], Alexander Harpke[1], Norbert Hirneisen[3], Martin Musche[1], Oliver Schweiger[1], Josef Settele[1,4]

[1]Helmholtz Centre for Environmental Research - UFZ, Halle, DE
[2]Helmholtz Centre for Environmental Research - UFZ, Leipzig, DE
[3]Science4You, Bonn, DE
[4]German Centre for Integrative Biodiversity Research (iDiv), Leipzig, DE
[5]Senckenberg Deutsches Entomologisches Institut, Müncheberg, DE, martin.wiemers@ufz.de

The German Butterfly Monitoring Scheme (TMD) is a Citizen Science project which was started by the Helmholtz Centre for Environmental Research in 2005 with the main focus to provide long-term trends for an important indicator group of insects. It is embedded in a network of European butterfly monitoring schemes which is currently being extended by the EU-funded project ABLE. During the last 14 years more than 1000 transects have been established in all German states, of which more than 300 have been surveyed for at least 8 consecutive years. After an initial increase the number of active transects has remained stable with about 410-490 transects walked each year providing data for about 80% of the ca 140 butterfly species. In total, more than 3 million butterflies have been counted since 2005. A survey of the community of butterfly counters helped to understand the complex network of players, including essential key players and aspects of added value which appear important for the successful long-term collaboration.

Session 34-O11 - Biodiversity monitoring schemes

Bridging Agricultural and Forest Biodiversity Monitoring in Germany

Heike Kappes[1], Franz Kroiher[2]

[1]Thünen Institut für Biodiversität, Braunschweig, DE, heike.kappes@thuenen.de
[2]Thünen-Institut für Waldökosysteme, Eberswalde, DE

Both agriculture and forestry are expected to balance societal demands for production with the maintenance of biodiversity and ecosystem functioning, while also providing a healthy environment and accounting for climate adaption. Monitoring biodiversity at a national scale becomes increasingly important to provide data for reporting and optimization of production systems in terms of biodiversity and sustainability. Currently there are independent initiatives in Germany including (1) various forest monitoring programmes that are in place but usually apply surrogate indicators such as coarse deadwood and (2) an agricultural biodiversity monitoring scheme recently launched by the Thünen Institute, the Julius-Kühn Institute, and the Federal Office for Agriculture and Food (funding: German Federal Ministry of Food and Agriculture).
We will provide examples for the concept that, from an ecological and management perspective, (traditional) agriculture and forestry form gradients, and summarize shared questions from a monitoring perspective. Among these shared questions are biodiversity-related effects of soil quality and carbon retention, climate change adaptation with new (introduced) crop/tree species, long-term effects of different rotation intervals and harvesting methods, the integration versus segregation of production and nature protection (land sharing or land sparing), or the efficiency of different habitat enrichment (greening/deadwood) programmes.

Session 34-O12 - Biodiversity monitoring schemes

Nationwide biodiversity monitoring in Germany - status and perspectives

Andreas Krüß[1], Wiebke Züghart[1]

[1]Bundesamt für Naturschutz, Bonn, DE, Andreas.Kruess@bfn.de

The Nature Conservation action programme 2020 points to the precarious situation of biodiversity in Germany and presents measures for reversing the trend. One of the central issues is the implementation of a comprehensive nationwide biodiversity monitoring. This aims at providing statistically sound data on the state and changes of biodiversity relevant for fact-based policy advice. Monitoring data is an important basis for well-founded analyses of the causes of biodiversity decline and point out possible courses of action for biodiversity protection.
According to their respective responsibilities, the German Federal Government and the Länder monitor the state and changes of nature and landscape (§ 6 German Federal Nature Conservation Act, BNatSchG). Already established monitoring programmes serving nature conservation throughout Germany include nationwide bird monitoring, monitoring of high nature value farmland and monitoring under the Habitats Directive. A monitoring of habitat types and a monitoring of insects are currently being tested or are under development.
The overall objective is to develop and implement a nationwide biodiversity monitoring in which the programmes complement each other and synergies can be used. Nationwide spatially representative sampling ensures data evaluation at the federal and Länder level. Besides the development of supplementary monitoring modules, the enhancement of ongoing programmes is also of great importance. Wherever it makes sense, methodological innovations such as digital data acquisition are implemented.
In the coalition agreement for the 19th legislative period, the German federal government committed itself to the establishment of a scientific monitoring centre for biodiversity. This is intended to support the expansion of a comprehensive nationwide biodiversity monitoring in Germany.

Session 34-O13 - Biodiversity monitoring schemes

Biodiversity monitoring schemes and indicators – challenges and feasibilities

Petra Dieker[1], Jens Dauber[1]

[1]Thünen Institute of Biodiversity, Braunschweig, DE, petra.dieker@thuenen.de

The loss of biodiversity is worldwide progressing at an alarming rate. There is a growing awareness of the serious consequences of biodiversity loss not only for nature conservation but also for human well-being and economy, e.g. through the loss of ecosystem services. The recent discussion about the massive loss of biomass resulted in a strong debate about the causes and consequences of this decline and revealed that there is general lack of scientifically sound data to quantify the decline of biodiversity and its underlying causes and consequences. This has opened widely a political window for the financing, promotion and development of monitoring initiatives from local to European level. These circumstances offer consequently the opportunity to establish sound biodiversity monitoring schemes and networks for evidence-based assessments of biodiversity trends and causes and consequences of it. The results of these assessments are usually reported through indicators that form the basis for evaluating the effectiveness of environmental measures and advising policy makers. The development of indicators, however, in particular those that can be applied from regional to European level, is challenging due to the high variability in environmental settings. Subsequently, the generation of appropriate data for indicators covering various spatial scales is difficult. To tackle this issue, recent upcoming monitoring initiatives could coordinate meaningful indicators by fostering harmonisation of data sampling across administrative borders. Such developments are needed to monitor the achievements of the CAP objectives from regional to European level and thus to be able to make pan-European statements about the status of biodiversity as well as to tailor agri-environmental measures to regional settings.
The talk aims at discussing challenges and feasibilities for designing and establishing sound pan-European indicators for monitoring schemes that allow feedback loops.

Session 34-P1 - Biodiversity monitoring schemes

Development of Biodiversity monitoring in China

Keping Ma[1]

[1]Institute of Botany, Chinese Academy of Sciences, Beijing, CN, kpma@ibcas.ac.cn

Forest is maintaining 80% of the carbon stocks of vegetation on earth. So, forest plays a critical role in mitigating climate change. In this sense, forest dynamics plot approach can be a useful platform for carbon research. We began to set up the Chinese Forest Biodiversity Monitoring Network (CForBio) in 2004. Before that, we have established a number of similar permanent plots for the same purpose, but much smaller in area. Up to now, we have set up 18 plots with the area more than 9 hectares. The plots are distributed in different climatic zones. The key features of the forest dynamics plot approach are mapping and tagging. All of the stems with DBH more than 1 cm in the plots were mapped and are re-censused in every 5 years. The major objectives of the network are 1) to know the dynamics of major types of ecosystems in China; 2) to understand the mechanisms of species coexistence and associated impact factors such as logging, climate change. From 2013, we began to expand the current forest biodiversity monitoring network for covering major taxa of species in most of the dominant ecosystems in mainland of China. The Chinese Academy of Sciences decided to invest 30 million USD to expand the network from CForBio to Sino BON. Sino BON consists of 1 synthesis center, 10 thematic sub-networks. So far, based on datasets from the networks, more than 200 papers published in international journals.

Session 34-P2 - Biodiversity monitoring schemes

Biodiversity Monitoring South Tyrol (BMS)

Matteo Anderle[1], Andreas Hilpold[1], Georg Niedrist[1], Ulrike Tappeiner[1,2]

[1]Eurac Research, Bolzano, IT, matteo.anderle@eurac.edu
[2]University of Innsbruck, Department of Ecology, Innsbruck, AT

A permanent biodiversity monitoring system (BMS) for South Tyrol is currently being set up on the initiative of the South Tyrolean provincial government and under the direction of Eurac Research. The monitoring not only serves basic research, but is also intended to provide the scientific basis for political decisions, especially in connection with spatial planning, agriculture and nature protection. The BMS aims at the survey of species groups that react sensitively to environmental and land use changes. In addition to birds and vascular plants, various insect groups, such as grasshoppers and butterflies, will be surveyed. A soil and a limnology part are also planned. The 320 study areas are distributed evenly over the country and include a representative selection of different habitats. Particular attention is paid to the habitat types of the cultural landscape, such as vineyards, apple orchards or meadows. Comprehensive surveys in 64 areas have been conducted in 2019. First results will be presented.

Session 34-P3 - Biodiversity monitoring schemes

MonViA - a long term farmland biodiversity monitoring for Germany

Petra Dieker[1], Holger Beer[2], Stefan Schröder[3], Jens Dauber[1]

[1]Thünen Institute of Biodiversity, Braunschweig, DE, petra.dieker@thuenen.de
[2]Julius Kühn Institute, Kleinmachnow, DE
[3]Federal Office for Agriculture and Food, Bonn, DE

About 50 % of the area of Germany is used for agricultural purposes. Therefore, agriculture plays a crucial role in the preservation and promotion of biodiversity. Current statements point out that the way in which agricultural land is used and the loss of landscape structures are among the main reasons for the decline in biodiversity. At present, data and indicators from existing monitoring programmes, however, permit only to a limited extent scientifically reliable conclusions on underlying cause-effect relationships or on the impact of agri-environmental measures to promote biological diversity. Therefore, a national farmland biodiversity monitoring programme is necessary in order to provide scientifically sound answers (based on representative data) to the following questions: How do agricultural production, land-use and structural change in agriculture influence biodiversity in open agricultural landscapes? How does biodiversity change affect the productivity and resilience of agricultural production systems? How do agri-environmental measures affect biodiversity and which measures should be recommended to farmers and policy makers?

Under the acronym *MonViA*, the Thünen Institute, the Julius Kühn-Institute and the Federal Office for Agriculture and Food are developing a farmland biodiversity monitoring that is designed to complement existing monitoring approaches and starts with feasibility studies on the development of innovative indicator systems and sampling methods for the three subareas: a national wide trend monitoring, a question-based monitoring on specific issues at the scale of representative agricultural landscape units, and a Citizen Science-based monitoring. In the latter case, farmers in particular are to be involved in monitoring activities. In addition to the diversity of agricultural landscapes and quality of agricultural habitats and soils, the monitoring includes various groups of organisms, with a focus on insects and their ecosystem services.

Session 34-P4 - Biodiversity monitoring schemes

Tracking changes at the large scale: a new insect monitoring initiative based on the Long Term Ecosystem Research and Monitoring Network LTER-D

Mark Frenzel[1], Peter Haase[2]

[1]Helmholtz Centre for Environmental Research UFZ, Halle, DE, mark.frenzel@ufz.de
[2]Research Institute Senckenberg, Gelnhausen, DE

Recent studies indicating insect decline have considerably raised awareness among scientists and in the public. Although it is likely that the observed pattern of e.g. the Krefeld study can be up scaled, we are missing data which are representative for Germany. As a consequence, politically and scientifically motivated initiatives started in developing concepts and programs for a German-wide biodiversity monitoring. The German network for long term ecosystem research and monitoring, LTER-D, addressed this issue recently with an insect monitoring program based on Malaise traps. The program started in April 2019 and is intended to run for at least 10 years. More than 25 institutions from the North Sea / Baltic Sea to the Alps responded to the initial call for participants. The participants are operating the traps on a voluntary base and the samples will be centrally processed at the Research Institute Senckenberg. The poster shows the basic setup of the program and the geographical distribution of the traps over Germany.

Session 34-P5 - Biodiversity monitoring schemes

The project BienABest: Standardized monitoring of wild bees for the evaluation of their potential as pollinators in the agricultural landscape

Hannah Burger[1], Sabrina Krausch[1], Ulrich Neumüller[1], Heike Seitz[2], Ljuba Woppowa[2], Hans Schwenninger[1], Manfred Ayasse[1]

[1]University of Ulm, Institute of Evolutionary Ecology and Conservation Genomics, Ulm, DE
[2]VDI-Gesellschaft Technologies of Life Sciences, Düsseldorf, DE

The aim of the joint project BienABest (standardized monitoring of wild bees for the evaluation of their potential as pollinators in the agricultural landscape, supported by the Federal Program for Biological Diversity in the focus area "Ecosystem Services") is to safeguard and extend the ecosystem service "Pollination by Wild Bees". To this end, procedures will be developed and standardized that can also be used as a basis for a systematic long term monitoring. The project consists of an implementation project (University of Ulm) and a standardization project (VDI). In the implementation project, procedures will be developed to counter the drastic decline of wild bee populations, to increase their abundance and diversity and to promote the pollination potential. A method of live determination for wild bees will be developed, and subsequent scientific generations will be trained so that they can apply these methods. In the standardization project, the new procedures will be described within VDI guidelines that will be available to all interested parties after publication. The public will be informed about the benefits of the biodiversity of wild bees as part of a comprehensive public relation work and measures for their preservation and protection will be presented. One focus will be on the use of social media, which can also be used to draw the attention of young people to this topic. Meanwhile the project is successfully running since May 2017 and will end in April 2023.
The Association of German Engineers (VDI e. V.) co-ordinates the project. The associated partner is the University of Ulm. This project is funded by the Federal Agency for Nature Conservation (BfN) with resources from the Federal Ministry for Environment, Nature Conservation and Nuclear Safety (BMU). The project is financially supported by the Ministry of the Environment, Climate Protection and the Energy Sector Baden-Württemberg, BASF SE, and the Bee Care Center of Bayer AG.

Session 34-P6 - Biodiversity monitoring schemes

Deep Learning Approaches for Automatic Analysis of Plant Species and Coverage Determination

Matthias Körschens[1,3,4], Christine Römermann[1,2,4], Solveig Franziska Bucher[1,2,4], Josephine Ulrich[1], Joachim Denzler[3,4]

[1]Institute of Ecology and Evolution with Herbarium Haussknecht and Botanical Garden, Department of Plant Biodiversity, Friedrich Schiller University Jena, Jena, DE, matthias.koerschens@uni-jena.de
[2]German Centre for Integrative Biodiversity Research (iDiv) Halle-Jena-Leipzig, Leipzig, DE
[3]Institute of Computer Science, Computer Vision Group, Friedrich Schiller University Jena, Jena, DE, matthias.koerschens@uni-jena.de
[4]Michael Stifel Center Jena, Jena, DE, matthias.koerschens@uni-jena.de

Due to the increase of anthropogenic influence in nature, especially with regard to climatic change, monitoring plants and animals is becoming more and more important to quantify the impact of humans on the natural environment and methods for successful nature conservation.
The continuous observation of species or also individuals can be extremely laborious and time-consuming due to the large amounts of data that ideally have to be recorded for each monitored plant or animal. This is especially true, if a large number of different species or individuals are being observed.
In the last years there have been great advances in the field of computer vision with the development of convolutional neural networks (CNNs). CNNs are machine learning models capable of extracting information from data, for example texts and sound files, but also especially images. Thus, they are suited for automating large parts of the data collection process through image analysis and hence lifting quite a large workload off the shoulders of field researchers.
Currently CNNs are applied in many different scenarios, some of the most prominent examples being automatic translation, voice assistants and self-driving cars. In biological research areas, especially biodiversity research, there are also many possible applications of this technology, but there is only a small number of cases where it is actually utilized.
We are developing and presenting a system using convolutional neural networks to support field researchers with automatic analysis of the coverage in images of, for example, vegetation plots, with the aim of extending it to also cover the phenology of the plants. With such a system, the analysis of large amounts of image data, e.g. from extensive time series, will become feasible and time efficient. The system is developed in an interdisciplinary fashion in a cooperation between biologists and computer scientists.

Session 34-P7 - Biodiversity monitoring schemes

Combining remote sensing and field surveys in the Austrian farmland biodiversity monitoring "ÖBM Kulturlandschaft"

Stefan Schindler[1], Gebhard Banko[1], Dietmar Moser[1], Martin Neuwirth[1], Stefan Lackner[1], Roland Grillmayer[1], Kathrin Pascher[2]

[1]Environment Agency Austria, VIENNA, AT
[2]University of Natural Resources and Life Sciences Vienna (BOKU), Institute of Zoology, VIENNA, AT, kathrin.pascher@boku.ac.at

"ÖBM-Kulturlandschaft" is an Austrian biodiversity monitoring program for habitats and species in Austrian cultural landscapes, including alpine pastures. The stratified random selection of the sampling sites is based on the 1 km² grid of Statistics Austria with a minimum of 50% of agricultural area. 100 sampling sites are arranged hierarchically by (i) remote sensing based landscape survey: 3 x 3 km² - landscape plots, (ii) habitat mapping: 625 m x 625 m test areas; and (iii) organismic surveys (vascular plants, grasshoppers, butterflies) in ten test circles per test area. A rolling survey was conducted: in the first year of the survey, 50 of the 100 sampling plots were covered, in the second survey year the remaining 50. The repetition of surveys will take place every four to five years. Survey methods for organismic groups are closely aligned with those applied in the monitoring program Biodiversity-Nature-Safety (BINATS) that focusses on arable land (maize and oilseed rape cultivation areas). Recording of habitat types is based on the Austrian Habitat Red Lists. Remote sensing analyses include phenological characterizations of the habitat types and detection of changes in ecosystem functions (e.g. NDVI) and ecosystem structure (e.g. land cover). In this poster, we demonstrate the methodological approach and report first results from the baseline survey, conducted in the years 2017/18. We further discuss implications and suggestions for a European monitoring of biodiversity in agricultural landscapes.

Arboreal shelters along an elevation gradient: Amphibians in tank bromeliads

Yonatan Aguilar Cruz[1], María de los Ángeles Arenas Cruz[3], Leticia M. Ochoa Ochoa[2], Gerhard Zotz[1]

[1]Carl von Ossietzky Universität Oldenburg, Oldenburg, DE
[2]Universidad Nacional Autónoma de México, Mexico City, MX
[3]Benemérita Universidad Autónoma de Puebla, Puebla, MX

In Neotropical forest, bromeliads are by far the most important epiphytes in terms of biomass and abundance. Many bromeliads produce water-impounding phytotelms that are often inhabited by amphibians, which depend directly or indirectly on them. Bromeliads can buffer the impact of adverse environmental conditions and provide otherwise missing resources, such as water and foraging, mating and nesting grounds on trees. In this study, we applied a non-destructive sampling technique to investigate how frequently amphibians use tank bromeliads as a shelter and evaluated the association with plant size, tank water and organic matter. Our study was conducted in five different forests along an elevation gradient (0–2200 m a.s.l) in the central region of Veracruz, Mexico. In each forest, we relocated 15 tank bromeliads on large trees at 1.5 m above the ground. In monthly intervals during 2018, we inspected the bromeliads for amphibians and quantified the amount of organic matter and water in the tanks. Our results show that bromeliads were used by amphibians in all five ecosystems along the elevation gradient, with no significant site differences in the monthly encounter rate. Over 12 months, we found 34 specimens belonging to seven species, including six anurans and one salamander. Anurans dominated the amphibian communities in the lower part of the gradient (≤1000 m a.s.l.), while lungless salamanders (Plethodontidae) were exclusively found in the cloud forests in the middle part (1600–2200 m a.s.l), where they were more abundant than any other amphibian. The amount of water in the tank of bromeliads was positively associated with the presence of amphibians, whereas the opposite was true for the interaction of water and organic matter. Neither plant size nor organic matter alone had a significant effect on the presence of amphibians in bromeliads. Our non-destructive sampling technique proved to be effective for recording frogs and salamanders in different ecosystems, as it does not require special equipment and represents a practical option for future biodiversity studies on amphibians in the Neotropics.

SESSION 35

Means vs. extremes - what shapes our ecosystems?

Chairs: Tobias Mette, Wolfgang Falk

In 2018, Germany experienced the longest-lasting drought ever recorded. But did it trigger long-term changes in our ecosystems? Or how extreme must an event become to substantially disturb ecosystem functions? Motivated by the methodological challenges of extreme event ecology, this session brings together studies that address eco-physiological responses to extreme events. The focus lies primarily on climatic extreme events like droughts, late frost, extreme precipitation, flooding, storms and fires. The response scale ranges from individual traits to population structure to ecosystem functions. The type of study includes experimental, observational and modelling approaches. Examples of possible research questions are:

- How does the investigated extreme event affect the organism/ population/ ecosystem?
- What is the dose-response relationship between the “extreme”ness of an event and the reaction of the organism/ population/ ecosystem?
- At what intensity/ frequency does an extreme event lead to long-term or even irreversible changes in the organism/ population/ ecosystem?
- Do organisms/ populations/ ecosystems possess an ecological memory that allows for a higher resilience to future extreme events?
- How does climate change alter extreme event frequency/ intensity and what is the impact on organism/ population/ ecosystem level?
- What options exist to mitigate adverse consequences?

After a decade of research on the ecological impact of extreme events mani-fold evidence has given insight into how far extreme events shape our ecosystems. The session aims to assemble current research work on different spatio-temporal scales. It encourages the scientific exchange on problems and solutions of investigating rare events in ecology, and identifies knowledge gaps for future research.

Session 35-O1 - Means vs. extremes

Australian aquatic fauna in European mountain forests: black swans (*Cygnus atratus*) are coming

Harald Bugmann[1]

[1]Forest Ecology, ETH Zurich, Zurich, CH, harald.bugmann@env.ethz.ch

The impacts of climate change on ecosystems have been the subject of a lot of research over the past two decades. Initial model-based projections for forests suggested massive dieback events due to the mismatch between climate and the requirements of tree species. Later research has shown that this alarmist view may not be fully appropriate.
I will present a review of the state-of-the art of climate impact assessment on mountain forests and their ecosystem services, pointing out under which circumstances dramatic responses may be expected, and what the role of climate-adaptive forest management may be.
I will explain why, under most circumstances, mountain forest dynamics will be progressing in a smooth manner in response to chronic climate change, whereas unexpected phenomena (such as the black swans of Australia that were believed to be impossible from a European perspective) are likely to have dramatic consequences for mountain forests (actually, forests in general) and the ecosystem services they provide, including carbon storage, diversity, and the protection from gravitative natural hazards such as avalanches and rockfall. I will provide examples of such black-swan effects in forests and beyond.

Session 35-O2 - Means vs. extremes

No easy answers for complex questions - lessons from a decade of intense research on ecophysiological responses of trees to extreme drought

Henrik Hartmann[1]

[1]Max-Planck Institute for Biogeochemistry, Jena, DE, hhart@bgc-jena.mpg.de

During the last decade numerous reports of elevated tree mortality in response to extreme climate, in particular drought and heat, have been published. These alarming reports suggested a potential climate change risk for global forest survival and underscored the need for predicting forest dynamics under ongoing climate change. Several case studies of forest responses to extreme events indicated that impacts on trees are highly species-specific raising questions about the underlying mechanisms. The seminal paper by McDowell et al. (2008) hypothesized two interdependent mortality mechanisms, hydraulic failure and carbon starvation, as explanation why some species die during drought while others survive. Interestingly, carbon starvation is also the main woody vegetation mortality mechanism in many dynamic global vegetation models, making investigations on drought mortality also highly relevant for vegetation modellers. A decade of fruitful research on drought mortality has provided many interesting insights into tree functioning under severe water limitation. It has become apparent that damages to the hydraulic system often go along with changes in carbon storage availability corroborating the interdependency of the tree water and carbon budget. At the same time, however, intensifying forest decline in North America and Europe from biotic agents increasingly underscores the need for a better understanding of how climate change drives tree physiological interactions with biotic agents. Such knowledge is urgently needed to improve forecasting of forest dynamics under ongoing climate change and also for developing mitigation strategies for forest management. In this presentation I will give a brief overview of research on drought-induced tree mortality during the last decade and provide one example of where substantial progress can be made – tree interactions with bark beetles.

Session 35-O3 - Means vs. extremes

Quantifying spatial patterns of forest resilience to local drought stress using NDVI and defoliation data across Europe

Sven Rubanschi[1,2], Arnaud Guyennon[3], Wanda De Keersmaecker[4], Georges Kunstler[3], Björn Reineking[3], Florian Hartig[2]

[1]Technical University of Munich, Munich, DE, sven.rubanschi@tum.de
[2]University of Regensburg, Regensburg, DE, sven.rubanschi@tum.de
[3]Université Grenoble Alpes, Grenoble, FR
[4]KU Leuven, Leuven, BE

Forest resilience describes the ability of forest ecosystems to withstand and recover from disturbances. One of the most important disturbance agents, in particular in the context of climate change, are droughts. Resilience to droughts has been examined in many studies at the local scale, but so far, we have few methods to extrapolate these results in space and produce comprehensive maps of drought susceptibility at continental scales. Here, we explore a new indicator based on the drought response of satellite remote sensing (NDVI) to drought stress (SPEI). We decompose the NDVI sensitivity to drought into contributions of climate, forest composition, and residual variation, the latter being interpreted by us as variability in local resilience that is unexplained by the former factors. In a second step, we validated our results to defoliation measurements from forest inventory data. Our results show that the estimated sensitivity of NDVI to drought is similar to the sensitivity of the locally measured defoliation signal, suggesting that our indicator is a useful measure of leaf-level resilience to drought. We thus expect that this indicator should correlate well with short-term growth responses. However, because the magnitude of drought effect was much smaller for defoliation than NDVI, it is crucial to evaluate, in further studies, whether this indicator corresponds to lasting damage to the trees, in particular mortality. Mapping our indicator across Europe suggests that Southern Europe forests react overall stronger to droughts. We conclude that our NDVI-based resilience indicator is a promising way forward to create continental maps of forest resilience to drought. More research, however, is needed to better understand the correlation of this indicator with forestry-relevant variables, such as mortality or reductions in forest productivity.

Session 35-O4 - Means vs. extremes

Impact of the extreme summer drought 2018 on the physiological integrity of European tree species

Matthias Arend[1], Günter Hoch[1], Rachel Patthey[1], Bernhard Schuldt[2], Roman Link[2], Ansgar Kahmen[1]

[1]Universität Basel, Basel, CH, matthias.arend@unibas.ch
[2]Universität Würzburg, Würzburg, DE

In 2018, an exceptionally strong summer drought impacted forests in Northern and Central Europe, causing striking tree damages and mortality. At the recently established Swiss Canopy Crane II site, we investigated the effect of this exceptional drought event on the physiological integrity (water and carbon relations) of adult individuals of Beech, Oak, Maple, Horn beam, Ash, Service tree, Spruce, Silver fir and Scots pine. Mid-day twig water potentials reached low values in summer and early autumn, coming close to, or even exceeding, the critical xylem pressure leading to a loss of hydraulic conductance and hydraulic failure. In leaves, stomatal conductance was strongly reduced in Beech, Spruce and Silver fir, while the other species maintained much higher values during and after drought. The analysis of non-structural carbohydrates showed that carbon reserves were depleted in the tested tree species during the drought event but recovered in the following autumn. Among the observed tree species, only Beech and Spruce developed visible symptoms during the drought event, with strong leaf browning and shedding in Beech and fast canopy die-back and subsequent tree death in Spruce. Canopy die-back in Spruce was accompanied by a sudden decline of water potentials to exceptionally low values and a complete loss of xylem hydraulic conductance, suggesting desiccation and hydraulic failure as the main cause of drought-induced mortality. In Beech, we observed die-back of the upper canopy in the following spring, which was associated with a persistent loss of xylem hydraulic conductance. Taken together, our observations show that Spruce and Beech were most impacted by the summer drought 2018, exceeding the tipping points of physiological integrity. Furthermore, the sudden desiccation and mortality of Spruce during drought and the post-drought canopy damage in Beech suggest nonlinear responses of trees to extreme drought events.

Session 35-O5 - Means vs. extremes

Ecological impacts of climatic extreme events: Heavy rainfall has clearer effects on grassland ecosystem functioning than drought

Mohammed A. S. Arfin Khan[1,2], Juergen Kreyling[3], Peter A. Wilfahrt[1], Anke Jentsch[1]

[1]Disturbance Ecology, University of Bayreuth, Bayreuth, DE, mohammed.arfin-khan@uni-bayreuth.de
[2]Forestry and Environmental Science, Shahjalal University of Science and Technology, Sylhet, BD, mohammed.arfin-khan@uni-bayreuth.de
[3]Experimental Plant Ecology, University of Greifswald, Greifswald, DE

Future climate change predict higher frequency and intensity of extreme climatic events with long term changes in ecosystem functioning. Climate impact research predominantly focus on drought effects, with less attention paid to heavy rainfall. Furthermore, ecosystem functioning is usually examined by focusing on primary production, though results have been mixed as to whether climatic events stimulate extreme ecological responses across multiple ecosystem functions. Combining both ends of precipitation extremes with multiple ecosystem responses are necessary to understand grassland systems regulation in future.
We report on the effects of drought events relative to heavy rainfall from a six-year precipitation manipulation experiment in a European mesic grassland. Plant communities were planted at multiple diversity levels, and drought and heavy rainfall treatments were imposed by simulating 1000-year events based on the local climate records. We report on measured response parameters representing five categories of ecosystem functioning: Primary production, water regulation, carbon fixation, nutrient cycling, and community response.
Heavy rainfall had significant effects in 24 of the 30 response parameters in at least one year. Most striking was an observed increase in primary production under heavy rainfall, while drought had no significant effect. Additionally, decomposition rate, mycorrhization rate, and soil microbial biomass increased due to heavy rainfall with increasing availability of soil nitrogen in the form of nitrate and ammonium. Moreover, we found changes in plant physiology and community dynamics.
Responses of our grassland to heavy rainfall were rapid and promoted increased productivity across multiple trophic levels, while drought effects initiated ecosystem-regulating functions to maintain levels of plant biomass. This suggests that temperate grasslands can be water-limited, and heavy rainfall may trigger long-term ecological changes than drought.

Session 35-O6 - Means vs. extremes

Immediate plant trait and community response to extreme drought indicate high sensitivity and performance advantages in montane *Nardus* grasslands

Nils Stanik[1], Gert Rosenthal[1]

[1]University of Kassel, Department of Landscape and Vegetation Ecology, Kassel, DE, nils.stanik@uni-kassel.de

It is predicted that impacts of global change will affect the biodiversity of grassland ecosystems particularly in mountain regions. For example, extreme drought periods are considered to influence not only plant species' fitness but also grassland's community composition. In order to gain insights into responses of plant species and the community composition of a European montane grassland type of high conservation value (species-rich *Nardus* grasslands), we investigated impacts of heavy / moderate drought in combination with management change. In a rainout-shelter experiment in the Rhön Mountains (Germany), we examined both the intra-specific response of *Arnica montana* and responses of the *Nardus* grassland community. At species' level, we compared morphological, reproductive and physiological plant functional traits of three *Arnica* provenience and at community level, we assessed the community response by using community structure and composition measures.
We found that both *A. montana* and the community composition of *Nardus* grasslands show immediate responses to heavy drought. For *A. montana*, the results highlight a significant response of traits in all tested groups. Response curves, especially those of morphological and physiological traits, were rather attributed to the management treatment and *Arnica*'s provenience than to a specific drought treatment, considering the extreme weather conditions in 2018. The *Arnica* provenience from higher altitudes had a better trait performance than those from lower altitudes. Moreover, the *Nardus* grassland community showed a strong abundance-driven shift towards a more heterogeneous species composition and community structure under last year's drought in all treatments. Based on recent data from the ongoing experiment gained in 2019, we suppose an indication of resilience in the vegetative performance of *A. montana* but a rather vulnerable state of the *Nardus* grassland community.

Session 35-P1 - Means vs. extremes

The Influence of Average Climate Conditions and Extreme Climatic Events on Survival of Spruce, Pine and Beech in Europe

Susanne Brandl[1], Tobias Mette[1], Wolfgang Falk[1]

[1]Landesanstalt für Wald und Forstwirtschaft, Freising, DE

Throughout the world increases in tree mortality have been observed in recent years. Often these increases have been associated with heat and drought due to climate change. Based on a pan-European data set (Level I and Level II data, ICP Forests 2018) we investigate the relationship between climate and mortality risk for Germany's three most common tree species, Norway spruce, Scots pine and European beech. Using exploratory methods from epidemiology and survival analysis we assess both the long-term influence of average climate conditions (30-year averages), as well as the short-term influence of single years (climate indices calculated annually) on mortality risk. In line with the decline disease concept (Manion 1981), a theoretical concept of stress-induced tree mortality, our results indicate that mortality risk is determined by a complex interaction of predisposing factors (i.e. average climate conditions) and inciting factors (i.e. extreme climatic events) which are difficult to disentangle.

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Session 35-P2 - Means vs. extremes

Early emergence increases survival of tree seedlings in Central European temperate forests despite severe late frost

Eva Bianchi[1], Harald Bugmann[1], Christof Bigler[1]

[1]Forest Ecology, Institute of Terrestrial Ecosystems, Department of Environmental Systems Science, ETH Zurich, Zürich, CH, eva.bianchi@usys.ethz.ch

Global warming is expected to result in earlier emergence of tree seedlings that may experience higher damages and mortality due to late frost in spring. We monitored emergence, characteristics and survival of seedlings across four tree species in temperate mixed deciduous forests of Central Europe over one and a half year. 2017 was very favourable for the purposes of this study because both a severe late frost and summer drought occurred in the same year. Almost two-thirds of the seedlings died during the first growing period. Our study on the development of germination and seedling survival in 2017 provides empirical evidence of the fundamental ecological importance of emergence time in combination with late frost events for seedling survival of multiple tree species in temperate forests of Central Europe. The timing of seedling emergence represents a trade-off between decreasing the frost risk and increasing the length of the growing period, which has not been systematically investigated before. While early emerging seedlings had high survival probabilities in spite of facing an exceptionally severe spring frost event, survival decreased with later emergence time. Our results further indicate seedling- and substrate-specific effects such as the number of leaves and height along with seedbed and microsite as decisive for survival during the first growing period. Apart from the adverse effect of frost on the survival of beech seedlings, climatic conditions and light availability had relatively weak impacts on seedling survival. Our findings nevertheless indicate that tree seedling survival during the first growing period depends on a multitude of interacting biotic and abiotic factors. In light of the relatively low survival during the first growing period, the first months of a seedling's life appear to represent a major bottleneck for successful tree regeneration, which will ultimately have an impact on the future development of forest stands.

SESSION 36

Grasslands: causes and consequences of biodiversity decline

Chairs: Nico Blüthgen, Nadja Simons

Naturally assembled grasslands, including meadows, pastures, dry swards and wetlands, are particularly vulnerable ecosystems and contain numerous threatened plant and animal species. Increased fertilization and eutrophication, intensive mowing with effective machinery, changes in grazing regimes, climate change and intensification in the surrounding landscape are known to negatively affect the biodiversity in grasslands. Declines in biodiversity occur across all trophic levels, from plants as primary producers, to insects as herbivores or pollinators, to mammals or birds as secondary consumers. Often, declines in one trophic level lead to declines in higher trophic levels even though if those are not directly impacted by the original drivers of biodiversity decline. In this session, we hope to learn about (1) the extent of current changes in biodiversity; (2) drivers of declines in abundance and species diversity or changes in community composition; (3) the consequences of such losses for biodiversity or ecosystem processes within and outside the grassland systems. Contributions from all types of grassland systems are welcome.

Session 36-O1/2 - Grasslands

Larval and phenological traits predict insect community response to mowing regime manipulations

Roel van Klink[1], Myles Menz[1,3], Hannes Baur[1,3], Oliver Dosch[1], Isabel Kühne[1], Lukas Lischer[1], Henryk Luka[4], Sandro Meyer[1], Timea Szikora[1], Debora Unternährer[1], Raphaël Arlettaz[1,5], Jean-Yves Humbert[1]

[1]University of Bern, Bern, CH
[2]University of Western Australia, Crawley, AU
[3]Natural History Museum Bern, Bern, CH
[4]Research Institute of Organic Agriculture FiBL, Frick, CH
[5]Swiss Ornithological Institute, Sion, CH

For the restoration of biodiversity in agricultural grasslands, it is essential to understand how management acts as an ecological filter on the resident species. Mowing constitutes such a filter: only species that possess functional traits enabling them to withstand its consequences can persist in the community. We investigated how the timing of mowing modulates this filtering effect for insects. We predicted that two traits drive species responses. Species with larval development within the meadow vegetation will suffer more from mowing than species whose larvae develop in or on the ground, or outside the meadows, while species with a later phenology should benefit from later mowing. We conducted a five-year experiment, replicated at 12 sites across the Swiss lowlands, applying three different mowing regimes to low-intensity hay meadows: (1) first cut of the year not earlier than 15 June (control regime); (2) the first cut delayed until 15 July; and (3) leaving an uncut grass refuge on 10–20% of the meadow area (after earliest first cut on 15 June). Before the first cut in years 4 or 5, we sampled larvae of Lepidoptera and sawflies, and adults of moths, parasitoid wasps, wild bees, hoverflies, ground beetles, and rove beetles. Overall, before the first cut of the year, abundances of species with vegetation-dwelling larvae were higher in meadows with delayed mowing or an uncut grass refuge, with some taxon-specific variation. In contrast, species whose larval development is independent of the meadow vegetation showed no differences in abundance between mowing regimes. Species richness did not differ among regimes. For species with vegetation-dwelling larvae, a fourth-corner analysis showed an association between early phenology and the control regime. No associations were found for the other functional groups. Our results show that slight modifications of mowing regimes, easily implementable in agri-environmental policy schemes, can boost invertebrate abundance, potentially benefitting insectivorous vertebrates. Ecological Applications, 0(0), 2019, e01900.

Session 36-O3 - Grasslands

Effects of land-use stress and pesticides on the chemical communication of wild bees

Florian Straub[1], Heike Layer[1], Judith Kimmich[1], Miriam Teuscher[2], Juliane Vogt[3], Manfred Ayasse[1]

[1]Ulm University, Institute for Evolutionary Ecology and Conservation Genomics, Ulm, DE, florian.straub@uni-ulm.de
[2]Senckenberg Gesellschaft für Naturforschung, SBiK-F, Biodiversity Exploratories, Frankfurt/Main, DE
[3]Technical University of Munich, Chair for Terrestrial Ecology, Biodiversity Exploratories, Munich, DE

In the last years, there is clear evidence for significant declines of insect pollinators such as wild bees in agricultural areas. These declines are due to many factors e.g. habitat and food loss, emergent diseases, pesticides and climate change. In intensified agricultural areas pollinators are chronically exposed to various pesticides that were found to negatively affect foraging bees by altering orientation and learning behaviour. An effect of pesticides or other stressors on chemical communication, however, has rarely been investigated.
We studied the effects of stressors, which affect pollinators in intensified agricultural areas, on chemical communication of wild bees. In the Biodiversity Exploratories, *Bombus lapidarius* workers were caught in grasslands with different land-use intensities. In chemical analyses of cuticle surface odours with a function in chemical communication, we found a significant effect of land-use intensity on scent bouquet. In a further study, we tested the effects of single stressors such as neonicotinoids, on communication and antennal sensitivity for semiochemicals. Bumblebees and mason bees were treated with field realistic doses of neonicotinoids. Workers of *B. terrestris* differed significantly in their chemical profile after treatment with thiamethoxam or clothianidin, in the mason bee *Osmia bicornis*, clothianidin decreased antennal sensitivity to common floral volatiles.
In our study we found an effect of neonicotinoids on the production and perception of semiochemicals in bumblebees and mason bees. For *B. lapidarius*, it is not finally clarified, which stressor led to the changes in the scent bouquet. However, our results indicate that agricultural management and agricultural practice may have a negative effect on chemical communication and pollination.

Session 36-O4 - Grasslands

Do Agri-Environment Schemes Increase Species Diversity in Grassland? - Long Term Development of Managed Grassland

Sabine Heinz[1], Franziska Mayer[1], Gisbert Kuhn[1]

[1]Bayerische Landesanstalt für Landwirtschaft, Institut für Agrarökologie, Freising, DE, Sabine.Heinz@LfL.Bayern.de

Whereas the less intensive grassland management of former centuries led to the development of distinct species rich grassland plant communities, restructuring and intensification of the last few decades caused the opposite effect. To counteract this trend agri-environment schemes (AES) co-financed by the European Union have been developed to compensate for financial disadvantages of the farmers in exchange for low-intensity management.
In a first survey 2002-2008 the Bavarian grassland survey investigated the vegetation of over 6000 grassland sites of different farming intensities and geographical and climatic conditions. In the second survey 2485 of the grassland sites were revisited between 2009 and 2012. Whereas about half of the repeated plots belonged to any AES, the others served as reference plots without AES. On each plot of 25 m² the plant species composition and the proportion of total yield of each species was documented.
As in the first survey grassland plots participating in AES showed higher mean species numbers than plots without. Comparing grassland plots participating in different AES showed a relation between the extent of the scheme adopted and species number. Extensive management constraints diminished the yield and increased species richness.
Comparing sites which continued the same measure with sites changing the measure or leaving the AES showed, that clinging to the same measure further increased species number. Sites leaving AES distinctively decreased their species number, while sites joining the AES increased species number. This effect was also influenced by the species number of the site: Especially species poor sites below the Bavarian mean of 20 species / 25 m² benefitted of joining AES and their species number was increased. Changing, leaving or staying in the same AES showed a correlation to species number and stocking rate in the first survey.

Session 36-O5 - Grasslands

Resistance of loess steppe fragments to native woody encroachment

Béla Tóthmérész[1,2], Balázs Teleki[1], Judit Sonkoly[3], László Erdős[4], Péter Török[4]

[1]University of Debrecen, Department of Ecology, Debrecen, HU, tothmerb@gmail.com
[2]MTA-DE Biodiversity and Ecosystem Services Research Group, Debrecen, HU, tothmerb@gmail.com
[3]MTA-DE Lendület Functional and Restoration Ecology Research Group, Debrecen, HU
[4]MTA Centre for Ecological Research, Institute of Ecology and Botany, Vácrátót, HU

The effect of native woody encroachment was studied on grassland biodiversity in loess steppe fragments with increasing level of encroachment. Both ancient and recovered grasslands were studied. We explored the following hypotheses: (i) increased woody cover decreases total diversity, and the cover and species richness of dry grassland species; (ii) both grassland origin and woody cover affect grassland biodiversity. 54 loess grassland fragments were studied in Hungary. Percentage cover of trees, shrubs and herbaceous vegetation were recorded in 400-m2-sized plots. We found that moderate woody encroachment decreased neither the total herb cover nor the cover and species richness of dry grassland species. Grassland origin caused no significant difference in the herbaceous vegetation. We found that both species richness and species composition were highly resistant to moderate woody encroachment, significant changes were detected only at high woody cover. Moderate woody encroachment does not influence species composition and does not decrease diversity of loess grasslands. Thus, shrub encroachment cannot be regarded as degradation in contrast to overuse and/or misuse of grasslands. These findings suggest that moderately encroached loess grasslands can be restored by the suppression of woody species, as their species pool still contains many dry grassland species targeted for restoration.

Session 36-O6 - Grasslands

The impact of large-scale agricultural change on biodiversity and ecosystem processes across the Eurasian steppes

Johannes Kamp[1], Matthias Baumann[2], Andrey Dara[2,3], Martin Freitag[1], Brett R Hankerson[2,3], Norbert Hölzel[1], Tobias Kuemmerle[2,4], Daniel Müller[2,3], Alexander V. Prishchepov[5,6], Florian Schierhorn[3], Alyona Koshkina[1,7], Frederike Velbert[1], Ruslan Urazaliyev[1,7]

[1]Westfälische Wilhelms-Universität Münster (WWU), Institute of Landscape Ecology, Münster, DE, johannes.kamp@uni-muenster.de
[2]Geography Department, Humboldt-University Berlin, Berlin, DE
[3]Leibniz Institute of Agricultural Development in Transition Economies (IAMO), Halle/Saale, DE
[4]Integrative Research Institute on Transformations of Human-Environment Systems (IRI THESys), Humboldt University Berlin, Berlin, DE
[5]Department of Geosciences and Natural Resource Management, University of Copenhagen, Copenhagen, DK
[6]Institute of Steppe of the Ural Branch of the Russian Academy of Science (RAS), Orenburg, RU
[7]Association for the Conservation of Biodiversity of Kazakhstan (ACBK), Center for Conservation Science, Almaty, KZ

The Eurasian Steppe stretches from Ukraine to the Altai Mountains. Ten percent of the world's natural grasslands are found in Kazakhstan alone. The steppes host a considerable number of globally threatened and biome-restricted plant and animal species. They also harbour large populations of what is known as "farmland biodiversity" in Central Europe.
The steppes of Kazakhstan remained largely untouched until the 1960s, when 25 million hectares of grassland were converted to cropland. Thirty years later, the break-up of the Soviet Union in 1991 led to a collapse of the state farming sector and massive rural human outmigration. This resulted in large-scale cropland abandonment, a collapse in grazing livestock numbers and changing grazing patterns.
We aimed to map extent and time-scale of these land-use changes, to assess biodiversity responses and evaluate potential impacts on ecosystems processes. We found that 30% of all cropland remains abandoned in Kazakhstan, and that the area of regularly grazed steppe declined tenfold since 1991. The number and size of wildfires in the Kazakh steppes increased seven- to eightfold in the same period, triggered by increased biomass accumulation after cropland and pasture abandonment and changing cropland management. Steppe bird and small mammal communities recovered on abandoned cropland, but were negatively affected by a lack of grazing. A high fire recurrence rate led to a homogenization of vegetation with an increased cover of grasses, which in turn affected community composition and abundance of birds.
In our talk, we will present a synthesis of a decades' worth of ecological research and will discuss the application of our results for conservation planning and management.

Session 36-O7 - Grasslands

Scale-dependent impact of land management on above- and belowground biodiversity

Eleonore Slabbert[1,2], Oliver Schweiger[1], Tesfaye Wubet[1,3], Antje Kautzner[1], Tiffany Knight[1,2,3]

[1]Department of Community Ecology, Helmholtz Centre for Environmental Research - UFZ, Leipzig, DE, eleonore.slabbert@ufz.de
[2]Institute of Biology, Martin Luther University Halle-Wittenberg, Halle (Saale), DE, eleonore.slabbert@ufz.de
[3]German Centre for Integrative Biodiversity Research (iDiv) Halle-Jena-Leipzig, Leipzig, DE

Detailed spatial responses of biodiversity to environmental change are of high importance to identify underlying mechanisms causing structural changes to biotic communities. Currently, most research focuses on responses at single spatial grains and of a single taxonomic group. This limits our ability to generalize whether results vary across space and taxonomic groups. To address these knowledge gaps, we investigated scale-dependent effects of land management (LM) (pastures vs. meadows) and land-use intensity (LUI) in central Germany for plants, fungi and bacteria.
Plants and soil microbe (fungi and bacteria) diversity were sampled from plots in pastures and meadows at five study sites that occur along a gradient of LUI. Plants were identified to species, while soil microbes were identified to operational taxonomic units using genomic DNA and 16sRNA. Analyses included diversity partitioning of species richness (S) and related biodiversity components (i.e. number of individuals (N); species abundance distribution (SAD) and spatial aggregation) at α- (plot), β- (turnover) and γ- (site) scales.
Scale-dependent responses to LM were taxa- and site-specific, with a varying role of LUI. Plants responded more to LM at α-scale, while the soil microbes responded at both α- and γ-scales. Differences across taxonomic groups were presumably due to varying dispersal abilities and consequences of historic land-use practices. Changes in S were not caused only by altered N, but rather by changes in the evenness (SAD) of communities. Our findings provide evidence of scale- and taxa-specific biodiversity patterns in response to LM that are not easily extrapolated along LUI gradients. Insights gained can be used to understand underlying changes to biodiversity in managed ecosystems and be applied toward management practices and policies that aim to conserve biodiversity across multiple-scales.

Session 36-O8 - Grasslands

Effects of land-use and biodiversity on ecosystem resilience - a meta-analysis of manipulative experiments in German grasslands

Abiel Rindisbacher[1], Santiago Soliveres[2], Markus Fischer[1], Eric Allan[1]

[1]University of Bern, Bern, CH, abiel.rindisbacher@ips.unibe.ch
[2]University of Alicante, Alicante, ES

Evidence from biodiversity experiments and observational studies indicates that biodiversity is important for the resilience of ecosystems. However, how land-use effects resilience directly or indirectly via biodiversity in real-world systems is less well known.
To address this question, we synthesized available evidence from manipulative experiments that were conducted within the framework of the Biodiversity Exploratories. This large-scale and long-term research project in Germany covers a land-use intensity gradient in 150 temperate agricultural grasslands. In these experiments, different types of perturbations where applied and a wide range of ecosystem variables were measured. We quantified the resistance as the deviation of the treatment level from the control level using log response ratios. This meta-analytic approach allowed for a comparison across different measurements and different types of perturbations.
We found that ecosystem variables in real-world grasslands with a higher (aboveground) biodiversity showed a greater deviation from the control level and thus a lower resistance to disturbance compared to grasslands with a lower diversity. However, the direction of the deviation was different for aboveground and belowground ecosystem variables: while aboveground variables decreased more, belowground variables increased more with increasing biodiversity due to the disturbance. Land-use affected resistance to disturbance indirectly via its negative effect on biodiversity. For climate change related stresses (drought, temperature increase) and fertilizer addition we found no effect of biodiversity or land-use intensity on resistance.
Our results suggest that real-world grassland systems with high biodiversity are potentially less resistant and thus more vulnerable to disturbances. However, these systems could still be resilient by recovering from disturbances.

Session 36-O9 - Grasslands

Increasing plant diversity in agriculturally used grasslands via disturbance and seeding

Martin Freitag[1], Valentin Klaus[2], Ralph Bolliger[3], Markus Fischer[3], Ute Hamer[1], Till Kleinebecker[4], Daniel Prati[3], Deborah Schäfer[3], Norbert Hölzel[1]

[1]University of Münster, Münster, DE, martin.freitag@uni-muenster.de
[2]ETH Zürich, Zürich, CH
[3]University of Bern, Bern, CH
[4]University of Gießen, Gießen, DE

Diverse grasslands provide important ecosystem services and regulating functions. Biodiversity however has drastically declined due to agricultural intensification and the restoration of species-rich grasslands is thus a major target in nature conservation. Opening the vegetation sward and seeding diverse plant mixtures is a promising tool to increase diversity, but has rarely been applied in agriculturally used grasslands. Whether land-use intensity affects the enrichment success and how increased diversity affects ecosystem functions in real-world grasslands therefore remain widely unknown.
We established a full-factorial seeding and disturbance experiment in 73 grasslands along a land-use intensity gradient in three regions in Germany. Topsoil disturbance and a diverse seed mixture were applied to test how effectively plant diversity could be increased. Plant species richness, productivity and effects on soil nutrient availability were monitored over five years.
Our study shows that the combination of topsoil disturbance and seeding significantly increased diversity in most grasslands, while seeding alone is much less effective. After five years, plant species richness was considerably higher in the combined treatment compared to the control. Productivity and soil nutrient availability were only temporarily affected by disturbance and quickly recovered to original levels. We conclude that it is possible to increase plant diversity in most grasslands without long-term negative impacts on productivity or nutrient losses.

Session 36-O10 - Grasslands

How can grassland management help to reduce a poisonous plant without jeopardising biodiversity?

Marie-Therese Bleicher[1], Johannes Kollmann[1], Harald Albrecht[1]

[1]Technische Universität München, Weihenstephan - Freising, DE, marie-therese.bleicher@tum.de

European semi-natural grasslands are threatened by both intensified and reduced management. These land-use changes cause biodiversity losses and local dominances of unwanted species. Marsh ragwort (*Senecio aquaticus*) is a native Asteraceae occurring in wet grasslands of the pre-alpine region in Germany, Austria and Switzerland. Over the past decades, populations of that species have become more widespread and local dominance is observed. This development is unfortunate as all parts of the plant are poisonous. As herbicides or mineral fertilizer are prohibited, organic and conservation grassland are particularly affected by this problem. The present study develops suitable management options on such low-intensity grasslands. The objective is to suppress marsh ragwort by increasing competition of the associated plant assemblage and by preventing seed production, while do not jeopardising biodiversity. Thus, two experiments were established on 13 sites in total. On six nutrient-poor sites five treatments were tested with different degrees of shading to suppress the ragwort, while on seven nutrient-rich sites additional cutting regimes were applied to suppress reproduction of the ragwort. Effects on abundance and flowering of marsh ragwort and on plant diversity were monitored. The results indicate a stronger decrease in abundance of marsh ragwort in fallow or late-mown plots. In contrast, the customary management of the region did not suppress marsh ragwort or even boosted its abundance. We conclude that increased competitive ability of the grassland community helps reducing marsh ragwort.

Session 36-O11 - Grasslands

Don't judge a book by its cover - Genetic and epigenetic variation among populations of *Trifolium pratense* from contrasting habitats

Theresa Anna Lehmair[1], Peter Poschlod[1], Christoph Reisch[1]

[1]University of Regensburg, Regensburg, DE, theresa.lehmair@ur.de

Trifolium pratense L. exhibits a broad ecological niche in central European grasslands. It occurs in considerably varying ecosystems, e.g. extensively managed calcareous grasslands or intensively used oat grass meadows. In contrast to genetic mechanisms, epigenetic processes may be directly affected by highly different habitat conditions. Thus, we assume epigenetic (and maybe even genetic) differences among calcareous grassland and oat grass meadow populations.
In order to characterize possible variation patterns of *T. pratense* populations, we used methylation-sensitive amplification polymorphism (MSAP) as well as amplified fragment length polymorphism (AFLP) analyses. We investigated 160 individuals from 10 populations (5 per habitat type) all over the Swabian Alb in Southwest Germany. Furthermore, we included possible explanatory variables for those variation patterns in our analyses. Therefore, we collected information about past and present surrounding landscape structures, soil properties, vegetation, and population structures.
The aim of our study was to test whether populations from two contrasting habitat types represent different ecotypes.

Session 36-O12 - Grasslands

Does the effect of nutrient addition and competition differ between stable and declining species from *Molinia* meadows of the Lower Lake Constance area – a garden pot experiment

Stefanie Höckendorff[1], Mark van Kleunen[1]

[1]Universität Konstanz, Konstanz, DE, stefanie.2.hoeckendorff@uni-konstanz.de

The Lake Constance ecosystem and the flora along its shores have continuously been exposed to extrinsic environmental changes (over the last century). These include, among others, fluctuations of annual water level, nutrient deposition, habitat fragmentation and changed land-use regimes. In combination with intrinsic species traits, these changes may have modified species' interactions and population dynamics. Yet, exact drivers behind species responses to environmental change are unknown for this and most other regions. Two common factors hypothesized to influence plant-species responses in *Molinia* meadows are competition and changed nutrient input.
Here, we focus on a selection of c. 55 terrestrial, herbaceous species typical for *Molinia* meadows along the shores of Lower Lake Constance (bordering Germany and Switzerland). Among these species, population decline and population stability, are common. In a garden pot experiment, we used seedlings raised from seed material originating from our previous collection at Lower Lake Constance sites. In a two-factorial design experiment, we assessed species performance towards competition to a common matrix species and towards differing nutrient concentrations applied over several months.
To allow for the investigation of response patterns across species, we relate current occurrences of plant species around Lower Lake Constance to occurrences reported c. one century ago. Here, a unique dataset by Baumann (1911) allowed for the application of the baseline to the plant inventory. We updated and revisited the sites mentioned in Baumann's work during an inventory as part of field work. Focussing on stable and declining species, we test how changes in occurrence frequency relate to the factors tested in this experiment.

Session 36-O13 - Grasslands

Improvement of mesotrophic grasslands in The Netherlands

Eva Remke[1], Emiel Brouwer[1], Jan Roelofs[1]

[1]B-WARE Reserach centre, Nijmegen, NL, e.remke@b-ware.eu

Within the Natura 2000 network of The Netherlands grasslands have very low protection status. More than 80 % have a moderately low to low quality. A small percentage (27%) are species-rich and mainly oligotrophic dry and wet grasslands (e.g. dune grasslands, chalk grasslands) and a large percentage (76%) are mesotrophic, dry to moist grasslands. Recent surveys in different provinces of The Netherlands (Overijssel, Brabant) supported this low biodiversity of grasslands, mainly measured as vascular plant diversity. More than the half of the grasslands are in a phase dominated by a few grasses such as *Holcus lanatu*sor *Agrostis* spp. and percentages of herbs are low, less than 5-10%.
Three case studies are presented: mesotrophic grasslands alongside the Dommel, the Roer and the Beerze. Reasons for low diversity are mainly high soil nutrient availability, combined with drainage and low ground water tables but also wrongly timed mowing regimes. Additional problems for the management are the high heavy metal accumulations in the soils (Dommel).
Most probably, only a change of management regime will not result in species-rich grasslands. At least, just initial sowing of species rich grassland mixtures and hereafter changes in mowing regimes mostly resulted in species poor grasslands along the Beerze and in Overijssel in the last two decades. In order to improve the diversity of grasslands, an experiment has been set-up in the grasslands along the Beerze, testing the effects of a short arable phase and soil inoculation on the new establishment of permanent grasslands prior to sowing. First results will be shown and potential implications for the future management given.

Session 36-P1 - Grasslands

Seed rain in temperate grasslands: A sneak preview to a large-scale seed rain study in the Biodiversity Exploratories

Svenja Kunze[1], Martin Freitag[1], Till Kleinebecker[1], Norbert Hölzel[1]

[1]University of Münster, Institute of Landscape Ecology, DE, svenja.kunze@uni-muenster.de

Land-use intensification through fertilization and a higher frequency of mowing and grazing is one of the main drivers for plant species loss in temperate grasslands. One major effect of the earlier onset and a higher frequency of cutting and grazing is, that in many plant species the maturation of seeds is hampered or even completely prohibited. However, seed rain plays a key role for the regeneration of grassland communities and the dispersal of plant species. Currently, we often don't know whether there is a lack of seeds, but there is definitely a lack of seed rain studies in temperate grasslands in which seeds are collected the whole vegetation period and also during agricultural activities. To close this gap of knowledge we performed a large scaled field study in temperate agricultural grasslands to analyze the size and composition of seed rain in relation to land-use intensity and diversity parameters of the established vegetation.
We collected seed rain in 145 grassland sites along a land-use gradient in three different regions in Germany. On each site we sampled an area of 670cm² by digging five trays filled with sterile sand at ground level. The seed rain was collected from the end of March till mid-August, also during agricultural usage. After stratification, sand was spread on trays in a greenhouse. Emerging seedlings were regularly counted and removed for eight months to determine the size and composition of seed rain.
We counted in total 40.326 seedlings from 126 plant species. Seed rain density ranged between 90 and 68.066 seedlings/m² with a mean of 4.977 seedlings/m². Three-quarters of the seedlings were grasses, with those particularly frequent in the established vegetation such as *Poa trivialis* (32%) and *Lolium perenne* (12%) as the most frequent ones. First statistical analyses showed that the seed rain size was positively correlated with land-use intensity, while the opposite was true for plant species richness.

Session 36-P2 - Grasslands

Time will not tell – landscape, vegetation, and population structure are more important for genetic variation of litter meadow species than habitat age

Theresa Anna Lehmair[1], Ellen Pagel[1], Peter Poschlod[1], Christoph Reisch[1]

[1]University of Regensburg, Regensburg, DE

Litter meadows are species-rich and diverse ecosystems. Established by traditional land use, these meadows drastically declined during the last decades since litter is no longer used in modern livestock housing. The aim of our study was to identify the drivers of genetic variation in litter meadow species. More specifically, we tested whether genetic diversity and differentiation depend on habitat age, landscape, vegetation and/or population structure.
Therefore, we analyzed 892 individuals of *Angelica sylvestris*, *Filipendula ulmaria*, and *Succisa pratensis* from 20 litter meadows across the Baden-Wuerttembergian Allgaeu in South Germany using Amplified Fragment Length Polymorphism analysis (AFLP).
All study species showed moderate levels of genetic diversity, while genetic differentiation among populations was low. Neither genetic diversity nor differentiation were clearly affected by habitat age. However, the structure of landscape, vegetation as well as populations showed different impacts on the genetic diversity of our study species. The present landscape structure turned out as key variable for genetic diversity patterns of *A. sylvestris* and *F. ulmaria*. Additionally, the genetic diversity of *F. ulmaria* populations was influenced by the local vegetation structure, while *S. pratensis* populations seem to be only affected by population structure.
All explanatory variables represent past as well as present gene flow patterns by anthropogenic land use. Therefore, we assume that genetic diversity and differentiation are shaped by two factors: historical creation of litter meadows via hay transfer and present mowing with large agricultural machines. These land use practices caused and still cause gene flow among populations.

T. A. Lehmair and E. Pagel contributed equally to this work.

Session 36-P3 - Grasslands

Effects of historical land use on current species richness of Central European grasslands

Pascal Scherreiks[1,2,3], Wolfgang W. Weisser[2,4], Boris Schröder[3], Jan Thiele[1,2]

[1]Thünen-Institute of Biodiversity, Braunschweig, DE, pascal.scherreiks@thuenen.de
[2]Biodiversity Exploratories, Frankfurt, DE, pascal.scherreiks@thuenen.de
[3]TU Braunschweig Institute of Geoecology Department Landscape Ecology and Environmental Systems Analysis, Braunschweig, DE, pascal.scherreiks@thuenen.de
[4]TU München Department of Ecology and Ecosystemmanagement, München, DE

Current ecosystem patterns, such as community composition and species richness, are not exclusively controlled by present conditions, but may be strongly influenced by historical land use, as it exerts considerable influence over ecosystem structures, compositions and functions for decades and centuries. Our aim is to investigate the following hypotheses: (a) species richness increases with patch size, amount and connectivity of grassland in the surrounding landscape, and (b) historical landscape configuration has a stronger impact on current species richness compared to the effects of the present landscape if significant land use changes occurred. Regarding newly established grassland patches, we will also (c) investigate the importance of the amount and connectivity of grasslands in the landscape at the time of creation. We mapped historical land use from the 19th to the 20th century of landscapes in the Swabian Alb, Schorfheide Chorin, and the Hainich (Biodiversity Exploratories). Using species abundance data from the Biodiversity Exploratories, we aim to model the legacy effects of historical landscape composition and structure on plant and arthropod species richness applying Generalized Linear Models. For several time slices, we calculated landscape metrics, e.g. patch area, shape index, nearest-neighbour distance, proximity index, number of patches, and edge density for 150 grassland plots and buffer zones of 100, 250, 500, 1000, and 2000 m around the plots. Our models provide an insight into the relationships between species richness and historical land-use that will help to identify thresholds of habitat configuration critical for community composition and the development of species richness, which in turn will help to incorporate the knowledge of historical landscapes into conservation projects.

Session 36-P4 - Grasslands

Land use at different spatial scales affects the functional composition of herbivorous insect communities in temperate grasslands

Felix Neff[1,2], Nico Blüthgen[3], Melanie N. Chisté[3], Nadja K. Simons[3,4], Juliane Steckel[5], Wolfgang W. Weisser[4], Catrin Westphal[6,7], Loïc Pellissier[2,8], Martin M. Gossner[1,4]

[1]Forest Entomology, Swiss Federal Research Institute WSL, Birmensdorf, CH, felix.neff@wsl.ch
[2]Landscape Ecology, Institute of Terrestrial Ecosystems, ETH Zürich, Zürich, CH, felix.neff@wsl.ch
[3]Ecological Networks, Department of Biology, Technical University of Darmstadt, Darmstadt, DE
[4]Terrestrial Ecology, Department of Ecology and Ecosystem Management, Technical University of Munich, Freising, DE
[5]Department of Animal Ecology and Tropical Biology, Biocenter, University of Würzburg, Würzburg, DE
[6]Agroecology, Department of Crop Sciences, University of Göttingen, Göttingen, DE
[7]Functional Agrobiodiversity, Department of Crop Sciences, University of Göttingen, Göttingen, DE
[8]Landscape Ecology, Swiss Federal Research Institute WSL, Birmensdorf, CH

Herbivorous insects are an important part of aboveground communities in temperate grasslands, affecting different ecosystem processes. Land use at landscape and local scale may change both species pools and dispersal possibilities, and act as environmental filter, thus altering the functional trait composition of these communities. Environmental filtering by local management has repeatedly been shown to affect assembly of insect communities. However, we know less about the role of land use at the landscape scale. In this study, we investigated the relative importance of land use at both local and landscape scale in shaping the functional diversity and composition of herbivorous insect communities. Furthermore, we studied land-use effect on functional β-diversity, because we expected high land-use intensity to homogenize functional composition among communities. We used abundance data of three major herbivorous insect groups from 150 grassland plots in three regions in Germany. Functional composition of communities was characterised using a set of nine morphometric traits, which are related to different functions (e.g. dispersal abilities). We found that land use at both the local and landscape scale affected the functional composition of insect communities. While some trait combinations were more sensitive to changes in management intensity, others reacted strongly to the availability of suitable habitats in the surroundings of the plots. We did not find an effect of land use on local functional a-diversity, but functional β-diversity decreased with increasing local land-use intensity. In conclusion, our study provides evidence that land use at both local and landscape scale shapes the functional community composition of herbivorous insects. Our results underline the importance of considering land-use intensity across multiple spatial scales in order to understand its effects on the functional integrity of insect communities.

Session 36-P5 - Grasslands

Land management information of the Biodiversity-Exploratories grasslands – Trends and variables of management compounds.

Juliane Vogt[1], Sebastian Meyer[1], Sebastian Seibold[1], Wolfgang Weisser[1]

[1]Technische Universität München, Freising, DE, juliane.vogt@tum.de

Permanent grasslands can harbor high biodiversity and fulfil important ecosystem functions and services, such as food and habitat provision for livestock, protection of soil and water resources, carbon sequestration and aesthetic appeal. Until now, little attention has been paid to long-term assessments of land use practices in grassland systems.
Grassland management can differ in the intensity and timing of management actions such as mowing, grazing, fertilization, or maintenance measures, with possible consequences to biodiversity.
To understand more mechanistically how land use intensification in grasslands affects biodiversity, we collected detailed information on grassland management for 150 grasslands in the Biodiversity-Exploratories project. The grasslands occur in three regions in Germany, Schwäbische Alb, Hainich and Schorfheide-Chorin. Information was collected annually since 2006 based on interviews with farmers. Linear mixed-effect models were calculated to detect temporal trends as well as differences between the three exploratory regions.
We found significant differences between the regions in main grassland use, whereby regions differed in the number and management intensities. There was variability both between grasslands within the same region as well as within grasslands over time in how they were managed. Over the analyzed period, the main changes concerned the presence of a particular management practice within a plot, i.e. the number of plots that were grazed, mown or fertilized changed over time. Within each management practice, there were few systematic changes over time. There were strong correlations between mowing and grazing intensity (negative) and mowing and fertilization intensity (positive) while the correlation between on-site fertilization and grazing was weak.
Detailed accounting of land use practices can only be achieved through intensive collaboration between land managers, land users and researchers, as done in our study.

SESSION 37

The use of wildlife detection dogs in nature conservation and wildlife research

Chairs: Anne Berger, Juliane Röder

With their outstanding sense of smell, their will to please and their learning ability, dogs are highly valued to cooperate with their humans in various fields. Wildlife detection dogs are trained to qualitatively and quantitatively complement established data collection methods in conservation and wildlife research and to even help to develop new monitoring methods in this field. In this session, we want to inform about the use of dogs for species detection in scientific research, in environmental planning agencies and official species monitoring. In order to use wildlife detection dogs scientifically and systematically, as well as to achieve societal recognition, national and international standards and certification options for the proof of their performance are being developed and implemented. We will discuss chances and challenges of using wildlife detection dogs in nature conservation and wildlife research projects, we will introduce projects using wildlife detection dogs and, thus, we want to disseminate this 'method' to a broader audience. It is possible to extend this session to other monitoring methods (camera traps, transect walks, remote sensing by drones) for broader comparatively discussion.

Session 37-O1/2 - Wildlife Detection Dogs in science and practice

Sniffing out solutions to enhance conservation: How detection dogs can maximise research and management outcomes, some lessons learnt through working with detection dogs for koalas

Romane Cristescu[1], Russell Miller[1], Celine Frere[1]

[1]University of the Sunshine Coast, Sunshine Coast, AU, rcristes@usc.edu.au

In conservation, consistent and extensive under-funding has necessitated creative thinking to address conservation issues on a low budget, and innovations are burgeoning as a result. One example is the use of dogs that, thanks to their heightened olfactory abilities and bond with humans, are trained to detect odours of interest to conservationists. Conservation dogs have proven to repeatedly outperform alternative survey methods in terms of accuracy, efficiency and/or cost. They have now been used for the detection of endangered and invasive species, fauna and flora, direct and indirect (e.g. scat) targets, on land and at sea, across every continent and most taxa from fire ants to whales. I will emphasise the versatility of detection dogs through their multiple uses applied to one species, the koala (*Phascolarctos cinereus*). Our team, Detection Dogs for Conservation, selected, trained, tested and deployed dogs to find koala habitat (koala scats), genetic samples (fresh scats only), koalas themselves and koala disease. I will share some of the lessons we learnt along the way, and some new concepts that might improve the democratisation of conservation detection dogs' use to enable them to fulfil their astonishing potential.

Advantages and limitations of wildlife detection dogs – a case study and a review

Annegret Grimm-Seyfarth[1,2,3], Wiebke Harms[1,3], Reinhard Klenke[1]

[1]Helmholtz Centre for Environmental Research - UFZ, Leipzig, DE, annegret.grimm@ufz.de
[2]Monitoring Dogs, Markkleeberg, DE
[3]Wildlife Detection Dogs e.V., Neunkirchen, DE

Proper species monitoring data are necessary to make evidence-based statements regarding species' distributions, population statuses and trends and to ensure appropriate conservation and management. Species monitoring is frequently done directly through visual or acoustic observations, or indirectly using evidences that the species was present. Since both direct and indirect monitoring poses particular challenges, the additional use of wildlife detection dogs has increased substantially in the recent past. Their use is particularly well established in America, New Zealand, Australia, and Africa, but also European monitoring projects increasingly deploy detection dogs. We tested the performance of detection dogs in a scat monitoring scheme of the Eurasian otter (*Lutra lutra*). We found that detection dogs were much better at finding scats of the correct species than humans visually searching for scat, which they frequently confused with that of the American mink (*Neovison vison*).
Moreover, detection dog teams were twice as fast and collected three times more scats. We also conducted a review of almost 800 publications looking for general advantages and limitation of wildlife detections dogs. In 90% of all reported cases, detection dogs performed better than any other method, sometimes being the only method that detected the target, making it also cost-effective. Moreover, their well-developed olfactory sense allowed dogs to differentiate much clearer between signs of related species reducing false detections. Occasionally, a combination with other methods, such as cameras, hair sticks, or live-trapping, was suggested. In the remaining cases, the performance usually depended on local weather or vegetation conditions. Poor performance was mainly due to inappropriate training.
We conclude that given proper training, wildlife detection dogs can significantly increase both data quantity and quality in species monitoring.

Session 37-O4 - Wildlife Detection Dogs in science and practice

Nose, eyes and ears: Method comparison for monitoring a wolf pack in an alpine region

Laura Hollerbach[1], Federico Tettamanti[2], Stefan Suter[3], Fridolin Zimmermann[4], Gabriele Cozzi[5]

[1]Senckenberg Research Institute and Natural History Museum Frankfurt, Conservation Genetics Group, Gelnhausen, DE, laura.hollerbach@senckenberg.de
[2]Ufficio della caccia e della pesca, Repubblica e Cantone Ticino, Bellinzona, CH
[3]Zurich University of Applied Sciences, Institute of Natural Resource Sciences, Wädenswil, CH
[4]KORA, Muri, CH
[5]University of Zurich, Department of Evolutionary Biology and Environmental Studies, Zurich, CH

Wolves (*Canis lupus*) are recolonizing their historic ranges across Europe. This on-going expansion process calls for a reliable, quick and affordable monitoring scheme to be used as a basis for conservation and management purposes.
To this end, we simultaneously used a scat detection dog, wildlife cameras and sound recorders to test cost-effectiveness of these three alternative non-invasive methods in a 100 km^2 rugged alpine environment in Switzerland. We compared data quality, staff working hours, equipment costs, and overall duration of data collection. We divided the study site into seven side valleys, in which one dog transect of about 10 km, four wildlife cameras, and one sound recorder each was located. Dog transects were visited twice (in spring and fall), wildlife cameras and sound recorders were operational for five continuous months.
Searches with detection dog took two times two weeks and resulted in 21 genetically confirmed wolf samples in five of seven side valleys. Three different wolves were identified through genotyping. Time effort for setting up wildlife cameras and evaluating pictures was about 100 hours and more than 200 AA batteries were needed. Five of the 28 cameras in three of seven side valleys took pictures of wolves and identified three adult wolves and three pups. Data from sound recorders are currently being processed, however, howls were recorded on only one occasion in the side valley where we collected the majority of scats (n=13) and obtained the vast majority of camera pictures. Placing and monitoring the seven recorders required 14 working days, 84 1D batteries and 7 solar panels.
While, based on the current data, a final statement on the best method may be premature, our preliminary results suggest that a combination of methods may be most suitable to quickly and precisely obtain data at the desired level of detail.

Session 37-O5 - Wildlife Detection Dogs in science and practice

Tell me if it was a Wolf!? Dogs as a supplementary tool for the on-site confirmation of wolf (*Canis lupus*) suspects in Schleswig Holstein.

Uta Kielau[1], Petra Schulz[1], Björn Schulz[1]

[1]Wolfsbetreuer Schleswig Holstein, Kiel, DE, info@k9-hundekunde.de

Wolves are returning to Germany since 2000. In landscapes of intensive land-use, of widespread use of domestic animals especially sheep, of no experiences with large predators, and of slowly adopting farming systems wolves can cause major problems. Recently in Schleswig-Holstein three young wolf males born in Denmark and having lost their mother at the age of five months have focussed on sheep as main food resource and cause a high proportion of wolf-related damages. At the same time there are still a high number of either dogs killing or injuring sheep or other animals feeding on carcasses of domestic animals having died by other reasons. Thus, wolves can be a reason for dead sheep but in many cases they aren't. The genetic analysis of DNA-samples taken on the carcasses usually takes several weeks. In some cases no genetic material or other proofs are available. So the reason for damages in herds remains undiscovered in many cases.

Dogs have the potential to detect even the smallest amount of traces a wolf usually leaves behind, when exploring a site or attacking a herd. It can be hair on fences or bushes, it can be urine or feaces or it can be saliva on a killed corpse.

In Schleswig-Holstein some official wolf managers have trained their dogs using the Scent Discrimination Method© which was introduced by Tom Middlemas. After the training period they started to use their dogs in real cases, when sheep killings or wolf sightings were reported to the wolf management system.

One important focus in our training system is the use of Supportive Leadership both in working with the dogs and in the everyday life. This leads to low stress handling which meets the legal regulations in Germany for the (semi-) professional use of dogs.

In our contribution we describe, how the "Wolf Detection Dog Unit" works as a part of the wolf management system, which training methods were used and what first results we achieved.

Session 37-P1 - Wildlife Detection Dogs in science and practice

A nose for conservation – in the field as well as to combat illegal wildlife trade

Birgit Braun[1], Anne Schmidt-Kuentzel[2], Tim Hofmann[2], Jane Sharp[1]

[1]Aktionsgemeinschaft Artenschutz (AGA) e.V., Korntal-Münchingen, DE, birgit.braun@aga-artenschutz.de
[2]Cheetah Conservation Fund, Otjiwarongo, NA

Detection dogs can perceive the smallest concentrations of odours and have a highly evolved ability to discriminate between scents. They are best known to detect hidden contraband like drugs, weapons and cigarettes, but are also suitable for the detection of wildlife and their derivatives.
In Namibia and Kenya, scat detection dogs are used to gather information about cheetahs (*Acinonyx jubatus*) living in the wild. The "Aktionsgemeinschaft Artenschutz (AGA) e.V." supports the scat detection dog units, which have been put in place by the "Cheetah Conservation Fund (CCF)" as well as "Action for Cheetahs in Kenya (ACK)" to increase the number of cheetah scat samples found in the field. Genetics laboratories can extract DNA from these samples and gather valuable information on the number and size of local cheetah populations as well as their health condition, diet and distribution.
At Frankfurt airport, wildlife detection dogs entered active service in 2008. This was a promising start for the development and implementation of wildlife detection dog programs to detect smuggled wildlife and their derivatives in several European countries as well as worldwide. Furthermore, the effectiveness of wildlife detection dogs to combat illegal wildlife trade has been widely acknowledged, including by CITES, INTERPOL and WCO.
In the field or at checkpoints, detection dogs have demonstrated that they have a nose for conservation.

Session 37-P2 - Wildlife Detection Dogs in science and practice

On the ant track - species discrimination by odour

Chiara Baschung[1], Denise Karp[2,3]

[1]Zurich University of Applied Sciences, Zurich, CH, chiara.b@schung.ch
[2]University of Zurich, Department of Evolutionary Biology and Environmental Studies, Zurich, CH
[3]Artenspürhunde Schweiz, Zürich, CH

As globalization proceeds, not only humans gain mobility, but also various non-native insect species conquer new habitats. Due to their small size they often don't get discovered until they reach large numbers and cause considerable damage. One of those typical profiteers is the ant species *Lasius neglectus*. It is especially successful as it builds super colonies with numerous queens and a large network of cooperating nests. When *Lasius neglectus* is established in an area, it extinguishes most ant species in the vicinity and many other insects too. Because of their large number, they cause damage on plants and buildings. To fight such super colonies effectively is almost impossible. It is hence desirable to detect new infestations of this invasive ant species as early as possible and eliminate the very last queen of the respective colony. But there is a significant challenge in this endeavour: the visual differentiation between *Lasius neglectus* and its relative *Lasius niger*, which inhabits similar habitats, is very difficult. With our study we present current research about the use of dogs to detect the invasive ant species *Lasius neglectus*. Dogs could be a suitable method to detect small infestations and enable early management measures. To investigate the possibilities of using detection dogs, this pilot study examines the following questions:

- Can dogs be taught to olfactory differentiate between closely related ant species?
- What is the minimum amount of target insects required per sample for the dog to be able to identify and indicate them correctly?

The basis for this study is a laboratory test conducted at the Institute for Science and Technology in Austria, in which two dogs were conditioned on the target odour *Lasius neglectus*, which they were then required to identify and discriminate from other closely related species in double blind line-ups. To test the minimum number of ants the dogs can recognize, the number of ants per sample is slowly reduced until the detection rate drops below 80%.

Session 37-P3 - Wildlife Detection Dogs in science and practice

Jackal and Hide - scat detection dogs help to monitor golden jackals (*Canis aureus*)

Felix Böcker[1], Lea Wirk[2], Miklós Heltai[3], Laszló Szabó[3], Sebastian Collet[4], Jennifer Hatlauf[2]

[1]Forest Research Institute Baden-Württemberg, Freiburg, DE, Felix.Boecker@Forst.bwl.de
[2]University of Natural Resources and Life Sciences (BOKU), Institute of Wildlife Biology and Game Management (IWJ), Vienna, AT
[3]Szent István University, Institute for Wildlife Conservation, Gödöllő, HU
[4]Senckenberg Research Institute, Conservation Genetics, Gelnhausen, DE

Golden jackal (*Canis aureus*) monitoring in central Europe is getting more important with the appearance of jackals in new, previously unestablished areas. Compared to research of other mammals, the genetic monitoring of golden jackals entails challenges. One of them, the incorrect discrimination of jackal scats from other related species - specifically the red fox (*Vulpes vulpes*) - could even cause false results in diet analyses and population monitoring (calculation of relative abundance) or high costs in DNA analyses. We assumed that human searchers are prone to error possibilities in identifying jackal scats by visual features. Therefore, we used trained dogs to locate and identify golden jackal scats in a Hungarian shrubland. We worked with two dogs to collect several scats that were then confirmed as golden jackal scats via DNA analysis in 2018 and 2019. Our preliminary results show that the implementation of trained scat detection dogs provides a very efficient method in dense shrubland study areas and help to answer questions for long-term golden jackal monitoring.
The European golden jackal project (www.goldschakal.at) was supported by the foundation of "Action Austria-Hungary" (by the Austrian Federal Ministry of Science, Research and Economy and the Hungarian Ministry of Human Capacities). J.H. is a recipient of the DOC Fellowship of the Austrian Academy of Sciences at the Institute of Wildlife Biology and Game Management, BOKU, Vienna

Session 37-P4 - Wildlife Detection Dogs in science and practice

How to be sure of hedgehog absence before building projects, bush pruning or clearing events?

Anne Berger[1,2]

[1]Leibniz Institute for Zoo and Wildlife Research, Berlin, DE, berger@izw-berlin.de
[2]Wildlife Detection Dogs e. V., Neunkirchen, DE

European hedgehogs (*Erinaceus europaeus*) are nocturnal, solitary, hibernating, ground-dwelling insectivores. There is a threatening decline in the hedgehog abundance of which the causes are being speculated. In Germany, hedgehogs are strictly protected but population development is not known as monitoring would be very complex due to the hedgehogs' way of life.
According to the German federal law on nature protection (BNatSchG § 42), it is not allowed to remove, damage or destroy the daytime or the winter nests of hedgehogs. These nests are mostly hidden in bushes close to meadows but they cannot be discovered by simple visual inspections of the bushes. Hence, nightly spotlighting was described as the most effective method to detect hedgehogs. However, nocturnal spotlighting is highly time-consuming and unreliable for consultancy or planning offices. Thus, hedgehogs are mostly not considered during local building or planning work. Moreover, out of respect for breeding birds and by law, most pruning or wood clearing work is done during the hibernation period of the hedgehog (November until April) in which these animals are unable to escape or move.
Wildlife detection dogs (trained on hedgehog odour) can be used to detect and indicate the hidden hedgehog nests. The dogs can work during the day in both summer and winter. As the hedgehogs stay in their nests at these times, a systematic search is possible. When indicating the nests, the dogs should not touch it in order to not disturb the animals in the nest. Hedgehog detecting dogs are now used in Zurich, the Lucerne region (Switzerland) and in Berlin (Germany). Considering the decline in the hedgehog abundance, hedgehog detecting dogs are recommended to be used as standard method in consultancy or planning offices during local planning and building processes. Using detection dogs will greatly improve the feasibility of removing the hedgehogs temporarily from the danger zone to protect the animals.

SESSION 38

Leveraging scale to build empirically tractable theory and metrics of stability and coexistence

Chairs: Adam Thomas Clark, Yuval Zelnik

Ecosystem stability and species coexistence are immensely important to basic ecological research, management, and conservation. Ecosystem stability typically describes the variance of temporal fluctuations of total biomass of species in the community, and has become a central tool for studying the relationship between biodiversity and ecosystem functioning. The closely related topic of coexistence refers to the ability of particular combinations of species to persist in the long-term, and is arguably the most important indicator of human impacts on diversity. Decades of theoretical and empirical work has demonstrated that estimations of both stability and coexistence can vary greatly depending on the spatial and temporal scale of measurement. For example, a species that shows stable behaviour at small scales may be wiped out due to dynamics occurring at larger scales.

Surprisingly few studies have addressed the interface between scale and these metrics, and it remains unclear what general patterns underlie observed patterns. In particular, a major challenge that limits practical applications of stability research is that most theoretical results and methods are not tractable in empirical systems. However, a number of recent results suggest that by combining information from across many different scales, it may be possible to broadly characterize dynamical behaviour of species and ecosystems, giving a robust result that will not be as sensitive to measurement issues.

This session has three primary aims: (i) demonstrate the influence that measurement scale has on perceptions of stability and coexistence; (ii) present the results of recent studies that address these challenges; and (iii) lay the groundwork for future studies and collaborations. We propose that the session be held in three stages. After a brief (5 min) introduction of speakers by session organizer A.T.C., the first stage would include 3-5 "standard" talks (15 min. each), given by senior leaders in the field to outline the major challenges. The second stage, composed of ~15 "lightening"-style talks (10 min. each – 7.5 min. talk + 2.5 min. questions), will summarize solutions to these challenges based on recent research. Finally, during a mini-workshop (1.5 hours) at the end of the session, speakers and audience members will plan future projects to help advance the field. The program organisers will subsequently write up a short summary report of the session, which will be used to plan a longer-form workshop in the near future (potentially immediately after the GFÖ meeting, funded through an UFZ "synthesis" grant).

Session 38-O1/2 - Scale, stability, and coexistence

On the stability of complex ecological systems: moving across and within stability concepts

Jean-Francois Arnoldi[1]

[1]Trinity College Dublin, Dublin, IE, arnoldij@tcd.ie

Since the 1950s numerous visions and definitions have been proposed to analyse ecological stability. This eventually led to a devastating clash between ecological intuitions and mathematical results. A clash that initiated a divide between empiricists and theoreticians. Here we propose a modest contribution towards a transparent theory, based on the notion of linear response of complex dynamical system, to help reconnect those two worlds. The strategy is to reveal underlying structures that bound various stability metrics together, and explain why contradictions between them can be the consequence of the fact that they reflect the behaviour of different species abundance class within the ecosystem (some are implicitly function of rare species, while others reflect the properties of an abundant core). In particular, this approach allows us to draw connections between rare species and long term return rates, impact of invasions to collective resistance to press, and variability in the face of environmental stochasticity with short term responses to extreme climatic events, driven by abundant species. We argue that such a multidimensional perspective on stability can help reveal the dynamical richness of ecological systems, and the underlying meaning of their stability patterns.

Session 38-O3 - Scale, stability, and coexistence

Stability of complex ecosystems: theory against data

Claire Jacquet[1,2]

[1]University of Zurich, Zürich, CH, claire.jacquet@eawag.ch
[2]Eawag, Dübendorf, CH, claire.jacquet@eawag.ch

The relationship between complexity and stability in ecosystems is one of the most long-standing debates in ecology. Early ecologists hypothesized that diversity begets stability, up until R. May showed that the opposite relationship should be expected. For four decades, ecologists have tried to isolate the non-random characteristics of natural ecosystems that could explain how they persist despite their complexity. Surprisingly, few attempts have been tried to test May's fundamental prediction empirically. In this talk, I focus on the analysis of a large dataset of empirically measured food webs. I show that classic descriptors of complexity (species richness, connectance and species interaction strength) are not correlated to stability in empirical food webs. A further analysis demonstrates that the non-random organization of energy flows between predators and prey allows complex ecosystems to be stable.

Session 38-O4 - Scale, stability, and coexistence

Spatial scaling of stability in natural communities

Dorothee Hodapp[1], Helmut Hillebrand[1,2,3]

[1]Helmholtz Institute for Functional Marine Biodiversity, Oldenburg, DE, dorothee.hodapp@hifmb.de
[2]Alfred-Wegener Institute, Helmholtz Centre for Polar and Marine Reserach, Bremerhaven, DE
[3]Institute for Chemistry and Biology of the Marine Environment (ICBM), University of Oldenburg, Oldenburg, DE

Existing theory on the spatial scaling of stability predicts an increase in stability of any ecosystem property (e.g. biomass) with growing size of the sampled area. This increase can be caused by asynchronous dynamics of different species populations (species insurance hypothesis, "portfolio effect") as well as compensatory dynamics as a consequence of varying environmental conditions across space (spatial insurance hypothesis).
We apply recently proposed frameworks on the synchrony dependence of spatial scaling of stability to monitoring data sets (freshwater and marine) to discuss how the shapes of synchrony-stability relationships across scales depend on species community and ecosystem properties.

Session 38-O5 - Scale, stability, and coexistence

Measuring the stability of ecological communities

Virginia Domínguez-Garcia[1]

[1]Université de Montpellier, Montpellier, FR, domgarvir@gmail.com
[2]Université de Montpellier, Montpellier, FR

Measuring the stability of ecological communities is a matter of increasing importance in the context of global change. Yet, it has proved to be a challenging task. Many different metrics have been used to assess the stability of ecological systems, some of them measuring different aspects of stability (e.g. robustness, permanence, resilience, variability). Nonetheless, most studies have typically focused on only one of these metrics, while the reasons for choosing one metric over another may appear arbitrary, and different metric choices may result in conflicting conclusions regarding the stability of a community. Reconciling this discrepancy holds the key to improving our ability to measure the stability of natural systems and understand its drivers. Here, we simultaneously measured more than 20 metrics frequently used in ecological studies to assess the stability of ecological communities. Our approach is based on dynamical simulations of realistic trophic communities under different perturbation scenarios. We find that the metrics can be lumped into a few categories of independent stability components. Selecting metrics from each of these categories allows getting a more accurate and comprehensive quantification of the stability of ecological communities. These results open a way towards simplifying, while improving, the study and assessment of stability in ecological communities.

Session 38-O6 - Scale, stability, and coexistence

Functional stability in soil ecosystems - Insights from the microscale modelling perspective

Sara König[1], Hans-Jörg Vogel[1], Hauke Harms[2,3], Anja Worrich[2]

[1]UFZ - Helmholtz Centre for Environmental Research, Department of Soil System Science, Halle (Saale), DE, sara.koenig@ufz.de
[2]UFZ - Helmholtz Centre for Environmental Research, Department of Environmental Microbiology, Leipzig, DE
[3]German Centre for Integrative Biodiversity Research (iDiv) Halle-Jena-Leipzig, Leipzig, DE

Soil ecosystems have to cope with an increasing environmental pressure due to climate change. Simultaneously, agricultural demand is rising and land management strategies are altered; all together affecting soil and its important functions. For securing food health and bio-economical uses, we need to understand the stability of soil functions such as nutrient cycling, carbon storage or water filter.
Important player for many functions are soil microbes acting on a very small scale in a highly spatial heterogeneous system. This makes it difficult to measure and upscale their functions allowing for drawing conclusions about the overall ecosystem stability. To understand recovery behaviour, the dynamic response to disturbances needs to be analysed.
One promising approach is computational modelling, opening the possibility to analyse microbial dynamics on arbitrary scales. Here, we present an example of a microbial ecological model for simulating the response of bacterial degradation dynamics to disturbances of different spatial and temporal configurations. We analysed key processes for functional recovery and resistance on mm to cm scale and showed the relevance of bacterial dispersal. Moreover, we determined thresholds for functional collapse in dependence of spatial disturbance characteristics and different bacterial traits.
Although we apply a simple spatial structure, compared to the high heterogeneity of real soil systems, spatial aspects proofed to be quite important for functional stability already in this artificial system. However, how important this small-scale heterogeneity is for functional stability on the ecosystem scale is still unknown. It remains an open challenge to bridge the gap between effects on microbial or pore scale to profile or landscape scale. Systemic soil models incorporating mechanistic knowledge of microbial processes are a promising approach to overcome this gap and thus help to understand soil functional stability.

Session 38-O7 - Scale, stability, and coexistence

Towards "strategic theory-building" addressing ecological dynamics in the Anthropocene

Carsten Meyer[1]

[1]German Centre of Integrative Biodiversity Research (iDiv), Leipzig, DE, carsten.meyer@idiv.de

Abundances of individual species within communities and their changes are key to diverse theoretical and practical ecological applications in the wider context of ecosystem stability and coexistence. Explicit consideration of spatial or temporal scale of biodiversity observations is increasingly leveraged to develop better predictive theory. However, such approaches are severely hampered by data limitations that will likely persist into the foreseeable future. On the other hand, on the side of environmental drivers, scale is rarely leveraged for improving predictive capacity, although contiguous multi-scale driver measurements are now increasingly available, thanks to remote sensing. Similarly, several macroecological statistical laws have surprisingly strong capacity for adding pieces to the predictive puzzle, if only by providing broad probabilistic constraints within which predictions should fit. In my talk, I will argue that there is tremendous applied value in building "strategic theory", i.e. predictive ecological theory that as inputs exclusively relies on relatively "cheap" resources such as well-documented aspects of biodiversity, readily available environmental data, and known statistical laws and general macroecological relationships, while as outputs, it predicts "expensive" but widely needed phenomena such as species-level abundances. I will present a theoretical framework, currently being tested, addressing the stability and dynamics of ecological communities that is guided by these principals.

Session 38-O8 - Scale, stability, and coexistence

Utilizing the scale of disturbances

Yuval Zelnik[1], Jean-François Arnoldi[1,2], Michel Loreau[1]

[1]CNRS, Moulis, FR, zelnik@post.bgu.ac.il
[2]Trinity College, Dublin, IE

Ecosystems constantly face disturbances which are spatially heterogeneous, often markedly so, yet little is known on how this may affect their stability and persistence. We investigate this issue by considering the effect of a disturbance's spatial extent on ecosystem stability properties. By analyzing the return time to equilibrium following a pulse disturbance, we show that recovery dynamics involve two dimensions: isolated recovery, due to local processes, and rescue recovery, mediated by dispersal. Accessing return times implies monitoring disturbances individually, which is not always empirically feasible. We address this issue by shifting our focus to the overall temporal variability caused by random spatio-temporal sequences of disturbances. We derive a general relationship between return time and variability, valid regardless of how nonlinear the dynamics are, as long as locally strong disturbances do not interact with one another. When they do, variability becomes higher than predicted which signals that the ecosystem is under a critical level of stress and may be close to collapse. Our work develops new theory on how processes occurring in both local and regional scales affect the ecosystem's stability. This has practical implications for monitoring and management, as comparing between return time and variability can allow us to see the first signs of stress on the ecosystem, and the shape of either of these stability measures as a function of disturbance spatial extent informs us on the dynamics on a local scale.

Session 38-O9/10 - Scale, stability, and coexistence

Towards a spatial coexistence theory for species rich communities

Thorsten Wiegand[1,2], Xugao Wang[3], Andreas Huth[1,2]

[1]Helmholtz Centre for Environmental Research GmbH, Leipzig, DE, thorsten.wiegand@ufz.de
[2]German Centre for Integrative Biodiversity Research (iDiv) Halle-Jena-Leipzig, Leipzig, DE, thorsten.wiegand@ufz.de
[3]Institute of Applied Ecology, Chinese Academy of Sciences, Shenyang, CN

The high diversity of tropical forests has fascinated ecologists for long. Understanding the mechanisms that maintain high species diversity is at the core of ecologic theory, but not yet fully resolved. We argue that current coexistence theories for species rich communities are incomplete because they ignore the effects of the stochastic geometry of biodiversity, especially at the scale of the biotic neighbourhood where species interactions take place. To close this gap we inject spatial point process theory into classical population and community theory and reconcile it with studies on individual-level variation.
Using spatially-explicit census data and data on phylogenetic relationships between species from nine large forest dynamics plot we show that the variability in biotic neighborhoods is in general large and leads to substantial intraspecific variation in frequently used competition indices. When including this variation into analytical theory we obtain a spatial multispecies model that contains, beside of demographic parameters, measurable indices of the emerging spatial patterns that serve as correction factors in existing theory. For the case of higher species richness we can also derive an analytical expression for the equilibrium of the spatial multi-species model that demonstrates how spatial patterns influence community dynamics. For example, the emerging spatial patterns can allow for stable coexistence even if species do not differ in their ecology, thus questioning a longstanding paradigm in ecology.
Confirmation of our spatially-explicit theory by spatially-explicit simulations shows that spatial patterns can indeed stabilize community dynamics under a wide range of circumstances, especially if the mechanisms that lead to conspecific aggregation are independent on abundance. The new spatial coexistence theory shows that spatial patterns provide the missing mechanism to explain why so many tree species coexist in tropical forests.

Session 38-O11 - Scale, stability, and coexistence

Do dynamic estimates of conspecific negative density dependence correlate with global diversity patterns?

Lisa Hülsmann[1], Ryan Chisholm[2], Liza Comita[3], Florian Hartig[1]

[1]University of Regensburg, Regensburg, DE, lisa.huelsmann@ur.de
[2]National University of Singapore, Singapore, SG
[3]Yale University, Yale, US

Strong Janzen-Connell effects caused by specialized natural enemies that prevent species from becoming highly abundant are one of the most famous explanations for high tropical tree diversity. Together with intraspecific resource competition, the effect of specialized pathogens has jointly become known as conspecific negative density dependence (CNDD), and numerous local studies have found CNDD in tropical and temperate tree communities, yet at varying frequency and strength. Recent studies have assessed CNDD at larger spatial scales and claimed signatures of a latitudinal CNDD gradient in static forest structure. These analyses, however, have been criticized for severe statistical and conceptual problems, and dynamic analyses have been suggested as a robust, but globally not well explored alternative. Consequently, empirical evidence for a latitudinal gradient in CNDD under natural conditions and its contribution to diversity remains inconclusive. We therefore conduct a global analysis of conspecific neighborhood effects on demographic rates using repeated surveys from the Forest Global Earth Observatory (ForestGEO) network to test the hypothesis of a latitudinal gradient in CNDD. We focus primarily on CNDD in mortality, because this process is ultimately causing the spatial segregation of conspecific recruits and adults, a prerequisite for stabilization. Because quantifying and comparing CNDD is anything but straightforward, particularly across biomes, we pay special attention to an unbiased and comparable indicator of CNDD that is unaffected by potential problems such as rare species bias, habitat suitability, and non-linearity in effect sizes. In the suggested presentation, we will explain how to develop an appropriate indicator for CNDD and present novel insights into global patterns of CNDD that provide a more thorough test to understand the role of CNDD for one of the most fundamental ecological patterns, i.e. the latitudinal diversity gradient.

Session 38-O12 - Scale, stability, and coexistence

Diversity and stability are directly linked to fluctuating species interactions in a predator-prey system

Canan Karakoç[1,4], Adam Thomas Clark[3,7,8,9], Antonis Chatzinotas[1,4]

[1]Department of Environmental Microbiology, Helmholtz Centre For Environmental Research-UFZ, Leipzig, DE, canankarakoc@gmail.com
[3]Department of Physiological Diversity, Helmholtz Centre For Environmental Research-UFZ, Leipzig, DE
[4]German Centre for Integrative Biodiversity Research (iDiv) Halle-Jena-Leipzig, Leipzig, DE, canankarakoc@gmail.com
[7]German Centre for Integrative Biodiversity Research (iDiv) Halle-Jena-Leipzig, Synthesis Centre for Biodiversity Sciences (sDiv), Leipzig, DE
[8]Department of Ecology, Evolution, and Behavior, University of Minnesota, Saint Paul, Minnesota, US
[9]University of Leipzig, Leipzig, DE

Numerous studies have focused on the drivers of diversity and coexistence in communities. Several studies show that community dynamics are both driven by the identity of species (e.g. trophic group, resistance to predators) and by varying effects of interspecific interactions (e.g. between predators and prey) over time. Until recently, only a few studies have been able to quantify the relative contribution of these two factors to community dynamics. Here, we address this challenge with experimental microcosms composed of competing bacterial species in the absence or presence of a protist predator. Using abundance data, we employed empirical dynamic modelling tools to detect causal inferences between the predator, the edible and predation-resistant prey, and time-varying species interactions. We found that interactions between the predator and the prey species boosted the number of direct cause-effect relationships between the community members. Predation rapidly induced anti-predation traits, which altered the population dynamics of both prey species and predator, and caused fluctuations in the direction and strength of interspecific interactions. Moreover, we employed local stability measures to reveal the contribution of species interactions to community stability. Supporting current ecological theory, we found lower dynamic stability in the presence of predator and higher stability when the anti-predation traits were present in prey. We suggest that deducing cause-effect relationships between the components of communities and identifying the fluctuating interspecific interactions by controlled experiments and empirical dynamic modelling can substantially improve our understanding of highly dynamic communities, and their diversity and stability in more complex environmental systems.

Session 38-O13 - Scale, stability, and coexistence

A more generalizable approach to scale-wise analysis of stable coexistence, or, Chasing the Dragon, and two other methods

Adam Thomas Clark[1,2]

[1]Helmholtz-Zentrum für Umweltforschung (UFZ), Leipzig, DE, adam.tclark@gmail.com
[2]German Centre for Integrative Biodiversity Research (iDiv) Halle-Jena-Leipzig, Leipzig, DE, adam.tclark@gmail.com

Although many tools exist for analyzing stable coexistence in theoretical systems, relatively few of these are well-suited for empirical applications. In particular, real-world time-series are often not stationary - that is, they do not approach a single fixed value over time, but rather may have equilibria that drift or oscillate over time. Consequently, tests of coexistence are strongly influenced by the scales at which they are performed. Such scale dependence is particularly problematic, as it suggest that tests must be applied across many different combinations of spatial and temporal scales. Here, I discuss three well-established methods which, when combined, may allow for existing tools of stability analysis, e.g. methods based on variability or asymptotic return rates, to be applied to non-stationary time-series data. In test applications, these methods accurately reconstruct complex dynamics, and correctly estimate time to extinction based on observational data. Moreover, results seem to perform well when extrapolated across scales, such that measurements at the scale of a few plots can be used to accurately estimate stability at the landscape scale.

Session 38-O14/15 - Scale, stability, and coexistence

Dynamics of grasslands and forests - integrating vegetation modeling, remote sensing and observations

Franziska Taubert[1], Rico Fischer[1], Andreas Huth[1,2,3]

[1]Helmholtz Centre for Environmental Research GmbH - UFZ, Leipzig, DE, franziska.taubert@ufz.de
[2]University of Osnabrück, Osnabrück, DE
[3]German Centre for Integrative Biodiversity Research (iDiv), Halle-Jena-Leipzig, DE

Forests and grasslands cover in total more than half of the Earth's land area and contribute to global biogeochemical cycles. Although estimates on their current state have improved over the last decades by integrating observations, remote sensing and modeling, still the question arises if important vegetation attributes remain stable, especially under the pressure of land use and climate change. Here, we report on examples of forest and grassland modeling at the global and local scale and reflect on challenges that can arise in the analysis of ecosystems' stability. In the first example, we focus on grasslands. By the use of a process-based grassland model we show, on the example of a grass-forb mixture, how fluctuations in management and climate can affect the stability of species populations and ecosystem attributes. In the second example, we analyze the dynamics of forests at the continental scale. The Amazon rain forest is the world's largest known intact tropical forest. Precise estimates of the spatial variation of forest biomass need to consider small-scale variations of forest structures, and require large-scale information on the state of the forest. Here, we link a forest gap model and a canopy height map to derive the biomass distribution and spatial variation in forest structure for the Amazon rain forest.

Session 38-O16 - Scale, stability, and coexistence

Temperature effects on ecological stability across scales of ecological organization

Frank Pennekamp[1]

[1]University of Zurich, Zurich, CH, frank.pennekamp@ieu.uzh.ch

Global temperatures continue to rise due to the effects of man-made climate change. Despite temperature being one of the most prominent drivers of biological systems, we are still unable to accurately predict the effects of temperature on the stability across scales of ecological organisation for any given ecosystem. I will present results from three experiments (1-3) designed to understand the effect of increasing temperature on the stability of simple ecological communities -- a predator-prey pair, a simple food web and competitive communities of protists -- and contrast our results with available theory. Despite temperature generally leading to destabilization, I will illustrate the potentially different pathways leading to lower stability and how community complexity and additional stressors interact with temperature. My aim is to discuss how to better integrate temperature effects across scales, connect empirical and theoretical work on ecological stability and provide a more integrative approach to the multifaceted nature of ecological stability in the face of environmental change.

Refs:
1. U. Daugaard, O. Petchey, F. Pennekamp, *Journal of Animal Ecology* (2019).
2. F. Pennekamp *et al.*, *Nature*. 563, 109 (2018).
3. A. Tabi, O. Petchey, F. Pennekamp, *Ecology letters* (2019), doi:10.1111/ele.13262.

Session 38-O17 - Scale, stability, and coexistence

Unknown buffers – which facets of biodiversity stabilize natural plant communities against extreme droughts?

Maximiliane Herberich[1], Nicola Lechner[1], Katja Tielbörger[1]

[1]University of Tübingen, Tübingen, DE, maximiliane.herberich@uni-tuebingen.de

The stability of ecosystem functions is predicted to be strongly influenced by the increase in the magnitude and frequency of climate extremes. However, the observed impacts of specific climate extremes are highly variable. For example, the responses of plant communities to an extreme drought range from surprisingly high stability to significant reductions of ecosystem functions and/or changes in species composition.
In the case of mild interannual climate fluctuations, theoretical and experimental evidence highlights biodiversity as a key buffer for stabilizing ecosystem functions because many species may provide greater insurance that some will maintain functioning even if others fail. Thereby, the strength of this insurance effect depends on different facets of biodiversity such as asynchrony or evenness.
In this study, we tested whether differences in these facets could explain the variable results of extreme drought on plant communities. Specifically, we experimentally imposed an extreme drought and combined it full factorial with a diversity manipulation in natural plant communities in both grasslands and forests. We show that plant communities were resistant against extreme drought due to their naturally high biodiversity. Interestingly, the facets of biodiversity stabilizing the plant communities differed between forests and grasslands.

SESSION 39

Dead or alive - trees and their associated microbial communities

Chairs: Kezia Goldmann, Julia Moll

As long-living organisms, trees play an important role in forest, agricultural and also urban ecosystems. They contribute to nutrient cycling, act as carbon storage and provide diverse niches for many organisms. Amongst those are microorganisms, a group with high importance and value for ecosystem functioning. Microorganisms are engaged in close relationship with trees, and such associations should be considered as inseparable entities according to the hologenome theory. Functionally, the relationships between the trees and their microbiome encompass commensal or detrimental interactions. Tree microbiomes are highly complex communities made of pro- and eukaryotic microbes that inhabit tree surrounding soils, rhizosphere, roots, tree trunks, leaves, or litter. Biotic and abiotic factors differ tremendously between these habitats, so that the diversity, composition and functioning of their microflora as well as their assembly rules are highly specific and divergent over time. During their life, trees have to adapt to varying seasons and changing environmental conditions. Likewise, trees affect the microclimate, soil type, nutrient availability and turnover throughout all development stages, from seedlings, adult to senescent plants, and even after death. Deadwood, as emerging microbial habitat, often leads to changes in microbial functioning as dynamic shifts within and between mycorrhizal, pathogenic or saprotrophic microbes occur. The goal of this session is to unite researchers studying microbes associate to trees. It offers a platform to synthesize and integrate current advances in studies on the diversity, community composition, and functional roles of bacteria, fungi, protists, algae and/or viruses in, on, under or around trees.

Session 39-O1 - Tree-associated microbes

Soil microbial community of the tree root zone is impacted by both host tree selection effect and site specificity

Jean de Dieu Habiyaremye[1,2,3], Kezia Goldmann[1], Thomas Reitz[1,4], François Buscot[1,2,4], Sylvie Herrmann[1,4]

[1]Department of Soil Ecology, Helmholtz Centre for Environmental Research-UFZ, Halle, DE, jean-de-dieu.habiyaremye@ufz.de
[2]Department of Biology II, Leipzig University, Leipzig, DE, jean-de-dieu.habiyaremye@ufz.de
[3]Department of Mathematics, Science and Physical Education, University of Rwanda, Kigali, RW, jean-de-dieu.habiyaremye@ufz.de
[4]German Centre for Integrative Biodiversity Research (iDiv) Halle-Jena-Leipzig, Leipzig, DE

Trees are known to recruit beneficial microbial partners from the local soil microbial community to harness the microbes' ability to rapidly respond to changes in environmental conditions. To rationally analyze the recruitment process, the "PhytOakmeter" project released clonal oak saplings (*Quercus robur* L., clone DF159) produced via micropropagation as phytometers into different field sites within a close geographic space of the Central German Lowland region. Because the interaction partner recruitment depends on both, the local soil microbial pools and the specific selectivity by plants, we analyzed the microbial communities in the PhytOakmeter root zone versus the tree root-free zone. Two years after outplanting, soil samples of the root and the tree root-free zones were taken. Soil DNA was extracted, 16S and ITS genes were respectively amplified for bacteria and fungi, and sequenced using Illumina MiSeq technology. The obtained microbial communities were analysed in relation to soil chemistry and climatic data. Although the tree root zone microbial diversity level appeared similar among the field sites, the community composition was site-specific. Likewise, the microbial diversity levels between root zone and root-free zone were comparable, but the number of microbial taxa exclusive to either zone was higher in the root zone than in the root-free zone. PhytOakmeter 'core' and 'site-specific' microbiomes were identified and attributed to the host tree selection effect and/or to the ambient conditions of the sites. The identified root zone associated soil microbiome was dominated by chemoheterotrophic bacteria and ectomycorrhizal fungi. Soil pH and organic matter were significantly correlated with the microbial diversity and community composition. The current study makes an important step forward to understand how the community of soil microorganisms assists the host tree to adapt to local environment conditions.

Session 39-O2 - Tree-associated microbes

What drives evolution of mycorrhiza symbiosis in oaks (*Quercus petraea*)?

Andreas Prinzing[1], Pierre-Emmanuel Courty[4], Sebastian Vogel[5,6], Jörg Müller[5,6], Alexis Ducousso[3], Simon Thorn[1], Pille Gerhold[1], Mickael Pihain[1,2]

[1]Univ. Rennes 1, Rennes, FR, andreas.prinzing@univ-rennes1.fr
[2]Univ. Tartu, Tartu, EE
[3]Inra, Bordeaux, FR
[4]Inra, Dijon, FR
[5]Univ. Würzburg, Fabrikschleichach, DE
[6]Nationalpark Bayerischer Wald, Grafenau, DE

Mycorrhiza is a symbiosis between plants and fungi where plants provide photosynthesis and fungi provide among others enzymes to decompose litter, such as Laccase. Mycorrhiza is often essential for the plants but also costly. Some plant lineages invest particularly strongly into mycorrhizaa but it remains unclear which abiotic environments and biotic neighbourhoods select for increased investment into mycorrhiza. We hypothesize that stressful abiotic environments or distantly related biotic neighbourhoods select for investment into mycorrhiza as here the plants strongly need the support by mycorrhiza. Alternatively, stress-poor environments or closely related neighbourhoods might select for investment into mycorrhiza as resources or more specialized mycorrhiza are available. Descendants from the corresponding environments and neighbourhoods should show highest enzymatic mycorrhizal activity, associated to highest benefits/lowest costs of mycorrhizal activity. We tested these predictions using Sessile Oaks (*Quercus petraea*) and their ectomycorrhiza, where descendants from different provenance climates and neighbouhoods are grown together. We found that descendants from provenances with phylogenetically closely related neighbourhoods and cooler climates have increased mycorrhizal laccase activity. In descendants from the same provenances increased laccase activity associates with relatively increased performances (in terms of budburst advancement, accumulating nitrogen, or deterring lepidoptera herbivores). Overall, investment into mycorrhiza might be selected for in environments of little climatic stress and phylogenetically close neighbours, possibly reflecting availability of resources and of specialist interactions.

Session 39-O3 - Tree-associated microbes

Early stage root-associated fungi show a high temporal turnover, but are independent of beech progeny

Kezia Goldmann[1], Silke Ammerschubert[2], Rodica Pena[2], Andrea Polle[2], Tesfaye Wubet[3,4], François Buscot[1,4]

[1]UFZ-Helmholtz-Centre for Environmental Research, Department of Soil Ecology, Halle (Saale), DE, kezia.goldmann@ufz.de
[2]Georg-August University, Department of Forest Botany and Tree Physiology, Göttingen, DE
[3]UFZ-Helmholtz-Centre for Environmental Research, Department of Community Ecology, Halle (Saale), DE
[4]German Centre for Integrative Biodiversity Research (iDiv) Halle-Jena-Leipzig, Leipzig, DE

Soil fungi are highly divers and encompasses, according to estimates, up to several million species worldwide. Thereby, soils of forests ecosystems are fungal hot spots. Recently, it has been shown that soil fungal communities have certain tree species preference. Moreover, we could proof that tree roots offer something like a "protecting environment" for inhabiting fungi, which let to less fungal community variation explained by abiotic factors. Accordingly and as follow-up to those findings, the so called Beech Transplant Experiment asked the question, whether the plant intraspecific variations impacts the fungal communities around and inhabiting the roots of European beech (*Fagus sylvatica* L.) trees. Initially, beech nuts of three different sites across Germany were collected between 2009 and 2011. The growing of the seedlings took place in the Botanical Garden in Göttingen and excluded initial mycorrhization. In autumn 2012 saplings, originating from south, central and north Germany were transferred back to the beech forests of the latter. After two and five years, in autumn 2014 and 2017 beech roots as well as the surrounding rhizosphere soil were sampled and prepared for Illumina MiSeq sequencing of the fungal target region ITS2. Our results revealed that the beech progeny had no impact on the fungal communities in rhizosphere soil or roots at this early development stage. However, the fungal communities changed significantly between the two sampling years, which indicates that the tree age rather than the intraspecific differences shaped the fungal communities. This effect was more pronounced in the examined roots than in the rhizosphere soil. Detailed analyses on fungal taxonomical and functional turnovers within the two compartments enhance the importance of temporal studies of root-inhabiting fungi at early stage plant development.

Session 39-O4 - Tree-associated microbes

Altitudinal variation and tree composition drive heterogeneity of soil fungal communities in a temperate forest in the State of Bavaria - Germany.

Daniel Osieko Okach[1], Janno Harjes[1], Inna Gild[1], Gerhard Rambold[1], Markus Blaschke[1]

[1]University of Bayreuth, Bayreuth, DE, kosieko@gmail.com

Soil fungi form complex interactions with plant communities therefore enhancing ecosystem functions and processes. Changes in vegetation structure related to phenology, climate and disturbance alter the diversity of fungal species within temperate forests. This study assessed the distribution of soil fungal communities at mid (700-820 m ASL) and higher (915-1260 m ASL) altitudes within coniferous, deciduous, and mixed forests in the state of Bavaria - Germany.
We extracted nucleic acids (DNA) from soil samples using the NucleoSpin® Soil commercial kit (MACHEREY-NAGEL GmbH & Co. KG) and sequenced the ITS region using the Illumina Miseq3000 (Biocenter of LMU Munich), after successful multiplex library preparation.
Altitudinal variation and forest tree composition influenced ($p < 0.05$) the diversity of soil fungal communities. Higher diversity was reported in the deciduous and mixed forests located at higher altitude compared to the coniferous forests. Distinct fungal communities were observed between different forest types except between the mixed and coniferous forests. Majority of the fungal species present in the soil samples, belonged to the phyla Ascomycota (36.9%) and Basidiomycota (44.5%). The most abundant groups constituting > 50% of the total number of fungal classes in every sample were Agaricomycetes, Leotimycetes Mortierellomycetes, and Sordariomycetes. An analysis using a guild bioinformatics tool, revealed that saprotrophs and ectomycorrhizal fungi dominated the forest soils.
Our results demonstrate that the occurrence of deciduous tree species at higher altitudes, dominated by conifers promote proliferation of fungal species previously found in lower altitudes. This is attributed to current changes in climatic pattern that create suitable conditions for dispersal and growth of deciduous tree species particularly *Fagus sylvatica* at higher altitude. This largely accounts for the shift in distribution of the soil fungal community.

Session 39-O5 - Tree-associated microbes

Fungal communities and soil functionality respond rather to tree traits than to tree species richness in European forests

Luis Daniel Prada Salcedo[1,2], Anna Heintz-Buschart[1,3], Kezia Goldmann[1], Thomas Reitz[1], François Buscot[1,3]

[1]Helmholtz-Centre for Environmental Research, Department of Soil Ecology, Halle (Saale), DE, luis.salcedo@ufz.de
[2]University of Leipzig, Department of Biology, Leipzig, DE, luis.salcedo@ufz.de
[3]German Centre for Integrative Biodiversity Research, Leipzig, DE

Research on biodiversity in forests mostly covered the aboveground compartment. However, soil microorganisms such as bacteria and fungi are closely linked to the dominant tree vegetation, in particular via mutualistic relationships. Therefore, a deep understanding of the structural associations between communities aboveground (plants) and belowground (microorganisms) is crucial to gain comprehensive functional insights for forest ecosystems. Due to their close link to the dominant tree vegetation, and their crucial role in biogeochemical cycles, our study focuses on soil fungi.
We amplified and sequenced the fungal ITS rDNA region using Illumina MiSeq. DNA was extracted from soils of 64 well-characterized forest plots, encompassing monocultures to multispecies in Finland, Poland, Romania and Italy. Variations in C, N and P nutrient cycling were evaluated by soil enzymatic activities. Relationships between fungal communities, enzymatic activity and trees were evaluated by leaf, litter and roots traits using an approach based on community-weighted means (CWM).
We found higher fungal diversity in Poland and Romania than in Italy and Finland. The overall results did not show significant differences in fungal populations between multispecies and monocultures plots within the countries. Community composition differed strongly between countries and the differences appeared to be rather driven by tree identity than by tree diversity. In addition, the overall fungal population and specific groups like saprotrophs, symbiotrophs, and pathotrophs showed a significant correlation with the CWM traits. At the functional level, enzymes also responded mainly to the CWM over fungal diversity. Thus, particular tree species compositions traits can boost or diminish nutrient feedbacks and fungal populations, which determine ecosystem process.

Session 39-O6 - Tree-associated microbes

The impact of planting Douglas-fir in Central Europe on microbial biomass and community structure

Jingzhong Lu[1], Stefan Scheu[1]

[1]Universität Göttingen, Göttingen, DE

Sustainable forest management requires the combination of timber production and preserving ecosystem functioning. To meet these goals, replacement of Norway spruce by Douglas-fir and mixing conifers with native beech trees in Central Europe receives particular attention. However, impacts of such replacement on soil microbial communities remain obscure. We established forty forest plots at eight sites across Lower Saxony that contain pure species plots of European beech, Norway spruce and Douglas-fir, as well as mixed species plots of beech and spruce or beech and Douglas-fir. We measured microbial biomass and microbial community structure in litter, 0–5 cm and 5–10 cm soil layers by substrate-induced respiration (SIR) and phospholipid fatty acids (PLFAs) profiling, respectively.

Microbial biomass and microbial community composition significantly differed between monospecific stands, and were intermediate in mixed forests. Microbial biomass per unit of total carbon was highest in beech forest, and lowest in Douglas-fir both in litter and soil. Discriminant function analysis of PLFA patterns suggests that microbial community composition of beech, spruce and Douglas-fir differs more in litter than in soil. Conversely, a number of microbial indicators (qO_2, $Gram^+/Gram^-$ ratio, cy/pre ratio, SAT/MONO ratio) differed less in litter than in soil and indicate that microorganisms in soil of beech forests have higher maintenance carbon demand (qO_2), lower energy limitation ($Gram^+/Gram^-$ ratio) and are less stressed (cy/pre ratio, SAT/MONO ratio) compared to coniferous forests, especially Douglas-fir.

Overall, the results suggest that replacement of Norway spruce by Douglas-fir decreases microbial biomass. While microbial community composition remains similar, microbial energy supply in soil is reduced and microbial stress indicators are increased as compared to beech and spruce, but the mechanisms responsible for these changes need further investigation. Mixing beech trees with Douglas-fir reduce stress indicators and improve physiological state of microorganisms. Our results draw attention on Douglas-fir plantations in central Europe and support the trend of mixing Douglas-fir with beech considering the essential roles of microorganisms in ecosystems.

Session 39-O7 - Tree-associated microbes

Effects of Forest Management and Fungal Community Dynamics on Deadwood Decomposition in Temperate Woodlands

Aleksandar Zarkov[1,2], Harald Kellner[3], Sabrina Leonhardt[3], Martin Hofrichter[3], François Buscot[4,5], Julia Moll[4], Björn Hoppe[6], Claus Bässler[1]

[1]Bavarian Forest National Park, Freyunger Str. 2, 94481 Grafenau, DE, aleksandar.zarkov@npv-bw.bayern.de
[2]Animal Ecology, Department of Ecology, Faculty of Biology, Philipps-Universität Marburg, 35037 Marburg, DE, aleksandar.zarkov@npv-bw.bayern.de
[3]Dresden University of Technology (TU Dresden) - International Institute (IHI) Zittau, Markt 23, 02763 Zittau, DE
[4]UFZ - Helmholtz Centre for Environmental Research, Dept. of Soil Ecology, Th.-Lieser-Str. 4, 06120 Halle (Saale), DE
[5]German Centre for Integrative Biodiversity Research (iDiv), Halle-Jena-Leipzig, Deutscher Platz 5e, 04103 Leipzig, DE
[6]Julius Kühn-Institute - Federal Research Centre for Cultivated Plants, Institute for National and International Plant Health, Messeweg 11/12, 38104 Braunschweig, DE

Previous studies indicated that wood-inhabiting fungal diversity is affected by forest management in temperate forests. However, we still miss a deeper understanding how the change in fungal diversity and community dynamics, due to management, influences important ecosystem processes and in particular deadwood decomposition. Our study evaluated the relationship between wood-inhabiting fungal community, forest management and deadwood decomposition in Central European woodlands. Here, we combined fungal molecular (OTU) and fruit body data and compared fungal communities on different angiosperm and gymnosperm tree species, located at experimentally controlled plots in three distant regions in Germany. We linked changes in fungal community composition to forest management and decomposition rate by using piecewise structural equation models. Our results suggested a direct effect of community composition on decomposition rate. We found no direct effect of forest management intensity on decay. When considering our molecular (OTU) data, the number of fungal species showed no influence on the decay processes, although the fruit body data results hinted a slightly effect of species number on decomposition. As we expected, the molecular data results indicated that community composition is affected by environment due to changes in microclimate (canopy cover). Therefore, we suggested that the stability of decay processes remained mainly unaffected by forest management, even though fungal community composition might be influenced by management activities.

Session 39-O8 - Tree-associated microbes

Deadwood-based fungal and prokaryotic networks are highly modular and specialized

Julia Moll[1], Anna Heintz-Buschart[1,2], Martin Hofrichter[3], Harald Kellner[3], François Buscot[1,2], Björn Hoppe[4]

[1]Helmholtz Centre for Environmental Research - UFZ, Department of Soil Ecology, Halle/Saale, DE, julia.moll@ufz.de
[2]German Centre for Integrative Biodiversity Research (iDiv), Halle-Jena-Leipzig, Leipzig, DE
[3]Technical University Dresden - International Institute (IHI) Zittau, Department of Bio- and Environmental Sciences, Zittau, DE
[4]Julius Kühn-Institute, Institute for National and International Plant Health, Braunschweig, DE

Fungi and prokaryotes are important deadwood-inhabiting groups mediating critical steps in wood decomposition. Much progress has been made to explore their distribution in relation to varying wood properties and environmental conditions by the application of next generation sequencing techniques. However, studies that consider more than one microbial group and assess how these groups relate to each other are largely missing. Bipartite interaction networks provide the opportunity to explore this consumer-resource relationship in detail, as the comparison of network topologies and related indices is possible independent of sampling effort and matrix size. Here, we used Illumina sequencing data to analyse fungal and prokaryotic interaction networks based on deadwood of thirteen temperate tree species. Several diversity- and specialization-related indices were determined and the observed network structures were related to intrinsic wood traits such as water content, pH and lignin. The present study revealed highly modular and specialized interaction networks for both wood-inhabiting groups. Wood traits explained the community organization, indicating that many fungal and prokaryotic species are specific decomposers. Nevertheless, as the specialization of fungi significantly surpassed the prokaryotes, our results indicate higher ecosystem performance by fungi.

Session 39-P1 - Tree-associated microbes

How does plant-soil feedback contribute to the coexistence of *Pinus massoniana* and *Lithocarpus glaber*?

Naili Zhang[2]

[2]Naili Zhang, Beijing, CN, zhangnl@ibcas.ac.cn

Experimental evidence and demographic analysis shows detrimental effects of soil borne biota on the growth of seedlings are larger near than away from conspecific adult trees, yet the underlying mechanisms remain elusive. Based on both field and pot experiments, we would estimate the importance of the fungal group within microbial community in soils under individual tree canopies in generating feedbacks to focal tree seedling growth. The in-situ field experiment was established in an old-growth subtropical forest of Gutianshan National Nature Reserve, where tree pairs of *Pinus massoniana* and *Lithocarpus glaber* were randomly selected and the composition of microbial community in soils between each tree pair was measured. Soils under the canopy of the tree pair of *Pinus massoniana* and *Lithocarpus glaber* were collected as soil inocula for the pot experiment. We found that soils under the canopy of *Lithocarpus glaber* positively, though marginally affected the growth of *Pinus massoniana* seedlings. Similar positive plant-soil feedback of *Pinus massoniana* to the growth of *Lithocarpus glaber* seedlings was found, but the positive feedback disappeared when soils were added with fungicide benomyl. These findings indicate the importance of soil fungi for the plant-soil feedback and the neighbor tree species coexistence.

Session 39-P2 - Tree-associated microbes

How do bacterial metabolic traits affect the stability and functionality of European forest ecosystems?

Ikbel Kriden[1,2], Luis Daniel Prada Salcedo[1,3], Kezia Goldmann[1], François Buscot[1,3,4]

[1]UFZ-Helmholtz-Centre for Environmental Research, Department of Soil Ecology, Halle (Saale), DE, ikbel.kriden@ufz.de
[2]Private University of Tunis, Department of Biological Engineering, Tunis, TN, ikbel.kriden@ufz.de
[3]University of Leipzig, Department of Biology, Leipzig, DE
[4]German Centre for Integrative Biodiversity Research (iDiv) Halle-Jena-Leipzig, Leipzig, DE

Through the years, most of the research on biodiversity has been focused on aboveground population and community dynamics in forest ecosystem. However, results demonstrated that plant communities are strongly interacting with soil microbes. These interactions manifest themselves in different forms such as symbiosis, parasitism or decomposition. Thus, competition amongst soil microorganisms might be mainly limited by resource availability.
Bacterial communities play essential roles in ecosystem functioning since they contribute to both, the soil structure and biological fertility. They are key players in nutrient cycling and have an active role in the transformation and mineralization of natural compounds, control certain pathogens and the degradation of particular soil contaminants.
Within the frame of the BiodivERsA project "Soil for Europe", we performed high-throughput sequencing of the 16S rRNA gene using Illumina MiSeq. Sequences were then analyzed by MOTHUR based pipelines. Profiles of bacterial metabolism and *in-silico* functions were determined by Tax4Fun to evaluate key enzymes, affecting the nutrient cycles.
We aim to understand, how forest systems affect bacterial communities in four different European countries. Thereby, we study similarities and difference of bacterial communities in two forest management systems (monocultural vs. multispecies). We also like to know, whether community changes affect the plant development and/or other organisms groups that provide ecosystem services and stability.
We will present relevant results to define if the bacterial community composition shifts according to regional scale or forest management system. Additionally, the relationships between forest management system and abundance of key enzymes will be determined. Likewise, the interactions of trees and soil bacteria will be connected to forest ecosystems functionality and maintained sustainability.

Session 39-P3 - Tree-associated microbes

Does an insect decline affect the microbiome of a clonal oak?

Cynthia Albracht[1,2], François Buscot[1,2,3], Sylvie Herrmann[1,3], Mika Tarkka[1,3], Kezia Goldmann[1]

[1]Department of Soil Ecology, Helmholtz Centre for Environmental Research-UFZ, Halle, DE, cynthia.albracht@ufz.de
[2]Department of Biology II, Leipzig University, Leipzig, DE, cynthia.albracht@ufz.de
[3]German Centre for Integrative Biodiversity Research (iDiv) Halle-Jena-Leipzig, Leipzig, DE

The environmental consequences of the recent decline in insect biomass are not yet known. Though, such loss is relevant for ecological functioning and might affect also the belowground. Induced stress via herbivory may change biochemical profiles of plants. Thereby, microorganisms, which have a pivotal role in ecosystem functioning and which are controlled by host plants might be affected indirectly by an insect reduction.
Within the iDiv Ecotron, the experiment "Insect Armageddon" tried to recreate a holistic insight of possible effects of insect declines on plants, available nutrients, and soil microbes. In 24 EcoUnits insect reduction was simulated using three treatments of insect biomass (100%, 25% and no insects) in an artificial temperate grassland. Each EcoUnit contained also one oak of the *Quercus robur* clone DF159 as so called "PhytOakmeter". Assessing the oak microbiomes, leaves, roots and rhizosphere soil were sampled at the end of the experiment in November 2018.
To test, if the expression of herbivory-related genes parallels the insect biomass, transcriptome analyses of oak leaves were performed. For this, we used quantitative reverse transcriptase PCR with primers related to jasmonate biosynthesis, volatile production and general defence responses of the oak. We did not expect strong changes in gene expression, since no significant leaf damages were observed while sampling. First results showed indeed that none of the genes was differentially expressed.
Likewise, we assumed that an interaction with insects modifies the oak microbiome. For first insights of such effects metabarcoding targeting the 16s rDNA for bacteria and the ITS2 region for fungi using Illumina MiSeq was carried out. In accordance with the insect treatments, we expect to see different microbial community compositions. However, there might be taxonomical and functional overlaps of the microbiota in rhizosphere, roots and leaves.

SESSION 40

What are the mechanisms of biodiversity effects on ecosystem functioning in forests?

Chairs: Stefan Trogisch, Xiaojuan Liu, Gemma Rutten, Helge Bruelheide

The functions and services derived from diverse forests have become the focus of research in the last decade. While observational studies have already demonstrated that tree species richness has positive effects on multiple ecosystem functions and services, studies on the underlying mechanisms are lagging much behind. To study the causal basis for positive tree richness effects, Biodiversity-Ecosystem Functioning (BEF) forest experiments have been established worldwide since more than 20 years. Positive effects of biodiversity are usually observed at the scale of the community, such as an increase in stand-level production, but they probably are caused by mechanisms at a much finer scale, i.e. that of individual trees. The session will be devoted to novel findings in forest diversity experiments that show to which degree positive net biodiversity effects are brought about by complementarity or selection effects, and whether these effects are mediated by herbivory or pathogens. Progress has been also made to explain how functional traits of trees determine the trees' resource use strategy. A particular focus will be on mechanisms, such as the role of above- and belowground niche differentiation among tree species in reducing interspecific competition and a more complete resource use. Thus, this session aims at expanding our understanding on how tree-tree interactions in local neighbourhoods translate into the observed tree species richness effects on key ecosystem functions at the community scale.

Session 40-O1 - Tree interactions affect ecosystem functioning

Spatio-temporal dynamics of individual-tree crown plasticity as affected by local neighbourhood interaction in BEF-China

Maria D. Perles-Garcia[1], Matthias Kunz[2], Nora Meyer[2], Goddert von Oheimb[2]

[1]iDiv, Leipzig, DE, maria_dolores.perles@idiv.de
[2]TU-Dresden, Dresden, DE

In closed-canopy forests, light is one of the key resources in primary productivity. In species mixtures, competition for canopy space is an important process that can result in an interspecific complementarity in light harvesting by means of niche differentiation. Traditional inventory methods to measure the dimensions of the crown are not efficient and deal with several inaccuracies. To overcome these limitations, we use Terrestrial Laser Scanning (TLS), which is a light detection and ranging (LiDAR) system capable to acquire rapidly three-dimensional (3D) structural information non-destructively with a very high resolution. TLS data of plots with different levels of tree species richness (ranging from 1 to 16 species) have been recorded in the large-scale forest biodiversity – ecosystem functioning experiment "BEF-China" since 2012. These data allow to study the development of the individual-tree crown plasticity over the years in relation to the tree species richness of the local neighbourhood. We quantify the displacement of crown centres from the stem base and analysed the direction and extent of 3D crown asymmetry. Size, position, and distance of neighbouring trees are used to construct vectors of neighbourhood asymmetry. Circular–circular rank correlations between the direction of crown asymmetry and the direction of neighbourhood pressure are used to quantify to what extent trees position their crowns away from local neighbours and how this is modified by tree species richness. Furthermore, the branching patterns and branch morphology of individual-tree crowns are compared between crown segments, which underlay strong neighbourhood interactions and those segments where these interactions are weak along the tree diversity gradient.

Session 40-O2 - Tree interactions affect ecosystem functioning

Stronger species than within-species genotypic richness effects on tree demography in species diverse tree experiment due to trait variation

Franca J. Bongers[1], Bernhard Schmid[2], Li Shan[1], Keping Ma[1], Xiaojuan Liu[1]

[1]Institute of Botany, Chinese Academy of Sciences, Beijing, CN, fjbongers@ibcas.ac.cn
[2]University of Zurich, Zurich, CH

Biodiversity – ecosystem functioning research has repeatedly demonstrated that increase in plant species richness can lead to increase in plant productivity, while only few studies focused on the effect of within-species genotypic richness. While functional differences between species explain species richness effects, empirical evidence that functional differences between within-species genotypes would explain genotypic richness effects on productivity is, to our knowledge, absent. Therefore, we studied if trait variation could explain observed species and genotypic richness effects on tree growth demography. We measured tree growth, stand-level tree volume and survival and eight functional traits within a full-factorial species × genotypic richness tree experiment that was planted in 2010 in subtropical China. After eight years of growth, we observed that stand-level tree volume was positively affected by species richness but not by genotypic richness, while survival was not affected by either species or genotypic richness. Within-species genotypes explained a considerable amount of trait variation, on top of the amount explained by the species, and both species and genotypes showed trait responses to richness. We also observed a species richness effect on the multivariate trait volumes, but a minimal affect of genotypic richness. We conclude that the difference between species and genotypic richness effects on tree demography could be due to the larger variation in ecological functions among species than between genotypes, reflected by the more distinct functional trait values among species than between genotypes. Although strong genotypic richness effects were absent, we argue that trait variation among genotypes is substantial and is therefore important to increase ecological functions within diverse communities, which can have positive effects on plant productivity and other ecosystem functions.

Session 40-O3 - Tree interactions affect ecosystem functioning

Neighborhood species diversity affects leaf trait variation at inter-specific and intra-specific scales

Andrea Davrinche[1], Stan Harpole[1,2,3], Sylvia Haider[1]

[1]Martin Luther University Halle-Wittenberg, Halle (Saale), DE, andrea.davrinche@idiv.de
[2]Helmholtz Center for Environmental Research – UFZ, Leipzig, DE
[3]German Centre for Integrative Biodiversity Research (iDiv) Halle-Jena-Leipzig, Leipzig, DE

Functional traits play a key role in explaining the underlying mechanisms of complementarity and competition depending on species diversity. However, the different levels of trait variation, from the community to the individual, are still often neglected when scaling up these mechanisms to ecosystem functions. Here, we investigate how leaf traits vary at the inter-specific and intra-specific scale, and hypothesize that variation depends on the diversity of the local neighborhood.
Within the framework of the biodiversity-ecosystem functioning experiment BEF-China, we studied leaf morphological and chemical traits of 240 Tree Species Pairs (TSP). We used four groups of four species each. For each group, the ten possible 2-species combinations were investigated across a species diversity gradient. More than 5000 leaves were sampled from 0 to 12 m along the crown interaction plane of the TSPs. Near-infrared spectrometry was used for analyzing specific leaf area (SLA), leaf dry matter content (LDMC) and leaf nutrient contents.
First results show an increase of SLA with plot diversity, reaching a maximum in the 8-species mixture, with a stronger increase for mono-specific compared to hetero-specific TSPs. This might indicate that two different mechanisms are occurring: a stronger spatial aboveground complementarity (denser crown packing) leads to a more intense competition for light in high-diverse environments. Contrarily, strong intra-specific competition for other resources leads to slower growth (i.e. lower SLA indicating a more conservative growth strategy) in mono-specific TSPs and specifically in monocultures. Therefore, we expect leaf nutrient contents to also increase with plot diversity, but more for hetero-specific TSPs than for mono-specific TSPs.
These findings support the importance of considering all levels of variation in functional traits, and contribute to the understanding of the trees distinct use of available space and resources depending on diversity.

Session 40-O4 - Tree interactions affect ecosystem functioning

Within-individual leaf trait variation in a tropical rain forest biodiversity-ecosystem functioning experiment

Tobias Proß[1,2], Helge Bruelheide[1,2], Sylvia Haider[1,2]

[1]Martin Luther University Halle-Wittenberg, Halle, DE, tobias.pross@botanik.uni-halle.de
[2]German Centre for Integrative Biodiversity Research (iDiv) Halle-Jena-Leipzig, Leipzig, DE, tobias.pross@botanik.uni-halle.de

In plant ecology, community-weighted trait means are often used as predictors for ecosystem functions. However, most studies have neglected within-species trait variation, which is known to contribute to ecosystem functioning. We here go one step further and assess the role of intra-individual trait variation, assuming that every leaf in a plant individual adjusts to its micro-environment.
In the Sardinilla tree experiment in Panama, we analyzed the variation of SLA, LDMC, total leaf C and N, C:N ratio, and structural carbohydrates at the level of species, trees and leaves. We investigated how these leaf traits were influenced by the tree diversity of the local neighborhood and leaf position within the tree crown (sampling height).
LDMC and C:N ratio increased, while leaf N and SLA decreased with increasing sampling height. While leaf C did not vary with sampling height, the allocation of carbon to the different structural carbohydrates changed. Leaves had increasing lignin and cellulose and decreasing hemicellulose content with increasing height in the crown. Intra-individual trait variation was also affected by the local neighborhood, shown in a decreased variation in leaf N content with increasing species richness.
Our results suggest that with increasing sun-exposure leaves become thicker and richer in structural carbohydrates, and are thereby protected against extreme radiation and weather conditions. In contrast, higher SLA in the lower crown optimizes photosynthetic capacity under low light availability. These gradients are modified by the tree diversity in the local neighborhood. Nitrogen, a key factor in photosynthesis, is more evenly distributed in diverse neighborhoods. In contrast, high variation of leaf N within trees in monocultures indicates a stronger response to intra-specific competition. Our findings support the idea that the inclusion of within-individual trait variation is important to increase our understanding about BEF relationships.

Session 40-O5 - Tree interactions affect ecosystem functioning

The influence of species identity effects on functional responses in mixtures

John Connolly[1], Caroline Brophy[2], Helge Bruelheide[3], John Finn[4], Rafael de Andrade Moral[2]

[1]University College Dublin, Dublin, IE, john.connolly@ucd.ie
[2]MU, Kildare, Ireland
[3]MLU, Halle, Germany
[4]Teagasc, Wexford, Ireland

Functional responses of mixtures of species depend on the identity of the species (ID) and interactions among them (DE). We explore how differences between species identities can contribute to variation and correlation among responses of communities differing in species composition and richness.
Motivation: Variation among communities at the same richness levels should (a) depend on the size of differences between species and (b) decrease with increasing richness. (c) responses from communities with species in common may have positive correlation within and across richness levels.
To explore these relationships we use a model relating functional response to the identities of the species in a community. We motivate the enquiry by plots of functional responses in mixtures vs predictions from monocultures for each of two experiments[1,2] with richness levels 9 and 72, with responses plot biomass, plot microbial respiration. We analyse the model mathematically.

Results
Data: Generally a strong positive relation between mean community functional response and response predicted from monocultures, especially for lower richness, for one experiment but not the other. Why?

Mathematical analysis of the model shows that
Variation among mixtures depends jointly on variation among ID effects and community richness. For large s the model suggests that variation among r-species communities due to ID effects decreases with r.
(ii) ID effects can create links across mixtures varying in composition, evenness and richness.

This analysis broadly agrees with the observations from the data. We discuss implications for the analysis of BEF experiments.

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Session 40-O6 - Tree interactions affect ecosystem functioning

Tree diversity effects on arboreal spider communities in a European forest experiment

Dragan Matevski[1], Andreas Schuldt[1]

[1]Faculty of Forest Sciences, Forest Nature Conservation, Georg-August-University Göttingen, Büsgenweg 3, 37077, Göttingen, Germany, Göttingen, DE, dragan.matevski@forst.uni-goettingen.de

In an effort to understand the negative impact that the current loss of biodiversity has on ecosystem functioning, Biodiversity-Ecosystem Functioning (BEF) experiments have taken central stage in ecological research. While initial research had a strong focus on patterns and processes at the producer level, recent research has started to more thoroughly investigate the consequences of higher trophic levels and their important ecosystem functions.
Here we analyzed the effects of tree species richness on the functional diversity and community structure of canopy spiders as important generalist predators in forest ecosystems. Spiders were sampled by beating from 16 plots along a diversity gradient of 1-4 tree species (*Fagus sylvatica, Picea abies, Pseudotsuga menziessii, Quercus petraea*) in the framework of the BIOTREE experiment in Thuringia, Germany.
The analysis was performed on two levels: plot level and tree individual level. Effects of tree diversity and composition differed on the two levels, with tree species richness and stand type (deciduous, coniferous or mixed) showing significant positive effects on spider abundance, diversity and biomass only on the tree level, while tree height and the presence of deciduous trees were the main drivers of species richness, functional dissimilarity (FDis) and biomass on the plot level.
The scale dependent effects of tree species richness on spider communities show the importance of assessing the effects of diversity on ecosystem functioning at multiple spatial resolutions in order to better understand the role that diversity plays in promoting ecosystem functions and services.

Session 40-O7 - Tree interactions affect ecosystem functioning

Exotic tree species protects better than biodiversity against bark beetle infestation

Sylvie Berthelot[1], Jochen Fründ[1], Michael Scherer-Lorenzen[2], Carsten Dormann[1]

[1]Biometry and Environmental System Analysis, Uni Freiburg, Freiburg, DE, sylvie.berthelot@biom.uni-freiburg.de
[2]Geobotany, Uni Freiburg, Freiburg, DE

Until now studies are discordant whether tree diversity has a positive effect on insect pest reduction or not. To test effects of tree diversity an international diversity experiment with trees (IDENT) was designed in North America and Europe. The IDENT-Freiburg site has a species richness (SR) gradient ranging from 1 to 6 tree species per plot. After a severe drought in Germany in summer 2018 the young conifer trees were attacked by the Sixtoothed spruce bark beetle (*Pityogenes chalcographus*). The bark beetle boreholes on six North American and European congener species (spruce, larch and pine) were monitored in winter 2018/19.
Most interestingly no significant effect of SR reducing bark beetle infestation was found. Surprisingly, the origin of a tree species had a much stronger effect than SR: native conifers were significantly more and stronger infested than their exotic congeners. This could imply that the coevolution of the European bark beetle and the European trees species lead to the ability of the bark beetle to distinguish tree species even on genus level, presumably by olfaction. The European spruce and larch, even mixed with North American spruce and larch, were always more attacked than their North American congeners. Integration of exotic trees into forestry planning might be more promising for reducing bark beetle risk than a sole focus on tree species diversification.

Session 40-O8 - Tree interactions affect ecosystem functioning

Structural and functional diversity of tree communities drive arthropod diversity in subtropical forests

Andreas Schuldt[1], Matthias Kunz[2], Michael Staab[3], Goddert von Oheimb[2,4], Jiayong Zhang[5], Helge Bruelheide[4,6], Nico Eisenhauer[4,7]

[1]Forest Nature Conservation, Georg-August-University Göttingen, Göttingen, DE, andreas.schuldt@forst.uni-goettingen.de
[2]Institute of General Ecology and Environmental Protection, Technische Universität Dresden, Dresden, DE
[3]Nature Conservation and Landscape Ecology, University of Freiburg, Freiburg, DE
[4]German Centre for Integrative Biodiversity Research (iDiv) Halle-Jena-Leipzig, Leipzig, DE
[5]Key Lab of Wildlife Biotechnology, Conservation and Utilization of Zhejiang Province, Zhejiang Normal University, Jinhua, CN
[6]Institute of Biology/Geobotany and Botanical Garden, Martin Luther University Halle-Wittenberg, Halle, DE
[7]Institute of Biology, Leipzig University, Leipzig, DE

Subtropical and tropical forests harbor an impressive biodiversity that is under increasing threat due to human-induced environmental change. At the same time, many countries in these species-rich regions have started large-scale reforestation programs. Addressing the threats to biodiversity on the one hand and promoting activities to restore biodiverse ecosystems on the other hand both require information about the strength and structuring forces of diversity relationships across multiple trophic levels. The BEF-China experiment in the subtropical south-east China is one of the largest forest biodiversity experiments worldwide and has generated a wealth of data to address these issues. Based on these data, we tested the extent to which tree species richness promotes the species richness of arthropod herbivores, predators, and parasitoids in a subtropical forest system, and which components of tree diversity and composition (taxonomic, functional, stand structural) are the main drivers of these relationships across trophic levels. We found that functional and structural biodiversity components explain large parts of the diversity relationships between tree communities and higher trophic levels. Importantly, tree diversity effects on higher trophic-level species richness were mediated by modifications of consumer abundances. Our study therefore identifies important pathways connecting tree diversity and consumer diversity that have particular relevance in light of recently reported drastic declines in insect abundances (with respect to our latter finding) and efforts to foster biodiversity-promoting structures (with respect to strong effects of stand structural diversity in our study) in managed and plantation forests.

Session 40-O9 - Tree interactions affect ecosystem functioning

How do litter species identity and richness affect litter mixture decomposition via modifying fungal decomposers?

Hong Lin[1], Yinong Li[1], Helge Bruelheide[2], Haibao Ren[1], Xiaojuan Liu[1], Keping Ma[1], Naili Zhang[1]

[1]Institute of Botany, CAS, Beijing, CN, linhongshengwu2012@163.com
[2]Institute of Biology / Geobotany and Botanical Garden, Martin Luther University Halle-Wittenberg, Halle, DE

Widespread concern has been paid on the decomposition of litter mixture. However, the underlying mechanisms of how litter richness and identity influence on the decomposing processes remain elusive. Due to resource complementarity, we hypothesized that mass loss increases with increasing litter richness and litter richness enhances fungal diversity. To test these hypotheses, we conducted a litterbag experiment with the litter richness manipulation in a subtropical forest, in which stand plant community composition and functional traits, environmental factors, and microbial decomposers were measured. Our results showed that litter species richness had no significant effects on mass loss. However, litter species identity surpasses richness in influencing decomposition through modifying fungal community composition in leaf litter. The community composition of fungi decomposers dynamically changed during the processes of decomposition, with Ascomycota fungi dominated in the early stage of decomposition and fungi decomposers from the phylum Basidiomycota dominated at the later stage of decomposition. We also found significant associations of stand plant traits and soil properties with fungi community composition, but not with the fungal richness. Overall, our findings provide insight into the importance of litter species identity rather than richness in the mass loss of litter mixture via structuring the community composition of fungal decomposers. In the further litter decomposition studies, the composition and traits of stand plants should be systematically considered in order to disentangle the relative importance of direct and indirect effects of tree species richness on ecosystem functioning.

Session 40-O10 - Tree interactions affect ecosystem functioning

Leaf traits affect foliar fungal richness and infestation in a subtropical tree community.

Gemma Rutten[1,2], Lydia Hönig[1], Rowena Schwaß[1], Uwe Braun[1], Helge Bruelheide[1,2]

[1]MLU, Halle (Saale), DE, gemma.rutten@idiv.de
[2]iDiv, Leipzig, DE, gemma.rutten@idiv.de

Foliar fungal pathogens modify biodiversity-ecosystem functioning relationships by negatively affecting host plant performance. Moreover, plant pathogen infestation is expected to be influenced by species diversity among neighbouring host and non-host plant species. Yet, it remains unclear which host- and community characteristics best explain fungal pathogen infestation.
Here, we used 32 tree species from a common environment in the Biodiversity-Ecosystem Functioning experiment at Jiangxi (BEF-China), for which we established a phylogeny and measured leaf traits. The leaf traits represented characteristics related to the leaf economics spectrum, to stomatal conductance, to xylem properties, and included also leaf microscopic traits. We assessed 574 individual trees from tree communities with local neighborhoods differing in community-weighted means and functional diversity and species richness. To assess the foliar fungal richness and infestation rate of 5584 leaves, we identified all visible fungal structures and symptoms microscopically and studied fungi-specific traits such as conidia or spores in detail.
Contrary to our expectations, there was no phylogenetic signal, and thus, no difference in fungal species richness or fungal infestation at the *tree species level*. However, the community-weighted means and functional diversity of leaf traits *in the local neighborhood* of the 574 target individuals showed strong impacts. Specifically, trichome type, thought to be related to drought resistance, and presence of a sub-epidermis were traits that affected both fungal richness and infestation. Moreover, we found no effects by tree diversity indices on fungal species richness, but a negative effect of mean pairwise phylogenetic distance on fungal infestation. Overall, our study confirms the high importance of local neighborhood in controlling foliar fungal pathogens in forests.

Session 40-P1 - Tree interactions affect ecosystem functioning

Diversity effect on tree and shrub survival in a forest biodiversity experiment

Xiaojuan Liu[1], Shan Li[1], Bernhard Schmid[2], Helge Bruelheide[3], Keping Ma[1]

[1]Institute of Botany, Chinese Academy of Sciences, Beijing, CN, liuxiaojuan06@ibcas.ac.cn
[2]Department of Geography, University of Zurich, Zurich, CH
[3]Institute of Biology, Martin Luther University Halle-Wittenberg, Halle, DE

Although positive effect of biodiversity on plant productivity has been proved as a general result from decades of studies, but most of them are tested on plot level without considering the dynamics within the plot. The studies between diversity and ecosystem functioning in forest ecosystem are different from grassland ecosystem, as the community or population dynamics are determined by the demographic rates of individual tree. The observed positive relationship between diversity and productivity can due to either increase growth or decreased mortality per plot. However, there are few evidences for this. Therefore, with a 10-years diversity experiment in subtropical forest, we compared the survival rates for plots and each species across different diversity levels, for species within the same diversity level, for different functional groups and different extinction scenarios. The results generally have shown that compared to the earlier stage, the diversity effect has become more important roles in determine the survival rates and thus the ecosystem productivity.

Session 40-P2 - Tree interactions affect ecosystem functioning

Water use efficiency a key driver of drought resistance and resilience in mixed-species tree communities?

Florian Schnabel[1,2,3], Kathryn E. Barry[1,2], Anja Kahl[2], Jürgen Bauhus[3], Christian Wirth[1,2]

[1]German Centre for Integrative Biodiversity Research (iDiv) Halle-Jena-Leipzig, Leipzig, DE, florian.schnabel@idiv.de
[2]Systematic Botany and Functional Biodiversity, University of Leipzig, Leipzig, DE, florian.schnabel@idiv.de
[3]Chair of Silviculture, Faculty of Environment and Natural Resources, University of Freiburg, Freiburg, DE, florian.schnabel@idiv.de

The projected increase in frequency and intensity of droughts with climatic change threatens tree growth and survival. Tree ring and stable isotope analyses in temperate forests have shown that heterospecific tree neighbourhoods may improve water use and growth compared to conspecific ones, but also negative effects have been reported. Species-specific water-use strategies may explain these divergent results, i.e. isohydric vs anisohydric hydraulic strategies, but this has not been systematically addressed. Here, we present a framework for how to analyse neighbourhood tree species diversity effects on water use efficiency (~stomatal closure) and growth. The framework is being applied to a gradient of native tree species richness in the subtropical BEF-China experiment, where we analyse the influence of an extreme drought year (2016). Fifteen tree species with visible annual growth rings were selected with respect to their water use efficiency (isohydric vs anisohydric species) and hydraulic drought resistance. We expect that these two orthogonal species trait gradients are key for elucidating the mechanisms behind observed species richness effects on tree growth resistance and resilience during drought. Focal trees and their neighbours were sampled to create a neighbourhood diversity gradient with 1, 2 and 4 tree species and a total sample size of 450 focal trees (10 trees per species and diversity level). Identity, size and vitality of all neighbours were recorded. For each focal tree, one increment core was extracted and tree ring width as well as δ13C signatures of the years 2014-2018 (with 2016 being the drought year) will be measured. In addition to water use efficiency (δ13C signatures), we plan to analyse the short-term stability of tree growth. Under increasing frequency and intensity of extreme climatic events, our framework may contribute new insights into the mechanisms that drive enhanced water relations in mixed-species tree communities.

Session 40-P3 - Tree interactions affect ecosystem functioning

Differential soil fungus accumulation explains density dependence in a subtropical forest

Lei Chen[1]

[1]Institute of Botany, Chinese Academy of Sciences, Beijing, CN, chenlei@ibcas.ac.cn

Variation among species in the strength of conspecific negative density dependence (CNDD) could regulate tree diversity and abundances in forest communities, but the underlying mechanisms that generate such variation are poorly understood. By using a multilevel modelling approach, we combined long-term seedling demographic data from a 24-ha subtropical forest plot with snapshot fungal community via DNA sequencing to address the feedback of various guilds of soil fungi on density dependence of trees. We show that mycorrhizal type mediates tree neighborhood interactions at the community level, and much of interspecific variation in CNDD is explained by species differences in the rate at which trees accumulated density of fungi as they grew. Species with higher rates of accumulation of pathogenic fungi suffered more from conspecific neighbors, whereas species with higher ectomycorrhizal fungus accumulation rates were less inhibited by conspecific neighbors, suggesting that mutualistic and pathogenic fungi play important, but opposing, roles.

Session 40-P4 - Tree interactions affect ecosystem functioning

Mycorrhizal type drives subtropical forest biodiversity and ecosystem function relationships

Jianhui Ma[1,2,3]

[1]Jianhui Ma, Beijing, CN, JianhMa@126.com
[2]Lei Chen, Beijing, CN, JianhMa@126.com
[3]Keping Ma, Beijing, CN, JianhMa@126.com

Plant-soil feedbacks play an important role in community assembly processes, yet the conceptual frameworks for predicting their magnitude and direction are lacking. Recent work suggests that the kingdom fungi is one of the most diversity group of organisms on earth, and fungal richness is decoupled from plant diversity. More than 97% plants are engaged in symbiotic that have relationships with mycorhizal fungi. Mycorrhizal fungi affects not only species diversity, but also productivity. Therefore, the natural plants may have a positive and negative feedbacks on the interaction among their types of mycorrhiza formed, particularly between the dominant arbuscular mycorrhizal (AM) and ectomycorrhizal (EM). In this study, we hypothesized that the negative or positive relationships between productivity and species diversity will differ among tree communities (AM or EM trees). Under the low nutrient level with EM trees will show stronger negative relationship between plant diversity and productivity. However, the high nutrient level with AM trees will have stronger positive relationship between plant diversity and productivity. The dataset contained 13 AM tree species and 163 EM tree species n 24 ha permanent plot in a subtropical broad-leaved forest in the Gutianshan National Nature Reserve. The AM and EM trees accounted for 63.7% and 16.3% of all individuals. Moreover, The EM trees accounted for 62.1% of total aboveground biomass (AGB), while EM trees accounted for only 35.9% of total AGB. The AGB of AM tree significantly positively correlated with soil nutrient (R^2=0.08) and diversity (R^2=0.20), while the AGB of EM tree significantly negatively correlated with soil nutrient (R^2=0.18) and diversity (R^2=0.10). We also found that the interactions of soil nutrient and diversity shows a positive trend along AGB in EM tree. By contrast, the AGB in AM tree showed a negative trend along the interactions of soil nutrient and diversity. Taken together, tree mycorrhizal associations can greatly mediate forest community patterns and production.

Session 40-P5 - Tree interactions affect ecosystem functioning

Effects of tree functional diversity on foliar fungal pathogen load and richness in a Chinese subtropical forest

Mariem Saadani[1,2], Michael Köhler[1], Lingli Liu[3], Tesfaye Wubet[2,4], Helge Bruelheide[1,2]

[1]Institute of Biology / Geobotany and Botanical Garden, Martin Luther University Halle-Wittenberg, Halle (Saale), DE
[2]German Centre for Integrative Biodiversity Research (iDiv) Halle-Jena-Leipzig, Leipzig, DE
[3]State Key Laboratory of Vegetation and Environmental Change, Institute of Botany, Chinese Academy of Sciences, Beijing, CN
[4]UFZ-Helmholtz Centre for Environmental Research, Department of Community Ecology, Halle (Saale), DE

Leaf fungal pathogens alter their host species performance, and thus, changes in fungal species composition can relate to effects at the tree community scale. Conversely, the functional diversity of tree species in a host tree's local neighbourhood is able to affect the host's foliar fungal pathogen infestation. Therefore, understanding the factors that facilitate or impede fungal infestations at the local and community scale is important to advance our understanding of biodiversity-ecosystem functioning (BEF) relationships in forests. We here make use of the largest BEF tree experiment worldwide, the BEF-China experiment in Jiangxi (China), where we selected tree species pairs (TSPs) of hosts with different neighbour tree species. We hypothesized (i) that a larger tree richness in the neighbourhood decreases fungal load and increases fungal richness at the community scale and (ii) that the neighbour trees' identities might positively or negatively affect pathogens infestation via modifying the environmental conditions at the local neighborhood. Using microscopy facilities and next-generation high-throughput DNA sequencing techniques based on the ITS region, we analyzed the fungal taxa of a target tree in different TSP settings. We found a rich, and so far unknown, fungal community that was highly host species-specific, but also depended on the tree species composition of the host's local neighborhood. In particular, fungal infestation decreased with the diversity of the host's local neighborhood. Overall, our study point to BEF effects that are caused across different trophic levels.

Aspects of Biomass Prediction of Small Diameter Trees. A Diversity Experiment

Alexander Kaulen[1], Alexander Kaulen[1]

[1]Alexander Kaulen, Freiburg, DE

The experiments miniMyDiv and IDENT from Ontario/Germany assessed small diameter trees, including 18 species in monoculture as well as in mixture. These experiments tested the relationship between diversity effects and changes in biomass production. They evaluated the best way of quantifying biomass: cutting and weighing. This method is highly invasive and involves high costs. Often trees cannot be destructively sampled, even though biomass is the most important value to recognize shifts in growth caused by diversity. The heads of the miniMyDiv project set the target to design a project-specific way of biomass prediction that reduces costs and spares the plant for future measurements. Allometry, which is based on the relationship between easily collected variables and the true biomass based on solid but expensive measurements, is the common answer to nondestructive biomass estimation. This research confronts the lack of knowledge of influences on the biomass prediction of juvenile trees. Empirical substantiated studies about the estimation of small diameter trees, which are rare, do not consider the influence of mixture, growth habits, changes in HD-ratio or other noteworthy impacts. Since I was able to test a wide range of possible magnitudes of influence, I am confident to limit them to only a few significant ones: species combination, shifts in HD-ratio, and species-specific growth habits. When examining the mixture of species, the relationship of the stem to branch biomass and diversity level have no effect on the variation and error in biomass prediction outcome. Based on these findings, I modeled species-specific biomass equations with only the substance of root collar diameter, height or volume.

LIST OF PARTICIPANTS

Surename	Forename	Organisation		Email
Abdallah	Mohamad	Instituto Mediterráneo de Estudios Avanzados Imedea de la Universidad de las Illes Balears	ES	mohamad.abdallah@uib.es
Aberle	Isabella	Philipps-Universität Marburg	DE	isabella.aberle@posteo.de
Adamcik	Slavomir	Plant Science and Biodiversity Centre SAS	SK	slavomir.adamcik@savba.sk
Aguilar Cruz	Yonatan	Carl Von Ossietzky Universität Oldenburg	DE	treefolck@hotmail.com
Ahlborn	Julian	ZALF Sustainable Grassland Systems	DE	julian.ahlborn@zalf.de
Ahmed	Sajawel	Text Technology Lab, Goethe University Frankfurt	DE	sahmed@em.uni-frankfurt.de
Akbar	Siddiq	School of Life Sciences, Nanjing Normal University	CN	siddiqakbar@qq.com
Alas	Honey Dawn	Leibniz Institute for Tropospheric Research	DE	alas@tropos.de
Albracht	Cynthia	Helmholtz-Zentrum für Umweltforschung	DE	cynthia.albracht@ufz.de
Albrecht	Matthias	Agroscope	CH	matthias.albrecht@agroscope.admin.ch
Aljes	Vincent	Universität Kassel - Landschafts- u. Vegetationsökologie	DE	aljes@posteo.de
Alos Orti	Marta	Estonian University of Life Sciences	EE	martaalosorti@gmail.com
Ambarli	Didem	Terrestrial Ecology Group, Department for Ecology and Ecosystem Management, Technical University of Munich	DE	didem.ambarli@tum.de
Ammer	Christian	University of Göttingen	DE	christian.ammer@forst.uni-goettingen.de
Amthauer Gallardo	Daniel A.	Thünen Institut für Biodiversität	DE	daniel.amthauer@thuenen.de
Anderle	Matteo	Eurac Research	IT	matteo.anderle@eurac.edu

Surename	Forename	Organisation		Email
Annighöfer	Peter	Georg-August-Universität Göttingen	DE	pannigh@gwdg.de
Arend	Matthias	Universität Basel / Physiologische Pflanzenökologie	CH	matthias.arend@unibas.ch
Arfin Khan	Mohammed A. S.	Shahjalal University of Science and Technology	BD	mohammed.arfin-khan@uni-bayreuth.de
Argens	Laura	Technische Universität München	DE	laura.argens@tum.de
Arnoldi	Jean-Francois	Trinity College Dublin	IE	arnoldij@tcd.ie
Ayasse	Manfred	Institute of Evolugionary Ecology and Conservation Genomics	DE	manfred.ayasse@uni-ulm.de
Bae	Soyeon	University of Würzburg	DE	baelovejx@gmail.com
Baierl	Cindy	Universität Kassel, FB 06, FG Landschafts- und Vegetationsökologie	DE	cindy.baierl@uni-kassel.de
Baschung	Chiara	Zürcher Hochschule für Angewandte Wissenschaften (ZHAW)	CH	chiara.b@schung.ch
Basler	David	Harvard University	US	david.j.basler@gmail.com
Bastidas Urrutia	Ana María	Technische Universität München	DE	anamaria.bastidas-urrutia@tum.de
Batary	Peter	Hungarian Academy of Sciences, Landscape and Conservation Ecology	HU	batary.peter@okologia.mta.hu
Bauer	Markus	Technical University of Munich	DE	markus1.bauer@tum.de
Baur	Bruno	Universität Basel	CH	bruno.baur@unibas.ch
Beckers	Birgit	Dachverband Biologischer Stationen	DE	b.beckers@abu-naturschutz.de
Beermann	Ilka	ILÖK	DE	beermann@gmx.net
Beil	Ilka	University of Greifswald, Institut for Botany and Landscape Ecology	DE	ilka.beil@uni-greifswald.de
Benesh	Dan	Humboldt-Universität zu Berlin	DE	dbenesh82@gmail.com
Benthien	Oda	Bundeswehr, BwDLZ Bergen	DE	odabenthien@bundeswehr.org

Surename	Forename	Organisation		Email
Berger	Anne	Leibniz Institute for Zoo and Wildlife Research	DE	berger@izw-berlin.de
Berger	David	WWU	DE	d_berg20@uni-muenster.de
Berkhout	Boris W.	University of Leicester	UK	bwberkhout@protonmail.com
Bersier	Louis-Félix	University of Fribourg, Switzerland	CH	louis-felix.bersier@unifr.ch
Berthelot	Sylvie	Uni Freiburg	DE	sylvie.berthelot@biom.uni-freiburg.de
Bette	Julius	University of Marburg, Biology	DE	Bettej@students.uni-marburg.de
Beyer	Nicole	Universität Göttingen	DE	nicole.beyer@uni-goettingen.de
Bianchi	Eva	ETHZ Zürich	CH	eva.bianchi@usys.ethz.ch
Bieberich	Judith	University of Bayreuth	DE	judith.bieberich@uni-bayreuth.de
Bijleveld	Allert	NIOZ Royal Netherlands Institute for Sea Research	NL	allert.bijleveld@nioz.nl
Bink	Niek-Jan	Ingenieursbureau Wittich&-Visser b.v.	NL	nj.bink@wittich.nl
Bischofberger	Jenny	JESS - JEnnys Science Service	DE	Babel@posteo.de
Blaschka	Albin	AREC Raumberg-Gumpenstein	AT	albin.blaschka@raumberg-gumpenstein.at
Bleicher	Marie-Therese	TUM Lehrstuhl Renaturierungsökologie	DE	marie-therese.bleicher@tum.de
Blüthgen	Nico	Technische Universität Darmstadt	DE	bluethgen@bio.tu-darmstadt.de
Böcker	Felix	Forstliche Versuchs- und Forschungsanstalt Baden-Württemberg	DE	Felix.Boecker@Forst.bwl.de
Boetzl	Fabian	Deapartment for Animal Ecology and Tropical Biology (Zoology III)	DE	fabian.boetzl@uni-wuerzburg.de
Bolliger	Ralph	University of Bern / Institute of Plant Sciences	CH	ralph.bolliger@ips.unibe.ch
Bongers	Franca	Institute of Botany, Chinese Academy of Sciences	CN	fjbongers@ibcas.ac.cn
Bonkowski	Michael	University of Cologne, Institute of Zoology	DE	m.bonkowski@uni-koeln.de

Surename	Forename	Organisation		Email
Bonn	Aletta	German Centre for Integrative Biodiversity Research (iDiv)	DE	aletta.bonn@idiv.de
Borgmann	Peter	Botanischer Garten der Universität Osnabrück	DE	borgmann@biologie.uni-osnabrueck.de
Borregaard	Michael	Center for Macroecology, Evolution and Climate, GLOBE Institute, University of Copenhagen	DK	mkborregaard@bio.ku.dk
Bossdorf	Oliver	University of Tübingen	DE	oliver.bossdorf@uni-tuebingen.de
Boura	Marlène	University of Luxembourg	LU	marlene.boura@uni.lu
Bourlat	Sarah	Zoological Research Museum Alexander Koenig (ZFMK)	DE	S.Bourlat@leibniz-zfmk.de
Bowler	Diana	iDiv	DE	diana.bowler@idiv.de
Brandes	Elke	Thuenen Institute of Rural Studies	DE	elke.brandes@thuenen.de
Brändle	Martin	Philipps-Universität Marburg, Faculty of Biology, Department of Ecology, Animal Ecology	DE	braendle@staff.uni-marburg.de
Brandmeier	Jana	WWU/Institut für Landschaftsökologie	DE	jana.brandmeier@uni-muenster.de
Brandt	Thomas	Ökologische Schutzstation Steinhuder Meer	DE	brandt@oessm.org
Braschler	Brigitte	Conservation Biology, University of Basel	CH	brigitte.braschler@unibas.ch
Brauner	Ruth	Zukunft - Umwelt - Gesellschaft gGmbH, LIFE Advisory Office	DE	ruth.brauner@z-u-g.org
Bredemeier	Michael	Univ. Göttingen	DE	mbredem@gwdg.de
Brehier	Clarisse	HSWT	DE	clarisse.brehier@hswt.de
Breuer	Bettina	Climatology Research Group - University of Münster	DE	bettina.breuer@uni-muenster.de
Brinkert	Annika	Biologische Station Kreis Steinfurt e. V.	DE	annika.brinkert@biologische-station-steinfurt.de
Brouwer	Emiel	Onderzoekcentrum B-WARE	NL	e.brouwer@b-ware.eu
Bruchmann	Ines	NLWKN - LIFE Sandlandschaften	DE	ines.bruchmann@web.de

Surename	Forename	Organisation		Email
Bruelheide	Helge	Martin Luther University Halle-Wittenberg, Institute of Biology / Geobotany and Botanical Garden	DE	helge.bruelheide@botanik.uni-halle.de
Bucharova	Anna	University Münster	DE	anna.lampei-bucharova@uni-muenster.de
Bucher	Solveig Franziska	Friedrich Schiller University Jena	DE	solveig.franziska.bucher@uni-jena.de
Bucher	Roman	Philipps-Universität Marburg	DE	bucher@uni-marburg.de
Buchmann	Carsten	University of Hohenheim (Institute 320A)	DE	carsten.buchmann@uni-hohenheim.de
Bugmann	Harald	Forest Ecology, ETH Zürich	CH	harald.bugmann@env.ethz.ch
Burger	Hannah	Ulm University	DE	hannah.burger@uni-ulm.de
Burkhardt	Jürgen	University of Bonn, INRES - Plant nutrition	DE	j.burkhardt@uni-bonn.de
Busch	Verena	Justus-Liebig-Universität Giessen	DE	verena.busch@umwelt.uni-giessen.de
Butschkau	Susanne	AIM Advanced Identification Methods GmbH	DE	info@aimethods-lab.com
Buttschardt	Tillmann	Institut für Landschaftsökologie, Universität Münster	DE	tillmann.buttschardt@uni-muenster.de
Caboň	Miroslav	Institute of Botany, Plant Science and Biodiversity Centre	SK	miroslav.cabon@gmail.com
Cai	Qiong	Martin Luther University of Halle-Wittenberg	DE	caiqiongruc@163.com
Calabrese	Justin	Smithsonian Institution	US	CalabreseJ@si.edu
Capria	Loris	University of Geisenheim	DE	loris.capria@hs-gm.de
Casanelles Abella	Joan	ETHZ / WSL	CH	joan.casanelles@wsl.ch
CHEN	Lei	INSTITUTE OF BOTANY, CAS	CN	chenlei@ibcas.ac.cn
Chen	Kaining	Nanjing Institute of Geography and Limnology, Chinese Academy of Sciences	CN	knchen@niglas.ac.cn
Clark	Adam Thomas	Helmholtz-Zentrum für Umweltforschung (UFZ), Physiological Diversity	DE	adam.tclark@gmail.com
Connolly	John	University College Dublin	IE	john.connolly@ucd.ie

Surename	Forename	Organisation		Email
Conrady	Malte	Institut für Landschaftsöko-logie	DE	malte.conrady@uni-muenster.de
Cooksley	Huw	Institüt für Landschafts- und Pflanzenökologie, Universität Hohenheim	DE	huwcooksley@hotmail.com
Cormier	Marc-André	ETH Zürich	CH	cormier@erdw.ethz.ch
Cristescu	Romane	University of the Sunshine Coast	AU	rcristes@usc.edu.au
Dahms	Henriette	Sachverständigenrat für Umweltfragen (SRU)	DE	henriette.dahms@umweltrat.de
Dainese	Matteo	Eurac Research / Institute for Alpine Environment	IT	matteo.dainese@eurac.edu
Dammhahn	Melanie	Universität Potsdam/ Tierökologie	DE	melanie.dammhahn@uni-potsdam.de
Dauber	Jens	Thünen-Institut für Biodiversität	DE	jens.dauber@thuenen.de
Davrinche	Andrea	Martin Luther University Halle-Wittenberg	DE	andrea.davrinche@idiv.de
Deák	Balázs	University of Debrecen	HU	debalazs@gmail.com
Decarre	Julieta	National Institute of Agricultural Technology	AR	decarre.julieta@inta.gob.ar
Dege	Ilka	DNR e.V.	DE	Ilka.Dege@dnr.de
Deggelmann	Alice	MPI-BGC	DE	adeggel@bgc-jena.mpg.de
Dehling	Matthias	Albert-Ludwigs-Universität Freiburg	DE	matthias.dehling@canterbury.ac.nz
Dieker	Petra	Thünen Institut für Biodiversität	DE	petra.dieker@thuenen.de
Diekötter	Tim	CAU zu Kiel	DE	tdiekoetter@ecology.uni-kiel.de
Dietrich	Peter	Helmholtz-Zentrum für Umweltforschung (UFZ) Leipzig - Physiological Diversity (iDiv)	DE	peter.dietrich@idiv.de
Dietzel	Simon	Chair of Restauration Ecology | TUM	DE	simon.dietzel@tum.de
Díez Rodríguez	Bárbara	Philipps-Universität Marburg	DE	bardrdz@biologie.uni-marburg.de
Dobson	Andy	Princeton University	US	dobber@princeton.edu
Doerfler	Inken	AG Vegetationskunde und Naturschutz, Carl von Ossietzky Universität Oldenburg	DE	inken.doerfler@uni-oldenburg.de

Surename	Forename	Organisation		Email
Doktor	Daniel	Helmholtz Centre for Environmental Research - UFZ	DE	daniel.doktor@ufz.de
Dominguez Garcia	Virginia	Université de Montpellier	FR	domgarvir@gmail.com
Dominic	Anto Raja	Julius Kühn Institut	DE	Anto.Raja@julius-kuehn.de
Döpper	Veronika	TU Berlin	DE	v.doepper@tu-berlin.de
Dorji	Yonten	Georg August Universität Göttingen	DE	yonten.dorji@uni-goettingen.de
Dörler	Daniel	Institute of Zoology, University of Natural Resources and Life Sciences, Vienna	AT	daniel.doerler@boku.ac.at
Drago	Claudia	University of Potsdam	DE	drago@uni-potsdam.de
Driller	Christine	Senckenberg Gesellschaft für Naturforschung	DE	christine.driller@senckenberg.de
Durka	Walter	Helmholtz-Zentrum für Umweltforschung	DE	walter.durka@ufz.de
Dworrak	Tarja	Carl-von-Ossietzky Universität Oldenburg, IBU, AG Gewässerökologie und Naturschutz	DE	tarja.viviane.dworrak@uni-oldenburg.de
Ecker	Klaus	WSL	CH	klaus.ecker@wsl.ch
Egerer	Monika	University of California, Santa Cruz	US	megerer@ucsc.edu
Ehrnsperger	Laura	Climatology Research Group - University of Münster	DE	laura.ehrnsperger@uni-muenster.de
Eichenberg	David	iDiv - sDiv	DE	david.eichenberg@idiv.de
Einzmann	Helena	Carl von Ossietzky Universität	DE	helena.einzmann@uol.de
Eitzinger	Bernhard	University of Marburg	DE	bernhard.eitzinger@biologie.uni-marburg.de
Engelhardt	Eva Katharina	Biodiversity & Global Change Lab, Terrestrial Ecology Research Group, Technical University of Munich, Germany	DE	e.k.engelhardt@tum.de
Englmeier	Jana	Universität Würzburg	DE	jana.englmeier@uni-wuerzburg.de
Etterson	Julie	University of Minnesota Duluth	US	jetterso@d.umn.edu
Fabian	Yvonne	Agro-ecology group, University Göttingen	DE	yvonne.fabian33@gmail.com

Surename	Forename	Organisation		Email
Fabšičová	Martina	Institute of Botany, CAS, Department of Vegetation Ecology	CZ	martina.fabsicova@ibot.cas.cz
Falk	Wolfgang	Bayerische Landesanstalt für Wald und Forstwirtschaft LWF	DE	wolfgang.falk@lwf.bayern.de
Farwig	Nina	University of Marburg	DE	farwig@uni-marburg.de
Feilhauer	Hannes	FAU Erlangen	DE	hannes.feilhauer@fu-berlin.de
Feldhaar	Heike	Animal Ecology I, University of Bayreuth	DE	feldhaar@uni-bayreuth.de
Felipe-Lucia	María	UFZ – Helmholtz Centre for Environmental Research / German Centre for Integrative Biodiversity Research (iDiv)	DE	maria.felipe-lucia@idiv.de
Ferlian	Olga	German Centre for Integrative Biodiversity Research (iDiv) Halle-Jena-Leipzig	DE	olga.ferlian@idiv.de
Fijen	Thijs	Wageningen University & Research	NL	thijs.fijen@wur.nl
Filser	Juliane	Universität Bremen / FB 02, UFT Ecology	DE	filser@uni-bremen.de
Fink	Sabine	Swiss Federal Institute for Forest, Snow and Landscape Research, WSL	CH	sabine.fink@wsl.ch
Fischer	Leonie K	TU Berlin	DE	leonie.fischer@tu-berlin.de
Fischer	Christina	Restoration Ecology, Technische Universität München	DE	christina.fischer@tum.de
Fontana	Simone	Swiss Federal Research Institute WSL	CH	simone.fontana@wsl.ch
Formaglio	Greta	Büsgen-Institut	DE	greta.formaglio@forst.uni-goettingen.de
Fornoff	Felix	University of Freiburg	DE	felix.fornoff@nature.uni-freiburg.de
Franic	Iva	CABI	CH	i.franic@cabi.org
Frank	Thomas	University of Natural Resources and Life Sciences, Institute of Zoology	AT	thomas.frank@boku.ac.at
Freitag	Martin	Institute of Landscape Ecology	DE	martin.freitag@uni-muenster.de

Surename	Forename	Organisation		Email
Frenzel	Mark	Helmholtz Zentrum f Umwelt-forschung UFZ	DE	mark.frenzel@ufz.de
Fricke	Ute	Julius-Maximilians-Universität Würzburg	DE	ute.fricke@uni-wuerzburg.de
Friedland	Giulia	IGB Berlin	DE	friedland@igb-berlin.de
Fründ	Jochen	Albert-Ludwigs-Universität Freiburg, Biometrie und Umweltsystemanalyse	DE	jochen.fruend@biom.uni-freiburg.de
Fuchs	Daniel	Planungsbüro PAN GmbH	DE	Daniel.Fuchs@pan-gmbh.com
Fuhse	Lukas	Institut für Landschaftsökologie	DE	lukas.fuhse@uni-muenster.de
Fuhse	Martin	Institut für Landschaftsökologie	DE	m_fuhs01@uni-muenster.de
Gabel	Friederike	WWU Münster, Institute of Landscape Ecology	DE	gabelf@uni-muenster.de
Gadau	Jürgen	University of Münster	DE	gadauj@uni-muenster.de
Gaitán	Carlos A.	Centro De Estudios Conservacionistas Cecon/Usac	GT	gaitan.carlos@usac.edu.gt
Ganser	Dominik	Agroscope	CH	dominik.ganser@iee.unibe.ch
Ganuza Vallejo	Cristina	University of Würzburg	DE	cristina.ganuza_vallejo@uni-wuerzburg.de
Gathof	Anika	Technical University Berlin, Department of Ecology, Chair of Ecosystem Science / Plant Ecology	DE	anika.k.gathof@campus.tu-berlin.de
Gaube	Paul	Department of Bioinformatics, Biocenter, University of Würzburg	DE	paul.gaube@uni-wuerzburg.de
Geisen	Stefan	Netherlands Institute of Ecology	NL	s.geisen@nioo.knaw.nl
Georgi	Maria	Albert-Ludwigs-Universität-Freiburg	DE	maria.georgi@posteo.de
Georgieva	Simona	University of Valencia	ES	simona.georgieva@gmail.com
Gerken	Florian	Plant Ecology, Faculty of Biology, Philipps-Universität Marburg	DE	Gerken@students.uni-marburg.de
Gessler	Arthur	Swiss Federal Research Institute WSL	CH	arthur.gessler@wsl.ch

Surename	Forename	Organisation		Email
Gezin	Stephan	Department of Ecosystem Modelling, University of Goettingen	DE	stephan.getzin@uni-goettin-gen.de
Giladi	Itamar	Ben Gurion University of the Negev	IL	itushgi@bgu.ac.il
Glandorf	Sebastian	Hochschule Osnabrück, University of Applied Sciences	DE	S.Glandorf@hs-osnabrueck.de
Göcking	Christian	NABU-Naturschutzstation Münsterland	DE	c.goecking@nabu-station.de
Goldmann	Kezia	Helmholtz Centre for Environ-mental Research - UFZ	DE	kezia.goldmann@ufz.de
Goossens	Steven	Ghent University	BE	stevenf.goossens@ugent.be
Gordine	Samantha Alex	Formerly University of St Andrews	DE	sagordine@gmail.com
Gossner	Martin	Swiss Federal Research Insti-tute WSL	CH	martin.gossner@wsl.ch
Gottschalk	Thomas	Hochschule für Forstwirtschaft Rottenburg	DE	gottschalk@hs-rottenburg.de
Graham	Catherine	Swiss Federal Research Cen-ter (WSL)	CH	catherine.graham@wsl.ch
Grams	Thorsten	Ecophysiology of Plants	DE	grams@tum.de
Grass	Ingo	University of Goettingen	DE	igrass@gwdg.de
Grimm-Seyfarth	Annegret	Helmholtz-Centre for Environ-mental Research - UFZ	DE	annegret.grimm@ufz.de
Große-Stoltenberg	André	Justus-Liebig-Universität Gießen	DE	andre.grosse-stoltenberg@umwelt.uni-giessen.de
Grossmann	Anita	Technische Universität Berlin / Institut für Ökologie	DE	anita.j.grossmann@campus.tu-berlin.de
Gupta	Anubhav	IEU, University of Zurich	CH	anubhav.gupta@uzh.ch
Gypser	Stella	Brandenburg University of Technology Cottbus-Senf-tenberg	DE	stella.gypser@b-tu.de
Haack	Nora	University of Leipzig	DE	nora.haack@idiv.de
Habiyaremye	Jean de Dieu	Helmholtz Center for Environ-mental Research - UFZ	DE	jean-de-dieu.habiyaremye@ufz.de
Hackmann	Christina	ILÖK WWU Münster	DE	c_hack06@uni-muenster.de
Hafer-Hahmann	Nina	Eawag	CH	nina.hafer@eawag.ch

Surename	Forename	Organisation		Email
Hafner	Benjamin	Technical University of Munich	DE	benjamin.hafner@tum.de
Hagge	Jonas	Technical University of Munich, Chair of Zoology - Entomology	DE	jonashagge@posteo.de
Haider	Sylvia	Martin Luther University Halle-Wittenberg	DE	sylvia.haider@botanik.uni-halle.de
Hamer	Ute	WWU Münster / Institute of Landscape Ecology	DE	ute.hamer@uni-muenster.de
Hamřík	Tomáš	Mendel University in Brno, Department of Forest Protection and Wildlife Management	CZ	hamr.tom@seznam.cz
Harjes	Janno	Universität Bayreuth	DE	janno.harjes@uni-bayreuth.de
Harms	Wiebke	Universität Oldenbzrg	DE	harms.wiebke@t-online.de
Hartig	Florian	University of Regensburg	DE	florian.hartig@ur.de
Hartmann	Henrik	Max-Planck Institute for Biogeochemistry	DE	hhart@bgc-jena.mpg.de
Hartmann	Josephin	Universität Hildesheim	DE	hartmannl@uni-hildesheim.de
Hass	Annika	University of Göttingen	DE	ahass@gwdg.de
Hauenstein	Severin	University of Freiburg, Department of Biometry and Environmental System Analysis	DE	severin.hauenstein@biom.uni-freiburg.de
Haupt	Olaf	Neptun	BB	olaf@neptun.solutions
Haupt	Katharina	CAU Kiel, Institut für Ökosystemforschung, AG Geobotanik	DE	khaupt@ecology.uni-kiel.de
Häussler	Johanna	iDiv Halle-Jena-Leipzig	DE	johanna.haeussler@idiv.de
Hauswirth	Luise	ABU Soest	DE	lu.hauswirth@gmail.com
Heemann	Sonja	TU Dresden	DE	heemann_s@web.de
Heer	Katrin	Philipps University Marburg	DE	katrin.heer@uni-marburg.de
Hegazi	Esmat M.	Faculty of Agriculture, Alexandria University	EG	eshegazi@hotmail.com
Heidrich	Lea	University of Würzburg	DE	lea.heidrich@uni-wuerzburg.de
Heigl	Florian	Institut für Zoologie, Universität für Bodenkultur Wien	AT	florian.heigl@boku.ac.at
Heiland	Lukas	Universität Regensburg	DE	lukas.heiland@ur.de
Heilmeier	Hermann	TU Bergakademie Freiberg	DE	heilmei@ioez.tu-freiberg.de

Surename	Forename	Organisation		Email
Heim	Wieland	University of Münster	DE	wieland.heim@uni-muenster.de
Heim	Ramona	University of Münster	DE	ramona.heim@uni-muenster.de
Heinrichs	Steffi	Universität Göttingen/Abt. Waldbau & Waldökologie der gem. Zonen	DE	sheinri@gwdg.de
Heinz	Sabine	Bayerische Landesanstalt für Landwirtschaft, Institut für Agrarökologie	DE	Sabine.Heinz@LfL.Bayern.de
Heitmann	Nadja	Leibniz-Centre for Agricultural Landscape Research (ZALF)	DE	Nadja.heitmann@zalf.de
Held	Andreas	TU Berlin	DE	held@tu-berlin.de
Helletsgruber	Carola	Universität Salzburg - Fachbereich Geographie und Geologie	AT	carola.helletsgruber@sbg.ac.at
Helm	Juliane	Max-Planck Institute for Biogeochemistry	DE	jhelm@bgc-jena.mpg.de
Henneberg	Benjamin	Tierökologie 1, Universität Bayreuth	DE	ben_henneberg@web.de
Henning	Katrin	Anhalt University of Applied Sciences	DE	katrin.henning@hs-anhalt.de
Herberich	Maximiliane	University of Tübingen/ Plant Ecology	DE	maximiliane.herberich@uni-tuebingen.de
Hering	Robert	University of Potsdam | Plant Ecology and Nature Conservation	DE	rohering@uni-potsdam.de
Hertzog	Lionel	University of Gent	BE	lionel.hertzog@ugent.be
Hervé	Morgane	CBL, Universität Göttingen	DE	morganeherve.56@gmail.com
Hesse	Benjamin	Technical University of Munich, Chair for Ecophysiology of Plants	DE	benjamin.hesse@tum.de
Hikino	Kyohsuke	Lehrstuhl für Ökophysiologie der Pflanzen, Technische Universität München	DE	kyohsuke.hikino@tum.de
Hillebrand	Helmut	Universität Oldenburg	DE	hillebrand@icbm.de
Hiller	Anne	Fachgebiet Ökosystemkunde/ Pflanzenökologie, Technische Universität Berlin	DE	anne.hiller@tu-berlin.de
Hoch	Guenter	University of Basel	CH	guenter.hoch@unibas.ch

Surename	Forename	Organisation		Email
Höckendorff	Stefanie	Universität Konstanz	DE	stefanie.2.hoeckendorff@uni-konstanz.de
Hodapp	Dorothee	Helmholtz Institut für Funtionelle Marine Biodiversität an der Universität Oldenburg (HIFMB)	DE	dorothee.hodapp@hifmb.de
Hoeber	Vincent	University of Oldenburg, Institute of Biology and Environmental Sciences	DE	vincent.hoeber@gmail.com
Hof	Christian	Terrestrial Ecology Research Group, Technical University of Munich	DE	christian.hof@tum.de
Hoffmann	Annika	ZALF e.V.	DE	annika.hoffmann@zalf.de
Höfner	Johannes	WWU	DE	j_hoef03@wwu.de
Höhne	Annelie	Technische Universität Berlin, Fachgebiet Umweltchemie und Luftreinhaltung, Sekr. KF3	DE	a.hoehne@tu-berlin.de
Hollerbach	Laura	Senckenberg Gesellschaft für Naturforschung	DE	laura.hollerbach@senckenberg.de
Holloway-Phillips	Meisha	University of Basel	CH	m.holloway-phillips@unibas.ch
Holthaus	Leonie	Westfälische Wilhelms-Universität Münster, Institut der Landschaftsökologie	DE	holthaus.l@gmx.de
Hölzel	Norbert	University of Münster	DE	nhoelzel@uni-muenster.de
Hölzer	Corinna	Stiftung für Mensch und Umwelt	DE	hoelzer@stiftung-mensch-umwelt.de
Holzinger	Anja	Universtiät Bayreuth	DE	anja1.holzinger@uni-bayreuth.de
Holzträger	Sylvia	Hochschule Weihenstephan-Triesdorf	DE	sylvia.holztraeger@hswt.de
Hopf	Anne	Universität Kassel	DE	anne.hopf@uni-kassel.de
Hoppe	Helga	Universität Münster	DE	h_hopp06@uni-muenster.de
Höppner	Christian	NABU Niedersachsen	DE	christian.hoeppner@nabu-niedersachsen.de
Hordynska	Natalia	The F. Górski Institute of Plant Physiology PAS	PL	hordynska.natalia@gmail.com
Horn	Juliane	Graslandwissenschaft Georg-August-Universität Göttingen	DE	juliane.horn@uni-goettingen.de

Surename	Forename	Organisation		Email
Hortmann	Anja	Institut für Landschaftsökologie	DE	anja.hortmann@uni-muenster.de
Hövemeyer	Klaus	Göttingen	DE	khoevem@gwdg.de
Huang	Wei	Nanjing Institute of Geography and Limnology, Chinese Academy of Science	CN	whuang@niglas.ac.cn
Huber	Jakob	Technical University of Munich	DE	jakob.k.huber@tum.de
Hülsmann	Lisa	University of Regensburg	DE	lisa.huelsmann@ur.de
Humbert	Jean-Yves	University of Bern	CH	jean-yves.humbert@iee.unibe.ch
Huth	Franka	Institute of Silviculture and Forest Protection, Department of Forest Sciences Tharandt, TU Dresden	DE	f.huth@freenet.de
Ibanez	Sébastien	Université Savoie Mont Blanc	FR	sebastien.ibanez@univ-smb.fr
Ichinose	Tomohiro	Keio University	JP	tomohiro@sfc.keio.ac.jp
Imoto	Ikuko	Keio Research Institute at SFC	JP	imotoi@ga2.so-net.ne.jp
Ivanova	Larissa	Botanic Garden UB RAS	RU	ivanova.larissa@list.ru
Jacquet	Claire	University of Zurich	CH	claire.jacquet@eawag.ch
Jandt	Ute	Martin Luther University Halle-Wittenberg, Geobotany and Botanical Garden	DE	ute.jandt@botanik.uni-halle.de
Jansen	Florian	Universität Rostock	DE	florian.jansen@uni-rostock.de
Javed	Umar	Forschungszentrum Jülich GmbH / Institut für Energie- und Klimaforschung - Troposphäre (IEK-8)	DE	u.javed@fz-juelich.de
Jentzsch	Milena	WWU	DE	dorolena@gmx.de
Jerrentrup	Sabrina	DBU Naturerbe GmbH	DE	s.jerrentrup@dbu.de
Jeschke	Daniel	Hochschule Osnabrueck, Universitiy of Applied Sciences	DE	d.jeschke@hs-osnabrueck.de
Jing	Nan	Nanjing Institute of Geography & Limnology , Chinese Academy of Science	CN	313607221@qq.com
Jo	Hyunbin	Chonnam National University	KR	prozeva@jnu.ac.kr
Jochum	Malte	iDiv / Leipzig University	DE	malte.jochum@idiv.de

Surename	Forename	Organisation		Email
Jung	Eunyoung	University of Bayreuth	DE	eun-young.jung@uni-bayreuth.de
Käber	Yannek	Chair of Forest Ecology, ETH Zurich	CH	yannek.kaeber@usys.ethz.ch
Kahmen	Ansgar	Universität Basel	CH	ansgar.kahmen@unibas.ch
Kaiser	Corinna	Bezirksregierung Münster	DE	Corinna.Kaiser@brms.nrw.de
Kaldewey	Phillip	Philipps-University Marburg	DE	Kaldewey@students.uni-marburg.de
Kalthoff	Hannah	ILök	DE	h.kalthoff@googlemail.com
Kamp	Johannes	Institute of Landscape Ecology, University of Münster	DE	johannes.kamp@uni-muenster.de
Kappes	Heike	Thünen Institut für Biodiversität	DE	heike.kappes@thuenen.de
Karakoç	Canan	Helmholtz Center for Environmental Research-UFZ	DE	canankarakoc@gmail.com
Karl	Matthias	Helmholtz-Zentrum Geesthacht	DE	matthias.karl@hzg.de
Kasperek	Gerwin	University Library Frankfurt	DE	g.kasperek@ub.uni-frankfurt.de
Kaulen	Alexander	University of Alberta / University of Freiburg	DE	alex-kaulen@gmx.de
Keinath	Silvia	Museum für Naturkunde Berlin	DE	silvia.keinath@mfn.berlin
Keller	Alexander	University of Würzburg	DE	alexander.keller@uni-wuerzburg.de
Kelling	Marit	WWU	DE	marit.kelling@wwu.de
Kempel	Anne	University of Bern, Institute of Plant Sciences	CH	kempel@ips.unibe.ch
Keplin	Beate	Institut für Landschaftsökologie	DE	keplin@uni-muenster.de
Kiehl	Kathrin	Osnabrück University of Applied Sciences	DE	k.kiehl@hs-osnabrueck.de
Kielau	Uta	K9Hundekunde	DE	info@k9-hundekunde.de
Kiene	Carola	University of Bayreuth	DE	carola.kiene@uni-bayreuth.de
Klaus	Valentin	ETH Zürich	CH	valentin.klaus@usys.ethz.ch
Klaus	Felix	Georg August University of Göttingen	DE	felix.klaus@uni-goettingen.de
Kleijn	David	Wageningen University and Research	NL	david.kleijn@wur.nl
Kleinebecker	Till	University of Gießen	DE	Till.Kleinebecker@umwelt.uni-giessen.de

Surename	Forename	Organisation		Email
Klein-Raufhake	Theresa Lucia	WWU	DE	t_klei25@uni-muenster.de
Klemm	Otto	University of Münster	DE	otto.klemm@uni-muenster.de
Knop	Eva	Agroscope/University of Zürich	CH	eva.knop@iee.unibe.ch
Knorr	Klaus-Holger	ILÖK, Ecohydrology & Biogeochemistry	DE	kh.knorr@uni-muenster.de
Kober	Klarissa Maria	ZALF	DE	klarissa.kober@zalf.de
Koch	Hannah	Ökologische NABU-Station Oste-Region	DE	Hannah.koch.dt@web.de
Koch	Markus	Senckenberg Gesellschaft für Naturforschung	DE	markus.koch@senckenberg.de
Koether	Ann-Kathrin	iLök	DE	annkathrinkoether@uni-muenster.de
Köhler	Martina	Hochschule Anhalt	DE	martina.koehler@hs-anhalt.de
Köhler	Michael	Wittich&Visser Berlin	DE	m.koehler@meteowittich.de
Kollmann	Johannes	Technical University of Munich	DE	jkollmann@wzw.tum.de
König	Sara	UFZ - Helmholtz Centre for Environmental Research	DE	sara.koenig@ufz.de
König-Ries	Birgitta	Friedrich-Schiller-Universität Jena	DE	birgitta.koenig-ries@uni-jena.de
Korell	Lotte	Martin-Luther-University Halle-Wittenberg	DE	lotte.korell@idiv.de
Korn	Rachel	University of Firoubrg	CH	korn@cumulonimbus.at
Körschens	Matthias	Institute of Ecology and Evolution with Herbarium Haussknecht and Botanical Garden, Friedrich Schiller University Jena	DE	matthias.koerschens@uni-jena.de
Kosulic	Ondrej	Mendel University in Brno	CZ	ondra.kosulic@seznam.cz
Kotowska	Martyna	University of Göttingen	DE	martyna.kotowska@biologie.uni-goettingen.de
Kovács-Hostyánszki	Anikó	MTA Centre for Ecological Research, Institute of Ecology and Botany	HU	kovacs.aniko@okologia.mta.hu
Krah	Franz	Technical University of Munich	DE	franz.krah@tum.de

Surename	Forename	Organisation		Email
Krämer-Klement	Klara	RWTH Aachen University / Center for Molecular Transformations (CMT)	DE	kraemer.klement@rwth-aachen.de
Kreyling	Jürgen	University of Greifswald	DE	juergen.kreyling@uni-greifswald.de
kriden	ikbel	Helmholtz-Centre for Environmental Research	DE	ikbel.kriden@ufz.de
Krug	Rainer M.	University of Zürich	CH	Rainer.Krug@uzh.ch
Krüger	Oliver	Department of Animal Behaviour, Bielefeld University	DE	oliver.krueger@uni-bielefeld.de
Kruse	Stefan	Alfred-Wegener-Institut	DE	stefan.kruse@awi.de
Krüß	Andreas	Federal Agency for Nature Conservation/BfN	DE	Andreas.Kruess@bfn.de
Kühn	Paul	Martin Luther University Halle-Wittenberg	DE	paul.kuehn@student.uni-halle.de
Kunz	Friederike	Institute of Landscape Ecology	DE	fitzku@t-online.de
Kunze	Svenja	Westfälische Wilhelms-Universität Münster	DE	svenja.kunze@uni-muenster.de
Kurze	Susanne	Universität Bayreuth	DE	Susanne.Kurze@uni-bayreuth.de
Küster	Berit	SDEI (Senckenberg Deutsches Entomologisches Institut)	DE	brt.kuester2@gmx.de
Kwak	Ihn-Sil	Chonnam National University	KR	inkwak@gmail.com
Lamonica	Dominique	Hohenheim University	DE	dominique.lamonica@uni-hohenheim.de
Lampei	Christian	University of Münster	DE	christian.lampei@uni-muenster.de
Lang	Marion	Chair of Restoration Ecology, TUM	DE	marion.lang@tum.de
Lange	Maximilian	Helmholtz-Centre for Environmental Research - UFZ	DE	maximilian.lange@ufz.de
Lange	Fabian	ILÖK	DE	f_lang12@uni-muenster.de
Lawer	Eric	University of Freiburg	DE	ladjei@uds.edu.gh
Lázaro	Amparo	IMEDEA (UIB-CSIC)	ES	amparo.lazaro@imedea.uib-csic.es
Ledru	Léo	University Savoie Mont Blanc	FR	ledru.leo@hotmail.fr
Lehmair	Theresa Anna	University of Regensburg	DE	theresa.lehmair@ur.de

Surename	Forename	Organisation		Email
Lehmann	Marco	WSL Birmensdorf	CH	marco.lehmann@wsl.ch
Leidinger	Ludwig	Center for Computational and Theoretical Biology, Universität Würzburg	DE	ludwig.leidinger@uni-wuerzburg.de
Lenzewski	Nikola	Universität Hamburg, IPM	DE	nikola.lenzewski@uni-hamburg.de
Leonhardt	Sara	University of Würzburg	DE	sara.leonhardt@uni-wuerzburg.de
Leyer	Ilona	University of Geisenheim/ Department of Applied Ecology	DE	ilona.leyer@hs-gm.de
Lezama	Maite	Universität Münster	DE	maite.lezama@uni-muenster.de
Li	Hai-Dong	Institute of Zoology, Chinese Academy of Sciences, and Department of Biometry and Environmental System Analysis, University of Freiburg	CN	lihd@ioz.ac.cn
Lieneweg	Holger	RANA - Büro für Ökologie und Naturschutz Frank Meyer	DE	holger.lieneweg@rana-halle.de
Limpens	Juul	WUR	NL	Juul.Limpens@wur.nl
Lin	Hong	Institute of Botany, CAS	CN	linhongshengwu2012@163.com
Lindner	Kim	Philipps-Universität Marburg	DE	kim.lindner@uni-marburg.de
Link	Roman Mathias	Universität Würzburg, Lehrstuhl für Botanik II	DE	roman.link@uni-wuerzburg.de
Lins	Silvia Rafaela	UFPE	BR	silviarafaela@gmail.com
Liu	Bo	Institute of Botany, Chinese Academy of Sciences	CN	boliu@muc.edu.cn
Liu	Xiaojuan	Institute of Botany, Chinese Academy of Sciences	CN	liuxiaojuan06@ibcas.ac.cn
Lo	Lai Ka	University of Münster	DE	nikalklo@gmail.com
Lu	Jingzhong	University of Göttingen	DE	jlu@gwdg.de
Lückel	Patrick	Kreis Borken - Fachbereich Natur und Umwelt	DE	p.lueckel@kreis-borken.de
Ludewig	Kristin	University of Hamburg	DE	kristin.ludewig@uni-hamburg.de
Lüscher	Gisela	Agroscope	CH	gisela.luescher@gmail.com

Surename	Forename	Organisation		Email
Ma	Jianhui	Institude of Botany, Chinese Academy of Science	CN	jianhma@126.com
Ma	Keping	nstitute of Botany, Chinese Academy of Sciences	CN	kpma@ibcas.ac.cn
Madaj	Anna-Maria	Helmholtz-Centre for Environmental Research - UfZ	DE	anna-maria.madaj@ufz.de
Mainz	Ann Kareen	VWW e.V.	DE	info@natur-im-vww.de
Malyshev	Andrey	University of Greifswald	DE	andrey.malyshev@uni-greifswald.de
Mann	Philipp	Philipps-Universität Marburg	DE	mannph@students.uni-marburg.de
Marja	Riho	Estonian Environment Agency / Hungarian Academy of Sciences	EE	Riho.Marja@gmail.com
Matevski	Dragan	University of Goettingen	DE	dragan.matevski@forst.uni-goettingen.de
Mathijssen	Paul	WWU Münster	DE	paul.mathijssen@uni-muenster.de
Mattes	Hermann	ILÖK	DE	mattesh@wwu.de
Mätz	Daniela	gutschker-dongus	DE	danielamaetz@aol.com
May	Felix	Leuphana University Lüneburg	DE	felix.may@leuphana.de
McFadden	Ian	WSL Birmensdorf and ETH Zürich	CH	ian.mcfadden@wsl.ch
McKee	Moira	Universität Bremen	DE	moira.mckee@uni-bremen.de
Meinecke	Philipp	Ausgleichsagentur Schleswig-Holstein GmbH	DE	philipp.meinecke@ausgleichsagentur.de
Melman	Dick	WUR	NL	dick.melman@wur.nl
Menzel	Florian	Biocentre I, Faculty of Biology, University of Mainz	DE	menzelf@uni-mainz.de
Messinger	Eva	Georg-August-Universität Göttingen, Albrecht-von-Haller-Institut, Abteilung Pflanzenökologie	DE	messinger@gwdg.de
Mette	Tobias	Landesanstalt für Wald und Forstwirtschaft	DE	tobias.mette@lwf.bayern.de
Metz	Johannes	Universiy of Hildesheim	DE	metzjo@uni-hildesheim.de
Meyer	Sandro	University of Basel	CH	sandro.meyer@unibas.ch

Surename	Forename	Organisation		Email
Meyer	Michael	WWU Münster - Institut für Landschaftsökologie	DE	micmeyer@uni-muenster.de
Meyer	Hanna	University of Münster	DE	hanna.meyer@uni-muenster.de
Meyer	Peter	Nordwestdeutsche Forstliche Versuchsanstalt	DE	peter.meyer@w-fva.de
Meyer	Sebastian	Technical University of Munich	DE	sebastian.t.meyer@tum.de
Meyer	Carsten	German Centre for Integrative Biodiversity Research (iDiv)	DE	carsten.meyer@idiv.de
Meyer	Heta	Hochschule Weihenstephan-Triesdorf	DE	heta.meyer@hswt.de
Meyer-Grünefeldt	Maren	NABU Umweltpyramide	DE	m.meyer-gruenefeldt@nabu-umweltpyramide.de
Mi	Xiangcheng	Institute of Botany, Chinese Academy of Sciences	CN	mixiangcheng@Ibcas.ac.cn
Michalko	Radek	Mendel University in Brno	CZ	radar.mi@seznam.cz
Michler-Kozma	Diana	WWU Münster	DE	diana.michler@uni-muenster.de
Migalina	Svetlana	Botanic Garden UB RAS	RU	fterry@mail.ru
Mihaila	Victor	National Institute for Research and Development in Forestry	RO	mvictor14bv@gmail.com
Milcu	Alexandru	CNRS Ecotron	FR	alex.milcu@cnrs.fr
Milles	Alexander	Uni Potsdam	DE	alexander.milles@ufz.de
Minden	Vanessa	Univ of Oldenburg, Institute of Biology and Environmental Sciences	DE	vanessa.minden@uni-oldenburg.de
Mölder	Andreas	Northwest German Forest Research Institute	DE	andreas.moelder@nw-fva.de
Moll	Julia	Helmholtz Centre for Environmental Reasearch - UFZ	DE	julia.moll@ufz.de
Moretti	Marco	Swiss Federal Research Institute WSL	CH	marco.moretti@wsl.ch
Moser	Ulrike	Institute of Landscape Ecology	DE	ulrike.moser@uni-muenster.de
Mosner	Eva	University of Geisenheim/Department of Applied Ecology	DE	eva.mosner@hs-gm.de

Surename	Forename	Organisation		Email
Motivans	Elena	Helmholtz Zentrum für Umweltforschung-- UFZ	DE	elena.motivans@ufz.de
Mouslim	Bara	university of Guelma	DZ	mouslim.bara@gmail.com
Muffler	Lena	University of Greifswald	DE	lena.muffler@uni-greifswald.de
Müller	Christina	Bundesamt für Naturschutz	DE	Christina.Mueller@BfN.de
Müller	Jörg	Universität Würzburg	DE	joerg.mueller@npv-bw.bayern.de
Mupepele	Anne	University of Freiburg	DE	anne-christine.mupepele@biom.uni-freiburg.de
Nabavi	Seyed Omid	University of Bayreuth	DE	seyed.omid.nabavi@uni-bayreuth.de
Nakamura	Akihiro	Xishuangbanna Tropical Botanical Garden, Chinese Academy of Sciences	CN	a.nakamura@xtbg.ac.cn
Närmann	Felix	Institut für Botanik und Landschaftsökologie, Universität Greifswald, Partner im Greifswald Moor Centrum	DE	felix.naermann@greifswald-moor.de
Närmann	Sophia	Institut für Landschaftsökologie (ILÖK), Westfälische Wilhelms-Universität Münster	DE	sophia.naermann@uni-muenster.de
Neff	Felix	Swiss Federal Institute for Forest, Snow and Landscape Research WSL	CH	felix.neff@wsl.ch
Neßhöver	Carsten	Sachverständigenrat für Umweltfragen	DE	carsten.nesshoever@umweltrat.de
Neu	Alexander	Senckenberg Biodiversity and Climate Research Centre	DE	alexander.neu@senckenberg.de
Neuenkamp	Lena	Universität Bern	CH	lena.neuenkamp@ut.ee
Niedermayer	Jana	Hochschule für Forstwirtschaft Rottenburg	DE	jana.niedermayer@gmx.de
Niekisch	Manfred	SRU	DE	manfred.niekisch@mail.de
Nijs	Ivan	University of Antwerp	BE	ivan.nijs@uantwerpen.be
Nikolaus	Robert	Leibniz-Institut für Gewässerökologie und Binnenfischerei (IGB) im Forschungsverbund Berlin e.V.	DE	nikolaus@igb-berlin.de
Nolte	Stefanie	Universität Hamburg	DE	stefanie.nolte@uni-hamburg.de

Surename	Forename	Organisation		Email
Nürnberger	Fabian	Thünen-Institute of Biodiverity	DE	fabian.nuernberger@thuenen.de
Nzau	Muthio	Technical University of Munich	DE	muthio.nzau@tum.de
Obazee	Jennica	Bezirksregierung Münster	DE	jennica.obazee@brms.nrw.de
Ohler	Lisa-Maria	University of Salzburg, Department of Biosciences	AT	lisa-maria.ohler@sbg.ac.at
Ohse	Bettina	Leuphana Universität Lüneburg	DE	bettina.ohse@uni-lueneburg.de
Okach	Daniel Osieko	University of Bayreuth	DE	kosieko@gmail.com
Ostertag	Eva	Universität Hamburg	DE	eva.ostertag@uni-hamburg.de
Ostrowski	Andreas	Friedrich Schiller University Jena	DE	andreas.ostrowski@uni-jena.de
Ott	David	University of Münster (WWU Münster, ILÖK)	DE	david.ott@uni-muenster.de
Ouyang	Shengnan	Swiss federal institute for forest, snow and landscape research	CH	shengnan.ouyang@wsl.ch
Paap	Madeleine	Julius Kühn-Institut	DE	madeleine.paap@julius-kuehn.de
Paas	Bastian	WWU Münster / Institute for Landscape Ecology	DE	bastian.paas@uni-muenster.de
Pagel	Ellen	University of Regensburg	DE	ellen.pagel@ur.de
Pagel	Jörn	University of Hohenheim	DE	jpagel@uni-hohenheim.de
Paltrinieri	Sabine	Institut für Landschaftsökologie	DE	paltrinieri@uni-muenster.de
Pánková	Hana	Institute of Botany of the Czech Academy Sciences	CZ	Hana.Pankova@ibot.cas.cz
Pappagallo	Silvia	Münster University	DE	silvia.pappagallo@uni-muenster.de
Parreno	Alejandra	University of Zurich	CH	alejandra.parreno@ieu.uzh.ch
Pascher	Kathrin	University of Natural Resources and Life Sciences, Vienna (BOKU)	AT	kathrin.pascher@boku.ac.at
Patthey	Rachel	University Basel		rachel.patthey@unibas.ch
Pauler	Caren	Agroscope	CH	caren.pauler@gmx.de
Pennekamp	Frank	Universität Zürich	CH	frank.pennekamp@ieu.uzh.ch

Surename	Forename	Organisation		Email
Pereira-Peixoto	Maria Helena	University of Freiburg	DE	maria.pereira-peixoto@nature.uni-freiburg.de
Perennes	Marie	Department of Landscape Ecology, Christian-Albrechts-Universität zu Kiel	DE	perennes@phygeo.uni-hannover.de
Perles-Garcia	Maria D.	iDiv	DE	maria_dolores.perles@idiv.de
Peters	Birte	University of Würzburg	DE	birte.peters@uni-wuerzburg.de
Philipp	Bodo	WWU Münster, Institute for Molecular Microbiology & Biotechnology	DE	bodo.philipp@uni-muenster.de
Piayda	Arndt	Thünen Institute of Climate-Smart Agriculture	DE	arndt.piayda@thuenen.de
Pichler	Maximilian	University of Regensburg	DE	maximilian.pichler@biologie.uni-regensburg.de
Pierick	Kerstin	Georg-August-Universität Göttingen	DE	kerstin.pierick@uni-goettingen.de
Pinheiro Machado Rehm	Raphael	Institut für Geographie	DE	raphael-rehm@web.de
Pinkert	Stefan	Phillips-Universität Marburg	DE	StefanPinkert@posteo.de
Platzer	Karl	Institut für Strömungswissenschaften	DE	k.platzer@stroemungsinstitut.de
Plum	Christoph	University of Oldenburg	DE	c.plum@uni-oldenburg.de
Poppenborg Martin	Emily	University of Würzburg	DE	emily.martin@uni-wuerzburg.de
Potapov	Anton	Unversity iof Göttingen	DE	potapov.msu@gmail.com
Potthast	Karin	Friedrich-Schiller-Universität Jena/Institut für Geographie/ Bodenkunde	DE	karin.potthast@uni-jena.de
Potthoff	Martin	Universität Göttingen / Zentrum für Biodiversität und nachhaltige Landnutzung	DE	mpottho@gwdg.de
Prada Salcedo	Luis Daniel	UFZ	DE	luis.salcedo@ufz.de
Prinzing	Andreas	Univ. Rennes 1	FR	andreas.prinzing@univ-rennes1.fr
Proß	Tobias	Martin Luther University Halle-Wittenberg	DE	tobias.pross@botanik.uni-halle.de
Puhl	Marietta	Institut für Landschaftsökologie	DE	m_puhl01@uni-muenster.de

Surename	Forename	Organisation		Email
R	Reshma	Institute for Evolution and Biodiversity, University of Muenster	DE	rr@uni-muenster.de
Raabe	Peter	WWU Münster / Institute of Landscape ecology	DE	p.raabe@uni-muenster.de
Raffel	Martina	Bezirksregierung Münster	DE	martina.raffel@brms.nrw.de
Rakosy	Demetra	Helmholtz Zentrum für Umweltforschung - UFZ	DE	demetra.rakosy@gmail.com
Rascher	Silke	Department of Agricultural Economics and Rural Development, Georg-Auguts-University Goettingen	DE	silke.rascher@uni-goettingen.de
Ratier Backes	Amanda	Martin Luther University Halle-Wittenberg	DE	amandaratier@gmail.com
Rehschuh	Romy	Karlsruhe Institute for Technology	DE	romy.rehschuh@kit.edu
Reimann	Nina	Westfälische Wilhelms-Universität Münster	DE	n_reim04@uni-muenster.de
Reininghaus	Hannah	Universität Münster	DE	hannah.reininghaus@uni-muenster.de
Remke	Eva	B-Ware Research Centre	NL	e.remke@b-ware.eu
Remy	Dominique	Universität Osnabrück, FB5, Ökologie	DE	dremy@uos.de
Richter	Laura	Wildlife Sciences, Georg-August-University Göttingen	DE	laurarichter@posteo.de
Rieckhof	Sima	ILÖK Münster	DE	s_riec03@uni-muenster.de
Rieker	Daniel	Universität Münster	DE	daniel.rieker@gmx.net
Riesch	Friederike	Graslandwissenschaft, Department für Nutzpflanzenwissenschaften, Georg-August-Universität Göttingen	DE	friederike.riesch@agr.uni-goettingen.de
Rindisbacher	Abiel	University of Bern	CH	abiel.rindisbacher@students.unibe.ch
Risse	Benjamin	Faculty of Mathematics & Computer Science, University of Münster	DE	b.risse@uni-muenster.de
Ristok	Christian	Deutsches Zentrum für Integrative Biodiversitätsforschung (iDiv) Halle-Jena-Leipzig	DE	christian.ristok@idiv.de

Surename	Forename	Organisation		Email
Rizzo	Christine	Institue of Landscape Ecology WWU	DE	c_rizz01@uni-muenster.de
Roelofs	Jan	B-Ware Research Centre	NL	j.roelofs@b-ware.eu
Rohr	Rudolf P.	Department of Biology, University of Fribourg	CH	rudolf.rohr@unifr.ch
Rojas Botero	Sandra Liliana	Technische Universität München	DE	sandra.rojas-botero@tum.de
Rösch	Verena	Universität Koblenz-Landau	DE	roesch@uni-landau.de
Rosenthal	Gert	Fachgebiet Landschafts- und Vegetationsökologie, Uni Kassel	DE	rosenthal@asl.uni-kassel.de
Rößling	Holger	NaturSchutzFonds Brandenburg	DE	holger.roessling@naturschutz-fonds.de
Rotenhagen	Anna-Lena	Universität Oldenburg, Institut für Biologie und Umweltwissenschaften/ AG Bodenkunde	DE	anna-lena.rotenhagen@uni-oldenburg.de
Rothe	Louisa	University of Duisburg-Essen, Aquatic Ecology	DE	louisa.rothe@uni-due.de
Roth-Nebelsick	Anita	State Museum of Natural History Stuttgart	DE	anita.rothnebelsick@smns-bw.de
Rottstock	Tanja	Julius Kühn-Institut, Institut für Strategien und Folgenabschätzung	DE	Tanja.Rottstock@julius-kuehn.de
Rubanschi	Sven	Technical University of Munich	DE	sven.rubanschi@tum.de
Rumpf	Sabine	University of Vienna	AT	sabine.rumpf@univie.ac.at
Rupprecht	Denise	Institut für Landschaftsökologie	DE	denise.rupprecht@uni-muenster.de
Rutten	Gemma	Geobotany/ Martin Luther University Halle-Wittenberg	DE	gemma.rutten@idiv.de
Rzanny	Michael	Max-Planck-Institute for Biogeochemistry, Jena	DE	mrzanny@bgc-jena.mpg.de
Sadiq	Shadman	Ege university	TR	shadmantsm@tu.edu.iq
Sam	Katerina	Entomology Institute, Biology Centre CAS	CZ	katerina.sam.cz@gmail.com
Sanchez Mahecha	Oriana	Technical University of Munich	DE	oriana.sanchez@tum.de

Surename	Forename	Organisation		Email
Sandner	Tobias	Plant Ecology, Faculty of Biology, Philipps-Universität Marburg	DE	tobias.sandner@biologie.uni-marburg.de
Saunus	Tilman	Uni Münster	DE	t_saun01@wwu.de
Schädler	Martin	Helmholtz-Centre for Environmental Research	DE	martin.schaedler@ufz.de
Schall	Peter	Silviculture and Forest Ecology, University of Göttingen	DE	pschall@gwdg.de
Scharsack	Joern Peter	Institute for Evolution and Biodiversity	DE	joern.scharsack@uni-muenster.de
Schellhorn	Nancy	RapidAIM Pty Ltd	AU	nancy@rapidaim.io
Scheper	Jeroen	Wagenigen University	NL	jeroen.scheper@wur.nl
Scherber	Christoph	University of Münster, Inst. of Landscape Ecology	DE	Christoph.Scherber@uni-muenster.de
Scherreiks	Pascal	Thünen-Institut für Biodiversität	DE	pascal.scherreiks@thuenen.de
Scherrer	Daniel	WSL Swiss Federal Research Institute	CH	daniel.scherrer@wsl.ch
Schick	Ulrich	Johann Böske GmbH & Co. KG	DE	u.schick@natuerlich-boeske.de
Schilling	Dora	Institute of Landscape Ecology university of Münster	DE	schilling@uni-muenster.de
Schindhelm	Anne	GeoForschungsZentrum Potsdam	DE	annesch@gfz-potsdam.de
Schirmel	Jens	University of Koblenz-Landau, iES Landau, Institute for Environmental Sciences	DE	schirmel@uni-landau.de
Schlägel	Ulrike	University of Potsdam	DE	ulrike.schlaegel@uni-potsdam.de
Schlüter	Ralf	Landesamt für Natur, Umwelt und Verbraucherschutz NRW	DE	ralf.schlueter@lanuv.nrw.de
Schmeddes	Jonas	Experimental Plant Ecology, Institute of Botany and Landscape Ecology, University of Greifswald	DE	jonas.schmeddes@uni-greifswald.de
Schmid	Sebastian	Technische Universität Berlin	DE	s.schmid@campus.tu-berlin.de
Schmid	Ueli	Forest Ecology, ETH Zürich	CH	ueli.schmid@usys.ethz.ch
Schmidt	Susanne	Czech Academy of Sciences, Institute for Hydrobiology	CZ	susanne.schmidt@hbu.cas.cz

Surename	Forename	Organisation		Email
Schmidt	Sebastian	Bezirksregierung Münster	DE	sebastian.schmidt@brms.nrw.de
Schmidt	Annsophie	HNE Eberswalde	DE	annsophie.schmidt@hnee.de
Schmidt	Anja	German Centre for Integrative Biodiversity Research (iDiv) Halle-Jena-Leipzig	DE	anja.schmidt@idiv.de
Schmoock	Ilka	Centre of Biodiversity and Sustainable Landuse	DE	ischmoo@gwdg.de
Schnabel	Marina	Leibniz-Zentrum für Agrarlandschaftsforschung	DE	Marina.Schnabel@zalf.de
Schnabel	Florian	Deutsches Zentrum für integrative Biodiversitätsforschung (iDiv) Halle-Jena-Leipzig	DE	florian.schnabel@idiv.de
Schneider	Manuel	Agroscope	CH	manuel.schneider@agroscope.admin.ch
Schneider	Anne-Kathrin	Technische Universität Braunschweig / Landscape Ecology and Environmental Systems Analysis	DE	anne-kathrin.schneider@tu-braunschweig.de
Schnell	Marion	Kreis Paderborn	DE	schnellm@kreis-paderborn.de
Scholz	Carolin	Leibniz Institut für Zoo- und Wildtierforschung	DE	scholz@izw-berlin.de
Schönbeck	Leonie	Swiss Federal Institute for Forest, Snow and Landscape	CH	leonie.schoenbeck@wsl.ch
Schrieber	Karin	Kiel University / Institute for Ecosystem Research / Geobotany	DE	kschrieber@ecology.uni-kiel.de
Schröder	Roland	Osnabrück University of Applied Sciences	DE	r.schroeder@hs-osnabrueck.de
Schröder-Esselbach	Boris	Technische Universität Braunschweig	DE	boris.schroeder@tu-bs.de
Schuldt	Andreas	Universität Göttingen	DE	andreas.schuldt@forst.uni-goettingen.de
Schuldt	Bernhard	Universität Würzburg, Lehrstuhl für Botanik II	DE	bernhard.schuldt@uni-wuerzburg.de
Schulz	Meike	WWU	DE	m_sch137@uni-muenster.de
Schumann	Katja	Georg-August-Universität Göttingen	DE	katja.steinhoff@uni-goettingen.de

Surename	Forename	Organisation		Email
Schurr	Frank	University of Hohenheim	DE	frank.schurr@uni-hohenheim.de
Schwartze	Peter	Biologische Station Kreis Steinfurt e.V.	DE	peter.schwartze@biologische-station-steinfurt.de
Schwarz	Benjamin	Biometry and Environmental System Analysis, University of Freiburg	DE	benjamin.schwarz@biom.uni-freiburg.de
Schwarz (ehem Sohn)	Julia	Professur f Waldbau/ Uni Freiburg	DE	julia.schwarz@waldbau.uni-freiburg.de
Schweiger	Andreas	University of Bayreuth / Plant Ecology	DE	andreas.schweiger@uni-bayreuth.de
Schweiger	Rabea	Bielefeld University, Department of Chemical Ecology	DE	rabea.schweiger@uni-bielefeld.de
Schweiger	Sandra	Georg-August-University, Functional Agrobiodiversity	DE	sandra.schweiger@web.de
Schwelm	Jessica	Universität Duisburg-Essen, Fakultät Biologie, Aquatische Ökologie	DE	jessica.schwelm@uni-due.de
Seidel	Dominik	Georg August University of Göttingen	DE	dseidel@gwdg.de
Selbach	Christian	Aarhus University	DK	christian.selbach@uni-due.de
Setyorini	Lydia	Institut für Landschaftsökologie	DE	lydia.setyorini@stud.uni-due.de
Shi	Xiaoli	Nanjing Institute of Geography and Limnology, Chinese Academy of Sciences	CN	xlshi@niglas.ac.cn
Signer	Johannes	Georg-August-Universität Göttingen	DE	jsigner@gwdg.de
Simons	Nadja K.	TU Darmstadt	DE	simons@bio.tu-darmstadt.de
Singer	David	Nordwestdeutsche Forstliche Versuchsanstalt	DE	david.singer@nw-fva.de
Skarbek	Carl	Universität Freiburg / Institut für Umwelt und natürliche Ressourcen / Biometrie und Umweltsystemanalyse	DE	carl.skarbek@gmail.com
Slabbert	Eleonore	Helmholtz Centre for Environmental Research - UFZ	DE	eleonore.slabbert@ufz.de
Sladecek	Frantisek	Biology Centre of Czech Academy of Sciences, Institute of Entomology	CZ	franzsladecek@gmail.com

Surename	Forename	Organisation		Email
Smits	Ludo	N.N.	NL	ludosmits90@gmail.com
Spiegelberg	Jens	Kommunalbetrieb Krefeld AöR	DE	jens.spiegelberg@krefeld.de
Stanik	Nils	University of Kassel	DE	nils.stanik@uni-kassel.de
Stefan	Thorsten	University of Hohenheim	DE	thorsten.stefan@uni-hohenheim.de
Steinbauer	Manuel	Universität Bayreuth	DE	Manuel.Steinbauer@gmx.de
Stevens	Carly	Lancaster University	UK	c.stevens@lancaster.ac.uk
Stöckl-Bauer	Katharina	Bayerische Akademie für Naturschutz und Landschaftspflege (ANL)	DE	katharina.stoeckl@anl.bayern.de
Storch	Hartmut	Biologische Station Kreis Steinfurt e. V.	DE	hartmut.storch@biologische-station-steinfurt.de
Straub	Florian	Universität Ulm, Institut für Evolutionsökologie und Naturschutzgenomik	DE	florian.straub@uni-ulm.de
Striebel	Maren	ICBM University Oldenburg	DE	maren.striebel@uni-oldenburg.de
Suliman	Tammam	TU Dresden	DE	tammam.suliman@forst.tu-dresden.de
Sures	Bernd	University of Duisburg-Essen	DE	bernd.sures@uni-due.de
Sutcliffe	Laura	Georg-August University of Göttingen	DE	lsutcli@uni-goettingen.de
Szechynka-Hebda	Magdalena	The F. Górski Institute of Plant Physiology PAS	PL	szechynska@wp.pl
Tahadlova	Marketa	Faculty of Science, University of South Bohemia and Institute of Entomology, Czech Academy of Science	CZ	m.tahadlova@gmail.com
Tamburini	Giovanni	University of Freiburg	DE	giovanni.tamburini@nature.uni-freiburg.de
Taubert	Franziska	Helmholtz Centre for Environmental Research GmbH - UFZ	DE	franziska.taubert@ufz.de
Tchiofo Lontsi	Rodine	Goettingen University	DE	rodine14@yahoo.fr
Teichert	Lelaina	ILÖK	DE	l_teic02@uni-muenster.de
Thakur	Madhav	Netherlands Institute of Ecology	NL	m.thakur@nioo.knaw.nl
Thiele	Jan	Thünen Institute of Biodiversity	DE	jan.thiele@thuenen.de

Surename	Forename	Organisation		Email
Thieltges	David	NIOZ Royal Netherlands Institute for Sea Research	NL	david.thieltges@nioz.nl
Thompson	Amibeth	Martin Luther University Halle-Wittenberg	DE	amibeth.thompson@idiv.de
Thrippleton	Timothy	ETH Zurich, Forest Ecology	CH	timothy.thrippleton@usys.ethz.ch
Tiebel	Katharina	TU Dresden/Institute of Silviculture and Forest Protection	DE	Katharina.Tiebel@forst.tu-dresden.de
Tiede	Julia	University of Münster	DE	tiedej@uni-muenster.de
Tischer	Alexander	Friedrich-Schiller-Universität Jena/Institut für Geographie/ Bodenkunde	DE	alexander.tischer@uni-jena.de
Tóthmérész	Béla	University of Debrecen	HU	tothmerb@gmail.com
Trappe	Johanna	Institut für Landschaftsökologie, Uni Münster	DE	johanna.trappe@wwu.de
Trau	Fee Nanett	Julius Kühn-Institut	DE	Fee-Nanett.Trau@julius-kuehn.de
Treydte	Anna	Nelson Mandela African Institution of Science and Technology (NM-AIST)	TZ	anna@treydte.com
Trogisch	Stefan	Martin Luther University Halle-Wittenberg	DE	stefan.trogisch@botanik.uni-halle.de
Tropek	Robert	Charles University, Faculty of Science	CZ	robert.tropek@gmail.com
Tscharntke	Teja	Agroecology, University of Göttingen	DE	ttschar@gwdg.de
Tschöpe	Okka	Botanischer Garten und Botanisches Museum Berlin	DE	o.tschoepe@bgbm.org
Ullmann	Wiebke	Uni Potsdam	DE	wiebke.ullmann@uni-potsdam.de
Ulrich	Josephine	FSU Jena, Institute of Ecology and Evolution	DE	josephine.ulrich@uni-jena.de
Vailshery	Lionel Sujay	University of Bayreuth	DE	lionelsujay@gmail.com
Valkó	Orsolya	University of Debrecen	HU	valkoorsi@gmail.com
van Duinen	Gert-Jan	Bargerveen Foundation	NL	g.vanduinen@science.ru.nl
van Klink	Roel	iDiv	DE	roel.klink@idiv.de
van Tooren	Bart	Natuurmonumenten	NL	b.vantooren@natuurmonumenten.nl

Surename	Forename	Organisation		Email
Velbert	Frederike	Institute of Landscape Ecology	DE	frederike.velbert@uni-muenster.de
Verheyen	Kris	Ghent University - Forest & Nature Lab	BE	kris.verheyen@ugent.be
Veste	Maik	Brandenburgische Technische Universität Cottbus-Senftenberg / Ecology	DE	maik.veste@icloud.com
Vikuk	Veronika	University of Würzburg, Department of Animal Ecology and Tropical Biology	DE	veronika.vikuk@uni-wuerzburg.de
Villagómez	Gemma Nydia	University of Würzburg	DE	gemma.villagomez@uni-wuerzburg.de
Visser	Tim	Wageningen Environmental Research	NL	tim.visser@wur.nl
Vitali	Valentina	WSL	CH	valentina.vitali@wsl.ch
Vogel	Cassandra	Wuerzburg University	DE	cassandra.vogel@uni-wuerzburg.de
Vogt	Juliane	Technische Universität München- Biodiversitäts Exploratorien	DE	juliane.vogt@tum.de
Voigtländer	Jens	Leibniz Institute for Tropospheric Research (TROPOS)	DE	jensv@tropos.de
von Königslöw	Vivien	Universität Freiburg, Fak. Umwelt, Prof. Naturschutz und Landschaftsökologie	DE	vivien.von.koenigsloew@nature.uni-freiburg.de
Wagner	Katrin	University of Oldenburg	DE	ka.wagner@uni-oldenburg.de
Waite	Pierre-André	Department of Plant Ecology and Ecosystem Research, Albrecht von Haller Institute for Plant Sciences, University of Goettingen	DE	pwaite@gwdg.de
Wallinger	Corinna	Institute of Interdisciplinary Mountain Research	AT	corinna.wallinger@uibk.ac.at
Wallis	Christine I. B.	LCRS, University of Marburg	DE	christine.wallis@staff.uni-marburg.de
Weber	Monika	Julius Kühn-Institut	DE	monika.weber@julius-kuehn.de
Wegner	Mathias	AWI - Alfred Wegener Institute	DE	mathias.wegner@awi.de

Surename	Forename	Organisation		Email
Wehnert	Alexandra	Institute of Silviculture and Forest Protection, Department of Forest Sciences Tharandt, TU Dresden	DE	alexandra.wehnert@freenet.de
Weigel	Robert	Abteilung Pflanzenökologie und Ökosystemforschung, Universität Göttingen	DE	robert.weigel@uni-goettingen.de
Weijters	Maaike	B-WARE research centre/ Radboud University Nijmegen	NL	m.weijters@b-ware.eu
Welk	Erik	University Halle/Geobotany	DE	erik.welk@botanik.uni-halle.de
Wersebeckman	Vera	Institut für angewandte Ökologie Hochschule Geisenheim University	DE	vera.wersebeckmann@hs-gm.de
Wichelhaus	Anya	Universität Kassel	DE	anya.wichelhaus@uni-kassel.de
Wicke	gisela	Niedersächsischer Landesbetrieb für Wasserwirtschaft, Küsten- und Naturschutz NLWKN a.D.	DE	giselawicke52@gmail.com
Wiedenhaus	Hanna	Institut für Landschaftsökologie, Uni Münster	DE	hanna.wiedenhaus@uni-muenster.de
Wiegand	Thorsten	Helmholtz Centre for Environmental Research GmbH	DE	thorsten.wiegand@ufz.de
Wielers	Friedel	Kreis Borken - Fachbereich Natur und Umwelt	DE	f.wielers@kreis-borken.de
Wiemers	Martin	Senckenberg Deutsches Entomologisches Institut	DE	martin.wiemers@ufz.de
Wiersinga	Wim	OBN	NL	w.wiersinga@vbne.nl
Wilfahrt	Peter	University of Bayreuth	DE	peter.wilfahrt@uni-bayreuth.de
Wilkens	Jan	TU Dresden	DE	j.wilkens@gmx.net
Wirk	Lea	LUPUS Institut für Wolfsmonitoring und -forschung in Deutschland	DE	leawirk@gmail.com
Wöhrmann	Felicitas	Botanischer Garten der Universität Potsdam	DE	woehrmann@uni-potsdam.de
Wolff	Carmen	Uni Münster	DE	carmen.wolff@uni-muenster.de
Wöllner	Romy	TU München	DE	romy.woellner@tum.de
Wolters	Volkmar	Justus-Liebig-Universität	DE	volkmar.wolters@allzool.bio.uni-giessen.de

Surename	Forename	Organisation		Email
Wolz	Marina	Universität Bielefeld	DE	marina.wolz@uni-bielefeld.de
Wubet	Tesfaye	Helmholtz Centre for Environmental Research GmbH - UFZ	DE	tesfaye.wubet@ufz.de
Wynhoff	Irma	De Vlinderstichting	NL	irma.wynhoff@vlinderstichting.nl
Xiaozhi	Gu	Nanjing Institute of Geography & Limnology , Chinese Academy of Science	CN	guxiaozhi@163.com
Yoshida	Tomohiro	Tokyo University of Agriculture and Technology	JP	yoshitom@cc.tuat.ac.jp
Zahnd	Cedric	Universität Basel	CH	cedric.zahnd@unibas.ch
Zarkov	Aleksandar	Bavarian Forest National Park	DE	alexander.zarkov@gmail.com
Zeh	Lilli	Department for Soil Science and Site Ecology/ TU Dresden	DE	lilli.zeh@tu-dresden.de
Zelnik	Yuval	CNRS	FR	zelnik@post.bgu.ac.il
Zenker	Maren	WWU Münster	DE	m_zenk01@wwu.de
Zhang	Naili	Institute of Botany, CAS	CN	zhangnl@ibcas.ac.cn
Ziegenhagen	Birgit	University of Marburg, Biology	DE	birgit.ziegenhagen@biologie.uni-marburg.de
Zinsmeister	Daniel	Universität Bonn/Institut für Nutzpflanzenwissenschaften und Ressourcenschutz (INRES)/Abteilung Pflanzenernährung	DE	s7dazins@uni-bonn.de
Zizka	Vera	Universität Duisburg-Essen, Aquatische Ökosystemforschung	DE	vera.zizka@uni-due.de
Zizka	Alexander	German Center for Integrative Biodiversity Research (iDiv)	DE	alexander.zizka@idiv.de
Zoller	Leana	Martin-Luther University Halle-Wittenberg / Institut für Biologie / AG SIE	DE	leana.zoller@idiv.de
Zotz	Gerhard	Universität Oldenburg	DE	gerhard.zotz@uol.de
Zuev	Andrey	A.N. Severtsov Institute of Ecology and Evolution RAS	RU	agzuev.sevin@gmail.com
Züghart	Wiebke	Bundesamt für Naturschutz	DE	wiebke.zueghart@bfn.de

SUPPORTERS

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