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ECOLOGY – MEETING THE SCIENTIFIC CHALLENGES OF A COMPLEX WORLD

48th Annual Meeting of the Ecological Society of Germany, Austria and Switzerland

Universität für Bodenkultur Wien, 10 – 14 September 2018

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ECOLOGY – MEETING THE SCIENTIFIC CHALLENGES OF A COMPLEX WORLD

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PREFACE

Dear colleagues, friends and guests,

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I warmly welcome you to the 48th Annual Meeting of the Ecological Society of Germany, Austria & Switzerland (GfÖ) hosted by the University of Natural Resources and Life Sciences, Vienna (BOKU). Our university covers the three core areas natural sciences, technology and engineering, economic and social sciences and law. Combining these core areas is unique to Austrian universities making the BOKU particularly attractive to students, which is shown by the extraordinarily high increase of students over the last decade. This increase is due to both students from Austria and from abroad. The Department of Integrative Biology and Biodiversity Research consists of the Institute of Botany, Institute of Wildlife Biology and Game Management, Institute of Zoology, Institute for Integrative Nature Conservation Research, and Institute of Mathematics, and forms the backbone of the scientific committee and the local organizing committee of our conference.

Hosting the annual meeting of the GfÖ in 2018 in Vienna means a 25-years anniversary because the last meeting held in Austria took place in 1993 in Innsbruck. The meeting will take place at the former campus of the Vienna University of Economics and Business (Alte WU). It is an appropriate place for holding a meeting as it offers several large lecture halls in direct vicinity to each other and is easily accessible by public transport.

In times of changing conditions, ecological research is facing new challenges. On the one hand, complexity of the biosphere is increasingly reduced by human activities; on the other hand, human activities aggravate predictability of future developments. This poses new necessities for assessing ecological conditions and for discovering new ecological interrelations, which is reflected by our motto of this year, 'Ecology – meeting the scientific challenges of a complex world'. The conference provides the opportunity to present the state of the art of our scientific field, to interact with other research groups, and to stimulate synergies between the different disciplines.

I would like to thank the many people who have contributed to the successful organization of the meeting in Vienna. I am very grateful to Heike Kuhlmann as a core organizer of the meeting. I thank my colleagues from the scientific committee (Karl-Georg Bernhardt, Stefan Dullinger, Wolfram Graf, Harald Meimberg, Swen Renner, Marcela Suarez-Rubio, Karin Tremetsberger, Johann Zaller) for the fruitful collaboration. I thank all persons from the local organizing committee being responsible for non-scientific affairs (Dagmar Augustin, Franz Barth, Eva Dornstauder-Schrammel, Edith Gruber, Yoko Muraoka, Manfred Ranalter, Christoph Schauer, Christine Thurner). I further thank the chairs of the 34 scientific sessions for suggesting topics and organizing the sessions, and I express my gratitude to the keynote speakers (Pedro Beja, Nina Buchmann, Stefan Dullinger, Claudio Gratton, Stephan Hättenschwiler, Kerry Naish) for providing us with a comprehensive framework concerning recent developments in ecological sciences. Last but not least I would like to thank the organizers of the four excursions (Karl-Georg Bernhardt, Josef Greimler, Marianne Kohler-Schneider, Bernhard Kohler, Friedrich Schiemer) giving the attendees a good impression of four different habitat types being characteristic to Austrian landscapes.

Finally, I hope you will enjoy the stay in Vienna enabling you a stimulating atmosphere for discussions and for personal exchange with colleagues.

Thomas Frank

Institute of Zoology
Department of Integrative Biology and Biodiversity Research
University of Natural Resources and Life Sciences, Vienna

Dear friends and colleagues,


© V. Wolters

I cordially welcome you to the 48th Annual Meeting of the Ecological Society of Germany, Austria & Switzerland in Vienna. I can hardly imagine a nicer city for a scientific conference than the federal capital of Austria, which has just topped the EIU-ranking as the world's most liveable city. From a scientific point of view, Vienna hosts 25 research institutions with more than 40 000 people being employed in the research and development sector. If we remember renowned people like Othenio Abel, Karl von Frisch, Konrad Lorenz or Irenäus Eibl-Eibesfeldt, all of whom were born in Vienna or spent their entire lives there, we see that in this city scientific progress is linked to a long tradition of biological sciences. Obviously an ideal place for ecologists to discuss burning topics of our discipline, to be inspired and have fun. All the more so as that with a meeting in Austria a particular important issue has to come into focus: mountain ecology. After all, 76% of Austria's territory complies with the EU-definition of "mountainous area", i.e. many of these regions are key centers of biological and cultural diversity.

Our this year's conference is themed "*Ecology - meeting the scientific challenges of a complex world*". Well, this is a quite ambitious motto! To cite the famous American plant ecologist Frank E. Egler: "Nature is not more complex than we think, but more complex than we can think". I understand this phrase so much that you need a lot of dedicated people, great expertise and a variety of disciplines to approach the complex environmental challenges of our time. Can there be a better opportunity than a GfÖ conference to meet these conditions? In this sense, I am delighted that we will come together in a city full of music, art, science and friendly people.

Volkmar Wolters

President of the GfÖ

KEYNOTE LECTURES

MONDAY 14:30 – AUDIMAX (C.1.5.1)

Of facts and fiction: confronting data and models of alpine plant species response to a warming climate

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Climate change will likely reshape the flora and vegetation of mountain landscapes. It is generally expected that vegetation belts and their associated species will move upward confronting those already living at highest elevations with a nowhere-to-go situation. Empirical research on this issue has so far concentrated on either detecting range changes that have already taken place in the recent past, or on modelling these changes for the decades to come. However, these two lines of investigation remain loosely linked so far. In my talk I will present results of both recent re-survey and modelling studies. I will thereby demonstrate consensus, try to interpret apparent contradiction, and highlight areas where data to evaluate models are currently missing. In essence, both data and models suggest massive redistribution of mountain plants under warming temperatures, with prevailing movement towards higher elevations. However, while statistical modelling of species distributions predicts considerable loss of alpine plant diversity from many mountain ranges, re-survey studies on mountain tops indicate a steady increase of species at uppermost peaks resulting from frequent arrival of new colonizers but rare extinction of residents – a process that has obviously accelerated during the most recent decades. Whether these patterns represent a transient species surplus at high elevations, and thus an accumulating extinction debt, as suggested by dynamic range models, remains unclear. Yet, recent observations demonstrate that species from lower elevations actually move upward faster than their alpine counterparts lending some empirical support to these predictions. The consequences of climate warming for intraspecific genetic diversity represent an area where modelling just starts to explore possible futures. I will present ongoing such efforts which demonstrate that a warmer climate might actually produce counter-intuitive changes in the genetic setup of mountain plant populations and increase risk of extinction. However, data for evaluating predictions at the level of intra-specific diversity still await being sampled.

Can we design sustainable bioenergy landscapes? Balancing our needs for production and biodiversity

Claudio Gratton[1]

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Increasing demand for food, and now fuel, have put pressure on our agricultural lands. In response, the way we manage our lands is continuing to change land use and land cover with significant biological and ecosystem-level consequences. In the upper Midwest of the United States, these changes have resulted in the 'simplification' of the agricultural landscape, that is the removal of natural and semi-natural areas in the landscape and the increase in monocultures of annual crops. These changes affect more than mere aesthetics. Landscape simplification is typically associated with a decrease in species richness and an increase in crop pest abundance. The consequences of these changes are felt by growers who apply more pesticides in landscapes dominated by annual cropland. The question, then, is can we balance our needs for agricultural production (both food and fuel) in a way that supports other ecosystem services on which we as humans depend?

Our work as part of the Great Lakes Bioenergy Research Center has explored how management and changes of the landscape in response to bioenergy agriculture affects critical ecosystem services, including productivity, pollination, and biological control. Inevitably these services tradeoff and understanding their magnitudes and directions will be a key to designing 'custom' multifunctional landscapes that include bioenergy crops. Additionally, we have explored ways to make the science behind these relationships part of discussions in landuse planning by developing decision support tools that illustrate tradeoffs among ecosystem service in agricultural landscapes.

Managing genetic variation and adaptability in populations: considerations from conservation genomics in salmonids

Kerry Naish[1]

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A central goal in conservation and restoration activities is to maintain genetic variation so that populations can adapt to ongoing environmental and anthropogenic change. However, judging when and how to make an intervention is challenging, because the actions themselves might result in unintended changes to a population's genetic variability. Pacific salmon along the West Coast of North America serve as examples of the outcomes of such actions, because they are subject to extensive efforts to rebuild populations using approaches such as captive breeding and restoration, while also supporting harvest activities. In these systems, synergistic partnerships between geneticists and practitioners have focused on addressing and assessing appropriate responses. In doing so, novel genomic approaches have improved the power to evaluate best practices. Here, the implementation of these methodologies will be reviewed, and their potential in informing adaptive management within a decision-making framework will be explored. Specifically, I will use case studies to illustrate their use in the protection of vulnerable populations during harvest, and to examine the fitness of captive-reared individuals released into the wild. Proactive approaches aimed at determining 'best case' versus 'worst case' scenarios in captive rearing and restoration will be evaluated, especially where there are reduced options for population recovery. Finally, genomic based studies on natural populations are increasingly revealing loci of large effect on phenotypic traits; their role in designating units for protection will be discussed. Creative integration of genomics with solutions-driven research has significant capacity to contribute to conservation, and its continued integration into management decisions will support ongoing efforts to restore and maintain population health.

Biodiversity and soil organic matter

Stephan Hättenschwiler[1]

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Soil organic matter (SOM) received increasing attention as a critical component in the global carbon (C) cycle and how it is affected with ongoing global change. Considerable recent progress in the understanding of factors controlling SOM dynamics and its stabilization identified a key role for microbial uptake and transformation of C compounds. How the diversity of microorganisms, and other soil organisms more generally, and their interactions with plants influence the storage and turnover of SOM, however, is not well known. Conceptual and quantitative models continue to treat the tremendous diversity of soil organisms as black box. While this approach is operationally convenient, it neglects fundamental ecological processes such as competition, facilitation and complementarity among the diverse soil organisms, which depend on SOM as single basic resource for their energy and – to a lesser extent – nutrient requirements. This presentation attempts to highlight how biodiversity might influence SOM dynamics and ultimately affect soil C stabilization beyond microbial transformation of organic molecules. Three aspects of biodiversity will be considered more specifically: (1) the diversity of plant-derived organic compounds, (2) the diversity of soil organisms, and (3) the diversity of plant root structure and function in association with their symbionts. I will argue that biodiversity has a role to play in SOM dynamics and in the persistence of soil C. However, quantifying such biodiversity effects for the long-term soil C balance remains difficult, and their conceptual and operational integration in existing or new models is challenging. Tighter collaborations across disciplines, and closer interactions between ecologists and soil scientists in particular, are the way forward to foster new ideas about how to quantify and integrate the contribution of soil biodiversity in SOM dynamics.

Barcoding and metabarcoding: exploring exciting new opportunities in ecology

Pedro Beja[1]

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The advent of ever more powerful DNA sequencing technology has opened up possibilities in the biological sciences that were unimaginable just a decade ago. The field of ecology is no exception, with DNA barcoding in combination with high-throughput sequencing (metabarcoding) generating unprecedented capacity to describe complex ecological patterns and processes. However, mainstreaming these new tools in ecological research has remained relatively slow, mainly because they still involve a range of conceptual, methodological and technical challenges. Here I provide an ecologists' perspective to barcoding and metabarcoding, using the experience gained at my lab to illustrate the power and some limitations of these molecular tools. First, I show the importance of building comprehensive barcode reference collections to achieve ecologically meaningful taxonomic identifications. This is challenging, but by working closely with taxonomists we have been able to assemble a collection of > 1,500 arthropod species, which helped detecting new exotic species, solving some taxonomic problems, and highlighting many others that warrant further investigation. Second, I discuss the need to optimise field, lab and bioinformatics pipelines in relation to the specific research questions of ecologists. The considerable efforts required to meet this general goal are illustrated through case studies assessing impacts of biological and technical replication on metabarcoding results, testing multi-marker approaches to overcome primer biases, and developing procedures for non-destructive metabarcoding of invertebrate bulk samples. Third, I present some practical applications, showing how the high taxonomic resolution achieved through metabarcoding can provide major insights on biotic interactions and on community assembly of nocturnal arthropods in agroecosystems. Finally, I take a look into extant and oncoming technological developments that will provide further opportunities to ecological research.

THURSDAY 08:30 – AUDIMAX (C.1.5.1)

Grassland ecology and sustainable management, friends or foes?

Nina Buchmann[1]

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While grassland ecologists address fundamental research questions, motivated by highly relevant global challenges like climate change and biodiversity loss, grassland managers are confronted with exactly those challenges, e.g. increasingly frequent extreme events and changes in species composition. Moreover, both aim towards sustainable grassland management, also demanded by consumers and policy-makers alike. So the questions arise, how can managers learn from ecologists, how can ecologists learn from managers?

Ecosystem services, provided by grassland ecosystems and highly relevant for both communities, represent a common denominator for joint learning activities. High quality forage production for livestock and erosion control are intimately linked to species traits and community composition. Climate regulation and water purification clearly depend on management activities which in turn are driven by grassland composition and environmental site conditions. How these services are affected by climate change, but also to what extend grasslands contribute to climate change or can actually be used to mitigate it, are important research but also management questions. Resistance and resilience of grasslands are of main concern to grassland ecologists and managers.

Various networks and experiments with both intensively as well as extensively managed grasslands will be used to integrate both perspectives on grasslands. Drought simulations across elevational gradients, biodiversity experiments for identifiying multifunctionality in grasslands, and ecosystem flux measurements for assessing ecosystem vulnerability but also for quantifying carbon sequestration and N_2O mitigation potentials together provide crucial and beneficial insights to inform sustainable.

SPECIAL TALK ON INSECT DECLINE

TUESDAY 11 SEPTEMBER, 18:30 – AUDIMAX (C.1.5.1)

Insect declines and examples of biodiversity monitoring – knowledge and perspectives

Martin Sorg[1]

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Recent analysis of malaise trap results of 96 unique location-year combinations estimate a seasonal decline of 76 % in flying insect biomass over the last three decades. This happens apparently regardless of habitat type, while changes in weather and habitat characteristics cannot explain this overall decline.

There is an urgent need to uncover the causes of this decline, its geographical extent, and to understand the ramifications of the decline for ecosystems and the protection of biodiversity. Which data do we need for proper monitoring of the most important sites and habitats for insect biodiversity conservation? Where should we focus and what are the basics for sampling design?

The data set of the Entomological Society Krefeld using standardized sampling with malaise traps based on the design of Henry Townes begins in 1985 and has been continued until today. In addition to the documentation of decline trends through the gradual evaluation of the original samples, it opens up an insight into the interpretational potential of the methodology.

This also raises the question of the extent to which we are sufficiently aware of the species stock and the adequate protection solutions for nature reserves of the typical fragmented Central-European landscape. In this context, evaluations of protected area regulations and agricultural practices, including the use of pesticides, reveal massive deficits for sustainable biodiversity protection.

PUBLIC LECTURE

TUESDAY 11 SEPTEMBER, 20:00 – AUDIMAX (C.1.5.1)

Die Domestizierung unserer Gewässer und das Ende der Natur

Klement Tockner[1]

[1]Fonds zur Förderung der wissenschaftlichen Forschung (FWF), Wien, AT, klement.tockner@fwf.ac.at

Von der romantischen Vorstellung einer intakten Natur müssen wir uns wohl verabschieden. Zu massiv sind die globalen Eingriffe des Menschen, unumkehrbar viele Änderungen und immens die gesellschaftlichen Herausforderungen. Dabei befinden wir uns erst am Beginn der „Großen Beschleunigung" im Zeitalter des Anthropozäns. So wurden die meisten unserer Gewässer domestiziert, d.h. zum größtmöglichen Nutzen für uns Menschen verändert. Dabei setzen wir verstärkt auf großtechnische Lösungen: bauen Dämme, leiten ganze Flüsse um und entsalzen Meerwasser. Dabei gilt es Wasser als Ressource für uns Menschen und Gewässer als wertvolle Lebensräume langfristig zu erhalten.

ABSTRACTS

SESSION 1

Agroecology: science and practices for sustainable agriculture

Chairs: Jens Dauber, Lena Bassermann, Felix Herzog

Agroecology: science, practices and movements for sustainable agriculture

Lena Bassermann[1], Wolfgang Büchs[2], Jens Dauber[3], Felix Herzog[4]

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The need for a major transformation of the world's food systems has become a topic of international debate. Whilst industrial agriculture has been successful in producing large amounts of food, the ecological, economic and social costs involved are very high. Based on high-input and intensive use of natural resources, these systems have a significant impact on biodiversity and the environment. Diversified agroecological farming systems are seen as an alternative with the potential to transform food systems and delivering solutions to problems current production systems do not address. These include challenges such as food security, resource protection and social inclusion. By combining traditional and scientific knowledge, agroecology applies ecological and social approaches to agricultural systems, focusing on the rich interactions between plants, animals, humans and the environment. Agroecology has been practiced, scientifically researched and further developed by peasants and producers around the globe. Although several attempts have been made by international institutions, academics, civil society and social movements to define exactly what agroecology is, there is still a need to further develop a common/shared understanding of the term. To achieve its full potential, agroecology needs to be supported by a set of complementary public policies, relevant institutions and public investment. The clarification of the term agroecology must take into account that agroecology is at the same time a scientific research approach, which involves the holistic study of agro-ecosystems and a set of principles and practices that enhances the resilience and sustainability of food and farming systems while preserving social integrity. It is a socio-political movement which focuses on the practical application of agroecology while seeking new ways of thinking about agriculture, processing, distribution and consumption of food, and its relationships with society and nature.

Agroecology as a practice: sustainable production and consumption through integrated farming (case study India)

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Agroecology is about science, practice and movement in farm and food systems. In farm systems, it imbibes the principles of nature – collaboration, recycling, multilayered arrangement, combination of various species/ varieties and allowing succession. In food systems, it connects ecological-product-friendly market and responsible consumption. However, the agriculture system in the past few decades has gone beyond this to ecological simplification, also reducing the dietary diversity. To address this, working with more than 10,000 small farms during 2012–15, in rain-fed marginalised production areas, Sustainable Integrated farming system (SIFS) approach boost up small farmers, where not only crops but varied types of plants, animals, birds, fish and other aquatic flora and fauna are utilized for production. These were combined in such a way and proportion that each element helps the other; the waste of one is recycled as resource for the other. The farm-planning process by the farmers according to his/her needs, availability of resources and choices was the key step in the process which strengthened the autonomy of farmers in terms of selection of seed/breed and less dependent on external input and market dictates in production. In the next level, due to complex dynamics in market conditions with large buyers and unfavourable terms of trade offered by the traders and intermediaries, small holder farmers have poor access to the market. Advance selling of farm-products directly by the farmers, often when the price is lowest at the market, is very common. From 2016 onwards, these farmers were also linked with small holder market development and ecological food campaign which links producers-market and consumers based on clean-green-fair food systems. This paper describes the principles, impacts and indicators of transition of small farms in India, Bangladesh and Nepal to ecologically intensified agroecological farms which are also connected to sustainable consumption through urban-rural connect.

Data science for agroecology

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Agroecosystems fulfil a whole host of ecosystem functions that are essential for life on our planet. However, an unprecedented level of anthropogenic influences is reducing the resilience and stability of our ecosystems as well as their ecosystem functions. The relationships between drivers, stress and ecosystem functions in ecosystems are complex, multi-facetted and often non-linear and yet environmental managers, decision makers and politicians need to be able to make rapid decisions that are data-driven and based on short- and long-term monitoring information, complex modelling and analysis approaches. A huge number of long-standing and standardized ecosystem health approaches like the essential variables already exist and are increasingly integrating remote-sensing based monitoring approaches. Unfortunately, these approaches in monitoring, data storage, analysis, prognosis and assessment still do not satisfy the future requirements of information and digital knowledge processing of the 21st century. This presentation therefore discusses the requirements for using Data Science as a bridge between complex and multidimensional Big Data for environmental health. It became apparent that no existing monitoring approach, technique, model or platform is sufficient on its own to monitor, model, forecast or assess forest health and its resilience. In order to advance the development of a multi-source ecosystem health monitoring network, we argue that in order to gain a better understanding of agroecosystems health in our complex world it would be conducive to implement the concepts of Data Science with the components: (i) digitalization, (ii) standardization with metadata management after the FAIR (Findability, Accessibility, Interoperability, and Reusability) principles, (iii) Semantic Web, (iv) proof, trust and uncertainties, (v) tools for Data Science analysis like machine learning and (vi) easy tools for scientists, data managers and stakeholders for decision-making support. In this presentation we will present the framework for data science with the necessary components and requriements for better monitoring and understanding the complex systems of agroecology.

Biodiversity potential – an expert based method for biodiversity assessment on agricultural farms in Austria

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Assessing the biodiversity performance of agricultural farms has gained importance in recent years since conserving and promoting biodiversity and associated ecosystem functions in cultural landscapes is a key aspect in making agriculture more sustainable as discussed in science, politics and society. This contribution presents a method that estimates the biodiversity potential of agriculural farms in Austria (Schader et al. 2014 IJBESM). The assessment method covers the entire farm and its core consists of 99 parameters concerning agricultural practices and semi-natural habitats and their impacts on the diversity of eleven indicator species groups (ISG; e.g. soil fauna, vascular plants, birds, grasshoppers and spiders). These impacts were evaluated semi-quantitatively by expert judgements and aggregated for each parameter across all eleven ISGs based on food-web relationships between the ISGs in Austrian agricultural ecosystems. A farm gets a share of these parameter scores according to the practices carried out on the farm and a biodiversity potential is calculated ranging from 0 % to 100 %, where 100 % would be reached with the highest possible scores for all parameters. This approach proved to be feasible and efficient for assessing a large number of farms. It provides plausible results at the farm level and it allows for conclusions on farming practices and farming systems. Results can be obtained at the level of single farms but an aggregation at product or regional level is possible. Although the application of this method is currently restricted to Austria, the underlying framework allows to adapt the method for other regions. This contribution will give an overview of accomplished assessments (> 300 organic farms interviewed) as well as possible further applications and enhancements of this method.

Improving the ecological impact of maize cropping through sown wildflowers strips

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The enlargement of maize cropping within energy cropping systems among others is widely discussed as major threat to weed and wildlife biodiversity in Germany. The two main reasons for the negative impact on various biodiversity compartments are the late soil tillage date and the lack of weeds, flowers or vegetation structure at the early growing stages of maize. We developed a new cropping system for maize based on strip-till and band spraying technologies. Wildflowers were sown between the future maize rows after harvest of the last main crop in the year before. With these wildflower strips we wanted to avoid late tillage and provide flowers and vegetation structure on maize fields. We have conducted field trials at two sites in Germany, where the agricultural feasibility, ecological and yield impacts have been analysed. Within these trials the following five factors have been tested: i) two wildflower mixtures, ii) three cover crops for establishing the wild flowers, iii) two widths for the wildflower cover crops, iv) two widths for the wildflower strips, and v) two widths for chemical plant protection treatments. We present the results of these field trials with special regard on the agricultural feasibility and the ecological effects of the new cropping systems using conventional maize cropping as reference. The results show the successful establishment of the wildflowers strips between the maize rows. Flowering diversity and duration was ten times higher than in conventional maize crop stands and lasted the whole cropping season. Weed species diversity was elevated 3–4 times in the new cropping systems. Positive implications on pollinators could be proved. A yield reduction of 30 % was observed, but it could not be related to the wildflower competition alone. The management of spontaneous weeds needs some further improvement.

Wildflower strips enhance pollination in adjacent strawberry crops at the small scale

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Wildflower strips (WFS) are increasingly used to counteract the negative consequences of agricultural intensification on pollinators. To date, it is poorly understood how WFS promote flower visitation and pollination services in nearby insect-pollinated crops. We therefore ask whether WFS enhance pollination service in adjacent strawberry crops, and how such an effect depends on the distance from WFS. Moreover, we ask which of the major pollinator groups might cause such an effect. Over two years we examined the effects of experimentally sown WFS compared to grassy strips on pollination services in adjacent strawberry (*Fragaria ananassa*) crops across a total of 29 study sites. Moreover, we examined flower visitation, species richness and community composition of the most important insect pollinator taxa at different within-field locations varying in distance to WFS. Our study demonstrates that diverse WFS can increase wild bee visitation and pollination services in the field edges of adjacent strawberry crops, but that overall visitation and pollination services do not increase. Moreover, our findings show that major pollinator taxa exhibit distinct responses, resulting in a shift of pollinator community composition as a function of distance to WFS with direct effects on crop pollination. Our results that WFS enhance rather than reduce crop pollination services near WFS should distract possible concerns by farmers that WFS may locally absorb rather than export crop pollinators. Considering the spatial restricted enhancement of wild bees and associated pollination services we suggest to establish WFS in the centre of crop fields

Functional groups are differentially sensitive to temporal diversification in agricultural landscapes

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Agricultural landscapes comprise about 50 % of land surface in Central Europe. To reduce pests and diseases, many crops are grown in crop rotations. From a landscape perspective, these rotations can be described as a mosaic of undirected successions of artificial, short-term habitats. To evaluate the impact of temporal diversification on invertebrate communities, we performed extensive sampling in a long-term crop rotation experiment close to the village of Harste (North of Göttingen, Lower Saxony, Germany). We monitored seven rotation systems containing five different crops (silage maize, winter wheat, oilseed rape, sugar beet and grain pea), ranging from monocultures to one six-year-rotation including four crops. Sampling was conducted during the vegetation period from late April until harvest at the end of July 2016 using pitfall traps and pan traps. Results show that species groups are differentially sensitive to current grown crop and rotation system. Species with a high spatial mobility as flying insects are less sensitive and seem to be less influenced by the current crop or the rotation system than species with a smaller range of action, mostly ground-dwelling species. Especially herbivores and detritivores are influenced by crop identity. Particularly oilseed rape leads to an increase in individual and species number in this group. Detritivores are influenced by crops grown in previous years. Web building spiders predominantly occur in oilseed rape because this crop has the most complex spatial structure that permit spiders to construct their webs. Other ground dwelling carnivorous species in contrast are not restricted to a certain crop. For this species group, microclimate or prey availability are more important. Considering that crops influence functional groups in a different way, an increase in temporal diversity with various crops providing different food sources and microhabitats may lead to an increase of invertebrate diversity on a landscape level.

European agroforestry systems provide multiple ecosystem services

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In the context of sustainable intensification of agriculture and of the agro-ecological movement, novel agroforestry systems such as alley cropping, energy strip coppicing, permaculture, forest gardens are promoted. Empirical evidence on their ecosystem service provision is scarce because only few long-term experimental sites exist. Therefore we investigated ecosystem service provision of twelve traditional agroforestry systems that are still relatively widespread across Europe, such as Dehesas/Montados on the Iberian peninsula, traditional fruit orchards and forest pastures in central Europe or hedgerow landscapes in the Atlantic zone. We investigated seven provisioning and regulating ecosystem services: 'biomass production', 'groundwater recharge', 'nutrient retention', 'soil preservation', 'carbon sequestration', 'pollination', and 'habitat diversity' with appropriate indicators. In each of the twelve case study regions, eight landscape test sites of 1 x 1 km, four dominated by agroforestry and four dominated by agriculture, were mapped and indicators were computed for each test site. Provisioning ecosystem services, namely the annual biomass yield, were higher in landscape test sites with agriculture, while the regulating ecosystem services were better represented in landscape test sites dominated by agroforestry. The differences were statistically significant for annual biomass yield, groundwater recharge rate, nutrient retention, annual carbon sequestration, and share of semi-natural habitats. Plot and landscape scale simulations indicate that novel agroforestry systems also provide increased regulating ecosystem services and even increased overall biomass yield. Leaning on those results and on observations from farmer innovations, the further development and implementation of novel agroforestry systems is recommended as an alternative to conventional intensification relying on external inputs.

Enhanced bee abundance due to diversified crop rotations with faba bean along a landscape heterogeneity gradient

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Pollinators and other beneficial insects can benefit from forage legume species that are cultivated as agri-environmental measurements as part of diversified crop rotations. However, bees need not only nectar and pollen resources but also nesting sites that are provided in extensively managed land use types. Focusing on faba bean (*Vicia faba*) we analyzed following questions: Does faba bean cultivation enhance the abundance of bumblebees and solitary wild bees at landscape scale? Is this effect modified by the amount of potential bee habitats (e.g. hedges, groves) and other flower resources (e.g. artificial flower strips, oilseed rape)? Comparable landscapes with and without faba bean were selected. Here, standardized transect walks were conducted in potential bee habitats, e.g. calcareous grasslands, fallows and flower strips, to survey the abundance of bumblebees and solitary wild bees. The local flower cover of the transect area was estimated. Cultivation of faba bean enhanced the abundance of bumblebees. Especially long-tongued bumblebees seemed to be positively affected. Bumblebee abundance increased with an increasing local flower cover within the transect area. The amount of potential bee habitats was not affecting bumblebee abundance. Solitary wild bees were more abundant when the local flower cover was high. The amount of mass-flowering oilseed rape and potential bee habitats and the cultivation of faba bean had little but yet positive effects on solitary wild bee abundance. We conclude that the cultivation of faba bean can enhance the abundance of bumblebees at landscape scale. Diversified crop rotations with faba beans seem to be especially beneficial for long-tongued bumblebees. To a lesser extent, the abundance of solitary wild bees is facilitated by the cultivation of mass-flowering crops. They rely on high amounts of potential bee habitats at landscape scale indicating that wild bees benefit from non-cultivated habitats for nesting and foraging.

Wet arable land – the missing link in the wetland network

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Wetlands are key habitats of Switzerland's Environmental Targets for Agriculture to promote biodiversity on agricultural land. Wet arable land (WAL) provides habitats for highly endangered animal and plant species. In the context of this project, WAL is permanently or frequently affected by ground-, slope-, or backwater. Without technical measures, yield losses for mesophilic crops are expected. The main processes causing water logging are excess water accumulation induced by relief and precipitation and insufficient percolation rates induced by soil- and geological characteristics. Data availability and data quality are not sufficient to quantify the processes but enable the estimation of their potential on a national scale. The overlay resulted in a Swiss wide wetness-potential map (WP-map). Using the WP-map as the basis for a cost map, we modelled the potential network connectivity of protected wetland sites for 346 species that exhibit a preference for wet habitats with an open land cover. We first used Circuitscape to create a neutral map of structural connectivity and verified the applicability of the WP-map to the dispersal behavior of species. Results indicated that wetland-species are not only more likely to be found within high potential wet zones, but the effect is amplified in well-connected regions, where clusters or linear segments of wet habitat promote the spread of individuals. The cost map was then used in a least-cost path analysis to generate a map of potential wetland corridors linking all inventoried bogs, fens, floodplains, and amphibian breeding ponds. The corridor map highlights and ranks potential corridors based on their permeability and contribution to the overall connectivity. Interpretation of the map can suggest target areas for biodiversity promotion which could bolster the existing network and improve connectivity through the introduction of new stepping-stone habitats on WAL.

Plant-pollinator mutualistic networks in fragmented calcareous grasslands

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Habitat loss and fragmentation are known as the main drivers of species loss. However this loss is preceded by changes in the characteristics of species interactions and interaction networks. Species interactions can be disrupted long before species disappearance (e.g. due to reduced encounter frequency) and hence they can stand as indicators of future species extinctions. Furthermore rearrangements on the structure of interaction networks (e.g. nestedness reduction) can evidence a decrease in web resilience that will negatively impact individual species. In this study we selected 30 calcareous grasslands, one of the richest and more endangered habitats in central Europe, where we analysed the characteristics of mutualistic interaction networks among butterflies, bees and flowering plants from early spring to late summer in two consecutive years. Our calcareous grasslands were selected to encompass independent gradients of habitat size and isolation and also varied in succession level and landscape composition. We analysed the effects of these variables on the characteristics of the interaction networks across sites and present results on web's structural changes. We found an interactive effect between habitat size and isolation on butterfly richness and also on bee abundance and bee-plant interaction richness. In particular bee-plant interaction richness and bee abundance increased with habitat size, this effect being especially important in isolated sites. Also we found that the butterfly-bee ratio increases in small and isolated sites, which indicates a reduced performance of bees in these sites. These results may allow a better understanding of the impacts of habitat fragmentation on biodiversity and may also contribute to the conservation of crucial ecosystem functions such as pollination.

Influence of environmental factors on apple proliferation epidemiology in South Tyrol using Bayesian modeling

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Apple proliferation (AP) is a phytoplasma disease that causes severe economic damage in European apple growing areas. AP is caused by the bacterium '*Candidatus* Phytoplasma mali', which in South Tyrol, Italy, is mainly vectored by the psyllids *Cacopsylla melanoneura* (Förster) and *C. picta* (Förster) (Hemiptera/Psyllidae). Although vector control is one of the most efficient AP management strategies, many ecological aspects of the AP epidemiology are still unknown. For example, different genetic variants of the AP phytoplasma within apple trees are known, but knowledge about their specific role in AP disease dynamics is missing. Although *C. picta* is considered the major vector of AP phytoplasma, its low presence in the study area suggests potential contribution of *C. melanoneura* as well. Furthermore, we lack knowledge about the susceptibilities of different apple tree varieties to AP infections. Therefore, our study aims to evaluate the importance of different factors in the epidemiology of AP. We used an extensive monitoring dataset containing information of visible AP symptoms of more than a quarter million apple trees from 2014 to 2017. By using a multilocus typing approach with more than 500 infected plants subjected to genotyping, we analyzed the genetic variability of the AP phytoplasma and found spatio-temporal differences of specific genotypes of the AP pathogen. Bayesian inference with generalized linear mixed-effect models was used to investigate spatio-temporal patterns of the disease while accounting for imperfect AP symptom detection and the genetic variability of different '*Ca.* P. mali' genotypes. Preliminary results of our model suggest the importance of vector, climate and topology of the apple orchard in the AP epidemiology. In conclusion, we discuss how our model results can be used to support pest management strategies, and reduce AP disease pressure.

POSTER PRESENTATIONS

SESSION 1-P1

Combination of spatial and temporal diversification in European cropping systems

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There is a lack of knowledge on the benefits of combining different crop diversification strategies both in time and space, which makes it difficult for farmers to find relevant information for the agro-ecological transition towards more diversified cropping systems. A network of 10 experiments (diverIMPACTS project) was built across seven European countries under both conventional and organic management. Each field experiment tests one or several diversified systems compared to a reference system less diversified and more dependant on external inputs. The three strategies of crop diversification are rotation, multiple cropping and intercropping. Expected impacts are higher productivity, increased revenues through access to new markets and reduced risks, lower environmental impacts and improved delivery of ecosystem services including biodiversity. This poster presents the approach, the strategies designed and the hypotheses concerning the effects of both temporal and spatial diversification.

SESSION 1-P2

Measuring biodiversity driven ecosystem services at the landscape scale – impacts of landscape heterogeneity, biotope elements and land use

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Landscape heterogeneity, biotope elements and land use intensity are some of the key impacts on biodiversity. With the present approach, we try to quantify the impact of these factors not only on biodiversity but on their ecosystem function supply. Methods of the Rapid Ecosystem Function Assessment (REFA) (Meyer et al. 2015) are used to quantify the supply of selected ecosystem functions empirically. Using REFA methods allows to measure the ecosystem functions directly. Field investigations have been carried out in the AgroScapeLab Quillow, an entire watershed located in the northeastern German lowlands from 2015 till 2017. The region is a typical agricultural area of 250 km^2 size. Within this area, single arable fields have been selected for the investigations based on a preliminary landscape GIS analysis regarding landscape heterogeneity gradients, the occurrence of two typical regional biotope elements (kettle holes and hedges) and information on the land management practices. The first results draw a puzzled picture for the singular ESF and the investigated factors. The applied methods served well and are feasible for quantifying ESF supply empirically. Measuring ESF directly may improve ESF assessments by avoiding over/under estimation of impacts. The results are integrating numerous interactions as typical for the landscape scale and agrarian land use impacts and thus provide more realistic insights.

SESSION 1-P3

Diversification of arable cropping systems with faba bean (*Vicia faba* L.): effects on epigaeic arthropods

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In European agroecosystems, for economic reasons, faba bean and other legume crops have been under-represented for decades. Yet, legumes can help in diversifying the established short crop rotations to support biodiversity and ecosystem services. Flowers and extrafloral nectaries of faba bean may benefit pollinators but also natural biocontrol agents such as parasitoids by providing additional food resources throughout the vegetative season. Possible effects of faba bean on epigaeic agents of natural pest control have rarely been in the focus of investigations. The project RELEVANT aims to quantify and evaluate effects of cropping systems including faba bean on epigaeic arthropods and natural pest control. In June 2017, the abundance and diversity of epigaeic arthropods (Carabidae, Staphylinidae, Araneae) was assessed in 19 landscape pairs (with and without faba bean in the cropping system; 1 km^2 landscape extent) in three regions of Germany. Between flowering (BBCH61) and milk ripening (BBCH77) 912 barber traps were placed in 4 crop fields per landscape (6 traps per field). The fields chosen represented the typical crop types of the region as well as faba bean or, in the control landscapes, a different alternative crop. Arthropods are sorted into 14 higher taxon levels. Of the more than 50,000 specimen sorted so far, carabids contributed the highest share, followed by spiders and rove beetles. For carabids, highest average number of individuals per field were found in maize (221.5), followed by summer barley (206.3), winter wheat (196.4), pea (174.8) and faba bean (170.9). For spiders, highest number of individuals per field were found in winter barley (107.1) and summer barley (100.3) with faba bean ranking sixth (66.1) out of the 10 crops sampled. For rove beetles, faba bean was only ranking ninth. Further comparative analyses of the species composition in the main crop types will show whether faba bean may contribute to beta diversity of the cropping system.

Effects of diversified cropping systems with faba beans on the abundance pollinators

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The introduction of grain legumes into cropping systems entails several environmental benefits, like the reduction of N fertilizer and a higher diversification of crop rotations. Moreover, flowering legume crops provide important pollen and nectar resources for insects. Additionally, faba beans (*Vicia faba*) may play an important role as supplementary floral resources especially in structurally poor agricultural landscapes. Their flowering period follows up the flowering of oilseed rape, the most common mass flowering crop in the EU and therefore prolongs the resource supply during midsummer, when floral resources are often lacking in simplified agricultural landscapes. This resource pulse can have beneficial effects on pollinator abundance and population growth.

We hypothesize that diversified crop rotations with faba beans enhance the abundance of bees and hoverflies at landscape level. Moreover, additional nectar and pollen resources will enhance colony growth of bumblebees (*Bombus terrestris*). Using a landscape-scale approach in three different regions in Germany, we selected 30 paired study landscapes, i.e. 15 landscapes with diversified cropping systems including faba bean and 15 landscapes with simple crop sequences without grain legumes. In each landscape 7 standardized transect walks were conducted at the field margins of the different crop types and the abundance of bees and hoverflies was assessed. To assess the effect of faba bean cultivation on the resource utilization and the colony development of bumblebees, colonies of *B. terrestris* were placed in the center of 11 landscapes with faba beans and 11 corresponding landscapes without grain legumes. The colony growth was monitored during oilseed rape and faba bean flowering in 2018. In total more than 8,000 bees and hoverflies were recorded during the three sampling rounds during the summer of 2017. So far, our results suggest a higher bee and hoverfly abundance in landscapes with faba beans. The weight of the *B. terrestris* colonies is recorded throughout the summer of 2018 and we expect colonies in faba bean landscapes to develop better and gain more weight compared to landscapes with simplified crop sequences due to the additional food resource. We conclude that diversification of crop sequences with faba beans might help to promote pollinators in agricultural landscapes.

Effect of tillage intensities on predator-prey interactions of spiders and springtails in vineyards from different landscapes

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Ecosystem services provided by vineyards and viticultural landscapes result from interactions between management intensity, soil properties and organisms inhabiting this agroecosystem. Often vineyards are surrounded by more or less heterogeneous landscapes which might alter ecological interactions at the plot level. However, there is actually very little known to what extent management and/or landscape factors influence the abundance and diversity of soil biota or predator-prey interactions taking place in vineyards. In this study we examined (i) to what extent different soil tillage intensities of vineyard inter-rows affect the activity and diversity of spiders (Arachnida: Araneae) and collembolans (Hexapoda: Collembola) plus their interrelations and (ii) whether and to what extent the surrounding landscape is altering these interactions. We collected data in inter-rows of 16 commercial vineyards in Austria, eight of which were periodically mechanically disturbed, eight had permanent green cover. All vineyards were embedded in a landscape ranging from structurally simple to complex. Both spiders and collembola were collected with pitfall traps; vegetation surveys included plant species diversity, and vegetation cover. The landscape surrounding the study vineyards within a radius of 750 m using orthophotos and additional field mapping in a geographical information system. Data were analysed with generalized mixed models selected using the Akaike Information Criterion. Results showed that soil tillage intensity interacted with the surrounding landscape and affected spiders and collembolans differently. While collembolan diversity was unaffected by tillage, spider diversity was higher under green cover than under periodically mechanically disturbance. Overall activity densities of both spiders and collembolans were highest under periodically mechanically disturbed inter-rows. Spider activity density was increased in periodically mechanically disturbed inter-rows especially when the proportion of semi-natural landscape elements in the surroundings was low. Our results suggest that potentially detrimental influences of soil management on spiders and collembolans appear to be compensated through interactions with the surrounding landscape. These investigations are part of the transdisciplinary BiodivERsA project VineDivers (www.vinedivers.eu) and will ultimately lead into management recommendations for various stakeholders.

SESSION 1-P6

Do agri-environmental schemes benefit biodiversity?

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A widespread and common technique in ecological intensification is the establishment of agri-environmental schemes (AES). These landscape elements are believed to benefit pollinators and act as refuges for biodiversity in agricultural landscapes, however evidence is scarce. We recorded biodiversity across multiple levels on 31 study sites in 31 independent landscapes for three years. The study sites were newly established flowering fields, refreshed flowering fields, continuous flowering fields (CAP greenings) and semi-natural calcareous grasslands depicting a gradient in management intensity and habitat age. First results showed different reactions on different levels of biodiversity. While diversity of some taxa was driven by management and habitat age, other taxa were equally diverse in all AES types but assemblage composition changed. For some taxa, landscape context was also an important driver of diversity. Therefore, managing biodiversity in agricultural landscapes is intricate. AES can help secure biodiversity but apparently not across all levels. The tailoredness of AES for certain taxa could therefore be increased to maximize positive effects on the manageable partition of biodiversity in order to secure biodiversity driven ecosystem functions in agricultural landscapes.

Understanding and improving the sustainability of agro-ecological farming systems in the EU – the UNISECO project

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Agro-ecological approaches are increasingly discussed as an alternative to farming based on chemical inputs to address the challenges of producing enough food and biomass while preserving soil, water and biodiversity necessary for ecosystem services. While it is widely acknowledged that farming systems implementing such approaches generally require more knowledge and labour per hectare in comparison to conventional farming, there is a need for a better understanding of the socio-economic and policy factors that hinder or enhance the development and implementation of such systems. Understanding drivers and barriers for further development and implementation of agro-ecological approaches in EU farming systems is complex and requires the integration of a wide range of socioeconomic, ecological and political settings. The newly funded transdisciplinary H2020 project UNISECO operationalizes an adapted socio-ecological systems framework that integrates external settings of farming systems into the assessment of drivers and barriers for implementation of improved agro-ecological approaches, paying particular attention to the role of different types of actors. The main objective of UNISECO is to strengthen the sustainability of European farming systems, through co-constructing improved strategies and incentives for the promotion of improved agro-ecological approaches. The strategies and incentives will be developed and practice-validated in participatory case studies in 13 EU Member States with particular attention paid to different biophysical, socio-economic and socio-cultural contexts of farming systems to facilitate more effective policy support in the diverse settings of EU agriculture. The presentation will introduce the conceptual and methodological framework of UNISECO and highlight its expected key results and impacts. UNISECO has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement N° 773901.

SESSION 2

Alpine ecosystems in the phase of global change

Chairs: Karl Hülber, Jürg Stöcklin, Manuela Winkler

Alpine ecosystems under global change

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Environmental changes in alpine regions that deserve the attribute 'global' are the uniform changes in atmospheric CO_2 concentration, the regionally variable rise in the temperature of the free atmosphere and reactive nitrogen deposition, as well as the stochastic (but global) change in land use. There is evidence that alpine plants are carbon saturated, hence take no advantage from elevated CO_2. Because nitrogen is almost always a growth limiting resource, additions of even small amounts of soluble nitrogen, shift species abundance towards responsive, often very abundant taxa, at the cost of slow growing, rare taxa. The consequences of a rise in temperature are hard to predict, because most alpine taxa operate at temperatures far above air temperatures reported by weather stations, and because temperatures vary strongly with topography across very short spatial distances. Also indirect effects are hard to predict, because climatic warming not only enhances snow melt, but also winter precipitation, with greater snow pack potentially compensating the warming effect on snow duration above certain elevations. Since snow distribution patterns are conserved by topography, but the date of snow release may vary from year to year, phenology responses are a central issue. Although the alpine belt faces only moderate land use pressure, both overutilization and abandonment exert significant impacts. I will underpin these statements with empirical data, and will argue against over-simplistic projections that overlook the intrinsically small scale mosaics of life conditions in the alpine life zone. While alpine biota are quite robust against climate variation, but at the same time are key for soil conservation on steep slopes, are richer in taxa than lowland biota, serve as biogenetic refugia, represent the last wilderness areas in many parts of the world, and will lose terrain by advancing montane forests, they deserve special protection.

Differing patterns of productivity and biodiversity of montane and alpine grasslands under climate change

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Climate change, especially warming, is likely to be most severe at higher latitude and altitude. This leads to uncertainty for future ecosystem services such as biodiversity and productivity of montane and alpine grasslands. Increasing temperature may increase growing season length and metabolic rates, but can conversely restrict growth by causing direct heat stress or indirect drought stress. Both mechanisms are supposed to alter aboveground biomass antagonistically to one or another and are likely to change interspecific competition of species within communities, thereby posing challenges to maintaining ecosystem services and biodiversity. This study aims at elucidating the effect of climate warming on aboveground biomass and plant community composition of montane and alpine grassland ecosystems. We conducted a downslope translocation experiment of 126 plant–soil monoliths of five different montane and alpine grasslands to lower sites representing an elevational gradient of 2,090 m in the European Alps, in order to simulate possible future climate scenarios and to test for ecological limits of community stability. Our findings after one entire year of translocated plant communities being exposed to a changed climate suggest that aboveground biomass increases with increasing temperature as long as precipitation regime is not severely altered. Whereas, species richness declines with warming. Functional group composition shifts towards more graminoid dominated communities. Community composition changes at the species level did not show evidence for deterministic species filtering. However, communities within themselves neither became more similar by deterministic filtering for competitive dominant species nor destabilized by random stochastic dispersion. Our results further suggest that plant communities of montane and alpine grassland are sensitive to water limitation, which may co-occur with increasing temperature.

Nitrogen addition and understory removal but not soil warming increased radial growth of *Pinus cembra* at treeline in the Central Austrian Alps

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Beside low temperatures, limited tree growth at the alpine treeline may also be attributed to a lack of available soil nutrients and competition with understory vegetation. Although intra-annual stem growth of *Pinus cembra* has been studied intensively at the alpine treeline, the responses of radial growth to soil warming, soil fertilization, and below ground competition awaits clarification. In this study we quantified the effects of nitrogen (N) fertilization, soil warming, and understory removal on stem radial growth of *P. cembra* at treeline. Soil warming was achieved by roofing the forest floor with a transparent polyvinyl skin, while understory competition was prevented by shading the forest floor with a non-transparent foil around six trees each. Six trees received N-fertilization and six other trees served as controls. Stem growth was monitored with band dendrometers during the growing seasons 2012–2014. Our three year experiment showed that soil warming had no considerable effect on radial growth. Though understory removal through shading was accompanied by root-zone cooling, understory removal as well as N-fertilization led to a significant increase in radial growth. Hardly affected was tree root biomass, while N-fertilization and understory removal significantly increased in 100-needle surface area and 100-needle dry mass, implying a higher amount of N stored in needles. Overall, our results demonstrate that beside low temperatures, tree growth at cold-climate boundaries may also be limited by root competition for nutrients between trees and understory vegetation. We conclude that tree understory interactions may also control treeline dynamics in a future changing environment.

How suitable are altitudinal transects for predicting plant responses to global warming?

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Alpine ecosystems are characterized by steep environmental gradients across short distances. Hence, altitudinal gradients are powerful tools to investigate the response of plants to changing environmental conditions. In the context of global change research, the change in altitude is often used as a surrogate for temperature changes. One problem, however, is the covariance of environmental factors along these gradients. Temperature changes are usually confounded with changes in precipitation, VPD, maximum and average PAR and growing season length, which all potentially influence plant performance. Therefore, we compared the responses of eight grassland species to changes in temperature, light and water availability in a full-factorial climate chamber experiment to patterns along eight elevational transects covering all aspects. We focused on the four functional traits specific leaf area (SLA), leaf chlorophyll content (Chl), stomata size and stomata density. SLA and Chl both decreased with high light and with low temperature under controlled conditions in the climate chamber. Along the altitudinal transects SLA and chlorophyll content responded differently at different aspects. A decrease with elevation occurred only at north facing transects for SLA and at eastern and western slopes for Chl. Noteworthy, SLA increased with elevation at slopes facing east and west. Stomatal size did not change with different factors in the experiment, but decreased with elevation on slopes facing south and west. In contrast, stomatal density increased with high temperatures and light in the experiment, but was constant along the altitudinal transects. Our results indicate that aspect is one important factor influencing the intraspecific trait variation along altitudinal gradients and can influence their suitability for climate change research.

Convergent and adaptive processes during adaptation to warmer and drier habitats in the alpine plant species *Heliosperma pusillum*

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To which extent can species adapt to an increasingly changing environment? Species distributed along the altitudinal gradient are ideal models to study the mechanisms underlying local adaptation in sensitive and dynamic habitats. We investigate the contribution of neutral and adaptive processes in shaping early stages of divergence during adaptation to drier and warmer habitats. The study systems are morphologically differentiated ecotypes (alpine glabrous vs. montane pubescent) of the species *Heliosperma pusillum* (Caryophyllaceae). The ecological divergence features not only temperature differences, but also moisture (dry montane vs. wet alpine habitats), availability of light (shaded montane vs. open alpine) and biotic divergence in the phyllosphere of the plants. RADseq analyses support a scenario of multiple parallel origins of the montane ecotype from the alpine across population pairs at different localities in the south-eastern Alps. With RNAseq we performed comparative transcriptomics on 24 representative individuals (i.e. 3 individuals × 4 populations pairs) grown in a common garden. We test for divergent patterns between the two ecotypes in each independent origin and search for overlapping patterns across origins. Our data show that drift and locally-relevant selection shape a major portion of expressed patterns. By contrast, enriched gene expression shared by independent divergence events show that natural selection shapes the expression patterns of a few ecologically relevant genes. The dry and shaded montane ecotype adapted to its new environment by up-regulating genes involved in epicuticular wax biosynthesis, responses to desiccation and biotic stress, while down-regulating other cellular responses to high light intensity and UV. Our study sheds light on the evolutionary processes allowing alpine populations to adapt to warmer and drier habitats. Given the recurrence of the divergence events, this appears to be relatively easy achieved in *H. pusillum*.

Trends in alpine biodiversity and microhabitat variability in the Central and South Alps

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Alpine ecosystems have highly heterogeneous habitats and therefore harbour a rich diversity of vascular plants. In the European Alps, the ongoing climate warming was found to enhance species richness at mountain summits from the treeline ecotone to the subnival zone. New species mainly arrive at the southern and eastern compass directions. Warm adapted and widely spread species are expanding upwards whereas cold adapted alpine-nival species may lose their habitats. Thus, the future of high altitude plant species diversity is a matter of debate. New insights can be obtained by experimental approaches or by long term observations. Within the long-term project GLORIA (Global Observation Research Initiative in Alpine Environments), vegetation changes at mountain summits are monitored throughout decades at two different scales: at the 1 m^2 plot level and at the summit area section level, 5 m and 10 m below the highest summit point, respectively, taking into account each compass direction. Per mountain region, four summits from the treeline ecotone to the lower and upper alpine and the subnival-nival zone were chosen and revisited every 5–10 years. Here we show the variability of microsite types (scree, bare ground, rock, vegetation, litter) and its correlation with diversity and the appearance of new colonizers at GLORIA summits. According to the niche concept, newly arriving species need empty microsites. However, species in high altitudes benefit from already established species as they offer safe sites. Negative effects might result from the presence of a litter layer caused by resident species or from the presence of rock, both inhibiting seed germination and seedling establishment. Using the data set of GLORIA regions situated in the Central and South Alps consisting of siliceous and calcareous bedrock we compared data from the first and last monitoring after 14 years. Our results highlight that different filters affect species arrival at new sites in high mountain regions.

How abandonment of mountainous meadows influence bumblebees, true bugs and grasshoppers: studies from the Austrian and Swiss Alps

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In recent decades, there is a serious decline of extensively managed mountain meadows due to abandonment. However, these meadows are of high conservation value, harbouring a high plant and insect diversity. Thus, we assessed the effects of land-use abandonment of mountainous meadows on species richness and assemblages of bumblebees, true bugs and grasshoppers. In the first study, we surveyed three abandoned (20–60 years old) and three annually mown unfertilized mountainous meadows in three regions across the Austrian and Swiss Alps in June and August 2015. Study regions were located in the Biosphere Reserves Großes Walsertal (Austria) and Val Müstair (Graubünden, Switzerland) and in the LTSER-region Eisenwurzen (Austria). In a second study, we conducted a follow-up investigation in the Eisenwurzen region in June and August 2016 to provide a detailed insight and to confirm the general applicability of previous results. We found significantly higher numbers of bumblebee species in managed meadows compared to abandoned meadows in both studies. Numbers of true bugs and numbers of grasshoppers did not significantly differ between meadow types in the first study, however, we found significantly higher numbers of phytophagous bug species in managed meadows in the second study. We did not find significant different numbers of grasshopper species. In the first study, we found that managed meadows harboured significantly different species assemblages of bugs and grasshoppers, but not of bumblebees. In contrast, we did not find significantly different species assemblages of the three insect groups in the second study. We showed that extensive management is especially important to preserve valuable foraging resources for bumblebees. Our results reveal that true bugs and grasshoppers benefitted from the habitat conditions of both meadow types. Thus, abandoned meadows, which are not yet re-grown into closed forest can still act as suitable habitats for true bugs and grasshoppers.

POSTER PRESENTATIONS

SESSION 2-P1

Influence of abandonment and monitoring methods on syrphid composition in mountainous meadows of Austrian and Swiss Alps

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In recent decades abandonment of extensively managed meadows is an ongoing challenge in European Alps. Syrphids have been recognized as a threatened group due to pollinator decline, and different methods are used to analyze their richness and abundance. We investigated whether abandonment of extensively managed mountainous meadows (mown once a year, no fertilizer use) affects syrphid abundance, richness and species assemblages. Also, we tested the effectiveness of two collection methods (line transects and observation plots). Adult syrphids were sampled over two consecutive years (June and August 2015–2016). Transects of 15 m long and 2 m wide were assigned in the center of each study site. Along with line transects, four 2 m^2 observation plots per study site were installed in a straight line. Syrphid abundance and richness were significantly higher in managed than abandoned meadows, and increased with increasing plant richness and flower frequency. Management and sampling time also significantly affected syrphid species assemblages. Syrphid abundance, probably leading to high pollinator success, was shown to be promoted by managed meadows. Syrphid abundance and richness were significantly higher in the observation plot method compared to the line transect method. Though the area recorded by the observation plot method was ten times smaller, significantly more species and individuals were recorded by this method. The observation plot method is more suitable for studies aiming at comparing differences in the numbers of adult syrphids in different grassland habitats.

SESSION 2-P2

Impacts of land use intensity in mountain semi-dry meadows on earthworms, litter decomposition and plant diversity

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Farming has created different agricultural landscape types and shaped the rural areas. However, ongoing socio-economic changes are following two trends on mountain meadows: intensification of sites that are easily accessible and abandonment of those that are difficult to manage. Both trends are known to affect plant diversity directly, while influencing indirectly litter decomposition via changes in abiotic conditions, plant community and the quality of litter. Effects on plant diversity are additionally expected to affect the activity and diversity of earthworm communities. We investigated whether abandonment of extensively managed mountain meadows affects plant parameters, litter decomposition and earthworms. Four managed (mown once a year, no fertilization) and four abandoned (no mowing, no fertilization) semi dry meadows in a mountain biosphere reserve in Austria were surveyed in June and August 2016. Plant parameters (species richness, vegetation cover, plant traits, biomass structure), litter decomposition (tea bag index) and earthworm parameters (species richness, density, biomass) were assessed. Additionally, soil parameters (temperature, moisture, electric conductivity) were measured. Results showed that plant species richness was significantly higher in managed than in abandoned meadows. Furthermore, management types resulted in different plant species assemblages. The structure of plant functional groups showed differences mainly in a higher necromass on abandoned sites. Litter decomposition rate was significantly higher in abandoned sites and correlated positively with higher necromass. Earthworm parameters showed marginal management effects, with marginally higher worm density on managed meadows. Moreover, the density of juvenile worms and endogeic worms was marginally higher on managed sites. Both management types showed similar earthworm species. We conclude that in order to sustain plant and earthworm biodiversity in this biosphere reserve both abandoned and extensively managed meadows matter.

SESSION 2-P3

Impacts of water stress on fine root dynamics in altitudinal forests of Himalayan Bhutan

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In Eastern Himalayan Bhutan, altitudinal forests are influenced mainly by soil moisture regimes and vulnerable to predicted climatic anomalies, especially reduced summer monsoon. In Bhutan, we established a throughfall exclusion (TFE) experiment in two forests of sub-alpine coniferous dominated by *Tsuga dumosa* and temperate mixed broadleaved dominated by *Quercus lanata* and *Quercus griffithii*, at the altitude of 3,300 and 2,300 m msl respectively, to study the impacts of drought episodes on forest ecosystems. The objective of the present research is to examine the effects of water stress on fine root dynamics under the manipulated drought conditions. We conducted a comprehensive study on root dynamics including fine root biomass, a number of morphological traits, production and turnover and fine root decomposition during two years of experiments. Although standing fine root biomass was unaffected in both forests, partial TFE enhanced the fine root mortality in *Quercus* dominated forest, which was however, partly compensated by increased production of fine roots. Data from morphological images of fine root showed that the specific root volume and root surface area of *Tsuga* and average fine root diameter of *Quercus* were significantly reduced after TFE treatments, presumably due to the species specific tolerance strategies. In contrast, the litterbag experiment of fine roots revealed that the TFE decreased the decomposition rates of both species in the respective locations. Finally, these findings will contribute to evaluate the vulnerability and resilience of the Himalayan forests in responses to global climate change.

SESSION 2-P4

Climate driven changes of high mountain plant communities at the cold edge of southern Europe

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The Mediterranean Basin is one out of globally 35 biodiversity hot spots (and the only one occurring in Europe), which comprise the Planet's biologically richest and most endangered terrestrial ecoregions. Mountain regions contribute substantially to its overall biodiversity, but its alpine areas are highly scattered and fragmented. The Sierra Nevada is the highest European mountain of the Mediterranean Basin, hosting an extraordinarily rich flora with a high degree of endemism. In the zone above 3,300 m more than 90 % of the species are local endemics. Given the limited area of low-temperature habitats, its endemic flora is at extremely high risk of losing their habitat not only through amplifying temperature rise but particularly through the combination with reduced precipitation. The Sierra Nevada National Park was one of the first GLORIA sites (Global Observation Research Initiative in Alpine Environments) established. GLORIA aims at investigating magnitude and velocity of biodiversity losses and transformation of species composition through anthropogenic climate change. We show recent changes in vascular plant species diversity and composition in permanent monitoring plots between 2001 and 2015. Our results indicate that the high-elevation vegetation is largely tracking recent climate trends. Considering the projections of increasing temperature and decreasing precipitation in the Mediterranean area of Europe till 2100, climate change effect may be highly detrimental for the unique flora of Sierra Nevada.

SESSION 3

Application of the functional trait framework in ecological theory and restoration ecology

Chairs: Camilla Wellstein, Christine Römermann

Functional diversity in equilibrium and non-equilibrium rangelands. A case study from Mongolia

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The ecological processes in the majority of rangelands are dominated by the local climatic conditions and grazing impacts. In drylands, water availability plays an exceptionally important role, as it is the key factor for both vegetation and livestock. Unclear is, however, the relative importance of climatic drivers and grazing impacts on plant community composition. Two coexisting concepts on rangeland dynamics encompass the relative importance of biotic and abiotic influences on rangeland vegetation. The concept of equilibrium dynamics (EQ) posits that grazing impacts dominate community composition in relatively wet rangelands. The concept of non-equilibrium dynamics (NEQ) states that the harsh climatic conditions in dry rangelands control livestock numbers and thus limit grazing effects on community assembly. We used the functional traits framework to assess differences in plant communities between EQ and NEQ systems. We investigated 12 local-level grazing gradients across a large-scale climate gradient in Mongolia that covered both EQ and NEQ systems. We collected 12 plant functional traits from 112 species. Three approaches were used: a) the reaction of the communities to several environmental variables was examined by a combination of RLQ and 4th corner, b) trait reactions to grazing and climate were tested by models of community weighted means and c) the functional trait space was modelled by a selection of functional diversity indicators. The main results suggested that community composition in NEQ systems is dominated by environmental filtering and grazing effects are limited to sacrifice zones. Communities in the EQ systems are rather affected by grazing which results in distinct dominance structures between several plant strategies. In this session, we will present our study results in detail and discuss our approaches to the framework of functional trait diversity.

Effects of climate, soil and land-use on plant functional traits along a 1,200 km latitudinal transect through Kazakhstan and Western Siberia

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The central Asian steppe region is severely understudied in regard to functional ecology. This is especially true compared to regions with similar climate (Mongolia and North American Prairies). We used data comprising ca. 1,400 vegetation relevés and more than 800 species across a 1,200 km latitudinal transect ranging from Western Siberian meadow steppes in the north via true steppe communities to dwarf-shrub dominated northern central Asian desert in the south (45°N to 57°N). As data on plant functional traits are rare except for the most northern part of the transect, we sampled leaf trait and height measurements for 164 steppe grassland species and also accessed unpublished sources. With increasing humidity and productivity towards the north, average vascular plant species richness per 100 m^2 increases from around 10 to 35. Community weighted mean (CWM) of specific leaf area decreased steeply from the lush northern meadow-steppe to the more drought adapted leaves in the true steppe. The subsequent transition from still herbaceous dry steppes to dwarf shrub dominated desert takes place around an aridity index of 0.3, where plant woodiness and C_4-photosythetic pathway increases steeply. Changes in land-use are also expressed by shifts in functional traits. Post-soviet abandonment of arable land leads in early stages of succession to a higher seed mass and a higher SLA compared to secondary grasslands on older ex-arable land and pristine steppe. Due to the breakdown of watering wells in the steppe, concentration of livestock grazing around settlements leads to a decreased canopy height and an increase of short-lived ruderals. Additionally, we found evidence for the inverse texture hypothesis, predicting that below a threshold of 380 mm of annual precipitation, sandy soils will support a more species-rich and mesophytic vegetation compared to loamy substrates.

Plant functional responses to fire and grazing after a dramatic shift in disturbance regimes on the Eurasian steppes

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The steppes and semi-deserts of Central Asia, in particular those of Kazakhstan, have been subject to major land-use changes during the 20th century. After the collapse of the Soviet Union in 1991, livestock numbers declined rapidly. The remaining animals now concentrate around settlements, whereas across vast areas further away from human settlements, pastures have been abandoned. We hypothesized that the widespread cessation of grazing has led to an increase in wildfire frequency and subsequent shift in plant functional characteristics of steppe vegetation. To examine the effects of the altered fire-grazing interplay on vegetation we sampled 204 vegetation plots stratified by grazing intensity and fire frequency (the latter derived from the MODIS burned area product). Multivariate RLQ analysis and fourth-corner analysis was used to assess the relative importance and effects of environmental drivers and plant functional traits. Livestock grazing was confined to the surroundings of villages whilst fires occurred solely in ungrazed or hardly grazed areas. Tussock grasses were favoured by high fire recurrence rates whereas with increasing grazing intensity, small-growing plants with a short life cycle benefitted. The transition from high livestock numbers managed in a semi-nomadic way to intensive grazing of smaller areas near villages has led to biomass being now exclusively consumed by fire across vast areas. The current fire regime in the Kazakh steppes rates creates and stabilizes rather monotonous grassy swards which may lead to changes in ecosystem functioning. We suggest the reintroduction of livestock grazing into the remote areas of Kazakh steppe to reduce fuel for wildfires, which would require considerable investment into rural infrastructure for a sustainable socio-economic development.

The effect of 'home' and climate on litter decomposition in Chile

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The effect of climate on leaf litter decomposition is highly complex. It results from direct effects (e.g. acceleration with increased rainfall) and indirect effects via litter quality, plant composition, plant cover and plant traits. To disentangle these relationships a reciprocal transplant experiment of leaf litter was performed. In this experiment the 'home'-adaptation hypothesis is tested against the hypothesis that leaf litter decomposes quicker in wetter climates. Along a climate gradient in the coastal cordillera of Chile (26 to 38°S) the decomposition of leaf litter of dominant species from four different climates (arid, semi-arid, Mediterranean, temperate forest) was evaluated for a year. In addition, precipitation was manipulated with rainout shelters, simulating a dryer climate in the semi-arid and Mediterranean climate. On a smaller scale the influence of soil humidity is studied by comparing north and south facing slopes within each climate. Our main result so far is that along the gradient, between slopes and between rainfall manipulation treatments the results are textbook knowledge i.e. decomposition increases with precipitation. However, when looking at in situ decomposition of local species the pattern is exactly the other way round with increasing decomposition towards the arid.

Leaf functional diversity effects on litter decomposition along a climate and vegetation gradient in the Chilean coastal cordillera

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Litter decomposition depends on climate and on vegetation. However, it is an open question to what extent the absolute values and diversity of plant functional traits contribute to decomposition speed, and how this contribution varies between climate zones. Understanding this contribution is important, though, to understand the importance of biodiversity, in particular functional diversity, for carbon and nutrient cycling in different ecosystems. We therefore studied diversity effects on leaf litter decomposition along the Chilean Coastal Cordillera, which holds a climate and vegetation gradient ranging from the Atacama Desert (26°S) to humid temperate forests (38°S). Based on a concurrent reciprocal transplantation experiment, we know that both climate and leaf traits strongly affect litter decomposition rates along this gradient. In a field experiment, we decomposed leaf litter of single species as well as mixtures of two, four and six functionally different species at four sites along the climate gradient. We analyzed the diversity effects by comparing the decomposition rate predicted by the rates of the single species to the observed rate in the mixes, and relating the diversity effect to the functional diversity within the litter mixes. We found positive effects of diversity on the decomposition of leaves in mixtures with four and six species at all sites, except for the northern (desert) ones. This could be explained by the small functional diversity of the species that compose this community, or the generally very low decomposition rates. Our results suggest that litter decomposition processes are generally enhanced by leaf functional diversity, but the diversity effect varies with climate.

Relationships between functional traits, success of reforestation, and habitat preferrence in a Costa Rican rainforest area

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Tropical deforestation is a major cause of biodiversity loss and an important source of CO_2 emissions, but tropical forest also have a high potential for regrowth, which supports biodiversity and serves as a carbon sink. However, for a successful and species-rich reforestation, information on the ecology and management of most tropical trees is scant. Functional traits are parameters that are relatively easy to measure and can be linked to tree performance and ecology and have been related to growth and habitat preference along a successional gradient in tropical forests. We measured tree growth and survival in a multi-species reforestation in La Gamba, Costa Rica, over several years and related demography to functional traits (wood specific gravity – WSG, branch hydraulic conductance, specific leaf area – SLA, leaf nitrogen content and seed mass) and the species' habitat preference. Tree growth was best explained by WSG and less by leaf N, but little by any other trait. However, tree growth was additionally (and not related to any trait) explained by habitat preference, which suggests that some traits that explain growth and are related to habitat are not captured by the traits commonly investigated. Only seed mass was strongly explaining habitat specialization. This suggests that occurrence in secondary forests is more related to dispersal capacity rather than to traits commonly linked to physiology. Species with high growth tended to have lower mortality, which contrast with a growth : mortality trade-off reported from old-growth forests. Based on selected traits and to some extent information on their habitat preference, trees can thus be selected that will grow fast and survive well to reforest degraded tropical areas. However, for an improved tree selection and management of many species, including less common traits and investigating the interactions between traits, habitat and demography requires more research.

Logging impacts functional trait composition and increases functional diversity of understory vegetation in Dinaric fir-beech forests

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The concept of plant functional traits demonstrated to be very effective in unravelling the mechanisms governing plant community response to disturbance, especially when research is focused on short-term post-disturbance vegetation dynamics. In this study, we established an experiment to quantify how logging intensity affects the plant functional trait composition and functional diversity of understory plant communities in the Dinaric fir-beech forests in Slovenia. Three different silvicultural treatments were implemented: control (no logging), 50 % of the growing stock removed, and 100 % of the growing stock removed. Vegetation surveys of vascular plants were made before (in 2012) and two years after (in 2014) the logging. Changes in species traits, C–S–R plant strategies (*sensu* Grime) and community-level functional diversity were analysed. The importance of traits such as small and light diaspores, short life span and anemochory increased with logging intensity. Moreover, species with the ability of both generative and vegetative reproduction, longer flowering duration, overwintering green leaves and functionally characterized as legumes and tall herbs increased in abundance after the logging. C–S–R strategies mainly shifted from stress-tolerators and competitors in the pre-logging conditions towards more expressed ruderal component in the post-logging stands. Logging in the short term increased functional diversity of post-disturbance plant communities, mainly due to newly colonized species being functionally dissimilar from persistent residents. Results suggest that logging intensity strongly influences the magnitude of change in both functional composition and diversity, which also has important implications of managing forests for biodiversity conservation. At the landscape scale, increasing spatial heterogeneity by creating a mosaic of forest stands subjected to different logging intensities will likely contribute to enhancement of plant functional diversity.

Enhancing our understanding of root systems using model-based techniques on phenotyping data

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Plant phenotyping is expected to provide new impetus to crop improvement and stress resistance but generally facilitates the characterization of plant traits in other, not agricultural, ecosystems. Advances in imaging technology have recently led to high-throughput phenotyping platforms above ground, overcoming limitations in data collection. However, sufficient throughput and resolution remain challenging when targeting root systems – particularly when studying mature plants. Thus, beside advanced sensor technology, novel modelling and statistical approaches are needed allowing for root phenotyping data to be increasingly translated to relevant information for breeders and plant ecologists alike. Using European legume accessions as examples, we show that 1) root system architecture models as a tool can overcome the inference problem between different ontogenetical stages of root system development, and that 2) machine learning (ML) approaches can be powerful tools to analyze trait variations between genotypes (driven by agro-climatic conditions). This contribution will thus provide 1) key root traits of peas to be phenotyped for model-assisted extrapolation from seedling towards mature root system architecture, and 2) methodological guidelines on how to use powerful machine learning methods such as random forest models for enhancing the phenotypical exploration of root systems. Overall, the presentation will outline how the integration of advanced techniques into the phenotyping pipeline can facilitate the analysis, interpretation and subsequent use of root phenotyping data by plant scientists.

Functional diversity in ferns is driven by species richness rather than by environmental constraints

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Understanding how biotic assemblages are composed is a central, yet challenging topic in community and functional ecology. One way to understand community assembly is to study complementary aspects of functional diversity such as functional richness, functional evenness, and functional divergence, along gradients of environmental conditions and species richness. In the present study, we determined functional diversity by describing fern traits directly related to resource acquisition along four tropical elevational transects with different environmental gradients and species richness. By comparing different gradients, we aimed to disentangle the influence of species richness from environmental influences on functional diversity. Furthermore, we evaluated if the functional volume is saturated at high levels of species richness, and assessed the relative importance of functional expansion or packing with changes in species richness. We found that functional trait diversity is mainly correlated to species richness and much less so to environmental conditions. Additionally, our results reveal that higher species richness contributes progressively to the expansion of the functional niche space without any signs of saturation, but with increasing functional niche packing. In summary, our findings illustrate that even though environment has an indirect influence on fern resource acquisition techniques, the amount of species is the fundamental driving force of functional niche structure.

Belowground plant functional ecology: what is beyond acquisition?

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In recent years, plant ecologists have increasingly focused belowground using trait-based approaches that greatly improved our understanding about plant processes and functions. However, most of the attention concentrated on the key function of acquisition, fine-root traits and mycorrhizal associations. Other important functions provided by belowground organs (e.g., rhizomes, bulbs) as on-spot persistence, space occupancy and recovery after damage remain largely unexplored. I will present a compartment-based approach built on biomass allocation into different functions, designed to studying belowground plant ecology comprehensively. Two compartments are identified, namely acquisitive and non-acquisitive. The former includes organs and traits referring to plant abilities to acquire resources. The latter deals with functions such as space occupancy, resource sharing, resprouting after disturbance, protection against climate adversity, carbon storage. As an operating example of the proposed approach, I will present results from Central European species and communities on: 1) biomass scaling between belowground (fine roots and rhizomes) *vs.* aboveground, and 2) longevity of connection among ramets in relation to species environmental requirements. I will discuss methodological challenges – related to assessing biomass partitioning and turnover across plant ontogeny and growth forms – and attempts to overcome such hurdles. Four areas where future research would be highly needed involve: i) biomass scaling, ii) clonality *vs.* resource acquisition relations, iii) linkages between resprouting and changing environments, and iv) carbon sequestration. Standardized procedures to collect traits informative on these less studied functions are urgent. Gathering such trait-data from different biomes in a comparable way is key, and would facilitate including poorly known functions and traits into global syntheses, so advancing our understanding of belowground plant ecology.

Temporal and spatial trade-offs between resistance and performance traits in herbaceous plant species

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Frost resistance (FR) is a highly adaptive trait and important for plant performance, survival and distribution. While overall seasonal changes in frost resistance of herbaceous species are well documented, the knowledge about the variability during the growth period is scarce. Responses could be expected due to differences in temperature and investment in frost resistance might be at the expense of plant performance. To analyse temporal and spatial variability, FR of leaves of six herbaceous species on five sampling dates and along an elevational gradient (ranging from 700–1,700 m asl) was assessed. We selected *Aposeris foetida* (L.) Less. and *Mercurialis perennis* L. as early flowering plants, *Knautia dipsacifolia* Kreutzer and *Phyteuma orbiculare* L. as late flowering species and *Trifolium pratense* L. and *Potentilla erecta* (L.) Raeusch as long flowering species to account for different life strategies. To test whether plant performance as measured via eco-morphological leaf traits (specific leaf area, SLA), leaf dry matter content, leaf P and Mg content as well as stomatal pore area index (SPI) is linked to FR, we measured those in parallel. We found that FR as well as performance traits exhibit a strong temporal variation whereas spatial variability was low. When analysing the relationship of FR to performance traits we found that SLA as a proxy of growth rate was negatively associated with FR indicating a trade-off between growth and resistance, whereas SPI showed a positive relationship to FR. This finding gives further insight in the variability of traits and will help to improve predictions concerning plant performance and distribution under changing climate regimes.

Trait correlation network analysis identifies stem traits as hub traits in herbaceous perennial plants

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Positive or negative correlations among plant traits often reflect trade-offs or allometric relationships in biological functions. We used network analysis to investigate correlation patterns of 23 traits of 126 herbaceous plant species from 381 plots covering dry to wet environments in Northwest Europe. Using a graph-theory approach, we found that size traits were the most central traits in the network, underlining the relevance of allometric relationships. Stem mass and stem specific length were 'hub' traits, due to their correlation with most other traits. Specific leaf area and leaf N were of minor importance. A cluster analysis revealed modules capturing size traits, seed traits, C and N concentrations, and organ mass fractions. A module representing a plant economics spectrum did not emerge. Our study suggests that stem traits have stronger regulatory roles in herbaceous plants than leaf traits.

Is it the right place for me? Seed germination requirements explain wetland species distribution at local scale

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Wetlands represent an extremely heterogeneous environment for their specific plants, because key abiotic factors, such as light, oxygen availability, and temperature fluctuations, vary there rapidly at relatively small spatial but also temporal scales. Yet, wetland plants exhibit the well-known clear distributional patterns within such compact and heterogeneous habitats. Despite a large number of studies on wetland vegetation ecology, there is still a substantial lack of knowledge in which and how plant traits control these sharp local distributional ranges. Seed germination is an important element of regeneration niche (*sensu* Grubb, 1977) and, due to its high sensitivity to environmental perturbation, was found to be critically important for understanding terrestrial and wetland plant distribution at different scales, their community assembly, and vegetation dynamics. In this study, we explore the seed germination requirements for light, oxygen, and temperature of 50 typical Central European wetland species in relation to the local niches they occupy. We clearly demonstrate that seed germination of wetland species is only triggered by the combination of environmental factors that reflect the onset of favourable conditions for successful seedling establishment. This finding, therefore, extends the applicability of 'gap-detection' mechanism of seed reproduction to aquatic habitats. Furthermore, the results of our study could help to reach a better understanding of the existing patterns of wetland plant distribution at local scales, wetland vegetation dynamics, as well as facilitates nature conservation measurements and aquatic habitat restoration.

It's a matter of taste: intraspecific size-mediated niche partitioning improves mixed leaf litter consumption

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Functional traits determine fitness of individual organisms and therefore processes at higher levels of biological organization. Nevertheless, intraspecific differences were thus far largely overlooked in trait-based ecology, especially with respect to animals and their effects on ecosystem functioning. Soil invertebrates contribute crucially to the functioning of one of the most diverse – but still poorly understood – ecosystem on Earth. Experimental approaches are a promising way to shed light on the mechanisms linking soil biodiversity and ecosystem processes. Here we tested experimentally the effect of intraspecific body size differences (two size classes) in the common isopod species *Oniscus asellus* on the consumption of two litter species (*Acer platanoides* and *Betula pendula*). We hypothesized the occupancy of different niches during consumer's ontogeny, due to stage-specific feeding modes and/or preferences, and consequent intraspecific niche partitioning. In a full factorial design with all possible isopod size class and litter species combinations, size mixtures enhanced consumption beyond the additive effect of each single class, and this pattern was especially strong in mixed leaf litter treatments. Our results suggest an interaction between litter and consumer diversity, which can drive intraspecific feeding niche partitioning with potential consequences for leaf litter consumption in natural ecosystems.

Environmental and trait variability constrain community structure and the biodiversity-productivity relationship

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There is still considerable debate about which mechanisms drive the relationship between biodiversity and ecosystem function (BEF). Although most scientists agree on the existence of two underlying mechanisms, complementarity and selection, experimental studies keep producing contrasting results on the relative contributions of the two effects. We present a spatially explicit resource competition model and investigate how the strength of these effects is influenced by trait and environmental variability, resource distribution, and species pool size. Our results demonstrate that the increase of biomass production with increasing species numbers depends on the concurrence of environmental and trait variability: BEF relationships are stronger if functionally different species coexist in a landscape with heterogeneous resource supply. These large biodiversity effects arise from complementarity effects, whereas selection effects are maximized when broad trait ranges coincide with narrow ranges of resource supply ratios. Our results will therefore help to resolve the debate on complementarity and selection mechanisms.

Using a trait-based model to study plant strategies under severe desert conditions

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We developed an individual- and trait-based model on a desert plant community. The aim of our model is to provide an understanding of the processes that underlie plant community structure and dynamics. Our specific research question is which role different plant functional traits play for community structure. We assess the importance of plant functional traits related to plant-plant interactions relative to those related to withstanding harsh environmental conditions in the desert. We show how biotic and abiotic interactions are linked in the model and how they influence spatial community dynamics. As main environmental drivers of plant community dynamics, we consider soil water content, soil salinity, and topography. The model is developed to consider intra-population, intra-specific, and inter-specific interactions. Structurally, the model includes two submodels: vegetation and environment. Each plant in the community is modelled individually and represents a certain species. Thus, community processes emerge as a result of interactions between plant individuals of the same and different species and of individuals with the environment. The model is parameterized based on empirical data gained from communities dominated by the true rose of Jericho (*Anastatica hierochuntica*) in the Negev desert in the south of Israel. We designed the model in such a way that it can be adapted to study the effect of plant traits on spatio-temporal community dynamics in other similar communities across the world.

POSTER PRESENTATIONS

SESSION 3-P1

'Live fast, die young': consistent response of annuals to grazing along a steep rainfall gradient

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Grazing is one of the most important land-use factors in arid and semi-arid regions with strong effects on functional diversity and community structure. In perennial plants the influence of grazing on the community decreases towards arid regions. In the same direction, species switch from a grazing tolerance strategy with a high ability to compensate herbivory to a grazing avoidance strategy characterized by traits reducing the attractiveness of the plant for herbivores. However, the response of annuals to grazing and their mechanisms (functional traits) for drought and grazing resistance are less known. We investigated the response (leaf and whole plant traits) to simulated grazing on 23 annual species, differing in their distribution across a steep rainfall gradient in the Eastern Mediterranean Basin. In a greenhouse experiment, plants were clipped once at the peak of the flowering season to remove approximately 75 % of their biomass. The annuals differed in all studied leaf traits, toughness, area, SLA (specific leaf area) and LDMC (leaf dry matter content), but trends across the rainfall gradient were missing in the clipped and control plants, as well as in their response ratios. Nevertheless, clipping induced compensation mechanisms, i.e. higher SLA, lower leaf toughness and LDMC, and resulted in an ambiguous response in leaf area. Clipped plants thus produced cheap constructed leaves to maintain high growth rates instead of investing resources in herbivore defence. This consistent grazing tolerance or escape strategy in all annuals across the rainfall gradient differs from the response of perennials. Ongoing analyses of whole plant traits will show whether this strategy is also reflected in the biomass allocation of the species.

SESSION 3-P2

BryForTrait – a life-history trait database of forest bryophytes

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In ecological research, plant functional trait analyses are widely applied to understand to which extent the inter-specific variation in trait attributes has an adaptive value or predict ecosystem processes and changes. Compared to vascular plants, trait studies using bryophytes are scarce, which is likely due to missing trait information for bryophyte species. With the BryForTrait database, we want to reduce this deficit. Our database represents a compilation of autecological information and morphological and regenerative trait data on different stages of the life-cycle of bryophytes occurring in forest ecosystems. The database contains information for 35 traits and 721 Central European bryophyte species; in total more than 23,000 trait values. The BryForTrait database will enable future trait studies providing new insights into bryophytes dominated ecosystems.

SESSION 3-P3

A simulation study comparing methods to analyse species habitat associations of forest trees

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Worldwide tree populations show a trend towards clustering. Possible processes leading to clustering can be either biotic (e.g. limited seed dispersal) or abiotic (e.g. habitat associations). Although the role of biotic and abiotic processes is an extensive studied research question, no consensus can be found about the importance of the two process types. Studying small-scale habitat associations can give insights into the importance of abiotic processes shaping the spatial pattern of the tree population. Most studies analysing tree habitat associations use mainly either one of two contrasting methods: the gamma-test or the torus-translation test. Both tests randomize the data to break possible dependencies between the tree pattern and the habitats as null model. The gamma-test randomizes the tree pattern data, whereas the torus-translation test randomizes the habitat data. However, we did not find a study explaining the decision on which method to use, considering possible advantages or drawbacks. To overcome this uncertainty, we conducted a simulation study to verify, analyse and compare the two methods. We compared the ability of either the gamma-test or the torus-translation test to detect habitat associations and how different parameters may influence possible study results. Therefore, we created simulation data with known, but varying strength of habitat associations and analysed if the two methods are able to detect the associations. Lastly, we propose to use pattern reconstruction as a modification of the gamma-test for tree populations with complex spatial patterns.

Growth strategies and allometric relationships of tropical trees in Costa Rica

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Tropical forests are characterized by high biodiversity, particularly of trees. Measuring growth characteristics of tree species is a daunting task, making a standard growth formula for all tree species rather imprecise. Instead studies describing individual species' specific growth strategies and their response to the local environment would provide better estimates of growth and biomass and potentially more insight into ecological processes. The quantitative relationships between two or more key characteristics of trees by using extensive measurements from a selection of one species to generalize the entire species population is known as tree growth allometry. Past research has indicated the need for further studies regarding the differing relationships between diameter and height growth. Pioneer tree species tend to grow quickly, while on the other end of the spectrum, late successional species tend to favor shade in their juvenile periods and grow slowly. After decades these slow-developing trees will overtake the pioneer species which had provided the shade necessary for their early development. During the months of March and April of 2018, height, diameter, crown dimensions, and the distance between neighboring trees were measured for populations from over 100 native tree species planted between 2012 and 2015 in a reforestation project (COBIGA) in La Gamba, Costa Rica. We used these measures to calculate tree allometric relationships and competition or shading by neighbors. We quantified the species' habitat preference with data on their occurrence in old-growth and young forests and asked if growth strategies are related to habitat preference. Specifically, we tested the following hypotheses: I) Species differ in their allometric relationships, II) pioneer trees invest relatively more in height growth than old-growth specialists, and III) pioneer trees respond to shading with increased height growth (higher height/diameter ratio) compared to old-growth specialists.

SESSION 3-P5

Biomechanical and morphological response of willows to tidal flooding

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Sea-level rise and dense population impact coastal wetlands that are desired as nursery ground for fish, biofilters, and coastal protection. Many systems may be resilient to these impacts but can suddenly reach a tipping point and catastrophically shift in response to slight changing conditions when a critical threshold is exceeded. Coastal wetland creation via salt marshes is proposed for ecosystem based coastal defence in estuaries and deltas where the settlement with flood-exposed people is condensed. However, salt marsh vegetation recovery reveals critical slowing down under increased inundation and defence services decrease due to seasonal loss of standing biomass. Woody willow floodplain plantations are proposed for wave overtopping reduction of dikes in the concept building with nature. *Salix*' flexible shoots remain active during the storm surge season and were studied in the BE-SAFE project. Softwood forests characterized by disturbance adapted willows shape floodplains along large European rivers up to their mouth, e.g. tidal freshwater wetlands along the Scheldt and Elbe. However, sea level rise with accelerated salt-water intrusion may change tidal freshwater wetlands and limit application of willows for coastal defence. We conducted a tidal experiment on willows of the transition from herbaceous to woody vegetation at mean high water level. Permanent flooding of roots combined with periodical flooding of shoots caused reduced shoot length, biomass, bending capacity and breaking resistance whereas periodical submergence of both root and shoots did not affect shoots morphology and biomechanical traits. Shoot diameter was reduced in permanent flooding of roots for *S. alba* but not for *S. viminalis*. Maximum breaking force increased with increasing diameter in *S. viminalis* but not in *S. alba*. Salinity up to 2 did not show significant effects. *Salix viminalis* performed better but both floodplain willows may serve as innovative supplement for coastal defence.

SESSION 3-P6

The functional diversity–ecosystem functioning relationship in natural lake phytoplankton communities

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Recent studies support a positive biodiversity-ecosystem functioning (BEF) relationship in phytoplankton. Furthermore, functional richness was shown to outperform taxonomic richness in predicting ecosystem functioning in natural phytoplankton communities. Independent functional diversity (FD) components (evenness, divergence, dispersion), however, have never been compared with functional richness in the context of BEF. Here, based on the functional trait (morphological, physiological, behavioral) and response group (functional groups *sensu Reynolds*) approaches, we tested whether the three FD components alone (FEve + FDiv + FDis), as well as on top of genus richness (G + FEve + FDiv + FDis) outperform functional richness in predicting resource-use efficiency in oligotrophic (Fennoscandian lakes) and eutrophic (Hungarian oxbow lakes) phytoplankton assemblages. FD components alone outperformed functional richness in BEF only in oligotrophic phytoplankton assemblages. However, on top of taxonomic richness, FD components enhanced highly our ability in predicting ecosystem functioning in both the oligotrophic and eutrophic phytoplankton data sets. In all BEF models, the FD components based on functional traits predicted ecosystem function better than the FD components based on the functional response group approach. Our results highlight that functional diversity components add valuable ecological information on top of taxonomic richness, and altogether outperform functional richness in BEF. Furthermore, functional trait diversity may potentially enhance our ability in modelling ecosystem functioning in natural lake phytoplankton communities.

SESSION 3-P7

Distinct flight patterns emerge from different social traits in pigeon flocks

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The 'many-wrongs' principle of social bird flights is based on the idea that individual variation is averaged out in a flock and thus makes group navigation more effective. Modern technologies, especially lightweight GPS sensors paved the way for empirical testing of how social traits affect flight patterns (Flack et al. 2018 Science; Nagy et al. 2010 Nature; Santos et al. 2014 PLOS One). Individual-based modelling can contribute to this understanding by demonstrating the emergence of simulated flock flight patterns from the theoretic understanding of social behaviour. This contribution seeks to understand the emergence of flight patterns from alternative social traits of pigeon flocks by means of individual-based modelling. The presented model is based on Reynolds (1987) influential boids model and includes recent insights on flocking behaviour and social organisation. It implements a constant trade-off of navigational decisions with flocking behaviour for each single bird. The emerging flight trajectories were strikingly distinct for different social traits. Hierarchical organisation was most effective in terms of individual flight distances. Tests against GPS data from a homing pigeon flock (Santos et al. 2014 PLOS One) showed that the hierarchical scenario also matched best with the flight trajectories of an even-aged pigeon flock of eight birds.

SESSION 4

Biodiversity and ecosystem services in agroecosystems

Chair: Silvia Winter

LUBIO: Integrating decisions on land use and climate change to assess biodiversity changes in cultural landscapes

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Land-use and climate change are important drivers of environmental change and pose major threats to biodiversity. Even though it is expected, that systemic feedbacks between changes in climate and land use will have important effects on biodiversity, research has rarely focused on the interaction between both drivers. LUBIO uses a case study in the LTSER region Eisenwurzen (Austria) to depict trajectories for future land use under climate change and to assess both the direct and indirect, land-use mediated effects of a warming climate on biodiversity. The study region encompasses 23 municipalities along the river Enns and represents a broad variety of land-use systems and farm types. The project uses an integrated socioecological approach consisting of three principal components: (1) an agent-based model (ABM) called SECLAND, which simulates decisions of relevant actors on agricultural land between the years 2014 and 2050, (2) a spatially explicit GIS model that on the one hand translates the SECLAND model outputs into changes in land use patterns, on the other hand calculates land use changes on forest areas, and (3) a species distribution model (SDM) that calculates changes in biodiversity patterns following from both changes in climate and the land-use decisions from SECLAND. In total 1,329 farms are the actors in SECLAND, making decisions based on their happiness due to income and time use. SECLAND is based on an integration of quantitative (statistical and spatial explicit) and qualitative data, derived by expert interviews in the fields of agriculture, forestry and regional planning as well as around 30 interviews with local farmers. The results of SECLAND are spatially explicit land-use maps for a reference, a business as usual and two shared socio-economic pathway (SSP1 und SSP5) scenarios. In all scenarios, the farms decline to about 750–900 in 2050, where on average, the most farms remain in the SSP1 scenario and the least in the SSP5 scenario.

Effect of natural habitats in the landscape on natural enemies of olive pests: the importance of the distance

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Efforts to increase agricultural production and thus cope with the growing global demand for food are leading to intensive agricultural management, as well as to more lands dedicated to agriculture. However, low-intensity agricultural management strategies, such as maintaining natural vegetation in agricultural landscapes, can sustain biodiversity and food production if biodiversity-based ecosystem services are increased. Among the services provided by ecosystems, conservation biological control of crop pests is one of the most attractive, because it not only can maintain high yields but can also cause a decrease in pesticide use. In order to know how this ecosystem service should be managed, it is important to determine the distance in which natural habitats can have an effect on pest and natural enemies. In some cases, long distances from the natural habitat to the crop can cause natural enemies to not disperse effectively, preventing the colonization of the crop and the delivery of biocontrol services. Conversely, in cases where pests can rely on natural habitat, natural habitat patches located near the crop can increase pest populations. Therefore, it is necessary to analyse these parameters to determine which is the best configuration of landscape at which biological control is optimized. In this work, we analyse the effect of patches of natural habitat at different distances in the two main pests of olive groves and their natural enemies in 27 olive groves of Granada (Spain). Pests showed a consistent negative effect of natural habitat at short distances (100–300 m). However, natural enemies displayed different effects at different distances with groups affected by natural habitat at long distance, others at short ones and other groups no affected by patches of natural habitat in the landscape. We discuss about the possible implications that these results can have in landscape planning.

What molecular gut content analysis can tell us about resource use by aphid predators prior to crop colonization

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Ladybirds (Coleoptera: Coccinellidae) are major predators of aphid pests. However, pest aphids in crops are available only during a relatively short period in the growing season. Thus, alternative aphid prey species outside crops are important to sustain ladybirds throughout the season in agro-ecosystems. Molecular gut content analysis targeting the COI primer region in aphids, was performed to better understand the spatio-temporal exploitation of aphid prey by ladybirds (*Harmonia axyridis* and *Coccinella septempunctata*) in agricultural landscapes. Ladybirds were collected using a random sampling design in major habitats of 23 agricultural landscapes in Switzerland and Germany. Our findings revealed that particularly early in the season, *Uroleucon hypochoeridis* (feeding on *Hypochaeris radicata*) was the aphid most frequently consumed by ladybirds, followed by *Microlophium carnosum* (feeding on nettles) and *Myzus cerasi* (with cherry as primary host). These results suggest that nettle stands, but also grassy habitats with *H. radicata* and woody habitats containing cherry trees, have high potential for enhancing pest control services by ladybirds.

Management innovations improve natural pest suppression in vineyards

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Agricultural intensification is a major driver of biodiversity decline including arthropods. This may also affect important ecosystem services such as natural pest regulation. With more than ten fungicide sprayings per season, grapevine is one of the most intensively sprayed crops in Central Europe. Spraying can be reduced by up to 90 % in novel fungus resistant cultivars. Additionally, in contrast to the traditional trellis system, the semi-minimal pruned hedge offers a structurally more diverse habitat for arthropods. We investigated two major grapevine pests, herbivorous mites and grape berry moth *Lobesia botrana* and their natural enemies in an experimental vineyard with variable fungicide intensities and traditional versus minimal pruning. Natural enemies of grape berry moths were identified with 24 h camera observations. Predatory mites and enemies of grape berry moths were significantly enhanced by reduced fungicide applications. Correspondingly, predation pressure on grape berry moth eggs was enhanced and damage to artificially inoculated berries reduced under reduced fungicide applications. Predatory mites also increased under minimal pruning. However, no significant effects on herbivore mites were detected. We conclude that in addition to other advantages, the cultivation fungus resistant grape varieties under reduced spraying intensity improves the natural control of major grapevine pests.

Solitary bees and wasps in vineyards respond differently to management system and landscape structure

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Biodiversity loss in agricultural landscapes due to land use intensification is a major threat for ecosystem services like pollination and biological pest control as nesting and feeding resources for arthropods are reduced. Within agricultural landscapes, vineyards as a perennial crop can constitute important habitats. Vineyard inter-rows can be used to enhance pollen and hunting site availability by sowing flowering strips and keeping a permanent vegetation cover. Organic agriculture aims to antagonize detrimental effects of land-use by promoting biodiversity. In order to assess if organic management can buffer habitat loss in intensively managed vineyard landscapes, we used a paired experimental set-up with 15 organically and conventionally managed vineyard pairs along a gradient of area covered by non-crop habitats in a radius of 1,000 m. We sampled abundance and diversity of two different guilds of arthropods with trap-nests: solitary bees as pollinators and solitary wasps as predators. Landscape characteristics and local vegetation variables were assessed. While abundance and species number of wasps did not differ between management systems, we found higher abundances and species numbers of bees in organic vineyards, having higher flower densities. Abundance of wasps was positively related to the vegetation cover in both systems. Further, we could show an interaction effect for bees between minimal distance to herbaceous habitats and management system, i.e. bee abundance and diversity was constant in organic vineyards regardless to the minimal distance to the next herbaceous habitat but decreased in conventional vineyards with increasing distance. On a landscape level, the area covered by vine negatively affected both groups. We conclude that vineyards can foster diversity and abundance of both investigated insect groups, but that bees and wasps need different conservation schemes on local and landscape levels to be supported.

Extensive soil management and high floral resource availability promote wild bees in vineyards across Europe

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Vineyards may be inhabited by many plant and animal species, especially when the inter-row space is vegetated with spontaneous vegetation or cover crops. Frequent soil tillage has resulted in the loss of habitat quality, biodiversity and biodiversity-based ecosystem services. Crops and wild plants are pollinated by wild bees, which depend on floral resources and suitable nesting sites. We hypothesize that lower tillage frequency, higher flower coverage and landscape diversity affect wild bee diversity and abundance in vineyards positively. We sampled wild bees semi-quantitatively in 63 vineyards under different tillage regimes across Europe (AT, ES, FR, RO). In each vineyard a 200 m^2 transect was sampled five times per year and a proxy for floral resource availability was based on visual flower coverage estimations. Tillage intensity was assessed by vegetation coverage (%) twice a year per vineyard. Landscape structure was mapped within a 750 m radius around each vineyard and the Shannon Landscape Diversity Index was calculated. The response of wild bees to predictors was analysed by considering species richness, abundance and characteristic functional traits using generalized linear models. Characteristic functional traits were first summarized by community weighted means and then assessed by multivariate analysis (i.e. sociality and body size). Wild bee species richness ranged between 22 and 64 species per country across Europe. Wild bee species richness and abundance increased significantly with high flower coverage combined with extensive tillage. High landscape diversity compensated the negative effect of low flower coverage for eusocial bee abundance. Wild bee diversity and abundance can be most efficiently promoted by increasing floral resources and reducing soil tillage frequency. High landscape diversity may complement for lower floral resource availability in vineyards for providing resilient pollination services in wine growing regions.

Honeybees vs. wild pollinators: foraging characteristics and response to diversity in sweet cherry orchards

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Pollinator diversity is key to provide efficient and stable pollination service in a wide array of agricultural crops. Previous studies in sweet cherry have highlighted the contribution of wild pollinators to sweet cherry production (Holzschuh et al. 2012 Biol Cons; Eeraerts et al. 2017 Agric Ecosyst Environ). Foraging behavior of honeybees and other pollinators and interactions between different pollinator species might explain the added value of pollinator diversity. In our study we focused on foraging characteristics of honeybees and wild pollinators in sweet cherry orchards in Belgium. The influence of pollinator diversity on these foraging characteristics was also investigated. Based on landscape analyses we selected 8 sweet cherry orchards with a gradient of semi-natural elements in the surrounding landscape within 250 m of the orchard (1.1–41.4 %). During full cherry bloom all flower-visiting insects were sampled in the study orchards for 1 day in order to measure the pollinator diversity of every orchard. During this sampling day data was collected of different foraging characteristics (flower visitation rate, the amount of flights between trees in the same row and the amount of flights between rows) of both honeybees and other wild pollinators (bumblebees, solitary bees and hoverflies). Honeybees were found to visit fewer flowers per minute than wild pollinators. Wild pollinators also showed a higher probability of changing trees in the same row and a higher probability of changing trees between rows than honeybees. We also found that both the flower visitation rate of honeybees as well as the chance that honeybees change trees between rows increased with increasing pollinator diversity. Foraging characteristics of wild pollinators were not influenced by pollinator diversity. Our results highlight the facilitative component of wild pollinator diversity to pollination service in agriculture.

Connectivity of wildflower strips promote stable wasp communities

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Habitat fragmentation causes species loss in agroecosystems. Subsidized wildflower strips are thought to counteract this loss and promote ecosystem services. While the benefits of wildflower strips for pollen-collecting insects are well known, knowledge gaps exist for taxa with other resource requirements and, thus, other ecosystem services associated with them. For a more complete picture of the biodiversity effects of subsidized wildflower strips in agroecosystems, we studied species richness as well as temporal turnover of wasps on 22 wildflower strips in central Germany from 2011 to 2013. Half of the selected sites where characterized by an isolated central wildflower strip (isolated) whereas the other half showed additional wildflower strips around the central strip (connected). Additionally, sites span an independent area gradient of semi-natural habitats and grassland in the surrounding. From yellow pan trap samples, we calculated abundance and species richness per site and the turnover of species per site between years. Across years, a total of 1,868 wasps from 105 species (20 ± 6 species/site) was sampled on wildflower strips. Euemidae and Pompilidae increased in abundance and richness over time, while Sphecidae and Tiiphidae peaked in the second year. On average, beta diversity between sites was significantly higher between the year of installment and the second year than between the second and third year. However, connected wildflower strips showed a more stable species composition than isolated ones over time. Species richness on isolated strips increased with grassland in the surrounding while species temporal turnover decreased with semi-natural habitats. In concert with accompanying studies our results demonstrate that the high availability of adult and larval food resources on subsidized wildflower strips benefits wasp diversity and contribute to a better understanding of the ecosystem service delivery associated with this agri-environmental scheme.

Vegetation management intensity alters functional traits and plant community compositions in vineyards across Europe

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Vineyard vegetation management has a crucial impact on biodiversity and ecosystem service provision. In the last decades, traditional intensive soil tillage was replaced by maintaining vegetation cover in the inter-rows to combat soil erosion and declining soil fertility in several European regions. However, bare soil management by herbicides and frequent tillage is still a widespread management practice to remove any competition for water or nutrients between inter-row vegetation and the vines. We aimed at comparing the effects of three different vegetation management intensities across four wine growing regions along a west-eastern European transect on vascular plant diversity, community composition and plant functional traits. We present the results of the plant diversity survey from 81 Austrian, French, Romanian and Spanish vineyards. We recorded vegetation cover, plant diversity, plant biomass and species composition in four plots within each vineyard. Landscape complexity was mapped within a 750 m radius around each vineyard for calculating Shannon Landscape Diversity Index and further landscape parameters. Species diversity of the most intensive bare soil management system was lower than in vineyards with permanent or temporary vegetation cover; herbicide use resulted in the overall lowest Shannon diversity index. Vegetation cover increased with decreasing management intensity in all countries. Different management systems favoured specific functional traits and life strategies, e.g. the relative cover of annual and ruderal species was clearly higher in bare soil vineyards in comparison to vineyards with temporary or permanent vegetation cover. Furthermore, plants with rhizome storage organs and leaf dry matter content increased with decreasing management intensity. The change in the plant community composition and vegetation cover influences biomass production and consequently various ecosystem services like soil erosion mitigation or carbon sequestration.

Effects of environment and vineyard soil management on soil microbial diversity and composition

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Soil microbial communities contribute to soil quality and soil health both linked to cycling and stability of soil organic matter, pathogen suppression, mineralization and aggregate stability among others. Vineyard management practices and production systems influence soil properties and thereby affect soil microbial communities. We aimed to analyze effects of cover crop managements (permanent cover, alternating cover, bare ground) within 9 Austrian vineyards with a metagenomics approach. Analyses were performed in the frame of the BiodivERsA/FACCE-JPI joint project 'PromESSinG'. In a first step the effects of the independent variables landscape, vineyard and treatment on determined soil parameters. Strong influences of the vineyards on actually all determined parameters were obtained, whereas small treatment effects were only observed for K_2O, Mg, C_tot, C_org and N_tot contents. This already points towards a strong influencing location factor on upcoming microbial analyzes overlaying the effects of the inter-row management. A weighted MANOVA on generalized Unifrac distances matrices derived from bacterial and fungal communities confirmed that both communities are not significantly influenced by the treatments applied in our analyses. The Shannon diversity index was calculated for all treatments and vineyards giving a diverse picture. Values between 3–3.6 and 5–5.6 were obtained for fungi and bacteria respectively and vineyards differed substantially. Combining all vineyards no significant influence of treatments on the Shannon index was determined, but a tendency of lower values in permanent cover inter-rows was observed. Possible hierarchical influences and site effects will be characterized in further bioinformatic analyses, as e.g. multivariate classification analyses like random forest models to evaluate influencing factors as well as single microbial groups and OTUs.

Soil biodiversity as the driving engine of agroecosystems

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Soil biota diversity is ensuring primary production in terrestrial ecosystems and agricultural productivity. Water and nutrient cycling, soil formation and aggregation, decomposition and carbon sequestration as well as control of pest organisms are important functions in soil that are driven by biota and biota interactions. In agricultural systems these functions support and regulate ecosystem services directed to agricultural production and agricultural sustainability. A main goal of future cropping systems will be to maintain or raise agricultural productivity while keeping production sustainable in spite of increasing food demands and ongoing soil degradation caused by inappropriate soil management practices. However, biological impacts on soil fertility and soil health are often neglected or overseen when planning and shaping soil management in arable systems. In this talk we will give examples of biota driven services and how to integrate these into best management practices of arable farming. We will refer to the current work and first results of the BiodivERsA-SoilMan-project. It is important to elevate soil biota from a 'biodiversity goal' to the 'farmer's engineering companion'.

Crop growth and pest supression effects of beneficial microbes alters under climate change

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Recent research has shown that the rhizosphere microbiome – the community of microbes growing in close association with plant roots – has the potential to promote crop plant growth and plant resistance to pathogens and insect pests. We inoculated the roots of the cereal crop barley (*Hordeum vulgare*) with a known plant-growth promoting rhizobacteria, *Acidovorax radicis* N35 to examine the effect on aboveground aphid populations across changing biotic (plant cultivar and earthworms) and abiotic (CO_2 and O_3) environments. *Acidovorax* promoted plant growth, but the strength varied across earthworm treatments and CO_2 levels. Effects further varied with plant cultivar and in the high-stress elevated O_3 environments. *Acidovorax* was better able to suppress aphid populations under ambient CO_2 particularly when earthworms were present. Our results suggest that climate change can alter the strength of effects of beneficial interactions in crop systems. Yet, less often the direction was changed, indicating high potential for predictable beneficial effects across variable environments. With the evolution of resistance to chemical pesticides in insects, it is important to identify sustainable alternatives for suppressing pest populations. Realising the potential of beneficial plant microbes is of vital importance in supporting sustainable food security and for developing practical solutions for farmers.

Can diversified farming practices reduce farmers' yield risk?

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Increased demand for environmentally friendly and socially acceptable production of food is currently transforming societal attitudes towards sustainable agriculture. The implementation of diversification of farmland (DF) practices represents one tool for environmentally-friendly food production. DF practices aim at the provision of critical ecosystem services and thus may improve the multifunctionality of agroecosystems. However, DF practices such as cover crops, a diverse crop rotation, intercropping and reduced tillage or no-till may be related to economic costs as they may reduce profit. Nonetheless, these practices may also mitigate yield risks, thereby increasing yield stability and reducing uncertainties faced by farmers. To address and mitigate consequences of climate change, management practices that buffer unpredictable climate events will be increasingly important. Here, we investigate to what extent farmers risk perception and motivations influence the adoption of DF practices. Using a qualitative economic risk assessment, we analyzed relevant DF practices in a case study in Germany. We surveyed 160 farmers across 22 counties in Lower Saxony to explore whether and to which extent farmers perceive that DF practices have the potential to mitigate the risk of yield loss caused by extreme climatic events, as represented by above-average dry and wet conditions. Results so far show that risk perception differs across regions and soil conditions and that DF practices differ in their potential to reduce risks. Based on their experience and expectations, farmers estimate that DF practices perform better under dry than under wet conditions. In a next step, we will use structural equation modeling to analyze the relationships among a suite of interrelated variables, i.e. characteristics of the farmers, region, soil conditions, risk perception and provision of ecosystem services (weed, pest, and diseases control).

Biodiversity–multifunctionality relationships in grasslands depend on identity and number of measured functions

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Biodiversity ensures ecosystem functioning and provisioning of ecosystem services. The importance of biodiversity for multifunctionality has repeatedly been used as an argument for conservation of biodiversity. Yet, it remains unclear how biodiversity-ecosystem multifunctionality relationships depend on the identity and number of functions considered. Here we used a multivariate index of multifunctionality to investigate the relationship between plant diversity and multifunctionality based on 82 indicator variables measured along an experimental gradient of grassland plant diversity. The multifunctionality index was calculated based on a principle component analysis based on the value of each function in each of 80 plots. We investigated how biodiversity affected multifunctionality in the experiment and recalculating the index for random subsets of ecosystem functions and how the strength of the biodiversity-ecosystem multifunctionality relationships changes when considering different identities and numbers of functions. Ecosystem multifunctionality increased strongly at higher biodiversity. The relationship was robust when changing the type of multifunctionality index used in the analysis. Analyzing subsets of functions revealed that effects of biodiversity on multifunctionality were stronger when more functions were included and that the strength of the biodiversity effects depended strongly on the identity of the functions included. Limits to multifunctionality arose from negative correlations among functions and functions which were not correlated with biodiversity. Our findings underline that managing of ecosystems for the protection of biodiversity cannot be replaced by managing for particular ecosystem functions or services. This need arises from the strong identity effects of the functions included in the calculation of multifunctionality and resulting weak relationships between biodiversity and multifunctionality for particular combinations of functions.

Future land management strategies and their impact on breeding habitats of endangered bird species in Saxony, Germany

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The land use intensification in recent decades led to a decline in many taxonomic groups. This has caused a higher awareness concerning the conflicts between agricultural production, biodiversity and cultural services. Generally, two conservation strategies are proposed: land sharing (i.e. the integration of biodiversity promotion into environmental-friendly agriculture) and land sparing (i.e. spatial separation of high-yielding agriculture and areas for conservation). The present study examined the effect of three spatially explicit future land management scenarios on the breeding habitats of 13 endangered bird species in the middle Mulde river basin in Saxony (Germany): a) a balanced business-as-usual scenario continuing the present process of settlement and forest expansion, b) a land sparing scenario, consisting of considerable afforestation and an intensification of the remaining crop- and grassland and c) a land sharing scenario with milder afforestation, extensive grassland use and establishment of linear landscape elements. The breeding habitat was modeled with a wide range of environmental predictors that relate to land cover, climate and soil properties, the occurrence of linear landscape elements and the distance to water and to highways. The prediction results revealed that the business-as-usual and the land sparing scenario both led to increases or decreases in the breeding habitat size depending on the bird species, with some species losing up to 85 % of their breeding habitat. The different outcomes of the scenarios highlight that each species has own, species-specific habitat requirements that are difficult to unite. However, the land sharing scenario facilitated this unification and yielded the best results with a habitat gain in the majority of the species while no breeding habitat loss occurred in any of the 13 endangered bird species.

Movement behaviour of Northern lapwing chicks *Vanellus vanellus* in agricultural landscapes

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Agricultural intensification is one of the major causes of a sharp population decline of farmland birds due to the loss of their natural habitats, such as wetland areas. Ground breeding birds, especially waders such as the Northern lapwing (*Vanellus vanellus*) are strongly affected species. Various studies already have investigated habitat use, predation risks and possible protective measurements of adult lapwings in agricultural compensation areas and nature reserves. However, besides investigating threats for adult lapwings, it is important to study habitat use and movement behaviour of chicks as factors of breeding success which directly influence the survival of the population. In this study, we examined habitat use and movement behaviour of lapwing chicks in agricultural landscapes in Upper Bavaria. We radio-tracked nine lapwing chicks to investigate habitat preference, home range size and diurnal movement behaviour in relation to age and hatching date. Main results were that (i) lapwing chicks preferred open, newly sown fields with high penetrability, especially maize; (ii) home range centres contained field edges which were frequently used by chicks; (iii) movement distance per hour was higher for older chicks (bill length over 15 mm) and chicks which hatched in June compared to April, and (iv) movement did change over daytime with an alternation of active periods with repeated resting phases rather than strong activity peaks. As lapwings regularly used agricultural areas as surrogate habitats, these sites must be included into conservation actions. Our results show, that management plans should account for the importance of field edges as chick habitat. Furthermore, it is important to extent protective measurements until June to ensure successful fledging of late clutches to maintain population sizes.

POSTER PRESENTATIONS

SESSION 4-P1

The use of rare, arable plants to increase the functional diversity in agro ecosystems

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Intensification of agricultural land use has led to a strong decline of biodiversity in European farmland. The rare arable plants particularly suffered from this development. Better knowledge of the functions of this species group could both provide strong arguments for their conservation and more sophisticated recommendations for biodiversity management. The objective of our study is therefore to fill this gap and to investigate the following ecosystem functions of rare arable plants: their contribution to species diversity, their impact on flower visitors, beneficial insects and parasites, on soil fertility and nutrient balance, productivity and landscapes aesthetics. The experiments are carried out in the Munich plain where 100 plots were installed on an experimental farm and under practical conditions. Ten species of rare arable plants were sown at varying crop densities. To investigate the establishment success of arable plants, soil seed bank analyses will be performed at the end of the study. The ecosystem effects of rare arable plants are compared to commercial flower mixtures which are actually sown to increase farmland biodiversity. To implement our results in conservation strategies, interviews with farmers shall provide information on suitable conditions for farmers to use rare arable plants for conservation. Finally, analyses of funding programs in Bavaria and Thuringia will present how concepts for the conservation of arable plants can be adequately integrated into conservation schemes. This study provides an opportunity for both species conservation of rare arable plants and also for improving the functioning of agro-ecosystems.

SESSION 4-P2

The effect of ploughing on earthworms and enchytraeids – soil biotic properties and carbon dynamics

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Annelids play an important role in the functioning of soils. Ploughing is known to be harmful for earthworms, but this is not widely known for enchytraeids. We carried out a microcosm lab experiment over three months, using undisturbed soil columns to investigate the effect of ploughing on soil annelids, measuring soil respiration and soil carbon dynamics in treatments of inverse tillage (ploughing) and no tillage (without ploughing). For this, two earthworm species were used: *Octolasion cyaneum* (endogeic) and *Lumbricus terrestris* (anecic). Two enchytraeid species (from a lab culture) were put together in the same columns. Half of the columns were ploughed manually in the lab and got chopped maize straw (5 g) as crop residues placed on top of the columns for the No-till treatments and below ground for the inverse ploughing treatments. We generated eight treatments: no till plus endogeic earthworms; no till plus anecic earthworms; no till plus potworms; no till control (no animals); inversal tillage plus endogeic earthworms; inversal tillage plus anecic earthworms; inversal tillage plus potworms; inversal tillage control (no animals). Preliminary results show that earthworms reached a higher biomass in all treatments. Numbers of enchytraeid individuals increased ten times. Carbon-dioxide was measured as an indicator of biological activity [mg CO_2 – C kg^{-1} dry soil] every 4.5 hours. Values show significant differences between the treatments in ploughed columns. Distribution of Microbial Biomass Carbon differs between tillage-treatments. Analysis of the biological activity shows that soil annelids respond in a different way to tillage, depending on size scales (enchytraids vs. earthworms) and on ecological performance (endogeic vs. anecic earthworms). It can be expected that annelid induced soil functions and services can be managed by certain tillage practices.

SESSION 4-P3

Diversity and abundance of soil mesofauna population in vineyards related to different soil cover management

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Soil fauna plays an important role through their effects on soil organic matter decomposition, nutrient mineralization, and amelioration of the soil's physical properties. The presented work evaluates the abundance and diversity of soil mesofauna in vineyards. Thereby we investigate the influence of different cover crop management between as well as below vine rows. In general soil mesofauna not only have been found to positively affect litter decomposition, they also influence the distribution of microbial populations in the soil by feeding on them or transporting microbes or their propagules on or in their bodies. They are predators feeding on nematodes and other microorganisms and in turn they are prey for macroarthropods, such as spiders, beetles, ants, and centipedes, thus building a bridge to the macrofauna and define food webs in soils. This study was carried out as a part of project 'PromESSinG' to examine the diversity and abundance of soil mesofauna population in 9 vineyards distributed across Burgenland and Lower Austria. In each of the 9 vineyards three different practices for inter-row management were established in 2015 (open ground, alternating ground cover, permanent ground cover). Per treatment 2 pooled soils core samples were used for mesofauna extraction with the Berlese-Tullgren method (May, June and September in 2016 and 2017). Twenty different taxa could be observed in the experimental vineyards used in this study. Among them the groups Acari, Collembola and Enchytraeids gave highest abundances. In total 15,357 individuals were collected while the highest amounts were collected in September. With 9,376 individuals the abundance of the mesofauna in inter-rows with permanent soil cover were significantly higher compared to bare ground (2,745) individuals. Ongoing analyses will specify site and treatment specific influencing factors on abundance and biodiversity levels within vine rows as well as between vine rows.

SESSION 4-P4

Vineyard vegetation management intensity affects root parameters in vineyards across Europe

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Vineyard vegetation management changed in many regions across Europe due to a paradigm shift of the importance of inter-row vegetation for combating soil erosion and soil fertility losses. Agri-environmental schemes supported vegetation cover in inter-rows to improve ecosystem service provision. However, bare soil management with herbicides or frequent tillage is still a widespread management practice in Europe. We aimed at comparing the effects of different vegetation management intensities across four wine growing regions within the European BiodivERsA project VineDivers on root parameters in vineyard inter-rows. We investigated 13 vineyards in France, 14 in Austria and 15 in Romania to study the effects of bare soil management, temporary vegetation (soil tillage in every second inter-row) and permanent vegetation cover on selected root morphological parameters. In each vineyard inter-row, six soil samples of 10 cm height of the top soil layer were extracted for the following analyses. Root length, root surface area and diameter were measured after cleaning the roots from the soil, staining, scanning and analyzing them with the WinRHIZO software. Next, the roots were dried at 60 °C to obtain their dry biomass. Vegetation cover and vascular plant diversity was recorded in four 1 m^2 plots per vineyard inter-row. The most intensive bare soil management regime in Romania and France significantly reduced root biomass, total root length and surface area in comparison to the temporary and permanent vegetation cover management. The differences between temporary and permanent vegetation cover in Austrian vineyards were less pronounced. Nevertheless, total root length, surface area and root biomass always showed the highest value in the vineyards with permanent vegetation cover. Low intensity vegetation management clearly contributes to higher root length, surface area and biomass which provides beneficial conditions for soil biota and improves ecosystem service provision.

SESSION 4-P5

Soil health – fitness tracking for vineyards?

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Soil health is one of the important factors determining productivity and resilience of vineyards for a sustainable management. A healthy vineyard soil supports a range of soil functional processes (e.g. water availability, nutrient cycling and mineralization, drainage, stability) allowing for uniform vine growth, support pathogen suppression and facilitate vineyard management. Vineyard management practices and production systems influence soil properties and thereby affect soil microbial communities. Nevertheless, the impact of the management system on soil functions and especially on the soil microbial community is not well understood. Relevant indicators are urgently required to assess and monitor soil health. Hydrolytic enzymes, mainly those involved in key reactions in the carbon, nitrogen, phosphorus, and sulfur cycles, are commonly used as biological indicators mostly because organic residue-decomposing organisms are probably the major contributors to soil enzyme activity. In the present project, we aimed to analyze and evaluate effects of cover crop treatment and below-vine management on soil function by using soil microbial enzymes as indicators. The 'tracking of soil fitness' is the final aim and in our believe soil microbial enzymes are the perfect candidates to fulfill this function. In the frame of the project 'PromESSinG' three different interrow management treatments (open, alternate, permanent cover) were established in 2015 in 9 vineyards. In the presented study, inter-rows as well as different below-trellis systems were evaluated in selected vineyards by analyzing β-glucosidase (C-cycling), Leucin aminopeptidase (N-cycling) and acid phosphatase (P-cycling). First results will be presented of experiments conducted 2018.

SESSION 4-P6

REGRASS – Re-established grasslands promoting colonization of beneficial predators in agricultural landscapes

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Agricultural intensification and decreased landscape heterogeneity are major threats to biodiversity loss and ecosystem functioning in Europe, despite the initiation of agri-environment schemes to counteract this trend. By discontinuing the establishment and maintenance of long-term set-aside on arable land since 2008 in the EU, the amount and area of this habitat type is rapidly decreasing, with poorly understood consequences for biodiversity and ecosystem services such as biological pest control and pollination. Since 2017, we investigate the diversity, abundance, dispersal and efficacy of predators (carabid beetles, spiders and ants) and pollinators (e.g., bees and hoverflies) in newly established grassland and field transects adjacent to old set-aside grassland in dependence of local and landscape parameters in Lower Austria. First results of this three-year study indicate that beneficial species and their associated ecosystem services spread into the ambient agricultural matrix along different spatial and temporal scales. Within the first year of the experiment, 64 epigeic predator species were recorded in the newly established grasslands, yet still mainly resembling species compositions of surrounding fields, depending on distance and landscape factors. Our results provide first insights into short-term colonization patterns and lag time of species spreading from semi-natural source habitat into surrounding agricultural land and newly established grassland strips to disperse or potentially constitute permanent populations. This allows an improved understanding of both suitability and efficacy of such short-term measures to provide temporal feeding habitat and dispersal corridors for beneficial arthropods and thereby promote biodiversity and ecosystem services in agricultural landscapes.

SESSION 4-P7

Future impacts of farmland abandonment on agricultural ecosystem services and biodiversity in Japan

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Agriculture provides a wide range of ecosystem services beyond its role of producing food and raw materials, and some agricultural systems also contribute to landscape and biodiversity conservation. In Japan, many of the functions and services associated with agroecosystems are increasingly threatened by farmland abandonment. Understanding the potential effects of farmland abandonment on ecosystem services and biodiversity in a spatially explicit manner is essential for developing effective management strategies. We examined spatial patterns of farmland ecosystem services and biodiversity in relation to the distribution of abandoned fields, and we quantified the potential loss of cultivated fields and its effects on the provision of ecosystem services and availability of habitat by extrapolating recent abandonment trends into the future. Results show a spatial overlap between areas with high provision of multiple ecosystem services and high biodiversity and those with high farmland abandonment trends. If abandonment continues at the current rate, a substantial amount of farmland ecosystem services and habitats which were available in 2015 could potentially be lost by 2030, mainly from remote and economically marginal areas where multifunctional landscapes are found. There is an urgent need for new agricultural policies as the existing support schemes for these 'less favored areas' have not been sufficient to prevent land abandonment.

SESSION 5

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

Chairs: Guenter Hoch, Henrik Hartmann, Michael Bahn

Inherent and environmental patterns in biomass allocation and allometry among higher plants

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It is well-known that plants may adjust the distribution of biomass over leaves, stems and roots depending on environmental conditions. It is also clear that size is an important factor as well. However, good quantitative insights are lacking. In this talk I analyse biomass allocation patterns to leaves, stems and roots of herbs and woody species. A database was compiled with ~ 11,000 records of leaf, stem and root biomass for ~ 1,200 species. First, I'll derive general dose-response curves that describe the relationship between biomass allocation and the 12 most important abiotic environmental factors and compare them with the changes in leaf, stem and root morphology. Second, I'll focus on allometric relationships between the various organs and test to what extent they comply with models like that for Metabolic Scaling Theory, where the slope of the log–log relationship between leaf and root biomass is expected to have a value of ¾. Third, I analyse how leaf, stem and root mass fractions change as a function of total plant size. This offers a great opportunity to test to what extent there are systematic differences in allocation patterns related to phylogeny (e.g. Gymnosperms vs. Angiosperms, grasses vs. herbaceous dicots) and functional group (e.g. deciduous vs. evergreens).

Sweet dreams are made of these – standardized protocols and procedures can solve the carbohydrate quandary

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Non-structural carbohydrates (NSCs) produced during photosynthesis are central to plant metabolism and carbon allocation as they provide energy and substrates for many physiological processes. However, their measurement has been proven extremely challenging because laboratories working with NSC often use very different methods and procedures for sample processing, NSC extraction and quantification. A recent study showed that concentration measurements can vary by orders of magnitude, limiting our ability to integrate and generalize patterns in plant C balance among studies. Here we show that the use of standard protocols can reduce most of this variability and solve this carbohydrate quandary. We measured a common set of nine plant material types, and two synthetic samples with known NSC concentrations, using three different quantification methods (ion chromatography, enzyme, acid) in six laboratories. We also evaluated effects of sample handling, different extraction solvents, and laboratory protocol execution on NSC measurements. For synthetic samples, NSC concentrations fell within about 11.5 % of known values for all three methods. The largest source of variation for natural plant samples was the quantification method, simply because the three methods tested in our study do not quantify the same NSCs. Sample handling prior to extraction and analysis had little effect on concentration values, while ethanol sugar extraction improved accuracy over water extraction. Our results demonstrate that different quantification methods can achieve very reasonable accuracies of NSC measurements, as long as protocols are robust and standardized. With our detailed protocols for extraction, digestion and quantification of plant NSCs, comparisons between measurements of different laboratories are now facilitated. Reporting detailed information on the plant sample types, collection time (e.g. diurnal, seasonal), and the methodology used is of great importance for improving inter-comparability of results. In addition, while true concentrations will remain difficult to determine in natural samples with highly varying biochemical matrices, we propose the use of standardized natural plant material as a crucial means to increase comparability of NSC measurements among laboratories.

Tracing plant carbon partitioning between primary and secondary metabolism

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Processes controlling plant carbon allocation into primary and secondary metabolism, such as photosynthetic carbon uptake, respiratory CO_2 emission and plant volatile organic compounds (BVOC) synthesis are still associated with high uncertainties. Moreover, vegetation-atmosphere CO_2 exchange is associated with a large isotopic imprint due to photosynthetic discrimination and ^{13}C-fractionation during respiratory CO_2 release. The latter has been proposed to be related to carbon partitioning in the metabolic branching points of the respiratory pathways and secondary metabolism linked to the central metabolite pyruvate. Notably, it is a known substrate for many secondary metabolism of BVOCs, such as volatile isoprenoids, oxygenated VOCs or aromatics. Here we investigate the linkage between BVOC emissions, CO_2 fluxes and associated isotope effects based on simultaneous real-time measurements of stable carbon isotope composition of branch respired CO_2 (CRDS) and BVOC fluxes (PTR-MS). We used positionally ^{13}C-labeled pyruvate feeding experiments to trace partitioning of single carbon atoms of pyruvate into BVOCs versus CO_2 emissions. In the light large arrays of BVOC were emitted by Mediterranean species, including volatile isoprenoids, oxygenated BVOCs, green leaf volatiles and aromatics, suggesting a high carbon flux through secondary metabolism including the pyruvate dehydrogenase bypass, mevalonic acid, MEP/DOXP, shikimic acid, and fatty acid pathways. Moreover, BVOC emissions were closely related to $^{13}CO_2$ decarboxylation from pyruvate-1-^{13}C in the light, while mitochondrial respiration was down-regulated. In the dark BVOC emissions dramatically declined while respiration was stimulated with emissions from pyruvate-1-^{13}C exceeding those of pyruvate-2-^{13}C during light-dark transitions. Thus, BVOC emissions are associated with significant pyruvate C_1 decarboxylation, indicating a tight control of carbon partitioning between secondary biosynthetic reactions, day and dark respiration. Our approach provides novel tools to better understand the mechanistic links between primary and secondary carbon metabolism in plants with important implications for a better understanding biosphere-atmosphere exchange of CO_2 and VOCs.

A new field-applicable method for measuring stem respiration by combining CO_2 and O_2 sensors

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Respiration in forest tree stems plays an important role in the terrestrial carbon cycle. Originally, it has been assumed that CO_2 respired by live stem cells diffuse directly into the atmosphere, making CO_2 efflux rates a suitable proxy for stem respiration rates. This assumption has been questioned due to evidence that respiratory CO_2 may be dissolved and transported in xylem flow, or re-fixed and metabolized via the enzyme phosphoenolpyruvatcarboxylase (PEPC) in parenchyma cells of tree stems, suggesting that measurements of stem CO_2 efflux underestimate actual respiration rates. Aside from CO_2 production, aerobic respiration also results in O_2 consumption which may be a better metric of respiration rates as it is not affected by the aforementioned post-respiratory mechanisms the same way as CO_2: The solubility in water is 28 times lower, resulting in very low xylem water transport rates. Additionally, there is no known enzyme activity that selectively affects O_2 and not CO_2 like is the case with PEPC the other way round. However, because of the high background of O_2 in ambient air, changes in O_2 concentrations in the range caused by plant respiration are difficult to detect and technically challenging. Here, we present a novel respiration chamber system for measuring CO_2 and O_2 repeatedly and fully autonomous – highly useful for field applications. The system allows assessing the ratio of CO_2 efflux to O_2 influx which provides a reliable proxy for CO_2 losses due to (potential) xylem flow and CO_2 refixation but also for stem respiration. Our novel system is affordable and field robust. Our tests showed promising results for the reliability of O_2 measurements, even at ranges relevant for plant respiration. Hence, our new method can help separate transport and locally occurring physiological processes in trees. We will present data from the first field season application after introducing issues related to conventional CO_2-based assessments of stem respiration.

Real time carbon allocation into BVOCs and day released CO_2 traced by a novel approach using ^{13}C-metabolite labelling

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Our understanding of biogenic volatile organic compound (BVOC) emissions and day released carbon dioxide from terrestrial vegetation improved substantially during the last years, partially due to new developments in measuring techniques. Nevertheless, there are still large uncertainties of processes controlling plant carbon investment into both fluxes and more precise, the carbon partitioning between BVOC biosynthesis and the linked CO_2 decarboxylation at central metabolic branching points, also with regard to changing environmental conditions. To shed more light on this carbon partitioning, we used a novel approach combining $\delta^{13}CO_2$ laser spectroscopy, high-sensitivity proton-transfer-reaction time-of-flight mass spectrometry and a multiple branch enclosure system (PTR-TOF-IRIS) with position-specific ^{13}C-metabolite labelling. Feeding experiments of a Mediterranean shrub and fast growing herb with $^{13}C_1$ or $^{13}C_2$-labelled pyruvate, a central metabolite in the BVOC biosynthesis, enabled online detection of carbon partitioning into ^{13}BVOCs and respiratory $^{13}CO_2$. We found *de novo* emissions of less well-studied compounds such as methyl acetate and several benzenoids, the latter might be biosynthesized via the MEP-pathway. Overall, substantial CO_2 emission from metabolic branching points during *de novo* BVOCs biosynthesis indicated that decarboxylation of $^{13}C_1$-pyruvate, as a non-mitochondrial source of CO_2, seems to contribute considerably to daytime CO_2 release from leaves. Moreover, the Mediterranean shrub with an active secondary metabolism revealed a more pronounced $^{13}CO_2$ efflux during diel $^{13}C_1$-pyruvate labelling compared to the less BVOC emitting herb, indicating a higher contribution of decarboxylation processes due to BVOC biosynthesis for day released CO_2. Changing environmental conditions, such as increasing temperature, partially increased BVOC emissions and, thus, might be influencing the day released CO_2 efflux as well. Our approach, combining PTR-TOF-IRIS with position-specific labelling now opens the door for real-time analysis tracing metabolic pathways and carbon turnover under different environmental conditions, which may enhance our understanding of regulatory mechanisms in plant carbon metabolism and BVOC biosynthesis.

Carbon and water – effects of 15 years of precipitation manipulation on C allocation and storage in trees

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Drought is known to strongly affect the carbon balance of trees, via processes like carbon uptake, transport, metabolism, and thereby alters also the carbon balance of forest ecosystems. However, there is not much information how long-term limitation of water supply and release of this limitation affect carbon allocation via changes in transport and storage patterns in old-growth trees. Here we took advantage of a long-term (15 years) irrigation experiment that is being conducted in a *Pinus sylvestris* L. dominated forest located at the dry margin of the species in an inner alpine valley. We measured on the one hand growth parameters (e.g. trunk diameter) and non-structural carbon (NSC) in different tree tissues in control and irrigated trees. To derive allocation fluxes, we pulse-labelled the crowns of 5 control and 5 irrigated trees with $^{13}CO_2$ and traced labelled carbon in different tree tissues as well as in CO_2 respired by the stem and the soil. $\delta^{13}C$ in stem and soil respired CO_2 was higher in the irrigated plots compared to controls and the label in respired CO_2 was detected approx. 24 h earlier in the irrigation treatment during a period with low precipitation. However, natural intensive rainfall events strongly changed ^{13}C transport dynamics in the normally water limited controls reducing the treatment differences. Irrigation resulted in higher growth rates but did not alter NSC levels. Long-term release of water limitation (i.e. irrigation) increased the ^{13}C allocation to stems and belowground and also speeded up transport. The observed NSC constancy across treatments (irrigation and control) provides evidence that carbohydrate storage may be homeostatically maintained when climate changes are slow enough to allow acclimation.

Carbon allocation and phloem transport in mature beech trees under reoccurring long-term summer drought

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Under drought tree functioning is often impaired, i.e. growth declines overall carbon relations are disturbed. However, such conclusions come mostly from potted saplings. We took advantage of the KROOF-project, a long-term throughfall exclusion (TE) experiment with mature European beech (*Fagus sylvatica* L.) conducting two experiments dealing with carbon relations under repeated summer drought. Drought intensity was quantified via pre-dawn water potential (Ψ_{PD}) and time-integrated soil water deficit (iSWD). I) We hypothesized that drought reduces carbon reserves and sink organs to be more affected than source organs. We investigated the winter concentrations of non-structural carbohydrates (NSC) in different organs (e.g. twig/stem/root phloem/xylem) in three years (2013 pre-drought and 2014/2015 with drought) in control (CO) and TE trees. No differences were found between sink/source organs and CO/TE trees in NSCs, suggesting that trees maintain a certain NSC-concentration. II) $^{13}CO_2$ branch labeling was employed to investigate translocation of recent photoassimilates under experimental drought in two years (2015/2016). We hypothesized that mean residence time of photoassimilates in leaves (MRT) increases, whereas phloem transport velocity (V_{phloem}) decreases under drought. Phloem transport was assessed via $\delta^{13}C$ of CO_2 efflux measured at two branch positions. MRT increased from 32.1 ± 5.4 h in CO to 46.9 ± 12.3 h in TE trees. V_{phloem} in 2016 decreased from 20.7 ± 5.8 cm h^{-1} in CO to 11.0 ± 2.9 cm h^{-1} in TE trees. MRT correlated positively with iSWD, suggesting accumulation of osmolytes under longer drought. Also, we propose that the positive correlation between V_{phloem} and Ψ_{PD} is due to lower water uptake of phloem conduits from surrounding tissues leading to higher phloem sap viscosity.

Nutrients might be rather foe than friend to drought stressed trees

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While carbon dynamics in drought exposed trees have gained increasing interest over the last years, the combined effects of drought and nutrient availability on tree functioning are still largely unknown. Nutrients might have negative predisposing effects on growth and survival of trees during drought, by influencing the shoot-to-root ratio and rooting depth, but might also directly modify effects of drought by influencing the sensitivity of stomata and the water uptake ability of roots. We hypothesized, that the negatively predisposing effects of high nutrients would overshadow any of the positive effects during drought. For this, we studied 3 yr old *Pinus sylvestris* trees in a semi-controlled experiment in 16 open top chambers (OTCs) during two subsequent years, using four different water regimes (watering close to field capacity, no water at all and two intermediate levels) and two soil nutrient regimes. We measured growth, gas exchange, NSCs, and C and N tissue concentrations. Only trees in the zero irrigation treatment were significantly affected by drought. Increased soil nutrient availability increased the mortality rate in dry plots, which could be explained by the fact that drought stressed trees with higher nutrient availability had a higher shoot-to-root ratio than those with lower nutrient availability. High soil nutrient availability is known to reduce the C allocation to fine roots as sufficient nutrient uptake is granted. Under drought this is a negative predisposition and trees were not able to compensate (e.g. by shifting C allocation to root growth). NSC storage was not affected by nutrient availability but did decrease in all tissues with increasing drought. Our results show that young trees adapt their growing strategy to changes in water and nutrient availability, but that high nutrient availability under drought might be more damaging than beneficial, supporting our initial hypothesis.

Land use alters drought effects on belowground partitioning of recent carbon in mountain grassland

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Belowground C allocation determines the belowground fate of recent assimilates and couples the major ecosystem CO_2 fluxes photosynthesis and soil respiration. Carbon allocation has been shown to be altered by land-use change and by drought. However, the combined effects of these global change drivers on belowground C allocation are uncertain. In an *in situ* common garden experiment, we exposed soil-vegetation monoliths from a managed meadow and an abandoned mountain grassland to an experimental summer drought. We applied two $^{13}CO_2$ pulse labeling experiments, at peak drought and during the early recovery phase. The assimilated ^{13}C was traced into root carbohydrates and was monitored at high time resolution in soil respiration, using isotope laser spectroscopy. In both grasslands, drought reduced the amount and the temporal dynamics of ^{13}C respired belowground and altered the belowground C partitioning. After rewetting, the coupling of photosynthesis and soil respiration was quickly restored and ^{13}C, which had accumulated in root sucrose during drought, was quickly respired. Grassland management affected the partitioning of recent C to belowground respiration and root storage carbohydrates. Under drought, the managed meadow reduced ^{13}C allocation into root starch and fructans and allocated a larger fraction of assimilated tracer into belowground respiration. By contrast, the abandoned grassland allocated relatively more ^{13}C to root starch and fructans and less into belowground respiration. These opposing response strategies were likely related to differences in the plant community composition. The meadow, adapted to management, already possessed large root carbohydrate pools. In comparison, the abandoned grassland maintained a larger rooting network, which requires higher investments of assimilates, but possessed smaller root carbohydrate pools. We conclude that in mountain grassland the use of recent assimilates under drought is altered by land-use change.

Cambial response of *Picea abies* to manipulated carbon availability indicates strong sink demand belowground

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Drought is one of the primary environmental factors which impairs tree growth because cell division and cell enlargement require adequate cell turgor. We tested the hypothesis that early culmination of radial stem growth in late spring found in several coniferous species in a dry inner Alpine environment is an adaptation to cope with drought stress, which might require an early switch of carbon (C) allocation to belowground. To accomplish this, we manipulated tree C status by physical blockage of phloem transport at distinct phenological stages of wood formation and experimentally applied two levels of soil humidity (well-watered versus drought) in six year old Norway spruce saplings. The influence of manipulated C availability and drought on stem and root growth and wood structure was analyzed. C limitation of radial growth above girdling was deduced from striking increase in ring width particularly under drought. Surprisingly, in response to phloem blockage reactivation of cambial activity in drought-stressed trees was detected above the girdling zone, while directly below girdling xylem formation stopped in both soil humidity treatments. On the other hand, radial growth in coarse roots strikingly increased in drought-stressed girdled trees at the expense of C reserves. The findings that (i) girdling stimulated radial growth in the stem and root and (ii) radial growth increase in girdled trees was significantly more intense in the drought-stressed compared to watered treatment indicate that wood formation in Norway spruce is controlled by C availability and environmental stress (drought). Due to the plastic response of girdled trees to water availability, we conclude that drought stress prioritizes early shift of C allocation to belowground to sustain adequate tree water status at the expense of aboveground stem growth. The research was funded by the Austrian Science Fund (FWF): P25643-B16.

SESSION 6

Citizen science in ecology: a long history in long term monitoring

Chairs: Florian Heigl, Daniel Dörler, Anett Richter

The common swift survey in Vienna – a citizen science approach

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The common swift (*Apus apus*) is a synanthropic bird which breeds at buildings mainly in larger cities. Currently, renovation and thermal insulation of buildings is happening at a high rate in Vienna as well as in many other European cities. This leads to a loss of suitable cavities for house-nesting birds. In 2017 the MA 22 (Municipal Department for Environment Protection of the City of Vienna) started to conduct a study about nest-sites of the common swift in the City of Vienna, Austria. The focus of the study was to identify as many buildings as possible with nest-sites in order to enable target-oriented protection in the future. Therefore, not flying individuals were counted, but buildings with nest-sites that were reported by citizens or already known by the department. In order to map as many buildings as possible, the citizen science approach was chosen. More than 100 volunteers have helped to map the number of nest-sites at the reported buildings since 2017. The standardized mapping was performed based on the proposed method of nest-site identification by Südbeck et al. (2005). The mapping took place in the evening hours, the observation of each building took at least 30 minutes and a nest-site was only counted if a common swift was observed when entering or exiting. In 2017 more than 830 nest-sites have been mapped at about 240 buildings across the city. In the middle of the breeding season 2018 already more than 100 buildings have been mapped and there's more to come. Because of its highly aerial lifestyle, the common swift is still a rather mysterious species, even though it's common. While conducting the project, new questions arose concerning the methodology of nest-site identification and the bird's breeding biology. The chosen citizen science approach might be a chance to bring light into the dark and help to conserve a common urban species in decline.

Viel-Falter becomes Butterfly Monitoring Tirol

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This year (2018) a regional butterfly monitoring program was initiated in Tyrol, Austria. The novelty of this monitoring program is its synergetic use of systematic expert assessments on species level and butterfly observation conducted by lay people using a simplified assessment scheme. This approach aims to systematically monitor the development of butterfly populations in a broad but cost effective manner, and at the same time promote public awareness and engagement for butterfly conservation issues. We will discuss experiences and challenges regarding this approach and report first results. The implementation of the butterfly monitoring in Tirol contributes to the monitoring of biodiversity in the Alps and is an important step on the way to establish a permanent butterfly monitoring program in Austria.

Involving pupils in long-term biological monitoring: lessons learnt and future perspectives

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Long-term records of biological data are important for generating new testable working hypotheses. Furthermore, recent research provides evidence for the importance of promoting scientific skills even among children. Since 2010 the Konrad Lorenz Research Station in Upper Austria is engaged in involving pupils in its research in the field of behavioural biology. The main focus is the relationship between social behaviour, physiology and environmental cues by using the free flying and individual marked bird species as models. Pupils of different grades were involved on both a short and long term in research. A study on greylag geese showed that reliable data can be obtained by well-trained children, whereas in a different study on ibises, students contributed to communicating science by investigating knowledge on this avian species. Furthermore, our results suggest citizen science to be suitable for informal education. The current presentation provides a cross section of different projects focussing on lessons learnt and future perspectives of the collaboration between science and education.

Bird conservation – experiences from the long-lasting work of BirdLife Austria

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BirdLife has been running bird censuses based on the help of volunteer counters for decades. The first big project was the nationwide census of wintering waterbirds, which was launched in the 1970ies and is still running today. From 1981–1989 the fieldwork for the first Austrian breeding bird atlas was conducted. After completion of this milestone of Austria's bird conservation, the collection of casual observations continued on a much higher level than before. The publication of the atlas was followed by single species surveys (e. g. jackdaw, common sandpiper). A next big step was the start of the yearly monitoring of common breeding birds in 1998. This program is still ongoing, and today the data covering the last 20 years delivers a most valuable source of information on the well-being of some 80 Austrian bird species. Recently, two big citizen science projects were started simultaneously: an internet-based platform for reporting bird observations – www.ornitho.at – and the field work for the second breeding bird atlas 2013–2018. The use of ornitho.at lead to a fulminate increase of reported data for both, casual observations as well as for the bird atlas. This talk will focus on some of the projects mentioned above, and aims to share experiences and constraints that arise when collecting data with volunteers.

Butterfly Monitoring Germany: 13 years in flight – recording the highs and lows of a citizen science project and of butterfly populations

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The Citizen Science project 'Butterfly Monitoring Germany' (TMD) is now running for 13 years. The basis of the TMD are volunteer transect walkers who count butterflies along a defined route. The scheme's success depends on the number and effort of these volunteers, who spend their free time collecting butterfly data all over Germany. The TMD network consists of transect walkers, regional coordinators with the Helmholtz-Centre for Environmental Research – UFZ acting as principal coordinator of the project. The regional coordinators are experts on butterflies (and moths) who have agreed to be contact persons for the recorders in their region or province. Like the recorders, they are volunteers. The year 2017 has had consistently high levels of participation with 338 volunteer transect walkers counting butterflies on 460 transects all over Germany. In this talk we will explain how we manage to keep this ambitious project running. Key factors for the project's success from the coordination side are quick answers to questions raised by the volunteers, writing annual reports, publishing a bi-annual newsletter, timed for the beginning and the end of each butterfly season, and planning yearly giveaways for active transect walkers. In addition we will present first analyses of trends for common butterfly species over the duration of the project. The results demonstrate that trends vary greatly among species, and whereas many species show a stable or even an increasing trend, some of them show a clear decline.

Potentials and challenges of heterogeneous biodiveristy data: citizen science data

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Biodiversity is a highly valued good for most people and societies. Citizen science, involving more and more people from different professions and levels of expert knowledge. Citizen science has a high potential to provide data that is urgently needed to assess the state of biodiversity in an ever changing world. However, due to differences in data collection, structure and taxonomic depth, analyzing and interpreting of such data is a challenging task in modern biodiversity studies. The German project sMon has collected a high number of biodiversity data from a wide variety of sources to assess temporal trends in the distribution of different taxa in Germany. In this talk we will give insights into our experiences on the potentials and challenges of combining mixed data to evaluate temporal changes in biodiversity on the scale of a whole country. Further, a major challenge is to identify attributes in data collection that require comparably low effort in amending current datasets typically available from citizen scientists that might allow for a deeper insight in biodiversity related trends for the future data to come. We will discuss such suggestions and show how harmonization of datasets and slight additions in the information obtained through citizen science may strongly increase the scientific significance of the ever growing wealth of data collected by citizen scientists.

POSTER PRESENTATIONS

SESSION 6-P1

Landscape and local garden management influence hedgehog occurrence in Austrian gardens – insights from a citizen science project

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As a synanthropic species hedgehogs often stay in the close vicinity of human settlements. Since various changes in land use degraded habitat quality in cultural landscapes, gardens represent important refugia for hedgehogs. Despite hedgehogs' popularity, only little is known about their general abundance and occurrence within the distribution range. As private gardens are usually not accessible to researchers, we developed a citizen science project called 'Hedgehogs in gardens' to obtain information on hedgehogs in people's backyards. Citizens observed the nocturnal animals with hedgehog tracking tunnels in gardens all over Austria. The triangular shaped tunnel, equipped with bait, colour and white paper, is positioned in the garden for five consecutive nights. Attracted by the bait, the hedgehogs pass through the tunnel and leave their footprints on the paper. Direct observations of hedgehogs could also be reported. In addition, citizens also completed an online form on garden structures and management. The effect of the surrounding landscape within a 500 m radius around the garden, was assessed by a GIS-supported landscape analysis. The dataset consisted of 293 Austrian gardens for which questionnaires were completed and hedgehog observation recorded within a citizen science project. Thereof, 179 gardens offered presence and absence data by using footprint tracking tunnels. In total, hedgehogs were reported in 55 % of the gardens with footprint tracking tunnels. Increasing landscape diversity and fragmentation as well as increasing proportion of hedges, built up areas, arable land and stagnant waters raised the probability of hedgehog occurrence. In the gardens, the presence of hedges, feeding sites, hedgehog boxes, piles of leaves as well as an average garden size showed a positive effect on the presence of hedgehogs. Citizen science offers a great potential to generate data from unexplored gardens and to raise awareness for synanthropic species.

'Nature's Calendar', a modular phenological smart phone app for collection of phenological observations by citizen scientists

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The collection of phenological observations through volunteers or citizen scientists (CS) in Austria dates back to 1851, where the first phenological network was organised by Karl Kreil, the director of the newly founded Austrian national weather service. Phenological data collection has always relied on volunteer observers, who were willing to regularly visit their selected plants and places, working with pencil and paper, filling in and sending the observational sheets to the national weather service. This traditional way of phenological data collection has been challenged by a number of not well known sociological factors, which altogether caused a dramatic drop in observations from about 1950 to 1995 in Austria. As a first step to appeal to new observers the web-portal for entering phenological observations was opened for the public in 2006, with not much effect. The recent development of mobile smart phones has a great potential to increase the stream of phenological observations. Thereby means have become available, which in fact have already facilitated CS ecological data collection enormously.

In a cooperation between SPOTTERON, LACON and ZAMG the smart phone app 'Nature's Calendar' has been created. The app has already been released for Android and IOS, along with an interactive map for desktop users at www.naturkalender.at. It is not just an app, but an app system, which allows to create apps for a range of individual citizen science applications with minimal effort. New features implemented for one application can easily be transferred to other applications. Amongst others it offers instruments for communication between the network operator and observers (push messages), for communication within the observer community and to upload photographs. The extensive observational manual with a detailed description of species and phenophases can be found on the Naturkalender home page. Time will tell, if our efforts will bear fruit.

SESSION 7

Microbial ecology and soil processes in a changing world

Chairs: Katharina Keiblinger, Hans Sanden, Taru Sanden

Influence of microclimatic conditions on biological soil crust wetness and activity on initial soils of reclaimed post-mining areas

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Biological soil crusts communities are key drivers of functional processes and the development of ecosystems. Although biological soil crusts can be found in open landscapes worldwide, their species composition depends on soil properties such as texture and pH, on microclimate, and their respective developmental stage. As photoautotrophic cryptogamic communities, they contribute to carbon and nitrogen accumulation and soil formation of initial soils. Worldwide, they play an important role in biogeochemical processes and fluxes. The ecophysiological processes of biocrust organisms are highly dependent on water availability, differing in time and space. For a better understanding of the biological functionality in ecosystems, the spatial and temporal activity and photosynthetic capacity of biocrusts need to be linked with microclimate. This is important for modelling biocrust activity and carbon fluxes. We investigated the microclimatic conditions and activity of moss-dominated biocrusts on initial soils in the open-cast mining area near Cottbus, Brandenburg, at the artificial water catchment Hühnerwasser. Moisture of the topsoil was continuously determined with a novel biocrust wetness probe (BWP) and related to precipitation events and cycles. Biocrusts' wetness and physiological activity were linked by using the latest digital imaging systems for NDVI and chlorophyll fluorescence in a controlled microcosm experiment. The advantages of biocrusts, i.e. the physical soil stabilization, the gain of organic carbon, and the promotion of soil formation in initial ecosystems can be used in restoration activities.

Impacts of tundra fires on soil carbon

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In Tundra ecosystems, wildfires have been rather uncommon phenomena. However, recent studies predict an increase in fire frequency and extent in the course of climate change. Tundra fires may have the potential to induce a worldwide feedback loop, regarding the extraordinary impact of climate warming in the Arctic, especially on thawing permafrost and resulting massive release of greenhouse gases. The ecological impact underlying processes of tundra fires on vegetation dynamics, carbon and nutrient cycling as well as mechanisms of thermokarst development and permafrost thawing are so far poorly understood. Here we will present first results of a study, which took place in the forest tundra ecosystem near Tazovsky in the Yamalo-Nenets Autonomous Region in the north of Western Siberia. We analysed soil parameters of paired burnt and unburnt plots in areas that were subject to burning 10 and 40 years ago, respectively. We found fire to influence the dense lichen cover negatively and 10 years after fire, the active layer was still deeper on the burned plots. We found no differences in active layer depth between burned and unburned plots in the area hit by fire 40 years ago, which might indicate a restoration of permafrost. Percentage of C was lower and ^{13}C was higher in burned plots of the area hit by fire 10 years ago, which could be related to higher microbial activity and decay of organic matter. In general our results indicate low impact of fire on carbon stocks. Surprisingly, we found relatively dry soils with low carbon storage.

Impact of nitrogen deposition on forest biogeochemical processes investigated using a tool kit of stable isotope methods

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Meta-data analyses and the model based hypotheses state that global soil C storage is controlled by microbial scale processes of fungal competition for available nitrogen (N). Global trends of increasing atmospheric N deposition and the continuing use of inorganic N fertilizer in both agriculture and forestry mean that the soils vital function as a carbon sink is potentially under threat. We set out to experimentally investigate these hypotheses across a trans-European gradient of forest soils and provide reliable information on soil microbial responses to nitrogen inputs for predictive climate change models. Changes in soil nutrient status could result in a chain reaction of interacting microbial mechanisms which in turn could lead to the shifts in underlying ecosystem biogeochemical process rates. Recent meta-analysis has shown that plant fungal symbiont community structure exerts a greater fundamental control over soil C storage than temperature, precipitation or net primary production. Based on the hypothesis that plant associated fungi effectively scavenge all available organic and inorganic N leaving little N for the growth of the free-living decomposer microbial community and preventing further breakdown of soil organic matter (SOM). We have set up an experiment in which a series of dual isotope labelled C and N in-growth beech litter bags have been incubating in-situ in the forest. Moreover the treatment plots have received additional inputs of inorganic nitrogen fertilizer over an eight year period. We have studied both nitrogen and carbon dynamics in these systems using a tool box of stable isotope techniques.

Dissimilatory nitrate reduction to ammonium (DNRA) and denitrification upon rewetting of subtropical pasture soils

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Rainfall and irrigation promote the rapid formation of anaerobic zones in in subtropical pasture soils. Under these conditions, denitrification and dissimilatory nitrate reduction to ammonium (DNRA) are thought to compete for NO_3^-. However, the relationship between gross NO_3^- production and consumption via denitrification (N_2 and N_2O) and DNRA remains poorly understood. We combined the quantification of N_2 and N_2O with a numerical 15N tracing model to establish the relationship between denitrification and DNRA in three different textured pasture soils after wetting. Soil microcosms were fertilised with NH_4NO_3 (35 µg N g^{-1} soil), wetted to four different water-filled pore space (WFPS) levels and incubated over two days. The increase in soil moisture triggered a burst of N_2 and N_2O emissions, with fluxes of N_2 > 13.1 µg N g^{-1} soil day^{-1}. At 95 % and 80 % WFPS, denitrification was dominated by N_2 emissions, while N_2O was the main product of denitrification at 60 % and 40 % WFPS. The wetting of soils resulted in increased DNRA rates across soils and WFPS. Both denitrification and DNRA increased with WFPS and NO_3^- availability. Increasing labile C availability did not affect the magnitude of denitrification, but lowered the soil redox potential by stimulating heterotrophic soil respiration, shifting NO_3^- consumption from denitrification to DNRA. These findings show that the high labile C availability under pastures drives heterotrophic soil respiration, reduces the soil redox potential and shifts NO_3^- consumption from denitrification to DNRA. This shift limits denitrification losses and is therefore critical for N retention in pasture soils.

Immediate effects of soil amendments with natural and NH_4-enriched chabazite-zeolitite on soil microbial biomass and gaseous emissions

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Zeolitites (ZTs) are rocks containing more than 50 % of zeolite minerals and are recognized as a valuable soil amendment. However, little is known about their effects on soil microbial biomass and gaseous emissions. This study aims at i) evaluating short-term effects of different chabazite-rich ZT (CHAZT) amendments on soil microbial biomass and ii) evaluating their effects on soil gaseous emissions. To this aim, a silty-clay agricultural soil was amended with different percentages of natural CHAZT (NZ) and NH_4-enriched CHAZT (CZ) in two separate experiments. In the first experiment, dissolved organic carbon (C), total dissolved N, NH_4, NO_3, NO_2, microbial biomass C and N, and ergosterol were measured over a 16-day period. In the second experiment, soil CO_2, N_2O, NO_x and NH_3 fluxes were measured for a total of 24 h both immediately after urea fertilization and without a further N input. In the first experiment, an increase in ergosterol content was observed in the soil amended with NZ at lower application rate, suggesting that fungal biomass development was favored. CZ amended soil showed evidence of nitrification, since microbial biomass N was directly related to NO_3 production and inversely related to NH_4. Isotopic measurements confirmed immediate assimilation of N derived from CZ. In the second experiment, immediate CO_2, N_2O, NO_x and especially NH_3 emissions after fertilizer application were generally reduced (up to 60 %) in soils amended with NZ. CZ application generally lowered CO_2 and N_2O emissions, but high NO_x fluxes occurred even without any further N input. NH_3 emissions were higher in CZ amended soil, but if the amendment is performed without further N inputs, the emissions can be significantly lowered with respect to a conventional urea fertilization. These results suggested that the CZ used in this study supplied an immediately available N pool to the microbial biomass and that NZ can be a suitable material for mitigating gaseous N and C losses from soils.

Stoichiometric controls of soil element cycling in a mesic grassland in South Africa – insights from a 66-years old nutrient addition experiment

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Terrestrial ecosystems have experienced raising nitrogen (N) and phosphorus (P) inputs since the last decades, but still it is not well understood how the two elements interact in plant nutrient acquisition and how elevated N and P inputs affect soil element cycles. It was assumed that microbial homeostasis is the key component for driving soil element cycling in the way that microorganisms increase the acquisition of limited elements, or *vice versa* increase the release of those elements in excess. We used a 66–year old fertilization experiment in South Africa consisting of four different levels of N addition (0, 7, 14, and 21 g N m^{-2} yr^{-1}) with and without P addition (0 and 9 g P m^{-2} yr^{-1}), and measured its responses on aboveground plant biomass, C and N mineralization, non-symbiotic N_2 fixation, and enzyme activities. Aboveground plant biomass increased through single N and P addition with a clear synergetic response once both elements were added together (N and P co-limitation). We found indications that organisms use N to acquire limited P as phosphates activity increased with higher N availability. In treatments with low available N, enhanced non-symbiotic N_2 fixation and a higher leucine-aminopeptidase activity revealed that microorganisms invest more into N acquisition. However, once microbial N demands are covered microbial N release markedly increases meaning that net N mineralization was 4.0–6.7 times higher in the N fertilized treatments. In contrast, soil carbon (C) cycling was mainly affected by soil acidification through long-term N addition. At the highest N level soil pH decreased by about one unit, and together with N inputs reduced the microbial biomass by 40 %, shifted the bacterial community composition, and suppressed C mineralization rates by 41 %. Overall, our study reveals that the property of the soil microbial biomass to maintain its stoichiometry controls the acquisition and release of C, N and P, and that organisms might use excessive N to facilitate P acquisition to mitigate co-limitations.

Linking litter decomposition to soil carbon stocks under Norway spruce, Douglas fir and European larch

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An increase in droughts and insect infestations threatens Norway spruce (*Picea abies*) stands across European forests. With a higher drought tolerance, Douglas fir (*Pseudotsuga menziesii*) and European larch (*Larix decidua*) became a suitable non-native and a native silvicultural alternative to Norway spruce. How tree species selection affects litter decomposition processes and soil carbon (C) sequestration is, however, still not fully understood. Therefore, this study aims 1) to answer if Norway spruce, Douglas fir and European larch differ with regard to litter mass loss partitioning into CO_2 and leaching of dissolved organic C (DOC) during decomposition, 2) to link mass loss partitioning to litter biochemical properties and 3) to link mass loss partitioning to soil C stocks. It is hypothesized that tree species with a higher partitioning into leaching of DOC have higher soil C stocks. The study takes place in the Vienna Woods, Lower Austria and measurements are conducted from April to November 2018. Litter decomposition is analyzed by means of respiration measurements and lysimeters, allowing for an *in situ* partitioning into CO_2 efflux and leaching of DOC. Litter bags are used to study mass loss and biochemical litter processes/properties (e.g. microbial respiration, lignin content). The results of this study will help to improve our understanding of tree species effects on the forest soil C cycle. In order to lower the uncertainties of carbon sequestration estimates for the forestry sector, this information is very important. Furthermore, new insights into the complex process of litter break down will be provided. Preliminary results of the study will be presented at the conference.

Testing mechanisms of community assembly between wood-inhabiting beetles, fungi and bacteria

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A central focus of community ecology are the patterns and processes underlying natural assemblages. Although vast amounts of data/patterns are easily available even for microorganisms using eDNA sequencing, the underlying assembly mechanisms are rarely understood. Niche and neutral processes are increasingly found to act together, leading to an integration of traits and null models to understand assembly processes. For example, organisms size was recently proposed as predictive trait for assembly processes. However, most commonly inferences are based on survey studies where many important factors are correlated (e.g. space and environment) or almost impossible to standardize (e.g. history). Thus standardized experiments are needed to disentangle factors which are otherwise confounding interpretation and analysis. Dead-wood is an ideal study system for assembly processes as dead-wood is easily manipulated in experiments and the centre of the saproxylic food-web, incorporating a multitude of species. Here we thus use an orthogonal experiment based on dead-wood logs, overcoming stated survey-study limitations and compared assembly processes between three organism groups: beetles (macroorganism), fungi and bacteria (large and small microorganism). We found that the drift to determinism (selection and dispersal) ratio was high for beetles and fungi and low for bacteria. We further found the selection to dispersal limitation ratio in the following order: beetles > bacteria > fungi and thus in a non-linear correlation to organism size. Our results suggest that assembly processes differ among wood-inhabiting organism groups and that organism size is not a linear predictor of assembly processes.

Temporal and small-scale spatial heterogeneity of soil fungal communities in a montane beech forest

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Montane forest ecosystems play important roles worldwide for slope stabilization and water supply. Soil development and vegetation can differ significantly from lowland sites, but little is known about soil microbial communities. In spring and summer 2015, soil physicochemical parameters and soil fungal communities were studied in a beech-dominated stand on a south-facing slope at an experimental site in the Austrian Calcareous Alps. The poorly developed soil is characterized by a near neutral pH and high content in organic carbon. The fungal community was analysed at a high spatial density by high-throughput amplicon sequencing of the ITS2 region. Interestingly, Ascomycota was the dominant phylum and saprotrophic fungi were the dominant guild. This is in stark contrast to lowland sites, where Basidiomycota and ectomycorrhizal fungi are more abundant. Russulaceae, which are normally among the most prominent ectomycorrhizal fungi in beech forest stands, are absent from the experimental site in the Austrian Calcareous Alps. While only a small shift in community composition was observed between spring and summer sampling, spatial heterogeneity was very high. Highest community differences were already found at small distances. Spatial heterogeneity can be partially explained by variations in soil pH. Differences in soil organic carbon, topology and understorey vegetation are likely additional influencing factors. Soil pH together with soil organic carbon content were also identified as main factors that distinguish the experimental site in the Austrian Calcareous Alps from beech dominated forest stands in lowlands investigated by others. Those factors most likely contribute to the development of the distinct fungal community in the herein studied montane beech forest. More research is needed to fully understand the impact of distinct soil physicochemical and microbial characteristics on ecosystem processes and services in mountain forest stands.

The anticipation of stress affects the community structure of soil fungi

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Organisms are subject to stressors of different nature and intensity and have developed various responses to counteract these stressors. One common resistance mechanism is the development of an anticipatory stress response elicited by a mild stressor, leading to higher resistance upon the occurrence of stronger environmental stress. This predictive stress resistance is called priming and its effects can strongly differ across species, influencing the fitness of the different members of a community in various ways, thus critically changing the outcome of community competition. In our study, we simulate the impact of stress and priming on soil fungal communities as model organisms. We developed a spatially explicit, individual-based simulation model based on laboratory experiments that provide sound parameters and that allow for validating the model output. We performed an analysis of systems of different complexity: starting with the effect of stress on single species, we then expanded the model to represent communities of two and three species that react differently to stress. We could show that by altering the species fitness, priming can change the community composition. Also, priming influences the species interactions and, vice versa, different interactions seem to influence a species' ability to be primed and thus the effect of priming onto the community. With our simulation models, we gain insight on the effect of priming onto microbial communities and process rates and, furthermore, we can predict microbial community development and structure. Ultimately, these models might help modulate communities by applying different stressors, increasing their applicability for agricultural, ecological or medical purposes.

Climate change scenarios can induce shifts in soil microbial communities in a managed grassland

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The site for climate manipulation experiments in Raumberg-Gumpenstein (Styria, Austria) is designed to study single and combined effects of elevations in temperature and atmospheric CO_2-concentration in a pre-alpine managed grassland. On selected plots soil bacterial and fungal communities were studied by a high-throughput sequencing approach. Additional soil and vegetation parameters were measured to allow evaluation of direct and indirect effects and to eventually link alterations in soil processes to shifts in soil microbial communities. In general, there were only subtle effects of the climate change treatments on the soil microbial community. However, a few operational taxonomic units (OTUs) showed significant responses to elevated temperature or CO_2. Selected bacterial and fungal OTUs showed a significant increase in abundance in the +300 ppm CO_2 treatment. Temperature increase had a strong positive effect on the abundance of white rot fungi in general, and especially on white rot fungi with preference for herbivore dung. No combined treatment effects could be identified on microbial communities after two years of manipulation. Besides, the soil fungal community showed a high autocorrelation with plot distance indicating that spatial variation has a significant effect on the community composition. Additional influence by vegetation on the fungal community was identified in one plot, where prevalence of *Rumex acetosa* was correlated with an unusually high abundance of *Mucor* spp. No spatial patterns could be observed for the bacterial community. Taken together, our results indicate only a small shift in community abundance caused by climate change after two years of manipulation. The temperature induced increase of coprophilous white rot fungi is supposed to be an indirect effect of mice preferring warmer plots.

Legacies of afforestation on soil nematode community composition, structure, and diversity in a northern Canadian prairie

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Afforestation resulting from fire suppression, modified grazing, and climate change poses a threat to northern prairie ecosystems in North America. Trees alter the composition and function of plant and soil communities and can compromise the restoration of affected prairies. Our objective was to determine whether legacies of afforestation persist in restored prairie communities and whether soil nematodes can be used as bioindicators of changes in the soil food web during restoration. To accomplish this, we compared the structure, diversity, and functional composition of soil nematode communities along a chronosequence of prairie restoration following tree removal. Study sites were located within two historic white spruce (*Picea glauca*) plantations established between 1930 and 1940 on rough fescue prairies in Riding Mountain National Park, MB, Canada. Within each site, we compared plant and soil nematode communities between areas of native prairie, remaining plantation stands, and three tree removal treatments. Our observations indicate that shifts in plant community structure following tree removal were accompanied by shifts in nematode feeding groups, with fungal and bacterial feeding nematodes decreasing over time and plant parasitic nematodes increasing to levels similar to those observed in native prairie. However, unlike the native prairie, the overall diversity of both the plant and nematode community declined with time and was lowest in the oldest restored treatment. Our results indicate that soil nematodes are sensitive to changes in the plant community following the removal of trees and can be effective indicators of changes in soil food web structure following the restoration of northern fescue prairies. Future work aims to connect restored plant and nematode community dynamics through the analysis of root traits

POSTER PRESENTATIONS

SESSION 7-P1

A gardeners effect on soil quality

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Globally, the majority of people live in cities. Green spaces such as urban gardens are important refuges and hot spots for biodiversity due to the sealing and densification of the urban landscape and the monotony of the agricultural areas around the cities. Surface sealing destroys most of the functionality of soils, whereas gardens are providing habitats for many plant and animal species: both above- and below-ground. Furthermore, gardens provide important ecosystem services (ES). Soil is the fundament of sustainable gardens, but we know little about the consequences of garden management on soil quality. We present a comprehensive assessment of soil quality, including biotic and abiotic site characteristics combined with details on land-use history and garden management obtained from a survey. Taken together, our results show that garden management is the most important factor supporting soil quality and soil functions. Furthermore, we identified urban garden soils to be fertile and to support a wide range of soil functions important for soil based ES. It is important to understand and support the quality of garden soils as vital elements of a liveable city.

Linking biodiversity and soil carbon dynamics

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There is general consensus on the need for studies with an integration of multiple parameters that characterize physical, chemical and biological changes for a more realistic and holistic understanding of impacts of global change scenarios on terrestrial ecosystems. Disentangling the many environmental factors driving ecosystem functions is a central goal in ecology. Controlling for multiple influential factors such as precipitation, temperature, and soil processes while studying natural variation in others is a difficult task, particularly along biogeographic gradients. In this study we take advantage of the multi site research approach by studying decomposition processes across natural gradients in temperature and precipitation and combine this with two common metric approaches focussing on plant community dynamics (Phytometer approach) and soil microbial and decomposition dynamics (TeaComposition approach). The unique experimental set up across well-investigated sites will allow us to disentangle and quantify feedback loops between abiotic (climatic parameters) and biotic factors (plant and microbial community composition, soil properties) on litter decomposition. Preliminary data on the linkage between biodiversity and decomposition will be presented and discussed.

Soil moisture integrates the influence of land-use and season on soil microbial properties and function in the Ethiopian highlands

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Conversion of old-growth natural forest to crop land or grazing land is prevalent under the existing socio-economic conditions in Ethiopia. Degraded grasslands are often planted with Eucalyptus. We investigated soil microbial and soil biochemical properties among the different land-use types of natural forest, Eucalyptus plantation and grazing land in the highlands of North-Eastern Ethiopia. Soil C and N, microbial biomass and soil extracellular enzyme were higher in the natural forest compared to grazing land, and were also higher in plantations of *Eucalyptus globulus* compared to grazing land. The microbial biomass C : N ratio was strongly negatively correlated with the soil moisture both within and between seasons. The higher microbial C : N ratio in the dry season (C : N 11–19) compared to the wet season (C : N 5–10) indicates that there is relatively more fungal biomass in the dry season. There was a strong positive correlation between microbial C : N ratio and the activity of chitinase which supports the idea that the C : N ratio reflects the fungal : bacterial ratio. Our study indicated that land use change in the Ethiopian highlands affects the soil properties and the amount of fungi compared to bacteria. However the increase in fungal : bacteria ratio after land use change is not mainly driven by changes in vegetation or soil nutrition but rather by soil moisture which is influenced by land use.

SESSION 8

Ecological and evolutionary background for nature conservation and restoration

Chairs: Anna Bucharova, Johannes Kollmann, Christian Braeuchler

Establishment gaps – a novel tool in grassland restoration

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One of Europe's largest landscape-scale grassland restoration projects was done in the Hortobágy National Park, East-Hungary by sowing low-diversity seed mixtures in 760 ha of former arable lands. As a result of the project a closed canopy of the sown grasses developed in just three years, which successfully hampered weed species establishment, but also hampered the establishment of typical grassland species due to propagule- and microsite-limitation. To increase the diversity of restored grasslands we used a novel approach and used 'establishment gaps'. Eight years after the restoration we selected four alkali- and four loess grassland sites and established differently sized gaps (1 m^2, 4 m^2 and 16 m^2), where we removed all the biomass, and sowed species-rich target forbs seed mixtures after soil preparation. We established two 16 m^2 establishment gaps from which one was fenced and the other one, along with the smaller gaps, was allowed for grazing animals. We monitored the species composition of establishment gaps in the following years. We found that all sown species established successfully in at least one of the establishment gaps. The majority of species had similar or increased cover scores in the second year compared to the first one. Smaller gaps were characterised by stochastic development, sown species had lower cover scores compared to larger gaps. Weeds cover scores decreased from the first year to the second one in all gap types. According to our results establishment gaps can effectively introduce species into the species-poor grasslands and overcome propagule- and microsite-limitation. We suggest the use of larger establishment gaps with stable vegetation development compared to the smaller ones. Extensive grazing is a proper management already from the first year because animals help species dispersal and create microsites. In the future we want to clarify to what extent they can improve the restoration success across the entire grassland.

Spatial regeneration patterns of the tree species *Aspidosperma tomentosum* (Mart.) (Apocynaceae) in a neotropical savanna in Paraguay

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Knowledge of spatial processes is crucial in order to determine the structures of populations and to identify the implications for ecosystem management and conservation. The spatial distribution of trees is the result of different processes, for example, regeneration. The study was conducted in the neotropical savanna (cerrado) in the Mbaracayú Nature Forest Reserve. The cerrado biome is part of the grand central Brazilian plateau, which extends to eastern Bolivia and northeastern Paraguay. The cerrado represents one of the 25 global biodiversity 'hotspots'. The endemism in the ecosystem is high with a total of 4,400 species representing 1.5 % of the world's total vascular plant species. The cerrado is a highly threatened ecosystem due to agricultural expansion, especially livestock. Natural regeneration has long been an enigma within savanna ecology. The aim of the study was to analyse the influence of shade effect on the spatial distribution of *Aspidosperma tomentosum* seedlings. The tree species is considered to be monoecious with anemochorous (wind) seed dispersal. Its distribution is continuous but sparse in southeastern Brazil and parts of Bolivia and Paraguay. The study design was established on two different sites with plots of 100 x 100 m. Seedlings smaller than 2 m in height were measured and mapped according to their Cartesian coordinates. The crown cover was characterised using a crown-mirror densiometer and crown density scales. Shade was derived from the canopy cover information for the plots. The results of Gibbs modelling indicated that increasing shade has a negative effect (estimate = −0.020) on the establishment of *A. tomentosum* seedlings (p-value = 0.0341). The analysis of seedling intensity as a function of shade effect showed that the probability of seedling presence decreases with increasing shade. The results of the spatial pattern analysis of *A. tomentosum* showed clumped or aggregated distributions for the seedlings on both study sites (p-value < $2e^{-16}$).

The relative importance of landscape structure on abundances of the grassland weed *Jacobaea vulgaris* and its herbivore *Tyria jacobaeae*

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Tansy ragwort (*Jacobaea vulgaris*) is a weed native to Europe and Asia, which preferably grows on extensively used grasslands and other habitats with a high share of open soil. In the past decades, tansy ragwort has spread rapidly in agricultural areas. Due to its content of toxic pyrrolizidine alkaloids, farmers fear its growth on their land and a framework is urgently needed to understand population outbreaks. Here, we investigate how local and landscape factors affect the spread of *J. vulgaris* and the presence of its antagonist, the cinnabar moth (*Tyria jacobaeae*). We conducted a GIS-based quantitative landscape analysis at varying spatial scales for selected *J. vulgaris* stands across Schleswig-Holstein, Germany. Landscape composition and configuration surrounding sites with high ragwort density differed strongly from those with low density. Landscapes surrounding sites with high ragwort abundance showed a more small-scaled and heterogeneous structure than those surrounding low abundance sites. Higher availability and closer proximity of suitable habitats seem to foster ragwort abundance on-site. Linear elements may act as networks for spread and facilitate the occurrence of *J. vulgaris*. Our results further indicate that soil water content may influence the successful colonisation of ragwort stands by *T. jacobaeae*. The moth was found more frequently in ragwort stands with dry compared to wet soils. Landscape factors did not affect the presence of the moth. Our outcomes highlight the importance of local as well as landscape factors when trying to comprehend the emergence of *J. vulgaris* as a native invader. In contrast to ragwort, the presence of its herbivore was only affected by local factors. Although ragwort generally prefers dryer soils, waterlogged soils may counteract the establishment of the moth and thus be especially prone to invasion by *J. vulgaris*. Our results may help to establish effective management practises to sustainably reduce the weed's abundance.

Can the poisonous grassland plant *Senecio aquaticus* be reduced by management intensity?

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In many European regions near-natural grasslands are declining due to changing land use. Intensification of grassland management can lead to losses in biodiversity and local dominance of unwanted species. In the pre-alpine regions of Germany, Austria and Switzerland marsh ragwort (*Senecio aquaticus*) is a native Asteraceae occurring in moist to wet meadows or pastures. Over the past decades it has significantly increased in that region and has started spreading also on more intensely managed grasslands. This development causes problems, because all parts of the plant contain pyrrolizidine alkaloids that are poisonous to livestock. Organic farmers are particularly concerned about this development, since their farming practice does not allow to use herbicides or mineral fertilizers for controlling *S. aquaticus.* In order to reduce its abundance and to counteract further spread of this species a new project aims to investigate management methods that allow a more effectively control of *S. aquaticus.* Thus, we installed field experiments on seven farms in SW Bavaria. Two extensive to medium management strategies (first mowing at peak flowering, followed by one or two cuts, low amount of slurry) and four more intensive, locally typical management procedures (four-time cutting, combination of mowing and mulching, medium to high amount of slurry) are tested for their influence on abundance and flower production of *S. aquaticus.* Preliminary evidence indicates that the more intense management is not suitable to control populations of *S. aquaticus.* Besides removing individual plants manually prior to mowing, medium management intensity seems to reduce not only the abundance but also the flower production of the species. This finding is in line with previous studies recommending to adjust mowing to peak flowering of *S. aquaticus*, to avoid seed propagation.

The effects of historical land use on the vegetation and habitat properties of wet meadows in South Germany

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Wet meadows (*Angelico sylvestris–Cirsietum oleracei*) are among the oldest and most species-rich ecosystems in Central Europe. These grasslands naturally occur in floodplains and wetlands or were established on drained marshlands, deforested areas and former arable fields or pond grounds. For assessing the impact of historical land use on the plant composition or habitat properties, wet meadows with a long-term usage as grasslands were compared with more recently established ones. The time span since the grassland management was first recorded was assessed using historical maps from the 1820ies, 1910ies and 1950ies. More than 60 locations situated in the 'Allgaeu' or in the nearby nature reserve 'Federsee' (South Germany) were studied using vegetation records and soil analysis. Additionally, pedoanthracological methods were applied to investigate the degree of deforestation since the beginning of the shifting cultivation and appliance of burning events. Preliminary results show that environmental properties are the most important factors to determine the species composition. However, historical land use affects the vegetation pattern and soil conditions. Some species are linked to a time span in the vegetation's dynamics of grasslands and either occur in old or young meadows. Therefore, historical land use should be taken into consideration for species protection measures.

Identifying post-disaster biodiversity hotspots after Chiles 2017 wildfires

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Central Chile is one of Norman Myers 24 biodiversity hotspots, characterized at the same time by high levels of biodiversity and endemism and human disturbance to both. In Central Chile, conversion of near natural forest ecosystems to commercial tree plantations is one of the central drivers of biodiversity decline. Neoliberal forest policies imposed by the Pinochet government have lead to unquestionable losses and fragmentation of native forest habitats. Native forests are found today almost exclusively in small remnants, disconnected from one another and beset to all sides from tree plantations imposing further degradation (e.g. during harvest). Among changes in ecosystem parameters and functions (such as soil functioning, soil hydrology, nutrient cycling) leading to decreases of native plant diversity and evenness, important changes as with respect to wildfire frequency and intensity are expected due to the fact that tree plantations accumulate more biomass, fine fuel loading, volatile compounds but less moisture in the canopy and soil. In early 2017, around 4,750 km^2 of land surface were burned down in wildfires occurring from north to south within the temperate zone. These wildfires have caused further damage to remnants of native forests and thus, biodiverse habitats. In order to protect native biodiversity, identifying remaining hotspots in the post fire situations for restoration and conservation is crucial. The contribution does so by four analytical steps. 1. empirical in situ biodiversity assessments (211 plots) were sampled to analyse relationships between land use and biodiversity, 2. these data were fusioned with remotely sensed land use data to produce a spatially explicit biodiversity model, 3. the model is run in pre-fire conditions and intersected with fire severity results, 4. by relating fire severity to biodiversity conditions, post-fire remnants of biodiversity are identified. The contribution may be of regional interest to researchers investigating in links between land use and biodiversity and of methodological interest to researchers in biodiversity restoration and conservation.

The impact of historical land use on the species assembly of dry sandy grasslands

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Dry sandy grasslands are highly endangered habitats in Germany, especially in the southeast. Reasons are declining disturbances by abandonment of grazing or turning into arable fields. To protect these habitats from extinction, conservation organizations are trying to create new sites. Therefore, they are transforming arable fields or clearing forests, with differing success. To understand the variation between the sites, we wanted to know if there are differences in vegetation composition caused by land use before they developed to dry sandy grasslands. To determine the former land use of the present sandy grasslands, we digitized historical cadastral maps and classified the land use. By performing an overlay-analysis of these maps, we could determine the development history of the present sandy grasslands. As study area, we chose the conservation area Hainberg (Nürnberg, Germany), which is protected and managed by grazing over the last 23 years. Due to this, we expected that management is not the determining variable for the vegetation structure. Therefore, appearing differences in species composition should be described by the previous land use. We focused on three categories of sandy grasslands: Continuously grazed grasslands since at least 200 years and grasslands which have developed either from arable fields or shrublands. The vegetation survey and the evaluation of the soil parameters showed differences between these groups. The variation in species composition and soil properties showed a strong correlation with the historical land use. Our study shows that the integration of the land use history allows us a better assessment which kind of habitats may be easier restored to new sandy grasslands.

Space use patterns and use of habitat connectivity in Eastern green lizards (*Lacerta viridis*) researched in the vineyards of Nußberg, Vienna

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Critically endangered *Lacerta viridis* is a thermophilic species, which is distributed in Vienna mainly in wine growing areas in the North-West of the city. Based on previous studies since 2011 this survey investigated a subpopulation of Green lizards on the Nußberg, a popular wine growing district where the lizards inhabit linear dispersed uncultivated slopes between the vineyards. In the last years, connectivity structures between those slopes were established in cooperation with the local wine makers to improve the habitat connectivity in the area. The current study worked with individual recognition of scale patterns on the lateral head sides of photographed Green lizards, which were surveyed in the activity season from March to October 2017. This first gives an overview of the resident population including population structure, distribution and phenological parameters, and second shows the movement patterns of the individuals within the survey area. It is determined, that the population shows clustered distributions along the slopes and the sex ratio of the collected data represents a surplus of male individuals. The males covered higher distances and used the connectivity structures to migrate between the habitat slopes. The biggest distance showed a two-year-old male, which moved more than 250 m within the connectivity matrix. Furthermore was tested statistically if the distances covered by the males correlate with population parameters. In particular males covered distances correlated negatively with the availability of females in the initially inhabited territory. Thus low female abundance causes emigration of males from the habitat patch. This underlines the importance of the connectivity structures, which help to connect subpopulation clusters within the single habitat patches.

Successful restoration of abandoned terraced vineyards and grassland in the canton Ticino, Switzerland

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Traditionally managed terraced landscapes are characterized by a high structural diversity promoting habitats for many different plant and animal species. Due to the cessation of traditional management practices in marginal and poorly accessible areas, forest areas are expanding by overgrowing these species-rich open habitats. We examined the potential restoration success accompanied with a re-introduction of traditional management practice by assessing the plant diversity of terraced vineyards and grassland in Ticino, Switzerland. We compared plant species richness, diversity and species composition in both the aboveground vegetation and soil seed bank in different management types (permanently used, abandoned for > 15 years and restored/re-used). We surveyed the vegetation 10–15 years after the restoration actions were carried out. We found both a reduced plant species richness and diversity and a changed species composition in the aboveground vegetation in abandoned vineyards and grassland compared to the permanently used and restored vineyards and grassland. Most important, species richness, diversity and composition of the aboveground vegetation did not differ between permanently used and restored areas. This indicates a successful restoration of the aboveground vegetation within 10–15 years in areas abandoned for 15–30 years. In contrast, species richness of plants emerging from the soil seed bank was less affected by the three management types, suggesting that the soil seed bank may play a minor role for the restoration of characteristic vineyards and grassland vegetation in the given time period. Our study shows that extensive management practices accompanied with a high landscape diversity and a large plant species pool are key factors for a successful restoration of abandoned open land habitats.

Does time heal all wounds? Evaluating trajectories of multiple peatland properties using a multifunctionality approach

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Ecological restoration has great potential for reversing anthropogenic degradation, while frequently aiming at the simultaneous recovery of numerous ecosystem functions and services. In the case of peatland restoration, those targets range from the conservation of threatened species to the mitigation of climate change. Rewetting actions are often supposed to raise the water level, to decrease nutrient loads, to increase the water holding capacity and to create suitable conditions for re-establishment of characteristic species. However, many monitoring projects report an incomplete recovery that would suggest a 'recovery debt' with time. Unfortunately, such projects are often too short-term and use too few indicators for drawing integrated conclusions in peatlands that are complex and slowly recovering. Our study aims at assessing long-term peatland recovery in an innovative way. We studied the development of rewetted peatlands in respect to characteristic plant diversity, water level, peat decomposition, water holding capacity and nutrient level using a chronosequence of 0–18 years after restoration. We used a 'multifunctionality' approach by simultaneously analysing multiple properties and by integrating temporal trends. The recovery of restored sites of different age was compared to an optimum value that was defined as the mean of the seven highest values. We found that more than half of the individual properties as well as the combined index significantly increased with time since restoration, while it was not possible to restore multiple properties simultaneously to a high level of functioning. However, at low and intermediate levels of recovery there was significant progress with time. Thus, even if not all peatland properties can simultaneously be restored, a considerable improvement is possible. Our results suggest that restoration of heavily degraded systems should focus on few targets in order to achieve higher levels of functioning.

Fungi in floodplains: modelled habitat suitability and refugia

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Riparian habitats along rivers show high species richness, but are also threatened due to river alterations and habitat fragmentation. Protected areas such as national parks and nature reserves can be refugia for specialized species, including fungi. The relative importance of single protected sites might vary across species, especially as the area and the protection status might have been chosen according to other criteria (e.g. presence of flagship or rare and threatened species vs. species richness). Additionally, knowledge on habitat key structures and potential for riparian species occurrence is crucial for evaluating the role of refugial areas and to maximize restoration effectiveness of dynamic floodplains. Despite the knowledge of the important role of fungi in floodplains e.g. for decay processes, little is known about fungal species distribution and important factors for species conservation in this dynamic habitat. In this study, we use data from the national database on Swiss fungi with 615,000 records to analyze fungal species occurring frequently close to rivers in Switzerland. We model the ecological niche along rivers in a 25 x 25 m grid for over 129 species representing various functional groups (ectomycorrhiza, saprobic soil fungi, dead wood species). We show that species with more than 100 observations can form a robust set for modelling, despite the database being mainly based on citizen science data. We predict areas of suitable habitat for fungi in Switzerland based on abiotic environmental predictors (geology, topology, climate). Our results show that while a majority of individuals of all species is currently reported to occur in protected landscapes, areas with high habitat suitability vary considerably among species and do not necessarily overlap with key areas for conservation. The modelling approaches allow to detect potential habitat for individual species. Moreover, candidate regions for new key areas for conservation for a maximum number of fungal species can be defined in order to optimize conservation efforts under space constraints along rivers.

More losers than winners: response of common Lepidoptera species to nitrogen enrichment in their host-plants

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The recent decline of Lepidoptera species strongly correlates with the increasing intensification of agriculture in Western and Central Europe. However, the effects of changed host-plant quality through agricultural fertilization on this insect group remain largely unexplored. We tested the response of eight common butterflies and moths, feeding on different plant families, to host-plants fertilized with quantities usually applied in agriculture. Larvae of *Aglais io*, *Aglais urticae*, *Coenonympha pamphilus*, *Lycaena phlaeas*, *Lycaena tityrus*, *Pararge aegeria*, *Rivula sericealis* and *Timandra comae* were distributed to three treatments comprising one control treatment without fertilization and two fertilization treatments with an input of 150 and 300 kg N ha^{-1} yr^{-1}, respectively. Fertilization raised the nitrogen concentration in all three host plants, *Poa pratensis*, *Rumex acetosella* and *Urtica dioica*. However, the fertilized plants increased the survival rate of the larvae only in both nettle-feeding butterflies, *A. io* and *A. urticae*, whereas they decreased the survival by at least one third in the six grass- and sorrel-feeding species. This different response undermines the general applicability of the well-accepted nitrogen-limitation hypothesis, which predicts a positive response in insect performance to dietary nitrogen content. Our study thus presents the first evidence that Lepidoptera species from oligotrophic and mesotrophic habitats do not tolerate the current fertilization quantities in agriculture and that this might contribute to their range-wide decline.

Newly created wood pastures as a tool for bird and grasshopper conservation

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In Central Europe, over centuries forests and agricultural land were tightly linked by a multitude of agricultural activities like grazing, coppicing and litter collection, resulting in open, light forests with a high structural complexity and biodiversity. By the end of the 19th century the focus of forest use shifted towards timber production and forests and agriculture became strictly separated. However, recently forest grazing has received more and more attention as a tool in nature conservation. In order to elucidate the value of newly created (< 10 years) wood pastures for the conservation of birds and grasshoppers we selected nine wood pastures (WP) in southern Rhineland-Palatinate (Germany). In all of them part of the trees had been mechanically removed to create more open conditions. WP are grazed with different types of livestock, i.e. goats, sheep, cattle or donkeys. Next to each WP an ungrazed forest (F) and an open pasture (OP) were selected as controls. In summer 2017 birds were recorded via territory mapping. Grasshoppers were recorded via standardised transect surveys complemented by the use of a beating sheet in order to record arboreal species. We found higher bird diversity in WP (Simpson index = 0.88) compared to OP (0.77) and more individuals per ha (7.45) compared to both F (5.72) and OP (3.62). Target species for conservation like European nightjar (*Caprimulgus europaeus*) and tree pipit (*Anthus trivialis*) could only be recorded in WP. Grasshopper diversity in WP and OP was comparable (0.66 and 0.70, resp.) while it was low in F (0.27). Species with conservation relevance like wart-biter (*Decticus verrucivorus*) and saddle-backed bush cricket (*Ephippiger ephippiger*) occurred in both WP and OP but not in F. We conclude that even in recently established sites forest grazing is a very effective tool in nature conservation, especially in order to promote bird and grasshopper species that favour open forest habitats with a high structural diversity.

Survival rates of the yellow-bellied toad (*B. variegata*) on the basis of a current census and existing long-term data

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The yellow-bellied toad (*Bombina variegata*) is a European endemic amphibian species. As a consequence of irreversible modifications in the landscape, the primary habitats (flood plains) were mostly destroyed and the species settled in water-filled tracks in forests, reflecting the disturbance regime of flood plains. This species experienced drastic recent declines and is listed in the annex II and IV of the European FFH-Directive and is an official national species of responsibility of Germany. As an originally classified species of open areas, studies in forest areas are generally rare and many forest populations are often ignored in national restauration programs. As many studies are often short-time studies, limited in their contribution to a full ecological understanding, this study aims to fill these knowledge gaps. In connection with a comprehensive census of the current population in a forest area in Germany in 2017, existing long-term data and pictures of the study area of the last 20 years were analysed, making this the first long-term study of its kind. Of extremely high importance is, in connection to the data of 20 years, the individual belly pattern of each animal. This made it possible to track and analyse each individual since 1997 by the pattern identification software AmphIdent, allowing a long-term examination of a whole population based on individuals. This study not only contributes new insights into the maximum age reached by this species in the wild, but also for the survival rates and recapture probabilities based on analyses with the software MARK. Further, the influence of different types of small ponds and pools on last year's reproduction success was investigated. All of these new insights are important for the development of a successful management plan and sustainable conservation of this species in forest areas, in order to meet the legal demands of the FFH-Directive.

Is there local adaptation in plant species to soil reaction?

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Seed-sourcing for ecological restoration is currently a highly debated issue in conservation. Where to take the seeds from, when ist he reintroduction of plant species necessary? In Germany there have been efforts made to delineate regions of seed origin for restoration based on physical landscape attributes. The purpose is to use only plants that are locally well adapted to their specific region. But the defined regions depend mainly on climatic conditions, ignoring other abiotic factors such as soil conditions. In this study, we test whether there is also local adaptation to soil pH and if this is similarly strong as or even overruling adaptation to climate. In a common garden experiment we tested six species from acidic and calcareous substrate of three regions and compared them with the performance of propagated regional mixtures from a seed trader (Regiosaatgut). In a reciprocal experiment plants from acidic and calcareous grasslands were planted into substrates with low or high pH-value respectively and vice versa. Results show that there are indeed differences for example in growth height and number of inflorescences between plant individuals from different sources. Remarkably, plants planted on substrate with low pH-value produced considerably more inflorescences – independent from their origin. But preliminary results indicate that there was no overall effect of the soil pH at the source on plant performance in the experiment. So in our example local adaptation to soil pH seemed to be less important than adaptation to regional climate.

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

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One of the key questions in ecosystem restoration is the choice of the seed material for restoring plant communities. The most common strategy is to use local seed sources, based on the argument that many plants are locally adapted and thus local seed sources should provide the best restoration success. However, the evidence for local adaptation is inconsistent, and some of these inconsistencies may be due to different experimental approaches that have been used to test for local adaptation. We illustrate how conclusions about local adaptation depend on the experimental design and in particular on the method of data analysis. We used data from a multispecies reciprocal transplant experiment and analyzed them in three different ways: (1) comparing local versus foreign plants within species and sites, corresponding to tests of the 'local is best' paradigm in ecological restoration, (2) comparing sympatric versus allopatric populations across sites but within species, and (3) comparing sympatric and allopatric populations across multiple species. These different approaches are related to different experimental designs. While a local versus foreign comparison can be done even in small experiments with a single species and site, the other two approaches require a reciprocal transplant experiment with one or multiple species, respectively. The three different analyses led to contrasting results. While the local/foreign approach indicated lack of local adaptation or even maladaptation, the more general sympatric/allopatric approach rather suggested local adaptation, and the most general cross-species sympatric/allopatric test provided significant evidence for local adaptation. Our analyses demonstrate how the design of experiments and methods of data analysis impact our conclusions on the presence or absence of local adaptation. While small-scale, single-species experiments may be useful for identifying the appropriate seed material for a specific restoration project, general patterns can only be detected in reciprocal transplant experiments with multiple species and sites.

POSTER PRESENTATIONS

SESSION 8-P1

Loss of diversity under protection – vegetation changes since 1955 in a long term protected conservation area

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Since the 1950s, land use changes caused an ongoing decline of semi-natural grasslands within the agricultural landscape of Central Europe. We were interested in the vegetation development of a large area of calcareous grasslands and oat grass meadows which is under protection since 1938. It was mapped in 1955 before land use changes started on a large scale. We asked the following questions: Did vegetation or species composition change since 1955? What is the distribution of phytosociological communities in 1955 and today? Did management, environment or even both cause any shifts? The study area is located on the Swabian Alb (Baden-Wuerttemberg, Germany). We compared historical and current phytosociological maps, as well as land use maps, to illustrate spatial and temporal changes within the study area. Additionally, we analyzed the development of species assembly in the respective communities and environmental parameters over the last 60 years by comparing vegetation relevées as well as applying Ellenberg and land use indicator values. Further, we examined the actual environmental conditions on the basis of soil chemical and physical parameters. During the last 60 years, 23 % of the grassland (communities) were replaced by fallows (incl. shrublands) and forests. The number of species, especially of the currently endangered ones, decreased in both plant communities, oat grass meadows and calcareous grasslands. Further, the homogenization of fodder and grazing tolerance values, as well as soil moisture and nitrogen indicator values constituted a gradual loss of habitat diversity. Species assembly in the plant communities changed since 1955. In oat grass meadows high cutting frequencies and the application of fertilizers resulted in a more uniform species composition, while abandonment and eutrophication caused the changes in calcareous grassland communities.

SESSION 8-P2

Pinus peuce and its habitats in Montenegro

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Pinus peuce Griseb is one of the two European pine species from subgenus *Strobus*. It is tertiary relict and endemic to the Balkans, occuring at the upper tree line in high mountains in Montenegro, Serbia, Albania, FYR Macedonia, Greece, and Bulgaria. The species is characterised by small and scattered populations often influenced by the Mediterranean climate. It is of special importance and provides several ecosystem services mainly related to biodiversity conservation. *P. peuce* is classified as nearly threatened by IUCN and is protected in Montenegro. With this work we aimed to provide relevant hints about the future conservation strategies for this tree species by undertaking four studies on *P. peuce* forests in SE Montenegro. These were: (a) genetic characterisation, which is considered as urgent for populations of forest species with geographically limited and fragmented distribution. We characterize genetic diversity of *P. peuce* by means of microsatelite genotyping: 11 nuclear and 6 chloroplast microsatellite markers (nSSRs and cpSSRs) selected among available genetic resources for *Pinus* spp. Comparison with remnant *P. peuce* populations from other areas and with other pines from the subgenus *Strobus* will provide an estimation of the divergence time and historical rates of gene flow; (b) the study on the growth restricting factors such as drought stress using stable isotope analysis. At the same time isotope signatures of *P. peuce* timber for selected sites were established; (c) the study on fungal communities that represent the largest microbial component associated with the living trees and directly influence several physiological processes, including carbon, nutrient and water cycles and may determine forest health and sustainability. Fungal communities were detected and identified in needles, roots and rhizosphere soil; (d) extended soil analysis that was carried out to establish physical and chemical properties of soils characteristic to *P. peuce* populations.

SESSION 8-P3

Natural restoration of disturbed forests by *Salix caprea* L.

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The natural restoration of disturbed temperate and boreal forests of the northern hemisphere through pioneer tree species provides an opportunity to convert unstable, human-made coniferous forests to stable, uneven aged mixed stands. Mixed stands can generate forest ecosystems rich in species, habitat and structural diversity, and improved ecosystem functioning. Willow species, especially *Salix caprea* L., are of great ecological importance in this context. The genus enhances soil nutrition, serves as a structural element with a long-term stabilizing effect, and provides habitat and food for many organisms. However, knowledge of the timing and extent of seed dispersal in *S. caprea* is rudimentary as yet. A study of seed dispersal and genetic offspring relationships was undertaken to address this shortcoming. The study took place on five windthrown forest sites of between 4–13 ha, at high altitudes and along ridges in the spruce-dominated Thuringian Forest in Germany. All *S. caprea* seed trees were mapped up to a search-zone distance of 500 m from the closest site edge and the gender determined for each individual. Seed densities decreased rapidly with increasing distance from the source. Highest seed densities occurred under the crowns of seed trees. However, seed densities of sufficient quantities to be of benefit from a silvicultural perspective were observed even far from seed trees (> 200 m). Seed dispersal was analyzed applying a phenomenological model. The models revealed no significant influence (i) of wind direction on seed dispersal direction or (ii) of seed tree positions on deposited seed densities. Parenthood analyses were carried out on one site. The low allele coincidences between the parent and the regeneration population, and the higher number of additional alleles of seedlings, suggested a significantly larger *S. caprea* parent population than the number of trees mapped within the search-zone. The study revealed that the dispersal potential of *S. caprea* has been underestimated until now.

SESSION 8-P4

Drivers of moth diversity in relation to habitat-scale and landscape-scale characteristics

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Biodiversity is essential for maintaining the functionality of ecosystems but itself is in crisis, as the Earth is currently facing diversity-loss at an unprecedented rate. Under a conservation perspective, understanding the relative importance of different drivers of biodiversity loss is one of the key goals. For protected areas surrounded by intense land-use, the landscape matrix as well as habitat quality inside the reserves are known to affect biodiversity. Disentangling the complex interplay between these two spatial layers can be important to increase the effectiveness of conservation management. To investigate habitat to landscape scale drivers of biodiversity, we studied moth communities in two isolated forest reserves near Ravenna (NE Italy). Moth sampling was done using automated light traps at 60 downy oak forest sites. Furthermore, we collated a multitude of local and regional factors like soil pH, tree crown density, plant species composition and landscape characters at three perimeters (from 200 to 1,000 m radius) around the sites. With this design we aimed to cover as much as possible the site-to-site variation that might explain changes in moth diversity within the two reserves. Thus far, more than 8,000 moth individuals of over 240 species have been analyzed. We found that besides local factors like plant diversity, moth communities are determined by regional drivers like the proportion of forest or reed area. Moreover, external stressors (viz. distance to intensely managed arable land) have significant influence on moth communities. Also affiliation of sites to one of the reserves is important. This leads us to conclude that besides local and regional drivers, the regional species pool (that might be affected by stochastic extinction events due to isolation) has been essential for shaping local moth diversity. Overall, we can explain 28 % of the total variation of moth assemblages between the sites.

SESSION 8-P5

Prescribed fire as an alternative measure for the conservation of grasslands

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Traditional fire use was an important part of the landscape management for millennia. Nowadays the majority of human-ignited fires are uncontrolled, which often have serious negative impacts on human life, property and biodiversity. The impacts of fire on grassland biodiversity are scarcely documented and there are contrasting opinions on the perspectives of prescribed burning management in European grasslands. One hand, prescribed burning can be a cost-effective method for the management of open landscapes, the reduction of accumulated litter and for decreasing wildfire risk. On the other hand burning can lead to the encroachment of competitor and invasive species and can threaten endangered plant and animal species; thus, inappropriate burning can result in a loss of biodiversity. Our goal was to review the publications on the application of prescribed burning in European grasslands considering general (timing, frequency and duration) and specific (grassland types, effects on endangered species) circumstances. We also reviewed prescribed burning studies from North-America to identify findings which can be adapted to the European grassland conservation strategy. We found that not only the application of fire management is scarce in Europe but there is also a lack of published studies on this topic. European studies – contrary to the North-American practice – usually used yearly dormant-season burning, and concluded that this burning type solely is not feasible to preserve species-rich grasslands. In North-America, application of burning has a stronger historical, practical and scientific background; it is fine-tuned in terms of timing, frequency and generally combined with other measures, such as grazing, seed sowing or herbicide application. By this complex approach several nature conservation goals can be fulfilled like increasing landscape-scale heterogeneity and invasion control. For establishing fine-tuned prescribed burning management plans for European grasslands the general findings of carefully designed case-studies should be combined with the practical knowledge of conservation managers.

SESSION 8-P6

Balancing biodiversity and erosion control on river dikes

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Flood protection gets improved in many countries including the construction and enlargement of river dikes. In Bavaria, conservation agencies regard these structures as secondary habitats for species-rich grassland communities in an intensively used agricultural landscape. The river authorities, on the other hand, expect these grasslands to serve as protection against erosion. Stands with a high above- and belowground density are desired on the water side, while on the land side topsoil slippage is a central problem. This allows for more diverse vegetation, if tap-rooted forbs establish. A vegetation and soil survey was conducted to evaluate the establishment of high-value grassland, using an official classification scheme of value points. Sampling took place on dikes constructed during the past 15 years along the Danube in Lower Bavaria. In general, high nutrient levels were found as former agricultural top soil was used in construction. However, no soil characteristics explained the distinction of mesophytic and semi-dry grasslands nor their floristic value. However, top soil thickness showed a negative correlation with the occurrence of high-value semi-dry grasslands. This indicates that less competitive species profited of a low field capacity and low absolute nutrient stocks in the topsoil, since these variables were highly correlated with top soil thickness. Evidence for future construction planning is provided by a field experiment established in spring 2018. It consists of 288 plots in six blocks on both sides of an existing dike section. Experimental treatments comprise different target vegetation types, seeding densities, topsoil depth and sand content. Sampled variables include vegetation structure and composition with a focus on plant establishment of calcareous grasslands. Furthermore, the above- and belowground vegetation structure is analyzed in terms of their fitting the requirements of erosion control.

SESSION 8-P7

Keystone species complexes in food webs

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Understanding and quantifying the relative importance of species (and functional groups) in an ecological community is not easy. A systems ecology perspective and the toolkit of ecological network analysis help to make quantitative predictions on key elements of food webs, candidate keystone species, and the surprisingly important direct and indirect interactions they are involved in. We present a novel approach that focuses on small groups of key species and identifies the small cores of ecological communities, keystone species complexes. We illustrate this novel approach on several examples, discuss ist limitations and its future potential.

SESSION 8-P8

The biology of loops in aquatic food webs

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In community ecology, network perspective can be useful in answering many different questions: besides describing and comparing different systems, it is often used in conservation biology to quantify the relative importance of functional groups and to identify keystone species within ecosystems. Despite the fact that food webs seem to be strictly hierarchical, food web models often contain so-called 'loops'. The biological/methodological reasons and consequences of the occurrence, frequency and distribution of these cycles are still poorly known, although they are likely to have a significant impact on the structure of the network and the estimated importance of the species. In this presentation, we summarise the biological analysis of the loops in 93 different aquatic food webs in order to clarify the correlations mentioned above.

SESSION 9

Ecological impacts of pesticides on non-target organisms

Chairs: Johann G. Zaller, Carsten Brühl

Pesticides and their distribution outside agricultural areas

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Pesticides are increasingly applied in agricultural crops on a global scale. However, these chemicals are not only present in the cropped areas in agricultural landscapes where they are applied but are also transported to other habitats. This transport acts on different scales. Pesticides reach field margins and hedges in the vicinity of agricultural fields by drift and run-off, and also over-spray occurs. They are also transported to remote montane areas, more than a few hundred kilometres from the agricultural fields where they were applied. And there are also global transport processes of some pesticides that finally reach arctic regions. It is important to recognise that pesticides are not restricted to fields in agricultural landscapes since they are biologically highly active substances that can cause effects at very low levels. The examples from working groups around the world include temperate and tropical regions to emphasize the generality of these transport processes. The assumption of studying a visually pristine habitat should be evaluated carefully by ecologists as pesticide presence can be a factor for observed species or biodiversity declines or changes in communities or behaviours and contamination can occur at long-distances from agriculture.

Protecting insects from pesticide effects – current status and perspectives

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In the EU, pesticides underlie an extensive environmental risk assessment procedure before authorisation. At the same time, there is strong evidence on a decline of insect biomass and diversity in agricultural landscapes, with the use of pesticides in intensive agriculture being discussed as one of the relevant drivers. This discrepancy suggests revising the current pesticides risk assessment and management schemes including the underlying data requirements and technical guidelines. We will give a critical view on the focus and the methods used in insect-related environmental risk assessment in current authorisation procedures of pesticides. In this context, we will pinpoint deficiencies and open questions and inform about the current state of the discussion on how to improve the risk assessment schemes as well as the risk mitigation in the agricultural practice. It becomes obvious that support by science will be needed to close relevant knowledge gaps. A tremendous amount of literature on the effects of the agricultural land use on biodiversity is available. Research on landscape structure, intensification, monoculture and so forth and their influence on the diversity of insect populations and on the ecosystem is published regularly. But mostly, the relevance of pesticides use for the observed patterns is not studied. Hence, an additional focus on pesticide in landscape ecology and biodiversity research is desired in order to intensify the cooperation between research and pesticide regulation.

Prediction of multiple stress effects

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The biodiversity crisis is the consequence of various anthropogenic stressors including climate change, habitat loss and toxicants. Additionally, organisms are generally confronted with a wide range of natural stressors related to unfavourable environmental conditions and individual interactions. These multiple stressors act in concert and may result in synergistic biological effects. Effective risk assessment and management of anthropogenic stressors need the ability to predict such combined multi stressor effects. We present an approach to predict the combined effects of multiple stressors. We revealed that stressor combinations synergistically increases individual sensitivity to stressors by a factor of up to 100. With our approach, we provide a tool that quantitatively predicts the direct effects of stressor combinations.

Biodiversity protection and pesticide regulation

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Biodiversity has become a key concept of nature conservation. The Convention on Biological Diversity aimed at halting the loss of biodiversity by 2010. However this was not achieved and a new strategy was adopted by the EU to halt the biodiversity loss in 2020. Maintaining biodiversity is an inherent goal of EU legislation such as Directive 92/43/EEC (Habitats Directive), Directive 79/409/EEC (Birds Directive), Directive 2000/60/EC (Water Framework Directive). Nature conservation efforts are often focused on pristine areas. However, agricultural landscapes are significantly larger than protected areas in Europe and a rapid decline of typical farmland species was observed over the last decades e.g. partridges. The pesticide Regulation (EC) no 1107/2009 states that a pesticide, in order to be approved, shall have no unacceptable effects on the environment and specifically (among other considerations) it should have no unacceptable effects on biodiversity and the ecosystem. For implementing this legislative requirement in risk assessment schemes EFSA developed a methodology to derive specific protection goals for risk assessment based on ecosystem services. Biodiversity should be covered in this approach as part of the ecosystem services which should be maintained in the agricultural landscape (e.g. pest control, food web support, aesthetic values). The risk assessment and approval process for active substances and plant protection products is based on a specific use in a certain crop. The overall risk for populations of non-target organisms dwelling in agricultural landscapes from multiple uses and other agricultural practices is currently not evaluated as this is not required in the pesticide regulation. A landscape based risk assessment taking into account multiple stressors and clearly defined protection goals will be more efficient in ensuring the protection of biodiversity in agricultural areas.

How glyphosate fights non-target biodiversity

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The currently high intensity of glyphosate applications in German agriculture indicates a systematic and constitutive dependency of farming on a total herbicide. This is in contrast to the commitment to Integrated Pest Management in German laws. Agricultural intensification with agrochemicals and the simplification of agricultural landscape structure is closely related to the recent biodiversity decline of insects, farmland birds and further taxa. Since 1990, three quarters of insect biomass has vanished from protected areas, and half of all endangered insect species suffered from further population declines. Direct effects of glyphosate applications include the disappearance of most of the ca. 300 arable weed species from arable fields as well as toxic effects on the soil fauna and amphibians. Particularly important are the indirect negative effects of glyphosate, as the loss of rich arable weed communities is associated with losses of belowground and aboveground foodwebs. This also affects faming birds, which experienced halving of their populations during the last decades. The current development to species poor, monotonous agricultural landscapes can only be stopped if policy changes towards biodiversity friendly management. This includes banning of total herbicides such as glyphosate and a move to biodiversity friendly farming systems maintaining or restoring multifunctionality of cultural landscapes.

Taking plant-soil feedbacks to the field: a novel experimental approach

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Plant-soil feedbacks (PSFs) involve changes to the soil wrought by plants, which can alter the biotic and abiotic properties of the soil, in turn affecting the performance of plants that grow in the soil at a later time. The importance of PSFs for understanding ecosystem functioning has been the focus of much recent research, for example, in predicting the consequences for agricultural production, biodiversity conservation, and plant population dynamics, particularly under global climate change. Here, we describe an experiment that was designed to test the effects of PSFs under field conditions. To our knowledge, this is one of the first large-scale field experiments of its kind. We removed the existent plant community and replaced it with target plant communities that consisted of contrasting grass and forb combinations. This was done in two successive years in two different subplots in order to investigate temporal aspects of soils that were conditioned by the same plant community. We created plant communities that consisted of species that were either 'fast' or 'slow' growing plants, in accordance with the plant economics spectrum. We choose this well-established paradigm because plants on opposite ends of this spectrum differ have developed contrasting strategies to cope with environmental conditions. This means they intrinsically differ in their feedbacks with soil abiotic and biotic factors. The unique and novel design of this experiment allows us to simultaneously test for the impacts of temporal effects, plant community composition and plant growth strategy on PSFs. Here, we present the experimental design and the preliminary ecosystem responses to the treatments (i.e., respiration, decomposition, soil microbial communities). Advancing our understanding of how the strength and direction of PSFs vary at the community level under natural, field conditions is critical to better predicting ecosystem function and initiating more successful restoration.

Anthelmintics negatively affect seed germination of three temperate grassland species

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Anthelmintics are regularly applied to control gastrointestinal nematodes in domestic ungulates worldwide. Among anthelmintics, macrocyclic lactones currently play a central role in animal farming since they have a high effectiveness and a broad action spectrum. However, it is well known that the residues of these substances are excreted with ungulate faeces and adversely affect decomposers. By contrast, knowledge about possible effects on wild plants is scarce. To bridge this gap of knowledge, we tested for effects of three anthelmintic formulations (Alfamectin, Cydectin, Dectomax) and its active ingredients (ivermectin, moxidectin, doramectin) on seed germination. We conducted a feeding experiment with sheep focusing on Cydectin and germination experiments in a climate chamber including all test substances. Three wide-spread plant species of temperate grasslands (*Centaurea jacea*, *Galium verum*, *Plantago lanceolata*) were studied. In the feeding experiment, the number of seedlings emerging out of faeces of sheep treated with Cydectin was significantly lowered by almost two thirds compared to seedling emergence out of faeces of untreated sheep. In the germination experiments, we found significant negative effects of both, formulations and active ingredients, on germination, e.g. percentage, speed, and synchrony of the tested species. Our study shows for the first time that anthelmintics have the potential to negatively affect plant regeneration. Our results suggest that treatments of livestock with anthelmintics should be carefully timed to not impede endozoochorous seed exchange between plant populations.

Potential pesticide exposure during the post-breeding migration of the common toad (*Bufo bufo*) in a vineyard dominated landscape

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Agriculturally used areas are the dominant landscape type in many parts of Central Europe. Within this matrix, structures like hedges, fallows or streams can be important habitats for a variety of taxa. The ongoing intensification of agriculture often leads to monocultures that can only be maintained by an extensive use of pesticides. Species living in or near agriculturally used areas are therefore potentially exposed to pesticides. As amphibians often use man-made ponds in agricultural landscapes as breeding habitats, they are considered as textbook examples for non-target species of such xenobiotic chemicals. Although many studies focused on the effects of pesticides on the aquatic life stages of amphibians, recent studies showed that there might be an underestimated risk during the terrestrial stage. However, data on the terrestrial habitat use of amphibians in agricultural landscapes that allow an estimation of the exposure risk are scarce, although they would be important for an effective pesticide risk assessment. To fill this knowledge gap we used radiotelemetry to investigate the habitat use and post-breeding migration of 51 adult common toads (*Bufo bufo*) from one breeding pond in a vineyard-dominated landscape near Landau in der Pfalz (Germany) between March and September 2017. We located the toads on a daily basis, recorded every movement over 30 cm and described the occupied habitat. To determine a possible spatial-temporal overlap of pesticide application and the migration of *B. bufo* we noted all pesticide applications observed during the field work in our study area and combined them with data from local farmers. On average each toad was relocated 44 times and over 500 position changes with an average distance of 37.5 m (max = 480 m) between two positions could be recorded. Most of the movements ended in different types of embankment, but 20 % of all movements ended in a vineyard where toads spent 15 % of the total time. Our data show not only how important a richly structured landscape is for amphibians, but also that there is indeed a high risk of pesticide exposure during the post-breeding migration that should be considered in an upcoming pesticide risk assessment for amphibians.

Using Unmanned Aerial Vehicles (UAV) to assess the effects of insecticides on Lepidoptera in oak forests at the individual tree level

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Assessing the effects of aerially sprayed insecticides on arthropods in tree crowns poses methodological challenges. Experimental set-ups are often constrained by logistical and financial obstacles generating design flaws such as insufficient or pseudo-replication. Resulting problems of heterogeneity among sites and lack of statistical power make it difficult to interpret results and may lead to biased estimates, particularly in assessments of non-target effects. Here we tested a tree-level approach using an Unmanned Aerial Vehicle to simulate aerial application to overcome replication issues. This experimental design was used to test the effects of the insecticides diflubenzuron and tebufenozide on folivorous Lepidoptera in a Bavarian oak stand infested with lepidopteran defoliators. Individual trees selected based on their pre-spray density of lepidopteran defoliators (high or low) were sprayed with one of the two treatments or left unsprayed in a fully factorial design. We sampled caterpillars dropping from the tree crowns following insecticide application and used this variable as a proxy for mortality. Frass droppings were also collected and used as a proxy for feeding activity. Insecticide application resulted in an increased mortality and a decreased feeding activity, with tebufenozide showing the strongest effect on both variables. Tebufenozide strongly increased mortality in the macrolepidopteran families Geometridae, Noctuidae and Notodontidae. Microlepidoptera were less affected, with only a marginal effect on Tortricidae and no effect on Pyralidae. Diflubenzuron had a very strong effect on Notodontidae, but did not appear to affect other families. Differing responses among macrolepidopteran families seemed to be primarily related to differences in larval phenology. Ecological factors such as shelter-making behavior may explain differences between Macro- and Microlepidoptera, but physiological mechanism may also come into play. The observed overall difference in potency between both insecticides was likely related to application rates. Our results showed that tree-level design using UAV technology allow for a more powerful and cost-effective assessment of target and non-target effects of aerially sprayed insecticide in forest. This type of small-scale studies could be used to link data from laboratory trials and large-scale experiments for more comprehensive assessments of the side-effects of aerial application on forest arthropods.

Forest biodiversity trades off against timber production but not revenue in the Oregon Coast Range

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Management intensification is a ubiquituous phenomenon in agricultural and silvicultural systems around the globe. Pesticides play a prominent, yet highly controversial role for the intensification of these production systems, as they can increase yield, but may also cause unintended negative side effects to biodiversity, ecosystem and human health. While biodiversity often trades off with yield in intensive production systems, it remains unclear how investment decisions affect biodiversity-revenue relationships. Here, we combined discounted cash flow analysis with seven years of biodiversity surveys (140,406 observations of 835 taxa) from a land-use intensity experiment on 32 commercial forest stands in Oregon, USA, randomly allocated to one of the following four treatments: light, moderate or intensive stand-scale herbicide treatments, as well as a no-herbicide control treatment. Herbicides caused yield-biodiversity tradeoffs: 5 - 49 % fewer species matched a 20 % yield gain under the typical rotation age, and the magnitude of the trade-off increased with increased rotation age. Herbicide effects on financial revenue were highly context-dependent (i.e. dependent on discount rate), and ranged from +40 % to −40 % across commonly used discount rates. At high discount rates the revenue-biodiversity relationship was decoupled from yield-biodiversity tradeoffs, resulting in biodiversity-revenue 'win–win' scenarios for risk-tolerant investors. This provides a previously unknown conservation opportunity for production systems that comprise roughly half of the global land surface.

You are what you eat: does mosquito control affect predators by altering wetland food chains?

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Since the discovery of its pathogenic activity in the late 70's *Bacillus thuringiensis* serotype *israelensis* (Bti) is used worldwide for the control of larval mosquitoes in seasonal wetlands. These temporary wetlands appear to offer suitable breeding sites for many aquatic organisms including mosquitoes but also amphibians, which are currently the most threatened group of vertebrates. Moreover, mosquitoes and the non-target chironomids constitute an important food resource for various predators during their aquatic life stages. However, there are only few studies that address the ecological compatibility of Bti treatments and specifically consider indirect effects through shifts in vulnerable wetland food webs. Hence, we conducted mesocosm experiments where newt larvae as key organisms were exposed to realistic stressors of seasonal wetlands in a two factorial design: Bti and predation by a dragonfly nymph. Next to the abundances of pelagic and benthic organisms, we studied the development and body condition of palmate newt (*Lissotriton helveticus*) individuals in Bti influenced food chains. Subsequently, we assessed the survival and development of several newt larvae under the presence of a dragonfly nymph (*Aeshna cyanea*). By means of variation in stable isotope values ($\delta^{13}C$, $\delta^{14}N$), we observed the trophic status of predators and differences in their food sources. Chironomids served as important food source for newt larvae but were significantly reduced after the Bti treatment. Furthermore, palmate newts showed a slightly lower body weight at the end of metamorphosis. The presence of the dragonfly nymph caused 25 % lower survival rates in newt larvae that are exposed to Bti. These results on indirect effects reveal evidence that the large scale application of Bti in seasonal wetlands should be considered more carefully since they serve as ecosystems desired to be conserved and also provide habitat for species in need of protection.

POSTER PRESENTATIONS

SESSION 9-P1

Pesticide effects on biodiversity

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In this poster we will present the potential direct and indirect effects of different pesticide classes on biodiversity. To be discussed.

SESSION 9-P2

Direct effects of mosquito control with *Bacillus thuringiensis israelensis* (Bti) on the European common frog (*Rana temporaria*)

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Bacillus thuringiensis var. *israelensis* (Bti) is presumed to be an environmentally friendly agent for use in either health-related mosquito control or the reduction of nuisance associated with mosquitoes from temporary flooded wetlands. Amphibians co-occurring with mosquito larvae in seasonal wetlands may be exposed to Bti products several times during their breeding season. Up until now, information regarding effects on the non-targeted group of amphibians has to be considered rather inconsistent. On this account, we evaluated how repeated exposures to frequently used Bti formulations (VectoBac®12AS, VectoBac®WG) in field-relevant rates affect European common frog (*Rana temporaria*) larvae. In a laboratory approach, tadpoles experienced exposure conditions similar to realistic mosquito control in the Upper Rhine Valley, Germany. We assessed potential effects with regard to enzymatic biomarkers (glutathione–S–transferase, glutathione reductase, acetylcholine esterase), development, body condition and survival until the end of metamorphosis. Regardless of the formulation, delivery form or application rate, tadpole survival rates and time to metamorphosis were slightly reduced after repeated Bti exposures, while body condition was similar throughout the treatments. Furthermore, Bti induced significant increases of all enzymatic activities irrespectively of the applied field rate and formulation, indicating oxidative stress as well as neurotoxic effects. Repeatedly executed Bti applications, especially acting on early developmental stages, seem to increase the risk for adverse effects. The examination of several biochemical markers is needed to evaluate the ecotoxicological risk of Bti for amphibian populations, especially in the context of worldwide amphibian declines. Nevertheless, following the precautionary principle, it may be advisable to implement certain thresholds for application numbers and intervals in order to ensure environmentally friendly mosquito control programs, especially in areas designated for nature conservation.

SESSION 9-P3

Effects of pesticides on the development of two European amphibian species: a long-term semi-field study

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Amphibians are declining worldwide and pesticides have been identified as one of the major reasons for these declines. Most studies examining the effects of pesticides on amphibians are conducted in simplified aquatic laboratory set-ups. However, most pesticides in the environment are present in mixtures. Therefore, synergistic sublethal effects on amphibians cannot be excluded after a long-term exposure in a natural scenario. The presented ongoing study investigates the effects of a realistic exposure using in situ enclosures on survival, development and fitness-related larval traits like body condition, enzymatic biomarker and swimming performance of *Rana temporaria* and *Bufo bufo* tadpoles. In spring 2018, tadpoles in Gosner stage 20 of each species were placed in enclosures in eight ponds of different degrees of pesticide contamination in the viticultural area around Landau (Pfalz) in Southern Germany. Individuals were removed weekly from the enclosures to determine mass, length, behavioral abnormalities as well as biomarkers for oxidative stress and neurotransmitter inhibition. Moreover, time till metamorphosis was assessed. The study will be proceeded in the terrestrial stage for two more years. The juveniles will be placed on soil exposed to realistic field concentrations of environmentally relevant pesticides and the endpoints mentioned above will be analyzed. To obtain population relevant data, the reproduction of *Rana temporaria* and the survival of next generation tadpoles will be assessed. First results and future plans of the study will be presented. With the findings of this study, the risk of applied pesticides in agricultural landscapes dominated by viticulture can be estimated for German amphibians and thus, the protection of amphibians in agricultural landscapes can be improved.

SESSION 9-P4

The impact of pesticides on insect pollinators: state of knowledge and research opportunities

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Insect pollinators are declining due to agricultural pesticide use among several other factors (e.g. habitat loss, climate change). Latest research on biodiversity in agricultural landscapes suggests that flower-visiting insects (FVIs) such as wild bees and butterflies are not sufficiently protected from the effects of pesticides. To counteract this development and preserve viable pollinator communities, it is necessary to have a detailed understanding of their ecology, assess their exposure towards pesticides and investigate the subsequent effects. Within the research and development project 'Protection of wild pollinators in pesticide risk assessment and management' (FKZ: 3715 64 409 0; funded by the German Federal Environment Agency) we screened the available scientific literature on FVIs and their reaction to pesticide applications. We used this information to identify the relevant FVI groups and assess their current threat level. Furthermore, we determined ecologically vulnerable groups, sensitive life stages and relevant exposure routes based on specific trait combinations. Unfortunately, there was only sufficient data to further evaluate bees and butterflies/moths in contrast to several other potentially relevant groups such as flies and beetles. Moreover, we researched and quantified the exposure of insect pollinator habitats to pesticides. Consecutively, we summarised the existing literature on laboratory and field effects of pesticides and compared effect thresholds to realistic exposure levels. Finally, we proposed research questions to alleviate apparent knowledge gaps and subsequently lead to effective measures to protect insect pollinators from pesticide impact.

SESSION 9-P5

Effects of herbicides on the activity and reproduction of earthworms: pure active ingredient glyphosate vs. commercial glyphosate-based formulations

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Glyphosate is one of the most commonly used active ingredients in herbicides. Even though various studies suggest manifold negative effects on ecosystems and biodiversity glyphosate still is used largely in agriculture and private gardens. The various commercial glyphosate-based herbicides contain glyphosate in different forms including isopropylamine salt, ammonium salt, diammonium salt and potassium salt. Additionally several adjuvants are mixed into these herbicide formulations. The toxicity of the additives can exceed that of the main active ingredient thus resulting in an over-all higher toxicity of the commercial formulation than the pure active ingredient itself. Aim of this study is to assess the effects of three commercial glyphosate-based herbicide formulations and three corresponding glyphosate salts on the activity, survival and reproduction of earthworms (*Lumbricus terrestris*) and associated soil parameters. Additionally, the influence of different humus contents on the accumulation and degradation of glyphosate will be examined. In a greenhouse experiment using 20 l pots containing a weed community, we examine the surface casting activity and the above-ground activity of L. *terrestris*. Reproduction success and mortality are determined at the end of the experiment. To analyse changes in the physiological functions of the nervous system or mechanisms of detoxification in earthworms, the biomarkers Glutathione S–transferase and AChE are examined. Soil temperature, soil moisture and electrical conductivity will be monitored regularly, litter decomposition is assessed using the Tea Bag Index. We further examine degradation and accumulation of glyphosate and its metabolites. We expect the humus content to alter the impact and degradation of glyphosate. We further hypothesize that based on its effects on earthworms, the application of herbicides affects soil functions like nutrient availability and decomposition. This study will be among the first disentangling the effects of three glyphosate active ingredients as compared to their respective commercial formulations on soil biota.

SESSION 9-P6

Non-target effects of three glyphosate-based herbicides and their respective salts of the active ingredient on Collembola and litter decomposition

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Glyphosate-based herbicides are the most commonly used and often discussed herbicides in modern agriculture. Besides glyphosate-salt, as active ingredient, the herbicides contain several not-declared adjuvants. This study aims to test non-target effects of three commercial herbicides (Roundup PowerFlex, Roundup LB Plus, Touchdown Quattro) and corresponding salt forms of glyphosate on the activity of Collembola (*Folsomia candida*). Additionally interacting effects of soil humus levels were tested. *Folsomia candida* is a standard test species recommended in OECD and ISO guidelines and a widely used organism in ecotoxicological research. In many soils, Collembola acting as detritivores are important for nutrient cycling, and act as prey for various arthropods, such as spiders and centipedes. The study was conducted in a greenhouse using 21 l pots filled with arable field soil and planted with *Amaranthus retroflexus* as a model weed population, simulating a microcosm. In each pot 200 individuals of *Folsomia candida* were added, and their surface activity assessed using pitfall traps. The decomposition rate was measured using the tea bag index. Furthermore temperature, soil moisture and electric conductivity were measured regularly. A three-factorial experimental design was used, including factors: (1) the three glyphosate-based herbicides corresponding to (2) glyphosate salt formulations (potassium, isopropylamin, ammonium) and (3) humus content (high and low). Control pots did not receive glyphosate salt or herbicide applications. This is among of the first studies simultaneously testing effects of commercial herbicides versus their active ingredients on Collembola. Greater influence of glyphosate-based herbicides than of glyphosate salts on the activity of *Folsomia candida* is hypothesized due to the effects of the not-declared adjuvants. Overall decreased activity and reproduction of *Folsomia candida* and decreased litter decomposition is expected in the microcosms treated with herbicides and the microcosms treated with glyphosate salt formulations.

SESSION 9-P7

Herbicides in vineyards reduce root mycorrhization, alter soil microorganism and nutrients in various parts of the grapevine plant

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Herbicides are increasingly applied in vineyards worldwide. However, not much is known on potential side-effects on soil organisms or on the nutrition of grapevines (*Vitis vinifera*). In an experimental vineyard in Austria we examined the impacts of three within-row herbicide treatments (active ingredients: flazasulfuron, glufosinate, glyphosate) and mechanical weeding on grapevine root mycorrhization, soil microorganisms, earthworms, and nutrient concentration in grapevine roots, leaves, xylem sap and grape juice. The three herbicides reduced grapevine root mycorrhization on average by 53 % compared to mechanical weeding. Soil microorganisms (total colony forming units, CFU) were significantly affected by herbicides with highest CFUs under glufosinate and lowest under glyphosate. Earthworms (surface casting activity, density, biomass, reproduction) or litter decomposition in soil were unaffected by herbicides. Herbicides altered nutrient composition in grapevine roots, leaves, grape juice and xylem sap that was collected 11 months after herbicide application. Xylem sap under herbicide treatments also contained on average 70 % more bacteria than under mechanical weeding, however due to high variablility this was not statistically significant. We conclude that interdisciplinary approaches should receive more attention when assessing ecological effects of herbicides in vineyard ecosystems.

SESSION 10

Ecological perspectives on urban environments

Chair: Marcela Suarez-Rubio

Technomass, a novel indicator to understand, measure and analyse urbanisation

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Ecological patterns and processes are directly and indirectly affected by urbanisation, which has become a ubiquitous phenomenon even reaching the last of the wild. To date, ecology analysis of urbanisation are dominated by the gradient analysis. Such approach has three important shortcomings: (1) needs a priori definition of 'urban' to build upon categorical assumptions, i.e. Boolean, of urbanisation, where particular land covers are described as urban or non-urban in mutually exclusive manner; (2) secondly, the underlying conceptual assumption is that urbanisation takes place following monocentric urban structures; (3) finally focuses mostly on sealed surfaces, using two spatial dimensions, but not including the third spatial dimension: heigh. In fact, current urbanisation patterns depict highly complex spatial structures, making standard gradient approaches short-sighted. On the contrary, urbanisation rather than categorical is a continuous and progressive process, persistently changing in space and time, and including three spatial dimensions and time. To analyse in a robust conceptual manner how urbanisation affects ecological patterns and processes, better indicators to describe the spatial-temporal complexity of urbanisation are needed. In this contribution, a novel indicator, namely the technomass, is introduced. The conceptualisation of technomass links industrial ecology and urban ecology, understanding urbanisation as a continuous spatial-temporal process of material accumulation. The indicator expresses urbanisation in one single measure, the weight/volume of anthropogenic materials per unit of space and time, which can summarise the complexity of the urbanisation process effectively. As such technomass proposes an operationalisation of urbanisation that is continuous rather than categorical, not needing any apriori definition of urban. At the same time, the indicator is not scaled dependent, as it can be developed and applied at any spatial scale and using different datasets. Technomass allows the description, measurement and analysis of the complex spatial-temporal behaviour of urbanisation, making possible direct comparisons between different geographical settings. The application of the technomass indicator in ecology is highly promising. It can help to advance the understanding of arising ecological processes and patterns, particularly of spatial structures and of community diversity under the pressures of urbanisation all over the world.

Biodiversity of birds along a gradient of urbanization in Bangalore, India

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Worldwide, urban areas are spreading at a massive and ever increasing rate. No other anthropogenic land-use alters the natural landscape in a more dramatic and persistent fashion than urbanization. However, the potential effects of urbanization on wildlife remain a poorly studied topic, especially in tropical and developing countries. In this context, we studied the diversity of birds along a gradient of increasing urbanization in the south Indian boom town Bangalore, which has experienced a rapid and uncontrolled growth in the last decades. Birds are an important component of biodiversity since they provide ecosystem services like pest control and pollination. Due to their cultural significance they are also considered a flagship group to promote conservation. To census them, we employed standardized point counts at 36 farm sites at 3 urbanization stages (urban, peri-urban, rural) during 3 seasons (monsoon, winter, summer). Preliminary results show a negative effect of urbanization on bird richness and abundance. In the first two sampling seasons we recorded a total of 154 bird species and 4,155 individuals. We found both the lowest species richness and abundance within the urban areas (82 species, 1,009 individuals), while the peri-urban areas harbored the highest diversity (128 species, 1,675 individuals), closely followed by rural areas (121 species, 1,471 individuals). Additionally, we were able to show that bird abundance as well as richness was negatively correlated to the proportion of surrounding impervious surface at the landscape scale. Furthermore, preliminary analyses also indicate that bird community composition, as well as ecological traits are influenced by urbanization. Our study highlights the need for more research on the effects of urbanization on biodiversity, especially in developing countries, as the vast majority of future urban expansion will take place in developing regions.

Bats along an urbanization gradient: the relative importance of artificial light and vegetation structure

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Light pollution is an emerging issue threatening biodiversity and nocturnal animals such as insectivorous bats living in urban environments may be particularly sensitive. Although adverse effects on foraging, reproduction and communication are documented, little is known about the role of vegetation structure and light intensity along an urbanization gradient. We analyzed the relative importance of light intensity and vegetation structure on bat activity and activity of selected species along an urbanization gradient (forest, sparse-developed, moderately-developed and highly-developed areas) in Vienna, Austria. We conducted three surveys on 129 sampling points distributed over the four urbanization categories in summer 2015. Bat activity was measured through acoustic surveys, light intensity was determined using a lux-meter and vegetation structure was quantified as tree density of large and small trees and proportion of understory vegetation cover. We also used a light pollution map to examine the influence of light on a broad scale around the sampling points. We found that highly-developed areas had the highest bat activity, whereas sparsely-developed areas had the lowest activity. The activity of selected species varied among the four urbanization categories, highlighting species-specific habitat requirements. Although artificial light had no effect on total bat activity, selected species exhibit different responses. For example, activity of *Nyctalus noctula* was not affected by light intensity, but activity of *Hypsugo savii* and *Pipistrellus pipistrellus* increased, whereas the activity of *Myotis* sp. and *Pipistrellus pygmaeus* decreased. Even though the effect of light on bat activity was species-specific, large trees had a highly positive effect on nearly all species. Thus, it is crucial to foster large trees and reduce light intensity especially near roosting sites of light-sensitive bat species (e.g. *Myotis* sp.) to support bats in urban environments.

Biodiversity matters even in a small urban forest – herb understorey stability after a disturbance

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Small forest fragments, even if within urban and intensively used agricultural landscape, increase local and, in highly fragmented landscape, regional biodiversity. Besides sustaining environmental quality, the urban forests can still provide essential ecosystem services (ES) that help and are beneficial for human health. We focused on differing species richness (S) of herb understorey in late successional (low S) and old (high S) small public urban forest on the same river island in Drava (Slovenia). Both forest types were managed, the old existing continuously for at least 200 years. The island and forest stands there serve a range of multi-purpose functions: recreation, swimming resort since the mid–19th century, a drinking water source, education and biodiversity sanctuary included in the Natura 2000 network. The ecological stability of small forests is crucial for maintaining their benefits and we studied how is it related to their S. In 2012 the island experienced the impact of a 100–year return flood. We had established the baseline data of understorey S and by using permanent plots, we were able to compare the species composition before and after the flood. We analyzed changes in the understorey through Sørensen pairwise dissimilarity indices and investigated differences in species survival and post-flood occurrence changes. Results showed that low S is challenging: recovery was slower, with more new species entering the existing species composition, among them alien invasives. Our study suggests that high initial S forms the basis for better disturbance resilience, with lower mortality and higher similarity to the initial understorey and therefore it is important to maintain high biodiversity in order to sustain the ecological resilience of even small and urban forests.

Garden management impacts soil quality, belowground biodiversity and ecosystem functioning in urban ecosystems

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The majority of people today live in cities. This increasing urbanization can impact biogeochemistry, hydrology and soil quality in cities and affects habitats and the composition of plants and animals. Green spaces such as urban gardens are becoming important refuges for both native and non-native species due to agricultural intensification around the cities and the fast sprawl of urban areas. Urban gardens are thus hot spots for urban biodiversity, both above- and below-ground. They provide a wide range of ecosystem services and are considered important for human health and well-being. However, only few studies have investigated soil functions and diversity of urban soils. Consequently, little is known about the human impact on soil quality, biodiversity and ecosystem functions in cities. To fulfil this gap, we assessed soil quality in 85 urban gardens and inventoried biodiversity, while running a decomposition experiment of standardised leaf litter in the city of Zurich, Switzerland. Our results show that distinct habitat types strongly affected both soil quality and litter decomposition. Soil fauna species richness was the principal driver of litter decomposition and the quality of litter residues. Multilevel structural equation model highlighted direct and indirect effects of garden management, garden environment and soil properties on litter decomposition. Urbanization described as the urban heat island effect had a positive effect on decomposition and affected several measures of soil quality. We conclude that soil quality indicators, habitat management, biodiversity and particular environmental variables of cities need to be considered to better understand urban ecosystems and promote soil based ecosystem services.

The impact of urbanisation and forest size on plant-galling infestation rates and leaf damage on young trees of three species

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Urbanisation is increasing globally and is considered to be a major driver of environmental change. Urbanisation-related factors including reduced habitat size and increased spatial isolation can change the dynamics of plant and animal populations in the remaining green areas. Urbanisation also can alter the abiotic conditions in the remaining habitat patches, which in turn may influence the quality and quantity of available plant resources. Consequently, urbanisation has the potential to disturb plant-animal interactions. In the urban-rural setting of Basel-city, we aimed to test whether the degree of urbanisation and forest size influence plant-galling infestation rates as well as the leaf area damage by mining and chewing arthropods on three tree species (sycamore, beech, and ash). We found tree species-specific responses to the degree of urbanisation and forest size. Gall infestation rate on sycamore was not affected by urbanisation and forest size. In contrast, gall infestation rates of beech and ash by gall midge species (Diptera: Cecidomyiidae) responded sensitively to increasing urbanisation and decreasing forest size. Among the mining and chewing arthropods, the percentages of leaf area damage in beech and ash were not influenced by urbanisation, whereas total leaf area damage on sycamore leaves increased with increasing forest size. The different responses of plant-galling, mining and chewing arthropods to urbanisation and forest size can be explained by differences in their biology and habitat requirements at different life history cycle stages, making others more sensitive to the effects of urbanisation and fragmentation. Our findings indicate that management of potential pest species on trees is more dynamic than previously thought.

Do urban environments with different degrees of naturalness differently effect human health and wellbeing?

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The urban European society is faced with a growing incidence of poor health because of mental stress and sedentary lifestyles, therefore leisure activities in urban and peri-urban green spaces are seen as a counter. It is assumed that green spaces can compensate for negative psycho-physiological effects. Unfortunately, previous studies on the assessment of restorative effects of urban and peri-urban green spaces rarely compared different types of green spaces depending on their degree of naturalness. Therefore, the project HealthSpaces, co-financed by the Earth-System Science & Austrian Man and the Biosphere Programme, explored the health effects of different green and grey spaces in the UNESCO Wienerwald Biosphere Reserve (Austria) and in Vienna. Standardised measurements of psycho-physiological health related landscape effects on participants (e.g. measuring of blood pressure, pulse rate, cognitive performance, self-condition scale) were carried out in 4 selected landscape types of the Wienerwald (forest, vineyard, pasture, small river in a forest) and an urban area (street). We used a dependent sample of 44 participants who spent about 45 minutes at each of the sites. The results showed that the visits to the green spaces, compared to the grey space, had positive effects on the perceived well-being of the participants. The cognitive performance of the participants increased after the visit of the vineyards, forests and meadows, while decreased for the urban site. Differences between the green spaces were observed for subjective well-being, cognitive performance, blood pressure and pulse rate. The study showed that green spaces are important for the well-being of urban populations and that restorative effects depend on the degree of naturalness and landscape type.

POSTER PRESENTATIONS

SESSION 10-P1

The effects of urbanization on soil invertebrate communities and decomposition

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Urban soils provide many of the same ecosystem services as natural or agricultural soils, e.g. decomposition and nutrient cycling, and provide the habitat for an enormous diversity of organisms. This study aimed at identifying anthropogenic factors that structure the abundance and diversity of invertebrate communities of urban soils and interrelated processes such as the decomposition of organic matter. Field investigations were carried out in 20 grassland sites along a rural-to-urban gradient within the city of Berlin, Germany. Here, we investigated the abundance, diversity and functional trait diversity of earthworms and soil microarthropods (mainly mites and collembolans). We used commercial teabags (green tea and rooibos tea) as standard substrates to study decomposition rates. Our results show that earthworm abundance is relatively low in the city of Berlin compared with studies focusing on natural or agricultural soils. Moreover, earthworm abundance and species richness declines with increasing urbanity (measured as human population density, percentage of impervious surface area and the floor area ratio around the site). Consequently, urbanity leads to a decline of earthworm functional diversity due to the fact that only few species may become abundant in highly urbanized sites. In contrast, the abundance and diversity of soil microarthropods did not show this negative relationship and the soil decomposition rates of tea bags had a nonlinear relationship with urbanity, i.e. decomposition was low in less urbanized and heavily urbanized areas and highest in mid-urbanized areas. For further investigations, we will take a total of 20 environmental variables into consideration, such as the presence of different kinds of anthropogenic pollutants and microclimatic variables. Finally, the role of urban soil biodiversity in maintaining important ecosystem services will be discussed.

SESSION 10-P2

The importance of anthropogenic disturbance for shaping urban soil fauna assemblages

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Much of the ecology of urban animals have focused on understanding the effects of urbanization on species and populations, while comparatively little is known about the effects on structure and composition of communities. Given the formative importance of anthropogenic influence for urban biotopes, we expect animal communities to be predominantly determined by disturbance, and much less by the abiotic and biotic conditions of their biotopes. Thus, we should be able to arrange urban animal assemblages along a disturbance gradient. The Oribatida form a group of small bodied (mostly < 1 mm), non-parasitic, predominantly soil living mites which populate almost all terrestrial biotopes in abundant and diverse communities. They are, hence, an excellent model group to study urban assemblages. We sampled the oribatid mite fauna of 100 sites in all major land use and vegetation types of Vienna, Austria. At each site, we also characterized a full array of above- and belowground parameters, and estimated the level of disturbance (hemeroby) at the site scale. As expected, we found very different assemblages, ranging from poor (no or only very few oribatids detected) to very rich sites with 10^4 individuals * m^{-2} and dozens of species. Thus, anthropogenic disturbance, and not site parameters, are the major determinants of the oribatid mite assemblages of Viennese soils.

SESSION 10-P3

Plant biodiversity of urban stormwater ponds

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Many aquatic and semi-aquatic habitats in urban areas are of anthropogenic origin. In heavily sealed urban areas, stormwater ponds (SP) are often the last available aquatic and semi-aquatic habitats. Nevertheless, they are affected by strong and diverse human disturbances. In addition to their primary function for the retention of stormwater, SPs can also act as sediment and nutrient traps, provide habitat for plants and animals and are used by people for recreational purposes. Three types of SPs (dry, wet and transitional forms) can be differentiated. Each is characterized by specific habitat conditions favouring different groups of plants, like macrophytes, wet meadow species or even dry grassland species. This indicates the potentially high importance of SPs as habitats for plants in urban areas, where suitable habitats for aquatic and semi-aquatic plants have been largely destroyed. While knowledge on the importance of SPs for amphibians, dragonflies and other macroinvertebrates exists, little is known about the species composition and diversity of vascular plants of different types of urban SPs. In 2017, we analysed the species composition of vascular plants in 80 randomly selected SPs in Hamburg, Germany. We recorded all plant species with their frequency and cover as well as site conditions, such as the inclination of the shore and the degree of shading by trees, in different parts of each SP (channel, permanent standing water, plain without permanent standing water and shoreline area). In total, 499 vascular plant species were found in the SPs and from these, 83 species were listed as endangered species for Hamburg. Covering less than 0.03 % of the area of Hamburg, 30.9 % of the species of the local flora of Hamburg were found in the SPs. These preliminary results indicate that SPs play an important role in preserving plant diversity in urban areas under heavy anthropogenic pressures.

SESSION 10-P4

Effect of urban environmental stress on mycorrhization and root morphology of roadside *Acer* and *Tilia* trees

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People in cities rely on roadside trees to provide a number of valuable services, such as shading, filtration of pollutants, and the cooling of air via evapotranspiration. In providing these services, roadside trees are exposed to numerous stress factors such as traffic pollution, drought, and contamination with de-icing salts. Urban trees therefore have a shorter lifespan than their forest counterparts, which results in city administrations incurring costs for replacing dying or dead individuals and in the loss of ecosystem services until replacement trees reach maturity. Mycorrhiza can help to mitigate stress in trees by increasing access to water and nutrients, by reducing vulnerability to attack by root pathogens, and by mitigating (salinity) stress. However, mycorrhization in roadside trees may also be negatively affected by urban stress factors, and isolated planting pits may hamper colonization. Despite the relevance for tree performance, the effect of traffic and de-icing salts on mycorrhization and root morphology of roadside trees in European cities has been largely neglected. This study examines ectomycorrhizal colonization rates and morphotype diversity in roadside *Tilia* trees, as well as root morphology, microbial activity, and soil chemistry in both *Tilia* and *Acer* roadside trees in Vienna, Austria. Differences in mycorrhizal or root morphological traits at different stress intensities within the urban environment will be presented.

SESSION 10-P5

Assessing plant trait response to urbanization in a pair of co-occurring native and non-native Asteraceae – a case of epigenetic adaptation?

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Urban environments are expanding worldwide, creating novel plant communities incorporating non-native and native species. Such abiotic and biotic alterations are expected to drive rapid phenotypic changes in urban plant populations, but these remain largely unexplored. In particular, we remain unaware of the extent to which phenotypic changes may be the result of plastic responses or heritable changes. We compared phenotypic, epigenetic and genetic differences in populations of two co-occurring Asteraceae species, an invasive (*Solidago canadensis* L.) and a native (*Tanacetum vulgare* L.) along a rural-urban gradient in Berlin, Germany. *S. canadensis* had previously been shown to have competitive effects on *T. vulgare.* We measured specific leaf area (SLA), height and seed weight in populations of twenty grassland plots. We also measured DNA methylation patterns in leaves to quantify epigenetic differences. We expected height and SLA to increase with urbanization as a strategy towards fast growth and short-lived leaves in frequently disturbed environments. Furthermore, we expected populations of both species located at the extremes of the gradient to vary in DNA methylation reflecting short-term local adaptation. Response to urbanization varied between both species. SLA increased with urbanization in *T. vulgare* but not in *S. canadensis.* Preliminary results indicate that there may be a significant interaction effect of urbanization and the presence of *S. canadensis* on trait values of *T. vulgare.* Urbanized environments appear to modify the resource acquisition and construction of leaves in the native, but not in the invasive species. Interestingly, the presence of the invasive species may dampen this response to urbanization in the native species. The results of DNA methylation analyses will be added to disentangle the effect of urbanization on epigenetics in this study system.

SESSION 10-P6

Movement of Japanese squirrel (*Sciurus lis*) in heavily fragmented urban landscape: a case study in Morioka, Iwate Prefecture, Japan

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Japanese squirrel (*Sciurus lis*) is an endemic species of Japanese islands, which is distributed in Honshu, Shikoku, and Kyushu. This species is arboreal, and thus vulnerable to fragmentation of forest habitats. The population of this species is very limited and fragile in urban areas where generally forests are heavily fragmented. The objective of this study is to clarify the actual situation of Japanese squirrels which inhabit urban small forests by radio-tracking focusing on movement between forest patches. This study was conducted in 8 forest patches and their surroundings located in northern urban fringe of Morioka, Iwate Prefecture, Japan. The size of forest patches ranges from 0.2 to 53.3 ha with an average of 12.2 ha. These patches are fragmented by an arterial road (National Route 4) and residential areas. We captured squirrels from May to October in 2016 and from May to September in 2017 using traps made by modifying commercial mousetraps. Captured squirrels were weighed, and radio-tagged only if their weight was over 200 g. Radio-tracking was conducted almost on a daily basis until the end of November 2017. We radio-tracked 10 squirrels (6 males and 4 females) during the survey period and observed 47 movements between forest patches. The movement between forest patches divided by orchards was observed for 21 times and that connected by roadside trees was observed for 22 times. There is a high possibility that these results suggest that squirrels can move more easily when forest patches are connected by roadside trees or orchards, which may function as corridor. In addition, low habitat connectivity was suggested for forest patches divided by arterial road or residential areas without roadside tress. The environment between forest patches would be a major factor to determine the frequency of movements. It is necessary to consider the spatial configuration of forest patches and environment between patches to establish urban ecological network.

SESSION 11

Ecology of biological invasions

Chair: Harald Meimberg

High seed density is more effective than limiting similarity in controlling grassland resistance against invasive alien plants

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Restoration sites offer great opportunities for supporting native biodiversity, but they also show frequent establishment of invasive alien plants. Following the limiting similarity hypothesis, this study addresses the question whether or not similarity of plant functional traits helps developing native grasslands with higher resistance to invasive species at an early stage of restoration. Using a system of linear equations, we designed native communities maximizing the similarity between the native and two invasive species according to ten functional traits. Total seed biomass of the communities was kept similar, and thus the small-seeded community had approximately a 10fold density compared to the large-seeded community. The communities consisted of native grassland plants, invaded by a large-seeded (*Ambrosia artemisiifolia*) or small-seeded (*Solidago gigantea*) alien species. The communities were grown in mesocosms within a greenhouse. We measured height of the invasive plants and aboveground biomass along with leaf area index, 4 and 8 months after sowing, respectively. Height and biomass of both invasive species were successfully reduced by the native small-seeded community designed to suppress *S. gigantea*. This result partially supports the limiting similarity hypothesis. However, given the success of the small-seeded mixture against both invasive species, suppression was most likely due to the higher seed density of this mixture. Furthermore, the dominance of fast developing competitive species also contributed to this effect. Thus, there was no univocal support for the limiting similarity hypothesis in terms of the traits selected. Instead we found that increasing seeding density of native species and selecting species with a fast development is an effective way to suppress invasive plants during early stages of restoration. If limiting similarity is used to design communities for restoration, early life history traits should be taken into account.

Niche expansion of a rapidly range expanding invasive plant despite evolutionary constraints

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Using invasive plant *Ageratina adenophora* (Asteraceae) as a model organism and we performed a global niche overlap analysis between its native range (Mexico) and its different invasive ranges (Asia, USA, Canary Islands, and Australia), respectively. Being a triploid apomictic plant, its potential for rapid evolutionary changes is largely limited due to lack of sexual recombination. The aim of the current study was to investigate any evidence of niche shift despite evolutionary restrictions imposed by its apomictic mode of reproduction. Global occurrence dataset of *Ageratina adenophora* was compiled from primary (field surveys) as well as secondary (online databases, expert opinion). Using bioclimatic data corresponding to the occurrence points, we performed a principal component analysis and quantified the pairwise niche overlap between native and invasive ranges. Additionally, we estimated the amount of unfilled and expanded niche for all the pairwise comparisons between native and invasive ranges. Additionally, we estimated the amount of unfilled and expanded niche for all the pairwise comparisons between native and invasive ranges. Results: Niche equivalency tests showed that niches in all invasive ranges differed from the native range. However, the degree of niche overlap differed considerably between different areas ranging from notably high overlap between Mexico and Asia to considerable niche shifts between Mexico and Australia. The occupied climatic niche in the invasive Australian range was unique due to both its high amount of expanded and unfilled niches. The species also showed considerable niche expansion into colder areas of Asia. Drawing evidence from other evolutionary studies on *Ageratina adenophora*, we discuss that the observed changes in niche space are not due to evolutionary changes in the fundamental niche but due to changes in the occupied niche likely driven by biotic interactions, dispersal limitations and control efforts.

The heterothermic wild boar: insights from implanting temperature loggers in a large mammal

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Biologging has become a major part in ecological and ecophysiological research and huge progress has been made with respect to size and accuracy of logging devices. However, when working with larger animals, things become complicated quite fast with questions arising like where to implant the logger, especially when core body temperature has to be measured. Many scientists therefore decide to implant the logger inside the abdominal cavity and sew it to the abdominal wall to facilitate explantation. Following this common practice we implanted 14 wild boar (*Sus scrofa*) with body temperature loggers and found a huge variation in 'core' body temperature with daily amplitudes of up to 9.7 °C. In comparison, not sewing the logger to the abdominal wall significantly decreased the variation in 'core' body temperature. Although mean temperature was also significantly higher in free floating loggers, we still observed regular drops in body temperature of several degrees centigrade and daily amplitudes of up to 3.2 °C. This indicates that core temperature of wild boars is maintained only in a small part of the body and not throughout the abdomen and therefore is very difficult to measure properly in larger species. These findings are highly relevant for the correct interpretation of 'core' body temperatures measured in large animals in general, but at the same time also allow for the identification of behavioural thermoregulation, such as wallowing, basking or huddling, especially when combined with a subcutaneous temperature logger. Despite an effect of body mass and thus differences in insulation of the wild boars, we identified general effects of ambient temperature and other environmental variables on the frequency and timing of these behaviours. Interestingly, our results indicate that wild boars show wallowing, a behaviour that decreases intra-abdominal body temperature by several degrees, already at surprisingly low ambient temperatures in winter.

Evolution and breakdown of nestmate recognition under multiple selective drivers

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During invasion species are exposed to new ecological situations that not only affect population dynamics but also change selective pressures, thus promoting (rapid) evolutionary change. A case in question may be the breakdown of nestmate recognition systems observed in some invasive social insects like fire ants. We present a simple model that (1) explains that nestmate recognition evolving (just) under pressure to avoid colony raiding has a tendency to develop evolutionary cycles, (2) that nestmate recognition may more likely have evolved to prevent predation or parasitism than as a mechanism to prevent raiding by other colonies and (3) that predicts the breakdown of nestmate recognition under various ecological situations as the may occur during invasions e.g. reduced intraspecific competition, increased abiotic stress, or release from predation or parasitism. Other than with previous explanations, a loss of genetic diversity at invasive fronts is not a required ingredient to predict the loss of nestmate recognition and the formation of supercolonies.

A new aspect of the dispersal of alien plants – human-dispersed seeds can survive and disperse after the laundry cycle

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Due to increased human mobility, cloth-dispersed seeds can be transported over long distances, which would not been bridged otherwise. Thus, human-mediated dispersal can be a starting point of biological invasions in some cases. We studied a formerly overlooked component of human-mediated plant dispersal by assessing the effects of lavatory washing on the dispersed seeds. We asked the following questions: (i) Are cloth-dispersed seeds able to germinate after the laundry cycle? (ii) What are the effects of washing on the fitness of germinated seedlings and on the temporal dynamics of germination? We studied the germination of 18 species, which have morphological adaptations for epizoochory and are commonly dispersed by people. We tested six treatments (washing with water, washnut or detergent, at 30 °C or 60 °C) compared to an untreated control. Our results showed that washing temperature was the most significant factor affecting germination. Washing at 30 °C did not suppress germination of any of the studied species. Washing at 60 °C supported the germination of two species, but suppressed six species. The intensive washing treatments at 60 °C decreased significantly the synchrony of germination. Our measurements showed that more than 70 % of attached seeds remain on our clothes for more than 8 hours and have the chance to enter the laundry cycle. 64 % of washed seeds fall down from clothes during drying, thus, they might establish in an urban or rural environment. The remaining 36 % of washed seeds can further disperse over a longer distance. Our results showed that people are not purely transporting seeds from one location to another, but via the laundry cycle we also influence the fate of the transported seeds by affecting germination potential, seedling fitness and germination dynamics. These results have new implications for understanding the early stages of biological invasions.

Encroachment of *Elymus athericus* in salt marshes – a tale of two ecotypes

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Salt marshes along the coast of the Wadden Sea are important for the protection of plant-diversity in NW-Europe as they harbour many specialised plant species restricted to this type of wetland ecosystem. Within the ecosystem we find a clear zonation of vegetation types mainly determined by the elevation which controls the flooding frequency. After the establishment of National Parks in the Wadden Sea area, cessation of livestock grazing has led to an encroachment of the late-successional tall grass *Elymus athericus*. This grass forms large mono-specific stands leading to a loss of plant diversity. However, the main driver of this encroachment in abandoned salt marshes is unknown. In a field experiment we tested how N-availability, sedimentation rate and elevation, as a proxy for flooding frequency affects the growth of individual *Elymus* plants. While N-fertilisation had no effect, our results suggest that *Elymus* is not able to grow in low elevations, most likely because these are flooded more often which causes hypoxia. However, in some marshes *Elymus* is found to spread into lower elevations which should be unsuitable for the plant. Here a distinct low marsh ecotype of the species was identified. In the following experiments, we therefore tested in the greenhouse how *Elymus* is able to spread into unsuitable wet habitat. We determined whether *Elymus* mother ramets of the two ecotypes are able to support daughter ramets under stress (waterlogging) via the rhizome, a process called physiological integration. Our results show that physiological integration indeed allowed connected daughter ramets to produce more biomass than disconnected daughter ramets. Furthermore, the results indicate that the low marsh ecotype of *Elymus* is already adapted to waterlogging and higher flooding frequencies, which might explain their ability to encroach even into previously unsuitable areas of the salt marsh.

Effects of the invasive *Impatiens glandulifera* on above- and belowground plant diversity in forests

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Invasive plants may severely impact native biodiversity and ecosystem functioning. Even if the majority of ecosystems have more than 50 % of plant biomass belowground, most studies investigating the effects of invasive species on plant diversity focus on aboveground vegetation. DNA-based methods are now established, which allow the determination of belowground plant species richness. Using these techniques, we examined potential effects of the invasive annual plant *Impatiens glandulifera* on the belowground plant diversity, by comparing both above- and belowground diversity in invaded and uninvaded forest plots in Northwestern Switzerland. We established 24 plots in deciduous forest areas invaded by *I. glandulifera* and in neighbouring forest areas, which were not yet invaded. In each plot, we determined plant species richness and abundance in the aboveground vegetation, and collected soil samples (depth: 20 cm) to determine belowground plant species richness. We extracted DNA from fine roots in the soil samples and applied the FAFLP technique (fluorescent amplified fragment length polymorphism) for three different regions of the chloroplast DNA (trnL intron, trnL–trnF intergenic spacer, P6 loop). We created a reference library for all plant species occurring in the study area to identify the species present in root samples. Our results showed that *I. glandulifera* caused a significant reduction in the aboveground plant species richness and a shift in species composition. The root biomass was reduced by 30–50 % in invaded plots, most probably due to allelopathic compounds released by the invasive plant into the soil. The invasive plant influences also belowground plant species richness. The reduction in both plant diversity and root biomass in plots invaded by *I. glandulifera* negatively affects soil stability.

Fluctuating resources and plant invasion: a field test

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There is accumulating evidence that a fluctuating resource supply makes some of the most problematic invasive species more successful at competing against natives. Most often the evidence comes from pot experiments in the greenhouse or garden where the invader competed against one or several natives. Such setups however have several known limitations of their realism. Therefore we set out to determine whether a fluctuating supply of nutrients promotes invasion in the field. In eight sites from South-West Germany invaded either by Japanese knotweed or Canadian goldenrod we manipulated the nutrient supply by applying liquid fertilizer. At ten time points separated by one week we applied on one square meter plots liquid fertilizer according to three treatments: constant – equal amount at every application, variable – double amount every second application, and control – water in the same volume used to dilute the fertilizer. There were four replicate plots for each treatment in every site. Before the treatments started we recorded vegetation and measured invader cover. On all plots invader cover was less than half so the invasion was underway. Both invasive species became more dominant with the variable nutrient supply, as measured from the harvested aboveground biomass in autumn. Interestingly, compared with control the invaders did not benefit from the additional nutrients when they were added constantly. This is the first field evidence for the role of fluctuating resources in promoting invasive species. Together with previous evidence from garden and greenhouse experiments this shows that nutrient fluctuations can accelerate invasion. Besides, we demonstrate that a fluctuating resource supply in the natural environment can produce observable effects even after a single growth season. It remains interesting to discover whether this is true for other problematic invaders or whether there are consistent links between the seasonal variation in available nutrients and the speed of plant invasions in general.

Tree-of-heaven: genetic imprints of geographic origin in Europe and gender distribution in Vienna

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Ailanthus altissima (Mill.) Swingle (tree-of-heaven), with its largest native distribution in China, is an invasive tree in Europe. It is a diploid, dioecious species, which reproduces both sexually and asexually. Its first reported introduction goes back to the middle of the 18th century, when the seed of *A. altissima* sent from China was believed to be that of another tree species, the Chinese lacquer tree. The tree-of-heaven soon became a popular planted species in Europe because of its ornamental foliage, the rapid growth, timber qualities, the tolerance to urban air pollution and for its use in soil stabilization or as a forage for silk-producing caterpillars. At the present this tree grows throughout the majority of European countries. Here, we focus on *A. altissima* trees planted/naturalised in large European cities and collected in botanical gardens, in urban parks, along roads and rivers. In these trees we analysed patterns of genetic variation and structure in order to infer the geographic origin and dispersal patterns of this species. In more details, were genotyped both nuclear DNA and plastid DNA in 62 populations collected in 31 European countries. Most of the trees were assigned to six genetic clusters. Analyses of plastid haplotypes are currently on the way in order to estimate the geographic areas of China from which *A. altissima* was introduced to Europe. In addition, the gender and its distribution were estimated in 358 trees planted after 1852 along roads and in urban parks in Vienna (Austria). Final results will be a) discussed with respect to the geographic origin of studied trees and b) gender distribution and its role in invasiveness of the tree-of-heaven.

The dynamics of invasiveness: modelling the evolution of plant-herbivore interactions

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What makes a terrestrial plant species become invasive? Thus far, there have been few answers to this question, but we do have many hypotheses. Among the most important ones are *enemy release* (ER hypothesis) and the *evolution of increased competitive ability* (EICA hypothesis). Here we use a simulation model to investigate what the implications are of these two hypotheses, increasing our mechanistic understanding of the dynamics of invasiveness. To study whether they can actually explain invasiveness, we make a systematic contrast between invasive species (expanding in a novel environment after a human-induced dispersal event), and range expanders (expanding their native areas e.g. under climate change). While both invaders and range expanders are under selection pressure for increased dispersal capacity and population growth, there are some important differences between them. Differences in enemy tracking and the possibilities of host switching affect *enemy release*, levels of gene flow and opportunities for hybridization with closely related species affect the exotics' evolutionary potentials, and thus the *evolution of increased competitive ability.* The first results of the model show that enemy release regulates the interspecific competition of the exotic and resident host species. Exotic evolutionary change occurs mostly under intraspecific competition and determines the speed of invasion. These and other results increase our understanding of the mechanisms underlying important invader hypotheses, and offer new hypotheses to test in the field and distinguish between them.

Biological invasions: hypotheses, evidence, and methodological challenges

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The question why species are able to establish and spread in areas outside of their native ranges is central to the discipline of invasion ecology. Over time, many ideas and hypotheses have been formulated how these questions could be answered. Some of these major hypotheses, like the enemy release hypothesis, have been addressed frequently with observational studies, experiments and mathematical models. Since there are many different methodological approaches to test such a major hypothesis, assessing the hypotheses' level of support is challenging. Together with 21 co-authors, we addressed this challenge by making use of the hierarchy-of-hypotheses (HoH) approach (Jeschke & Heger 2018). In an HoH, a major hypothesis is divided into sub-hypotheses, each addressing one aspect of the overarching idea, and these are further divided until a level of refinement is reached that allows for an empirical test. Applying this method, we developed hierarchically structured representations of the diverse approaches used to test 12 major invasion hypotheses. For every hypothesis and its sub-hypotheses, we assessed the level of empirical support. Since some of these hypotheses are conceptually similar, we additionally created a network illustrating these similarities. We linked the 12 HoHs explicating the level of support for the hypotheses to the network, and created an interactive web portal to make these results openly available (www.hi-knowledge.org). In the presentation, we will report the major results of our analyses. We will then discuss methodological challenges we encountered during our work, and suggest directions for future research.

Towards global scenarios of biological invasions in the 21st century

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Biological invasions substantially affect ecosystems, ecosystem services and human livelihoods alike, and the impacts of species invasions will rise in the future as the rate of establishment of alien species has increased strongly during the last decades with no sign of saturation. Further, they drive species extinctions worldwide and especially in phylogenetically rich regions such as island systems that contribute strongly to global biodiversity, causing high mitigation and adaptation costs. Consequently, different international initiatives and agreements such as the United Nations Sustainable Development Goals (SDG), the Convention on Biological Diversity (CBD) and the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) consider the assessment and control of biological invasions as a crucial step to sustain global biodiversity, ecosystem services and human livelihoods. The rising numbers and impacts of alien species, the de facto irreversibility and often limited manageability of alien species introductions, and the substantial time lags associated with different stages of biological invasions underpin the need for understanding the long-term trajectories scenarios of biological invasions. Here, we present a conceptual framework and a roadmap for the development of scenarios and models on how alien species richness and impact might change in the 21st century. This includes the establishment of qualitative scenario narratives and the quantification of pressures and impacts for these narratives. The recent advances in data availability of biological invasions for the first time allows addressing this task appropriately. We believe that the biological invasion scenarios concept proposed here provides an important contribution for understanding and pro-actively managing the future of biological invasions.

POSTER PRESENTATIONS

SESSION 11-P1

Gnathotrichus materiarius (Fitch, 1858) (Coleoptera, Curculionidae, Scolytinae) in Poland – since 2015

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Gnathotrichus materiarius (Fitch, 1858) for the first time was noted from Poland in 2015. One specimen was found in a barrier pheromone trap aimed at *Ips duplicatus* in the southern part of Poland. During the next two years beetles were found in the same kind of trap aimed at *I. duplicatus* and *I. amitinus*. Insects and galleries for the first time were noticed in August 2017. Bark beetles developed in pine wood (*Pinus sylvestris*) were cut at the beginning of spring. Since this time observations of the phenology, development and dispersion of *G. materiarius* has begun. Presently the species is observed in south-western Poland along the border with Germany and the Czech Republic in coniferous stands. We present data about the biology, ecology and morphology of *Gnathotrichus materiarius*. Research on other aspects – phenology, natural enemies, associated fungi (ambrosia fungi), dispersion and economical importance of the *G. materiarius* – are in progress.

SESSION 11-P2

Dynamics of alien and native understorey plants following variable retention harvesting in *Nothofagus* temperate forests

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Disturbances have frequently been shown to increase invasibility of communities by alien plants. Logging, the most common and severe anthropogenic disturbance in forests, enhances resource availability for alien plants. However, it is unclear whether and to which extent these initial changes are permanent or just temporary. Using annually surveyed permanent plots, we analyzed temporal changes of understory composition of Patagonian *Nothofagus pumilio* forests during 12 years under three site conditions created by variable retention harvesting: retained forest patches of 30 m radius in a density of 1 patch ha^{-1} (AR), edges of such retained patches (DRI), retained dispersed single trees (DR); and old-growth primary forests as control (PF). Most interesting trends include that (a) AR supported a high cover of forest species in the top layer that, however, declined during the 12 years and increasing alien species became dominant at 9 years after harvesting (YAH), (b) DR and DRI supported much higher cover of aliens in the top layer and aliens became dominant at 2 to 3 YAH, but started to decline after a maximum at 8 YAH; (c) in the bottom layer, the cover of forest species was high at the beginning but aliens surpassed them in DR and DRI after 4 and 7 years, respectively. Tree regeneration had significant relationships with understory dynamics, i.e. (a) in DR, a negative relationship with alien species cover and a positive relationship with native colonizers from other habitats; (b) in DR and in DRI negative relationships with alien species richness; (c) in DRI, a positive relationship with native colonizers (cover and richness). We conclude that alien plants invade Patagonian forests after logging, but decline with succession and increasing tree regeneration. Our results highlight the role of harvesting on facilitating plant invasions in southern temperate forests, and how this depends on treatments.

SESSION 11-P3

Comparison of biennial *Alliaria petiolata* life stages shed some light on their ecological role

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Even though *Alliaria petiolata* is a globally important invasive plant, for Europe it is a native humble understory species. We studied the population characteristics of *A. petiolata* in its native range (NE Slovenia) by evaluating its demographic structure. Since *A. petiolata* is a biennial plant, we compared the 1st–year non-flowering rosettes and the 2nd–year flowering plants. We expected both life stages to have differing ecological strategies, which would add some hints about the success of *A. petiolata* invasion in a non-native range. Therefore, we tested and compared the allelopathic potential of fresh plant material with bioassays on *Lepidium sativum* germination and seedling development. Further on, we performed a comparison of the eco-physiological measurements including chlorophyll fluorescence, SPAD-value and leaf conductance. The bioassays showed more suppressed germination by the 1st–year rosettes, higher SPAD-values and higher stress tolerance. Results confirmed ecological differences between both life stages and suggest that plants differ according to their ecological role: occupancy of space and nutrient-acquisition in the 1st year vs. fast growth and reproduction with seeds in the 2nd year.

SESSION 11-P4

Spatial modelling of insect pests under climate change

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The changing climate is forcing species to adapt their ranges in order to follow preferred climatic conditions. Meanwhile, increasing global trade and international travel support proliferation and propagule pressure. Therefore, pest pressure on crop plants will increase with climate change, thus requiring adaptation of crop protection measures. The development of these measures is supported by quantitative information on the future proliferation and spread of pests and pathogenic agents. We use high-resolution climate data and contemporary spatial distribution modelling approaches to prepare scenarios of the spread of economically relevant insect pest species. Additionally, we use the same methods to investigate distributional changes of host plants of these pests. The results of our study demonstrate increasing risk of occurrence of new invasive insect pest species under future climate change within Europe. Further, we predict changes in potential interactions between pests and host plants in the near future.

SESSION 11-P5

What's new about tropical *Pistia stratiotes* in the temperate zone?

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Tropical *Pistia stratiotes* L. (family Araceae) is a free-floating freshwater perennial macrophyte, one of the most important pantropical aquatic weeds. Summer occurrence of *P. stratiotes* has occasionally been observed in temperate zones during hot summers. In 2007 we reported about the first successful winter survival of a tropical plant *Pistia stratiotes* in a natural thermal stream in the temperate zone in Slovenia in 2003, in an area with an average January temperature of –6 °C, reaching minimum temperatures as low as –15 °C. We predicted then that, since plants flowered and produced viable seeds, they would present a potential source for further vegetative and sexual spread. Further on we assumed that climate change causing warmer conditions might create new problems: the species might extend its range. After that, new records of overwintering *P. stratiotes* plants were published for a thermally abnormal river in Germany and plants were spotted in numerous countries within the temperate climate zone. With our poster we present a review of *P. stratiotes* current distribution. For any tropical plant species to become naturalized in a temperate climate, adequate temperature and air humidity must prevail. Therefore, we studied the eco-physiological measurements on *P. stratiotes* plants along the temperature gradient in a thermal stream in Slovenia. We present data about seasonal chlorophyll fluorescence, plant growth, surface cover and spread. Plants survived winter near the warmest point, however, during the summer they died, and survived have plants downwards the stream. Even though invasions in aquatic systems are often considered a consequence of ecosystem degradation, the *P. stratiotes* invasion of the stream in Slovenia is not such a case.

SESSION 11-P6

Genetic variation of the invasive *Ambrosia psilostachya* in Europe

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Western ragweed (*Ambrosia psilostachya* DC.) is a perennial herbaceous Asteraceae species with horizontally running root stocks. Like common ragweed (*Ambrosia artemisiifolia* L.) the plant is native to North-America, but naturalized to Europe where it behaves highly invasive along rivers, costal sites and dune landscapes. Even though the plant produces seeds, the main reproductive mode lies in the highly clonal behaviour by root sprouts, enabling the species to colonize a wide range of climatic regions in Europe – from southern Italy to Scandinavia and Scotland, as well as from Southwestern Spain to Russia. However, the patterns of spreading, the mutual relationship of the various population as well as the structure of the invasive populations is still unexplored. Therefore, we sampled more than 60 populations throughout Europe and analysed genetic diversity and population genetic structure based on 16 microsatellite loci.

Preliminary results indicate clear genetic differentiation among populations. Allelic richness (N_a) varied between 3.27 and 5.0. With an F_{st}–value of 0.11 the genetic differentiation among populations was moderate whereas the genetic diversity within populations, based on Shannon-Index (I) was very high. This was confirmed by the results of AMOVA indicating that approx. 81 % of genetic variation lay within populations. We found significant deviation from the Hardy-Weinberg-Equilibrium indicating high homozygosity levels. Populations deriving from the same region showed reduced genetic distance compared to populations from remote regions. Clonal structures were detected significantly from genetic data in more than 50 % of the populations.

SESSION 11-P7

Does the diurnal niche constrain range expansion? Non-diapause effects of day length on fitness

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Northward range expansions cause organisms to experience novel day length-temperature correlations. Depending on the diurnal niche, organisms may benefit or suffer from changes in day length, thus potentially affecting the ability to expand the range. We assessed the impact of day length changes on larvae of *Chrysoperla carnea* (Stephens) and *Episyrphus balteatus* (De Geer), both of which prey on aphids. Larvae of *E. balteatus* are night-active, whereas those of *C. carnea* appear to be crepuscular. We subjected both species in climate chambers to day lengths of 16 : 8 L : D and, to circumvent diapause responses, 20 : 4 L : D. We recorded development times and predation rates of both species. *E. balteatus* grew 13 % faster in the 16 : 8 L : D treatment and preyed on significantly more aphids. In contrast, *C. carnea* grew 13 % faster in the 20 : 4 L : D treatment and higher predation rates in 20 : 4 L : D were marginally significant. Our results show that day length affects development and predation, but that the direction depends on species. Such differences in the use of day length may alter range expansion patterns in a changing climate.

SESSION 12

Ecosystem perspectives in wildlife ecology

Chairs: Johannes Signer, Niko Balkenhol, Marco Heurich

Estimating sustainable harvest rates for a high density European hare (*Lepus europaeus*) population

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Hunting regulations are used to regulate and protect game species by ensuring sustainable exploitation. However, unpredictable climatic events might interact with hunting, resulting in the extinction of vulnerable populations of game species. In this study, we established a population model with parameters based on spotlight counts and shooting bag analyses of European hares (*Lepus europaeus*) in Lower Austria. Our goal was to compare the sustainability of guidelines with that of actual and theoretical hunting quotas, especially in light of the potential for census error. In particular, we aimed to use targeted population modelling based on vital rates and densities to allow hunting quotas to be adjusted continuously and, hence, to make recommendations for sustainable harvest rates of game species such as the European hare. Survival of both adults and young of the year had the highest impact on the population growth rate (λ). The index of sustainable harvest rate (ISHR, i.e. harvest rates compatible with $\lambda \geq 1$) for the generic population was 5 %. A population viability analyses (PVA), with sustainable harvest rates defined as leading to quasiextinctions in less than 5 % of simulations, showed that harvest rates (HR) of 10 % were sustainable for populations of 45 hares/km^2, whereas HR of up to 15 % were sustainable only if there were > 190 hares/km^2. Moreover, our simulations showed that only hare populations with at least 15 hares/km^2 should be hunted applying hunting quotas of not more than 5 % to ensure sustainability. The recommended hunting regulation would outperform the observed one, since more hares could be harvested sustainably. Young of the year survival was strongly linked with weather and a single year with unfavourable weather conditions, in this study a low precipitation rate, negatively affects population densities. Wildlife, including the European hare, faces increasing frequencies of weather extremes due to climate change, suggesting that hunting regulations will need to be sensitive to frequent population fluctuations.

Ecosystem service flows from a migratory species: spatial subsidies of the Northern pintail

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Migratory species provide important benefits to society, but their cross-border conservation poses serious challenges. By quantifying the economic value of ecosystem services (ES) provided across a species' range and ecological data on a species' habitat dependence, we estimate *spatial subsidies* – how particular regions support ES provided by a species across its range. We illustrate this method for migratory Northern Pintail ducks in North America. Pintails support over $101 million annually in recreational hunting and viewing and subsistence hunting in the U.S. and Canada. Pintail breeding regions provide nearly $30 million in subsidies to wintering regions, with the 'Prairie Pothole' region supplying over $24 million in annual benefits to other regions. This information can be used to inform conservation funding allocation among migratory regions and nations on which the pintail depends. We thus illustrate a transferrable method to quantify migratory species-derived ES and provide information to aid in their transboundary conservation.

Statistical inference for home range overlap

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Despite the routine nature of estimating overlapping space use in ecological research, to date no formal inferential framework for home range overlap has been available. Part of this issue is due to the inherent difficulty of comparing the estimated home ranges that underpin overlap. Because overlap is calculated conditionally on a pair of home range estimates, biases in these estimates will propagate into biases in overlap estimates. Further compounding this comparability issue is the historical lack of confidence intervals on overlap estimates. This means that it is not currently possible to determine if a set of overlap values are statistically different from one another. As a solution, we develop the first rigorous inferential framework for home range overlap. Our approach is based on the AKDE family of home range estimators, which correct for biases due to autocorrelation, small effective sample size, and irregular sampling. Collectively, these advances allow AKDE estimates to validly be compared even when sampling strategies differ. We then couple the AKDE estimates with a novel bias-corrected Bhattacharyya Coeffcient (BC) to quantify overlap. Finally, we propagate uncertainty in the AKDE estimates through to overlap, and thus are able to put confidence intervals on overlap estimates. Using simulated data, we demonstrate how our framework provides accurate overlap estimates, and reasonable coverage of the true overlap, even at small sample sizes. When applied to empirical data, we found that building an interaction network for Mongolian gazelles (*Procapra gutturosa*) based on all possible ties, versus only those ties with statistical support, substantially influenced the network's properties and any potential biological inferences derived from it. Our inferential framework produces overlap estimates that can validly be compared across studies, sites, species, and times, and facilitates testing whether observed differences are statistically meaningful.

Megafauna extinction induced size reduction in European dung beetle assemblages over the last 53,000 years

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Dung beetles co-evolved with large-sized animals since millennia and sensitively depend on the feces of megafauna. Mammal community down-sizing as a result of past and ongoing megafauna losses is therefore likely to result in a concomitant down-sizing of dung beetle communities. However, empirical evidence for this co-down-sizing is generally lacking. In this study, we show a significant down-sizing of European dung beetle assemblages over the last ~ 53,000 years. This down-sizing of dung beetle communities was thereby not linear, but characterized by a weak decrease of community mean body size until the early Holocene but a strong acceleration in the recent pre-history coinciding with the completion of the Quaternary megafauna extinction and the start of major shifts in human agricultural land-use. In contrast, body size of non-coprophagous scarabids and ground beetles – two groups of beetles with no or weak relations to megafauna – was observed to increase towards the present with an acceleration of body size increase coinciding with the onset of late-glacial warming. In summary, the observed late-Quaternary down-sizing of European dung beetle communities is consistent with an effect of pre-historic megafauna losses. Ongoing down-sizing of mammal communities is therefore likely to result in further down-sizing of dung beetle assemblages, with potential effects on their important role ecological role.

Succession and use of carrion by scavenger communities in the Bavarian Forest National Park

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Scavenging is a widespread strategy with a noticeable contribution to energy transfer in ecosystems, illustrating interkingdom connections and energy flows. However, scavenging network structure and the associated community assemblage have been largely overlooked. In our study, differences of vertebrate communities utilizing carrion in the Bavarian Forest National Park, Germany, were examined. Using motion triggered camera traps the consumption of 48 deer carcasses (*Capreolus capreolus* and *Cervus elaphus*) with weight ranging from 4 to 150 kg over a study period of six years starting in 2012 was monitored. General linear mixed models were employed to investigate the influence of environmental factors i.e. habitat parameters or weather conditions on scavengers abundance and diversity. Influences on carrion presence and detection time and the local avoidance of herbivores during the carrion deployments were tested. A total of 18 vertebrate species at deer carcasses were detected and it could be shown that carrion mass and ambient temperature are decisive factors structuring the associated scavenger community. Top and meso predator abundance increased with carrrion mass and lower temperatures enhanced the presence of birds of prey and meso predators. Lynx prefered habitats containing higher forest cover with less human disturbance. At the same time wild boar abundance decreased with increasing shrub density of the surrounding area, while in contrast birds of prey preferred higher shrub density. Differing habitat preferences indicate that highest scavenging rates and scavenger diversities can be expected in a nature-orientated heterogenous forest. As an outcome it can be concluded that anthropogenic provided food supply can help stabilizing vertebrate scavenging communities by supporting carrion dependent carni- and omnivores.

POSTER PRESENTATIONS

SESSION 12-P1

Reproductive strategy in female Alpine mountain hares (*Lepus timidus varronis*): adaptation to different elevation?

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In *Lepus*, litter size is inversely related to the duration of the reproductive season resulting in a consistent yearly production of around ten leverets per female. In high latitudes, animals have few litters with large litter sizes, whereas in low latitudes, several litters with small litter sizes are common per year. Knowledge on reproductive performance of Alpine mountain hares (*Lepus timidus varronis*) is scarce. In this study, we analysed 89 hares from Grisons, Switzerland, by examining placental scars and eye lens weight. The general aim of the survey was to examine the reproductive performance of female Alpine mountain hares. In particular, we focused on the question whether this subspecies adjusts the reproductive strategy in relation to elevation such as other *Lepus* species do in relation to latitude. All adults of our sample reproduced, whereas none of the subadults had leverets. 39 % of the females littered twice and 61 % three times a year with a median litter size of 3.00. We identified a significant effect of elevation on litter size, whereas the elevation did not influence the number of litters. We found no significant difference of yearly reproductive output across elevation range. Hence, some reproductive parameters seem to indicate that the Alpine mountain hare changes the reproductive strategy in relation to elevation similar to the mountain hares living further north do in relation to latitude.

SESSION 12-P2

Dietary preferences of the European hare (*Lepus europaeus*): a herbivore selecting its diet for a high fat content

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European hares of both sexes rely on fat reserves, particularly during the reproductive season. Therefore, hares should select dietary plants rich in fat and energy. However, hares also require essential polyunsaturated fatty acids (PUFA) such as linoleic acid (LA) and alpha-linolenic acid (ALA) to reproduce and survive. Although hares are able to absorb PUFA selectively in their gastrointestinal tract, it is unknown whether this mechanism is sufficient to guarantee PUFA supply. Thus, diet selection may involve a trade-off between a preference for energy versus a preference for crucial nutrients, namely PUFA. We compared plant and nutrient availability and use by hares in an arable landscape in Austria over three years. We found that European hares selected their diet for high energy content (crude fat and crude protein), and avoided crude fibre. There was no evidence of a preference for plants rich in LA and ALA. We conclude that fat is the limiting resource for this herbivorous mammal, whereas levels of LA and ALA in forage are sufficiently high to meet daily requirements, especially since their uptake is enhanced by physiological mechanisms. Animals selected several plant taxa all year round, and preferences did not simply correlate with crude fat content. Hence, European hares might not only select for plant taxa rich in fat, but also for high-fat parts of preferred plant taxa. As hares preferred weeds/grasses and various crop types while avoiding cereals, we suggest that promoting heterogeneous habitats with high crop diversity and set-asides may help stop the decline of European hares throughout Europe.

SESSION 12-P3

Environmental and reproductive effects on stress levels in wild boar (*Sus scrofa*)

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The steady increase of wild boar populations and resulting economical and ecological damages in Europe necessitates specific management measures. These measure, however, require a better understanding of wild boar physiology and how they cope with climate change and other challenges. Measuring stress response allows a good insight into how well wild boars are able to cope with different stimuli but measuring stress without affecting the measurement is difficult. A non-invasive method to measure stress is the measurement of cortisol levels from saliva. Knowledge on cortisol levels in wild boar is still scarce and only little is known on circadian or seasonal effects on baseline levels. The aim of this study therefore was to find a suitable sampling method to measure salivary cortisol levels in wild boars, and to determine circadian and seasonal changes in baseline cortisol levels along with potential effects of climatic variables. Habituated female wild boars were observed between January and May 2017. Baiting buccal swaps with apple, which are mostly spit out again after the wild boar ate the bait, yielded sufficient amounts of saliva to analyse cortisol levels via ELISA without affecting the animals' behaviour. Saliva samples were then taken once a week between 10 and 17 o'clock from 17 individuals. These first data on cortisol levels in wild boar show that baseline levels increased with daytime. We further identified a significant increase in baseline cortisol from gestation to lactation. Taking these changes in baseline cortisol levels into account we found that cortisol increased with ambient temperature. These results show that our minimal invasive method is sufficient to detect differences in baseline cortisol levels as well as short term effects on the animals stress status. Our findings further suggest that increasing ambient temperatures affect the stress physiology of wild boar and thus potentially their ability to cope with stressful situations.

SESSION 12-P4

Automated identification of wild boar (*Sus scrofa*) behaviour using 3D-accelerometers

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In ecological research it can be relevant to track the behaviour of animals in order to identify activity patterns. Recording of such behavioural data, however, usually requires a huge time effort and mostly affects the behaviour of the animals. Therefore, automated identification of behaviour would be of major benefit. We aimed to develop a method for an automated identification of behavioural patterns in wild boar, the game species of likely the highest economic and ecologic relevance currently, due to the drastic and ongoing population increase. Ear tags with 3D-accelerometers were used to record accelerometer data of 14 semi naturally kept wild boars. Behaviour of these animals was videotaped and classified according to a defined ethogram, resulting in a total of > 89 h of coded individual behaviour. The classified behaviour together with the simultaneously recorded accelerometer data were used to train a machine learning routine consisting of a principle component analysis (PCA) followed by a linear discriminant analysis (LDA). A k-fold cross validation following a leave-one-out approach showed an overall accuracy of > 88 %. Highest sensitivity of 95.8 % was found for the behaviour feeding, which was also observed the most in the recorded behaviour. Classification of the other behaviours was less precise but these showed high values in specificity (range: 98.1–100 %). Repeating the analysis, but only focusing on feeding and resting behaviours, for which most data were available, resulted again in an overall accuracy of > 88 %, but improved overall sensitivity to 93 %, and average specificity to 35 %. Thus, the developed machine learning approach proved to be a sufficient method for automated detection of wild boar behaviour given that the routine is trained with enough observational data of the behaviours of interest.

SESSION 12-P5

Animal Movement Tools (amt): an R-package for managing tracking data and conducting habitat selection analyses

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Step-Selection Functions (SSFs) are commonly used to link environmental covariates to animal location data collected at fine temporal resolution. SSFs are estimated by comparing observed steps connecting successive animal locations to random steps generated under an assumed model for animal movement, using a likelihood equivalent of a Cox proportional hazards model. By including habitat- and movement-related covariates (functions of distances between points, angular deviations), it is possible to make inference regarding habitat selection and movement processes, or to control one process while investigating the other. Here, we present the R-package *amt* (animal movement tools) that allows users to fit SSFs to data and to simulate space use of animals from fitted models. The *amt* package also provides tools for managing telemetry data (e.g., functions to detect erroneous tracking locations).

SESSION 12-P6

A comparative approach to livestock-wildlife interactions in central Europe and sub-Saharan Africa

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The extinct aurochs (*Bos primigenius*) represents the common origin of European and African cattle, functioning as framework for our comparative study. Given existing conflicts between cattle farming and nature conservation, here we compare livestock-wildlife interactions in both geographical regions to develop effective management strategies. The research design comprises a combination of methods from environmental and social sciences within case studies adjacent to different protected areas in Germany, Tanzania and Namibia. Stakeholder interviews enable thorough insights into existing conflicts and mitigation strategies, while wildlife occurrence and behaviour are analysed via camera traps. In Europe, where cattle is thought to replace the extinct aurochs, grazing is commonly used as conservation measure. However, we show that grazing practices, which are supposed to be particularly sustainable, can also lead to a reduction in wildlife activity, owing to associated management practices (electrified fences). Strategies towards carnivore-livestock conflicts were not part of grazing management in our German research areas. In contrast, efficient approaches to mitigate predation by carnivores can be found in Africa (e.g. herders during day; 'bomas' for fencing out predators during night). Thus, we strongly recommend incorporating this historically grown knowledge into concepts for dealing with currently increasing carnivore-livestock conflicts in the fragmented landscapes of Europe. However, there are other relevant livestock-wildlife conflicts in the African context. The competition over limited resources seems to be a major issue. A case study at the border of the Serengeti revealed a grazing system, which has little in common with the historically grown pastoralism. Wildlife behaviour (particularly daily activity patterns) were strongly influenced by cattle grazing. Elements of European grazing management (e.g. integrating livestock into conservation concepts) are supposed to support the sustainability of livestock farming in Africa. However, the specific situation of sub-Saharan Africa (vulnerability of savannah ecosystems; cattle as an allochthon faunal element; naturally occurring megafauna still present) requires a careful consideration.

SESSION 13

Forest disturbance, land use change and plant-soil interactions

Chairs: Mathias Mayer, Boris Rewald

Impacts of natural disturbances on forest carbon cycling and their implications for ecosystem management

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Disturbances such as windthrow, insect outbreaks, and wildfires are important processes of natural forest dynamics. However, disturbance regimes are changing in forests around the globe, inter alia in response to climate change. I here show that intensifying disturbance regimes could substantially reduce the carbon (C) storage potential of Europe's forests. An increase in the activity of native disturbance agents could lower the continental C storage potential by more than 500 TgC. In addition, the invasion of alien pest species could lead to the emergence of novel disturbance regimes. This development is further fueled by climate change, and the spread of only a small number of aggressive pests could result in C losses that are in the same order of magnitude as those from native disturbance agents. Such a development could thwart the efforts to mitigate climate change by storing more C in forest ecosystems. The resulting feedbacks between climate and vegetation could further aggravate climate change, making disturbances a key element of future ecosystem management. To address this challenge, management as two basic options: Reducing disturbance risk and increasing disturbance resilience. Measures to reduce risk include containing the spread of invasive alien pests and making stands more resistant to the impacts of natural disturbances. Resilience can be enhanced by fostering the response diversity to and recovery from disturbances. However, natural disturbances have also positive effects on the forest C cycle, e.g. via a legacy sink effect and an accelerated adaptation of the ecosystem to changing environmental conditions. Ecosystem management should harness all these possibilities in order to safeguard forest functioning also under drastically changing forest disturbance regimes.

Outbreak of the bark beetle *Orthotomicus erosus* in the Mediterranean pine forests in Croatia

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Bark beetles have been documented as having relevant ecological and economic role in ecosystem functioning and their activity can indicate the health condition and vitality of forest. They are also very important forest pests that can cause serious dieback of forests on huge areas. With climate change there is a strong possibility that the frequency of their outbreaks will increase which makes Mediterranean forests more vulnerable to their attacks than temperate and boreal regions. Mediterranean forests have been strongly influenced by human activities over centuries but despite this, they have demonstrated strong resilience and possibilities of recovery from these influences. However, today they are under severe threat from climate change and it is predicted by FAO that the Mediterranean forest ecosystems will suffer from its impacts by 2050. Climate change could indirectly negatively influence forest ecosystems through range expansion and changing of seasonal phenology of insect pests, resulting in faster development and higher feeding rates of phytophagous insects. Recent heavy bark beetle's attacks of the species *Orthotomicus erosus* in Croatia shows that the negative influence seems to be accelerated with increased temperatures and frequency and intensity of drought with extended growth period of vegetation. Other negative influences of climate change on forests could be shown in physiological changes in tree defences and indirect effects through changes in abundances of natural enemies and competitors. Large areas of pine forests in Dalmatia have been attacked resulting in death of up to 30 % of trees which makes this problem challenging for the forest sector in coming years.

What is the impact of salvage logging after disturbance on the landscape-scale forest carbon balance?

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Forest disturbances alter ecosystem dynamics, including water, carbon and nutrient cycles. Disturbed environment generates feedbacks to the post-disturbance vegetation dynamics, which can be further altered by management or climate change. Such processes remain incompletely understood, though might be central to forest and landscape resource management or nature conservation. Forest models support the assessment of disturbance impacts, however, proper representation of interacting disturbances in models remains a challenging task. We evaluate here the ability of forest landscape and disturbance model iLand to represent wind and bark beetle disturbances typical of the European temperate forests. We use the long-term observed wind data and forest disturbance patterns from Landsat imagery to define the parameters of mechanistic wind model embedded in iLand. Further, we evaluate forest carbon dynamics emerging from the interaction of simulated wind and bark beetle disturbance, and the mitigating effect of management that includes salvage logging. We were able to simulate the long-term wind and bark beetle disturbance regime in a good correspondence with empirical records; however, reproduction of a real windthrow followed by a bark beetle outbreak was subject to substantial uncertainty. Simulated post-disturbance carbon fluxes were in a good correspondence with general theoretical concepts. Recovery of the total landscape carbon was strongly controlled by salvaging intensity that both directly affected the amount of carbon in the landscape and indirectly mitigated the disturbance impact via reducing the reproductive success of beetles. This indicates that understanding of trade-off between the two contradictory effects of salvaging (C loss from the system vs. reduction of bark beetle risk) might be central to managing forests for increased carbon sequestration.

Spruce forest after severe bark-beetle outbreak: patterns and processes driving regeneration

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Large, severe disturbances drive many forest ecosystems, but pose management uncertainties when human experience with them is limited. Following a series of large, severe (~ 99 % overstory mortality) outbreaks of spruce bark beetles (*Ips typographus*) in Central Europe, we evaluated regeneration dynamics and tree spatial pattern in Norway spruce (*Picea abies*) forests. We tracked 10 years of post-outbreak regeneration dynamics (density, height, composition, age, mortality) of all tree species and evaluated initial variations in successional pathway and structure. Median tree regeneration density increased from ~ 400 trees ha^{-1} at the time of outbreak to ~ 2,000 trees ha^{-1} within a decade. Most seedlings originated directly within the three-year dieback of canopy trees. However, importance of advance (taller and older) regeneration increased over time, because it had the highest annual survival rate (> 95 %). Besides height, survival was modified by microsite: seedlings established on dead wood survived best, whereas almost all seedlings surrounded by graminoids died. For 5 cm tall seedlings, annual mortality ranged from 20 to 50 % according to the rooting microsite. Tree spatial pattern showed high resilience to stand-replacing disturbance. After a self-thinning of recruits tightly clustered around parental trees, their spatial pattern will mirror the pattern of trees that formed the stand before the disturbance. Such pattern in regeneration process constitutes a key legacy effect, promoting structural complexity in early-seral forests as well as variable successional pathways and rates. This also implies a continuity in spatial ecosystem structure that may well persist through multiple forest generations. Our results showed that spruce beetle outbreaks effectively promoted Norway spruce in the long-term. Outbreak-affected forests are naturally self-replacing even after severe canopy mortality and 10 years after the outbreak the regeneration density is high enough to secure all the ecosystem functions of those forests. Thus, natural regeneration may be considered among the most effective ways to meet reforestation objectives in beetle-killed forests.

Herbaceous competition and browsing may induce arrested succession in central European forests

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Arrested succession, i.e., an ecosystem permanently halted in an early successional, typically non-forested state, has been suggested to result from intense above- and belowground competition by understorey vegetation, high browsing pressure and additional disturbances, but the relative importance of these factors is unclear. In addition, distinguishing between permanently arrested succession or merely delayed succession may be highly challenging, if not impossible, due to the large time-scales involved. We used the dynamic vegetation model LandClim to systematically explore the effect of multiple factors on delayed and arrested succession over a time span of 1,000 years, starting from an unforested state. We included abiotic and biotic factors as well as large-scale overstorey disturbance, in four Central European landscapes. Arrested succession occurred in 1–14 % of the simulations. Among the nonarrested simulations, 95 % reached a forested state (defined as ≥ 10 % canopy cover) within 100 years. Large herbaceous biomass was the most important predictor for arrested succession, followed by browsing and large-scale disturbances. Combinations of factors were important at particular locations in the landscape, where understorey competition and browsing jointly induced a strong establishment filter. Abiotic conditions consistently influenced the probability of arrested succession, with a low probability under mesic conditions and increased likelihood in more xeric parts of the landscapes. We demonstrated that permanently arrested succession has the potential to occur in temperate forests, particularly under a combination of high amounts of herbaceous biomass and ungulate browsing in drought-constrained landscape positions. Even though a landscape may appear to be at a low risk for arrested succession under present conditions, a shift towards intensified disturbance regimes or more frequent and severe drought events may change the situation considerably, with drastic consequences for ecosystem functioning, in particular carbon storage.

Effects of ungulate herbivory and secondary succession on soil respiration after forest windthrow

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Development and characteristics of secondary succession after forest disturbance is often determined by ungulate herbivory. How this affects the forest carbon cycle is largely unknown. In this study we investigated the effects of ungulate herbivory and secondary succession on soil respiration (Rs) and its autotrophic (Ra) and heterotrophic (Rh) components at two windthrow sites. The sites were located in the Austrian Alps and differed with regard to the time since disturbance (9 and 13 years after windthrow). Plots were established within fenced (herbivory affected) and non-fenced (herbivory unaffected) treatments at both sites. Tree regeneration at both windthrow sites was drastically reduced by ungulate herbivory. Secondary succession at non-fenced plots was rather dominated by herbs and grasses. The differences in establishing vegetation were, however, higher at the older windthrow site. At the younger windthrow site neither Rs, Ra, nor Rh were affected by treatment. At the older windthrow site, Rs and Rh were significantly ($p < 0.05$) higher at the non-fenced plots. The lower rates at the fenced plots were mainly related to lower soil temperatures underneath the young trees (crown shading). Our results suggest that ungulate herbivory and secondary succession can strongly determine post-disturbance soil carbon cycling in the Austrian Alps.

Moth outbreaks reduce decomposition of soil organic matter in subarctic birch forests

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Tree mortality from insect infestations can significantly reduce carbon storage in forest soils. In subarctic birch forests (*Betula pubescens*), ecosystem C cycling is largely driven by recurrent outbreaks of defoliating geometrid moths. Here, we show that soil C stocks in birch forests across Fennoscandia did not change up to 8 years after different levels of moth disturbance. We find that a decrease in woody fine roots was accompanied by a higher soil N availability following disturbance. A high N availability and less ectomycorrhiza lowered soil enzymatic activity and thereby decomposition. We conclude that a decrease in decomposition is a prime cause why soil C stocks of mountain birch forests have not changed after moth outbreaks. Compared to disturbed temperate and boreal forests, a CO_2 related positive feedback on climate change might therefore be smaller in subarctic regions.

Cross-regional modelling of fire ignitions in Europe

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In recent years, machine learning techniques such as Maxent, commonly used in species distribution modelling, have also been successfully applied in fire ecology studies. In this study, we developed a cross-regional model of fire ignition for Europe using Maxent to improve our understanding of spatial ignition patterns. For this purpose, we modelled the fire ignition probability in four case study regions in four countries (Austria, Spain, Switzerland and Turkey) based on historical fire data, and also created a cross-regional model. We used bioclimatic (BIOCLIM), anthropogenic (e.g., land cover, human settlement, road density), and topographic variables (e.g., slope and aspect) as predictors, and evaluated model performance based on AUC values, prediction and standart deviation maps. To test the transferability of the regional models, we applied each in all other regions. Furthermore, we also investigated the effects of sample size, as well as temporal and spatial resolution. We found that all coarse resolution (1 km^2) regional models performed well, with AUCs varying from 0.658 (Spain) to 0.835 (Switzerland). Fine resolution (100 m^2) models performed slightly better, with model AUCs varying from 0.689 (Spain) to 0.856 (Switzerland). Transferability of the regional models was better than expected, and among 20 transferred models only 4 of the coarse resolution models and 5 of the fine resolution models showed AUC < 0.6. Key variables of the models showed major similarities between regions. They also did not show differences depending on the spatial resolution. The study contributes a better understanding of statistical fire ignition probability and the spatial transferability of statistical fire ignition models.

The effects of forest-atmosphere interaction on regional climate in temperate Europe

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Land use and land cover changes are considered to be one of the highly important factors in the energy budget equation. Land cover changes through afforestation or deforestation can amplify or mitigate climate warming by changes in biophysical and biogeochemical mechanisms which further affect the ecosystem services. In the montane to subalpine zone of the South-Eastern Alps forests have constantly expanded for the last four decades on abandoned grasslands. Here, the warming rate was significantly lower compared to the mountain lower counterparts for the period 1976–2010 and the global radiation reduced by 2.0 ± 0.86 W m^{-2} $year^{-1}$ for the period 2000–2015. To interpret the potential role of forests expansion in producing such effects (cooling and dimming), neighbouring forest and non-forest FLUXNET sites in Central Europe were analysed. For all the studied sites a lower amount of incoming radiation was recorded at the forest site supporting the idea of forest driven dimming. A modelling approach which integrated biophysical mechanisms (albedo, surface roughness and Bowen ratio changes) and changes in global radiation showed the potential of afforestation to determine a reduction in total radiative forcing and thus on local air temperature. Such results suggest that afforestation affects local climatology both via albedo and radiation feedbacks but also by means of indirect biophysical and probably species-dependent mechanisms like enhanced evapotranspiration rates and biogenic volatile organic compounds emissions. We emphasize that land cover conversion towards forests has a paramount role in determining the local energy distribution, in both simple and complex orographic contexts, and future research and models should account for the forest driven dimming effects on local climate and its implications on ecosystem nutrient and carbon cycles.

SESSION 13-P1

Thinning practice influences soil microbial biomass, enzyme activities and organic matter dynamics in *Fagus sylvatica* plantation

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For centuries forests have been managed to maximize timber production for economic profit neglecting other forest ecosystem service. Nowadays, forests are recognized as key elements to combating climate change, and reducing risk of natural disasters. Thus it is imperative to schedule appropriate management practices to reach sustainable development goals. Incorrect forest management can cause negative effects on the stability of ecosystems in each of its forms, inducing soil erosion and loss of biodiversity and consequently forest productivity. Numerous studies have been carried out to understand the relationships between forest management, soil erosion and productivity, but few studies focused on the effects of forest managements on soil biological quality. The aim of this work was to assess if and how two different forest management practices, influence soil biological quality in terms of organic matter dynamic and microbial biomass activity, with the specific objective to identify a forest management practice to improve productivity and at the same time preserve forest soil quality. The effects of innovative thinning (preselected 50 trees/ha and removal of direct competitors) and traditional thinning (cutting of 12 % total trees/ha) have been evaluated and compared to unmanaged area (no thinning). Microbial biomass carbon, enzymatic activities, organic matter content, humification rates, ergosterol, dissolved organic carbon and microfauna community (EMI index) have been assessed. The results obtained showed highest dehydrogenase activity in soil under innovative thinning where a balance between mineralization and humification process was also observed. Conversely, fluorescein diacetate and catalase activities, were highest under traditional thinning, where the mineralization process prevailed. Both managed sites had the highest EMI index, suggesting that thinning increased soil biodiversity. Ergosterol, a fungal biomarker, was low in the innovative thinning area supporting lower hydrolytic soil activity. Largest amount of humified OM under innovative thinning, support this management strategy as a sustainable way to improve fertility and physicochemical soil stability.

SESSION 13-P2

Extracellular enzyme activity in a fire chronosequence of a hemiboreal forest

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The occurrence, duration, and severity of wildfires has recently increased, and long-term models suggest the trend will continue throughout the century. Fire disturbances in boreal forests are known to affect the biological communities for several years after their occurrence. Activities of extracellular enzymes allow us to understand how these changes translate into (loss of) ecosystem functions. We analysed the trends and relationships between enzyme activities and years after fire. We measured activities of six key enzymes (cellobiohydrolase (CEL), β–glucuronidase (GLR), β–glucosidase (GLS), laccase (LAC), N–acetylglucosaminidase (NAG), acid phosphatase (PHO), and β–xylosidase (XYL) along a fire chronosequence in Scots pine stands in north-western Estonia. Stand-replacing fires occurred 8, 19, 34, 65, 76, and 179 years before this experiment. To identify the trends in enzyme activities along the chronosequence, we scaled the activity rates to low, medium, and high based on quantiles. We also assessed the mass loss within the litterbags from which we quantified enzyme activity. In addition, we summarized the relationship among enzyme activities via a principal component analysis (PCA). Needle mass loss was significantly higher in the oldest site. The sum of medium and high enzyme activity of our older site amounted to at least 80 % of the total measured activity for all enzymes, while low activity ranged from 60–90 % of the total in 8 years old sites. Activities of GLS, NAG, and PHO exceeded low levels already 19 years post fire disturbance. Activities of GLR, XYL, and CEL surpassed low levels 34 years after fire, whereas LAC activity took 65 years to recover. The PCA produced two components, which explained 79 % of the variation. However, none of them significantly associated with fire age class. PC1 showed a strong positive association with XYL, NAG, CEL, GLS, and GLR, and a moderate positive association with PHO. PC2 showed a strong positive association with LAC.

SESSION 13-P3

Soil fungal guilds and decomposition in a disturbed forest ecosystem

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Disturbance is an important driver of the carbon and nutrient cycle of forest ecosystems. How forest disturbance affects soil microbial communities and its role in soil organic matter (SOM) decomposition is, however, largely unknown. In this study, we determined how tree girdling and clear-cut harvest affect the soil fungal community and decomposition processes in a forest of the Austrian Alps. Sampling prior and after treatment establishment allowed for a direct, plot-specific evaluation of treatment effects on the investigated soil variables. DNA extracted from the topsoil was subjected to high-throughput amplicon sequencing of the fungal ITS2 region for community profiling. Bioinformatically derived operational taxonomic units (OTU's) were subsequently assigned a fungal guild based on their lifestyle (i.e. saprotrophic, symbiotic and plant pathogenic fungi). Heterotrophic respiration and mass loss of standardized litter bags were measured and served as proxy for SOM decomposition. Treatment establishment had only little effects on soil fungal guilds in the first year after girdling and clear-cut harvest. Heterotrophic respiration rates and their temperature sensitivities (Q_{10} values) were similar among treatments. Litter mass loss was significantly increased at clear cut plots when compared to other treatments. Since soil temperature was markedly higher following clear-cutting, our results suggest that SOM decomposition was basically enhanced by warmer soil conditions in the initial period following clear cut harvest.

SESSION 13-P4

TreeScape: a trans-taxonomical study on the relationship between diversity and various aspects of heterogeneity in forests

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Environmental heterogeneity is assumed to provide niches in which otherwise competing species can co-exist and hence increases species diversity, whereas homogenization leads to a decrease in species diversity (habitat-heterogeneity-hypothesis, MacArthur and MacArthur 1961). This should be especially true in today's central European Forests, in which modern silviculture has severely altered the configuration of the forest landscape and the composition and physiognomy of forest stands. However, this relatively old theory has been doubted recently, given that high heterogeneity might also lead to a decrease in the amount of suitable area available for single species and thus could make stochastic extinction of species more likely. Thus, it could be possible that species richness does not monotonically increase with heterogeneity but decreases after a certain level is reached. The shape of the relationship between biodiversity and heterogeneity is thus as unknown as the question which single aspects of heterogeneity govern biodiversity. This uncertainty is based on the lack of a clear definition of heterogeneity, which encompasses several aspects which are not always easy to quantify, and on a lack of trans-taxonomical studies dealing with more than just linear relationships. Here, we present TREESCAPE, a project in which we comprise data of nine different taxonomical groups, from more than 300 Plots across Germany. We aim to a) identify the shape of the relationship between heterogeneity and biodiversity and b) to determine the major drivers of biodiversity among various aspects of environmental heterogeneity. In order to gain a precise measurement of heterogeneity, we use of airborne lidar and extensive field data, from which we were able to collect structural- physiognomic, floristic and topographic heterogeneity predictors. First results from non-linear analyses will be presented.

SESSION 13-P5

Insekten-Massenvermehrungen in Bayerns Wäldern: Handlungsbedarf, Managementoptionen und ökologische Auswirkungen

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Der Schwammspinner (*Lymantria dispar*) nimmt durch räumliche Ausbreitung und verkürzte Massenvermehrungsintervalle in Europa, Asien und den USA an Bedeutung zu. In Bayerns Eichenwäldern erweitern Schwammspinner und Eichenprozessionsspinner (*Thaumetopoea processionea*) in den letzten 20 Jahren ihre Befallsgebiete kontinuierlich. Kahlfraß durch die Raupen kann zu massiven Schäden in betroffenen Waldbeständen führen, sodass zu deren Erhalt der Einsatz von Pflanzenschutzmitteln erwogen werden muss. Die ökologischen Folgen einer Behandlung, aber auch die eines belassenen Kahlfraßes, werden durch das komplexe Zusammenwirken biotischer und abiotischer Faktoren in den Folgejahren bestimmt und sind kaum prognostizierbar. Das vorhandene Wissen über relevante Schlüsselparameter und ihre Wechselwirkungen reicht als verlässliche Entscheidungsgrundlage für Handlungsbedarf, -art und -umfang nicht aus. Auch Borkenkäferarten wie Buchdrucker (*Ips typographus*) und Kupferstecher (*Pityogenes chalcographus*) werden vom Klimawandel begünstigt. Vermehrte Extremwitterungen schaffen Brutraum, hohe Temperaturen befördern Befallserfolg und Brutentwicklung und so ein enormes Vermehrungspotenzial. Die Maßnahmen im Borkenkäfermanagement bestehen vorwiegend im Ausräumen von Befallsherden und führen zum Verlust weiterer Waldbestände. Einsatzmöglichkeiten verhaltensmodifizierender Substanzen zur Befallsprophylaxe werden seit Jahrzehnten untersucht. Die chemischen und biologischen Eigenschaften dieser Wirkstoffe machen die Herstellung eines praxisfähigen Präparates sowie die Qualitätssicherung und Reproduzierbarkeit der Wirkung solcher Produkte schwierig. Mittel- und langfristig müssen unsere Wälder durch waldbauliche Maßnahmen gegen sogenannte „biologischen Störungen" stabilisiert werden, wodurch Eingriffe und Gegenmaßnahmen seltener und in geringerem Umfang erforderlich werden.

SESSION 14

Forest ecology – linking diversity and function

Chairs: Douglas Godbold, Christian Ammer, Christa Schafellner

Re-analysis: the global tree diversity – forest productivity relationship evaluated across biomes

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The analysis of a large data set of productivity measurements in forest plots around the world has suggested that there is a global tree species richness-forest productivity relationship (Liang et al. 2016 Science). Here we present a re-analysis of this data set, after correcting for some statistical errors, challenging the main conclusions of the original paper. We extend the analysis to comparisons of the universal relationship with biome-specific analyses, and attempt to salvage some of the generalisable findings. Our re-analysis also puts particular emphasis on the potential for ecological misinterpretation of such analyses.

Ecological niche features crucial for the occurrence of xylobiont beetles

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Xylobiont beetles live under the bark or inside dead or decaying wood; they are crucial for wood decomposition and play an important role in the structural development of forests. Due to silvicultural practices, however, many xylobiont species are rare or critically endangered. Their presence is often an indicator of maturity and quality of a forest. Hence, there is a demand for detail information about the specific niche requirements that could help determine conditions under which conservation of these beetles could be incorporated into forest management. Using a number of selected species (*Buprestis splendens*, *Eurythyrea quercus*, *Dicerca aenea*, *Lacon querceus*, *Phaenops knoteki*, *Anthaxia tuerki*, *Ampedus quadrisignatus*) I will discuss important features of habitat requirements such as suitable breeding substrates, maturity of trees, stages of decomposition of deadwood and common biological characteristics like heliophelia, long lasting larval development, stongly monophagous feeding pattern, infrequent availability of host plant, and high position in the food chain.

Comparing community composition and diversity of birds and bats in nature reserves and selectively harvested stands

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Central Europe's temperate forests are shaped by centuries of human activity. Even though age-class forests composed of evenly aged trees of one species still dominate, modern forestry is promoting integrative approaches aimed at reconciling timber production with other objectives such as nature conservation. Instead of conserving biodiversity in large National Parks, such integrative strategies often include managed stands with different tree species, selective harvesting, and uneven-aged stand structures, as well as small nature reserves, but the effectiveness of such strategies is rarely established. On 40 beech and beech-oak forest plots in a large forested area in southern Germany, we compared species richness and community composition of birds and bats between forest reserves where management ceased 7 to 39 years ago and selectively harvested stands, both located in a large forest area under integrative management. In addition to the management regime, we analyzed the effects of tree species composition on both target groups, with the spectrum ranging from pure beech plots to oak-dominated stands. Bird species were surveyed using line transects on our plots on five different occasions between March and June of 2017. Bat diversity and activity were assessed via repeated bioacoustic monitoring using bat call recorders and automated identification of species combined with manual checking. Overall, species richness of birds (38 species) and bats (13 species) was high. We found that species composition and species richness in unmanaged forest reserves did not differ significantly from the one in selectively harvested stands for both bats and birds, despite a trend to more species of bats in the forest reserves. Bat activity was significantly higher in unmanaged stands, with more than double the number of minutes with recorded activity per night. Tree species composition, i.e. the share of oak and beech, had no significant impact on the community composition or species richness of either group. While our results indicate that managed stands under integrative management are comparable to unmanaged forest reserves in their value for bird and bat conservation, the relatively young history of abandonment in the unmanaged stands may have contributed to the uniformity of managed and unmanaged stands. Implications for the integrative management of forests and the role of small nature reserves will be discussed.

How does forest management affect diversity, species composition and functional composition of forest communities?

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Forests are crucial ecosystems, as they are not only providers of renewable resources but also sustain fundamental ecosystem services. In addition to that, they are home to many different species. The species communities found in these habitats are an integral part of forest ecosystems as they mediate ecosystem processes and functioning. Forest management practices modify stand structure and microclimate and, thus, may alter habitat quality. Yet, ecological impacts of silviculture on forest communities remain not fully understood. The aim of this study was to evaluate ecological consequences of different forest management practices applied in the Eifel region (Germany). We investigated the effects of four different forest management types (age class stands of European beech, Norway spruce, and Douglas fir plus near-natural permanent beech forests) in contrast to unmanaged beech reserves. In order to assess the effects of forest management on forest communities, we investigated plants, weevils (Coleoptera: Curculionoidea), woodlice (Isopoda), ground beetles (Coleoptera: Carabidae) and spiders (Araneae). Subsequently, we compared the different forest types particularly with regard to diversity, structural and functional community composition and correlated the community patterns with forest structures of different spatial scales (single tree, micro habitat and stand) as well as with forest management intensity. The study clearly showed several management related shifts in the structural and functional community composition of every trophic level. Above all, we found communities shifting functionally from highly specialised to mobile and ecologically flexible species. These shifts were correlated to forest management intensity well as to the studied forest structures. Additionally, we found shifts in the size class distribution of invertebrate communities, which may alter processes of nutrient and energy cycling.

Insects contribution to forest ecosystems services and disservices – case study: plantations in Portugal

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Worldwide forest plantations cover about 280 mill ha, corresponding to 7 % of the total forest area (Payn et al. 2015), most of which comprise of a single tree species. Yet, monocultures lead to a decrease of the integrity of ecosystem services (ES) (Gamfelt et al. 2013). Plantations are prone to insect invasions by alien species, as well as to large fluctuations of the established populations, processes that often determine the fate of production oriented systems. In forest plantations insects assume a range of ecological functions, thus contributing to all types of ES, consequently interfering with human well-being. Although it has been established that across taxa and regions, ecological and economic impacts are highly correlated (Vilà et al. 2009), a lack of general guidelines for deploying integrated valuation processes still persists. An analysis of ES for pine plantations in Portugal is presented, based on a methodology that integrates the concepts of services and disservices (Branco et al. 2015). Although the ES concept has received increasing attention (Gómez-Baggethum et al. 2010), it remains mostly overlooked by decision makers and environmental policy. While it is generally straightforward to calculate the economic impact caused by insects to production services, a thorough evaluation is precluded due to the existing information gap on multiple ecosystem values (Pejchar & Mooney 2009). The role of the most relevant insect species present in pine plantations in Portugal is evidenced and based on an integrative management framework (Branco et al. 2015), the ES affected are analysed. Since disservices are often induced by management practices (Schowalter et al. 2018), results can contribute to the implementation of prevention and control strategies, aiming at sustainable economic development, as measured by the Inclusive Wealth Index (IWI), which focuses on stocks, rather than flows (Costanza et al. 2017).

Towards multifunctional, biodiverse and sustainable productive forest landscapes in the northwestern Uruguay

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The ongoing debate on bone or bane of monocultural timber plantations demonstrates the need to develop alternative approaches that achieve productivity while conserving biodiversity as a global challenge in forestry. Multifunctional approaches emphasize on holistic forest values including environmental, social and economic perspectives. Within the *Campos* ecoregion in southeastern South America, grasslands cover about 70 % of the Uruguayan territory and constitute a heavily used socio-ecological system subject to expanding land use changes by grassland intensifications, afforestation and soybean plantation for the globalized market. With the aim to review and develop strategies for a functional integration of forest landscapes into a grassland dominated region, we assessed forest community characteristics and stand parameters within one-hectare permanent plots of nine native forests and nine *Eucalyptus* plantations in northwestern Uruguay. Species composition reveals significant distinctive community groups, which are determined by regeneration density, native and exotic richness, species and structural diversity. Native forests have a great similarity in species composition, including occurrence of invasive species (e.g. *Ligustrum lucidum*, *Gleditsia triacanthos*, *Melia azedarach*), they harbor many specialist species that are absent or rare in forest plantations and therefore play a decisive role in maintaining biodiversity. *Eucalyptus* plantations also harbor native species in the understory, including multi use species, and demonstrate the possibility to develop strategies such as mixed species plantation. Even if plantations supported fewer specialist species than native forests they can play a decisive role in biodiversity conservation at the landscape scale providing habitat for native diversity and catalyzing successional processes. Strategies to enhance regeneration of native tree species within plantations, to diversify horizontal structure and species composition will foster integration of plantations into the local setting and are promising steps towards multifunctional, sustainable productive and biodiverse friendly landscapes.

The effect of land use change on soil carbon stock and quality at Ethiopian highland ecosystems

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Soil organic carbon (SOC) is accumulated if inputs from biomass are greater than losses. Despite the large quantity of C stored in the soil, a consensus is lacking on the dynamics and the extent of land use change effects on soil C storage and quality, mainly for tropical ecosystems. Several field and laboratory techniques were carried out in the NW Ethiopian highlands and semi-arid savannah woodland to examine the magnitude of SOC stock changes due to land use conversion and identify their biological origin of input materials. The land use systems studied were natural forest, eucalyptus plantation, exclosure, grazing land, and cropland. Inputs from above- and below-ground materials were quantified using litter traps and ingrowth methods while mineralization was measured using a MicroResp method. Individual biomarkers were identified and quantified by gas chromatography and mass spectrometry at a molecular level. Results showed that land use conversion from native forest to cropland or grazing land reduced SOC stocks by 70 % in < 50 years. Afforestation and exclosure led to an increase of SOC; however, the rate of increase (ca. 0.3 kg m^{-2} yr^{-1}) was lower than losses (ca. 0.4 kg m^{-2} yr^{-1}). The geomarker analysis (Sr/Ca and Ba/Ca ratio) and vertical distribution of carbon suggest that the major factor for SOC reduction is erosion while the C loss through mineralization ranged from 1.6–3.9 mg g soil-1 yr^{-1} and increased with increasing temperature. This is consistent with C availability in the soil. Conversion of native forest to grazing land and cropland resulted in the reduction of C input into the soil by > 90 %. Fine roots decomposed slower (decomposition rate constant of 1.7 yr^{-1}) than leaf litters (2.5 yr^{-1}). The variation in decomposition is due to their chemical composition. From the biomarker analysis, the amount of suberin was 2–times that of cutin further confirming higher inputs of recalcitrant carbon from fine roots. The dominance of aliphatic lipids and the ratio of lignin-derived phenols of syringyls to vanillyls suggested that angiosperm plants are a major input of SOC while microbial inputs were present as minor components (< 1 %). Overall, conversion of native forest to open lands in Ethiopian highland resulted in substantial loss of SOC stock due to both erosion and mineralization.

Resilience of lowland forests in Eastern Austria – Norway spruce at the trailing edge

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Land use and forest management can strongly alter the natural tree species composition by favoring species that hold high economic value. In Central Europe, Norway spruce (*Picea abies*) is naturally a significant part of mid- to high elevation landscapes, but due to its high economic value the species has been favored by management also in areas that are at the fringe of its natural range. Low elevation landscapes naturally dominated by beech (*Fagus sylvatica*) and mixed stands have been converted to Norway spruce-dominated stands to support timber production. Such forests offer a unique opportunity to study vegetation dynamics at the trailing edge of a species' distribution, and assess the resilience to increasing pressures associated with climate change, e.g. bark beetle outbreaks and extended periods of drought. The aim of this study is to analyze the resilience of Norway spruce to climate change at the trailing edge of its current distribution. Specifically, we ask whether resilience can be influenced through deliberately choosing the spatial configuration and composition of species on the landscape. We use iLand, the individual-based forest landscape and disturbance model, to simulate the dynamics of a managed lowland (200–750 m asl) landscape with a forested area of 6,700 ha in Eastern Austria. The natural potential vegetation of the landscape is dominated by beech, but due to past management, the current share of Norway spruce makes up 45 % of the growing stock. We quantify the impact and recovery of Norway spruce to climate change under different climate scenarios by comparing mortality and recovery rates to a baseline scenario with historic climate. Different configurations and compositions of Norway spruce on the landscape are simulated to analyze their effect on species resilience. The study thus underlines the potential and limitations of landscape-level factors for a population at the trailing edge, and provides important insights for ecosystem managers.

Recovering the function of sweet chestnut: classical biological control of invasive *Dryocosmus kuriphilus* with introduced parasitoid *Torymus sinensis*

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Sweet chestnut (*Castanea sativa) is* a valuable forest species which is endangered by two highly invasive organisms: chestnut blight (*Cryphonectria parasitica*) and Asian chestnut gall wasp (*Dryocosmus kuriphilus*). These harmful organisms have significantly influenced health and function of European sweet chestnut forests. *D. kuriphilus* is the most recent introduction and in the last 10 years it has spread quickly in Europe making significant damages in sweet chestnut foreststst. The only effective option was application of classical biological control and use of *Torymus sinensis*, a classical biocontrol agent of chestnut gall wasp *Dryocosmus kuriphilus*. The parasitoid was released in Croatia, Slovenia and Hungary in 2015 and 2016. Following the introduction, the research of parasitism rates and population genetic indices on 40 different sites was performed in order to monitor and evaluate the success of establishment. *T. sinensis* established viable and genetically diverse populations and also successfully spread naturally from Italy across Slovenia to Croatia and Hungary. Population genetic indices showed that populations of *T. sinensis* did not suffer from bottleneck-induced founder effect phenomenon. This rapid dispersal of *T. sinensis* was aided by high concentration of the host, as well as the lack of competition of native parasitoids. This successful application of classical biological control in forestry, first of its kind in Croatia, Slovenia and Hungary has enabled recovery and return of functions of sweet chestnut trees and lowering the population level and damages of *D. kuriphilus*.

EcoSens – comprehensive measurement of air quality and other environmental parameters in urban areas

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Progressing climate change and environmental pollution, especially air pollution, are two crucial problems we all are facing today. Measures like the Paris climate agreement and other national projects, like the air quality directive by the European Union, try to set steps to counteract the increasing traffic, environmentally harmful manufacturing processes and other greenhouse and toxic gases produced by major building and production projects. The main point of the directive is to secure observance of limits to protect the human health. Cities and urban areas are also metropolitan areas for environmental pollution. Location, numbers for measuring stations and measuring procedure are regulated by Europe-wide uniform legal requirements. Realization of an area-wide coverage in urban areas is not possible with such prescribed measuring stations, due to the spatially and temporally highly heterogenous nature of those regions. Especially the knowledge of those local and temporal peaks is a key information for targeted countermeasures. So, an area-wide measurement, instead of single local measuring stations, is a major step towards an increase of air quality in those urban areas. The presented research and development project 'EcoSens' should, driven by the rapid technological progress in sensor technology, provide the required data to create emission maps for urban areas. By mounting an enclosed system, which not only houses the sensors but also GPS, to trucks, cars or even bicycles it will be possible to even collect data from the most rural areas. Aside from measurements out of the air (e.g. CO_2, particulate matter, ozone, NOx, etc.) also other important factors, such as temperature, humidity and of course the location will be collected to visualize air quality and environmental influences. Subsequent evaluation and visualization can be used as data basis for various environmental projects, as measure to increase air quality in cities or to visualize the positive effects of 'green lungs' (parks, meadows, etc.) in urban areas. Realizing this project as an anonymous citizen science project, with an as heterogenous community as possible, seems reasonable. To implement 'EcoSens' as part of a founded, self or investor financed research, development and innovation project we are in search for partners from research and administration. Especially those with experience in following fields: urban ecology, emission measuring in urban areas, citizen science, server-based real time evaluation of environmental data.

POSTER PRESENTATIONS

SESSION 14-P1

Steps of an integrated bark beetle management

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In commercial forests the management of bark beetles is a crucial task for foresters in order to ensure a highly demanded timber supply and carbon fixation. Numerous species of bark beetles may affect almost every kind of tree species which are prevailing in forests. But due to the wide spread of *Picea abies* the most dreaded species is the bark beetle *Ips typographus.* Taking the potential natural tree species composition into consideration *Picea abies* is much wider spread than it is supposed to be. Many forests got converted into even aged monocultures in context of forest utilization history. The present disadvantage at those frequently not site adequate stands is that they are quite susceptible to abiotic disturbances as well as pathogens and especially to insects like *Ips typographus.* Nowadays more than 90 % of sanitation felling due to insects is related to *Picea abies.* Mass outbreaks of bark beetles are predominantly initiated by abiotic disturbances like storm, snow damage combined with persistent warm and dry weather conditions. Subsequently still healthy standing trees get attacked and affected especially under drought conditions. The rate of beetles' development is very much dependent on the available warmth sum and weather, site as well as stand conditions or elevation respectively. The bark beetle management in Europe in most cases is based on the principles of an Integrated Pest Management (IPM) according to plant protection acts which itself follow the directives of the EU. The aspect of prevention is very much given priority applying adequate silvicultural decisions and methods, followed by biological, biotechnical, technical or mechanical measures far before, as an absolutely last resort (ultima ratio), insecticides are taken into consideration. Although in many parts forestry aims strongly at converting inadequate *Picea abies* stands to closer to nature forests not least because of climate change, a certain number of even aged monocultures will still remain for a while. Moreover in naturally mixed and indigenous stands consisting of *Picea abies* also in future bark beetle mass outbreaks will take place as a part of forest ecology. To secure our basic needs for wood products it is beyond all questions that in commercial forests bark beetle management is required permanently.

SESSION 14-P2

Airborne LIDAR transforming the science and industry of ecological monitoring

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The crisis of ecosystems has fuelled development of the science of ecosystem features and functions and their connection with human well-being. Commitment to the protection of biodiversity and ecosystem services has launched a growing industry delivering ecosystem mapping and monitoring. New methods for quantifying species distributions and ecosystem processes are being developed, but both science and industry are still hampered by the large uncertainty of such datasets. Most studies rely on sparse field samples or none at all and use land cover maps and simple models. Meanwhile airborne LIDAR has emerged as a remote sensing method that delivers detailed three-dimensional information on topography and vegetation. LIDAR has proven its utility for habitat status assessment, species distribution modelling and species richness prediction in local to regional scientific studies. 3–D models allow measuring exactly the biophysical quantities driving ecosystem processes and diversity instead of using land cover as a proxy. Many countries and regions have commissioned full LIDAR scans of their territory. Such datasets are often openly available. Therefore LIDAR can support environment impact assessements, biodiversity inventories, habitat maps and ecosystem service assessments. High resolution also allows directly linking reference data with remotely sensed pixels for rigorous quantification of error. LIDAR-based maps, datasets and scenarios can be rapidly produced and field effort can be optimized. Progress towards policy targets can now be monitored at extents and accuracies directly relevant for evidence-based decisions. Finally, for the science of ecology, the arrival of national-scale LIDAR means that hypotheses such as the biodiversity-ecosystem services connection or the processes governing species richness can be tested and verified at up to continental scale.

SESSION 14-P3

Development of an automatic HD minirhizotron imaging system by cross-sectoral collaboration

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Minirhizotron (MR) systems are a qualitative and quantitative observation tool to study root and hyphal growth, longevity and distribution *in situ* or mesocosms. MR systems are based on imaging the rhizosphere using transparent tubes (MR-T) inserted tightly into the soil. A new MR camera system was recently developed by cross-sectoral collaboration between academic and industrial partners to improve the imaging of large minirhizotron facilities (root labs, rhizolabs, walk-in root 'cellars', 'Ecotron' etc.) featuring dozens or even hundreds of MR tubes in semi-natural settings. The novel imaging systems allows to automatically capture full-HD images in MR-T installed horizontally or slightly angled, using a two bidirectional camera system module driving on am inserted gear rack. High image resolutions are decisive for detailed root morphological (e.g. root hairs, color change) and hyphae observations; automatic systems, which only require an operator to move camera modules between tubes, reduce workload for repeated imaging, and thus labor costs, significantly and ensure a correct image labelling especially in large experimental set-ups. This project highlights how cross-sectoral collaboration between industrial and academic partners can advance scientific instrumentation at moderate costs and at reasonable development times.

SESSION 14-P4

Additive positive effects of canopy openness on European blueberry (*Vaccinium myrtillus*) fruit quantity and quality

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The European blueberry or bilberry, *Vaccinium myrtillus* L. (Ericaceae), is an important food resource for many mammals, insects and birds in forests, including the endangered capercaillie (*Tetrao urogallus*). For capercaillie, a sufficient amount of bilberry fruits is crucial to store enough body fat for the winter period. Studies have shown that *V. myrtillus* reproduction is influenced by canopy openness, but specific effects of flower availability, light conditions and pollinators on fruit production remain unclear. We therefore assessed bud, flower and fruit abundance as well as quality traits for *V. myrtillus* fruits under different light conditions in 12 plots in the Black Forest National Park from April to July 2017. We further observed and identified flower-visiting insects and calculated the seed set for all collected fruits. With greater canopy openness, flower buds and hence fruit abundance increased. The few fruits that developed in the shade had fewer ovules compared to fruits under better light conditions. In the sun, seed set was highest, suggesting higher pollinator activity on these microsites. We identified five flower-visiting insect species of the genera *Andrena*, *Bombus* and *Lasioglossum*. The results show that canopy openness can trigger a number of additive positive effects on the number of flowers and hence potential fruits but also their quality due to an enhanced pollinator activity. Active canopy opening can therefore be used to increase food availability for capercaillie. Management plans to support capercaillie populations however, should also consider the time lag between active canopy opening and flowering response in *V. myrtillus*.

SESSION 14-P5

The multifunctional role of open dry forests in agri- and silvicultural modified grasslands in Uruguay

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Shifting the gaze to the role of strongly human modified ecosystems for biodiversity conservation and fostering ecosystems multifunctionality of cultural landscapes to enhance their sustainability is an important goal to meet the challenges of the twenty-first century. The so called 'park forests' and important but widely understudied open dry forests in Uruguay share space with invasive and exotic species like grasses, ruderal plants and cattle ranching. We characterize quantitative and qualitative the forest community within one hectare plots of ten park forests in four departments of Uruguay. We examined the role of scattered trees in regeneration by analyzing the natural occurrence of nurse-beneficiary interactions in 410 paired treatments in the open area and under the trees. The effect of habitat and tree scale variables on tree regeneration density, richness and grass cover was modelled by fitting generalized and linear mixed models. For the first time, we found evidence that the scattered tree community in park forests significantly enhance tree regeneration density and richness improving microclimate and attracting dispersers. We identify trees as key stones promoting forest regeneration and recovery besides being a biodiversity pool in human modified landscapes. We propose a strategy to conserve and restore floristically diverse park forest including silvo-pastoril systems. Our results provide valuable information for the management and restoration of one of the most threatened and poorly studied ecosystems in Uruguay.

SESSION 14-P6

In search of the threshold of dead wood in commercial forests – diversity of saproxylic beetles in pine and oak stands in Poland

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Dead wood was inventoried in 13 research areas – pine and oak stands with varying degrees of naturalness and way of management. Objects represent a wide range of management types: strict reserves, oak stands attacked by *Armillaria* sp., uneven-aged pine stands and commercial forests with intensive sanitation cutting. Beetle composition was analysed for species richness and diversity indicators, belonging to trophic and ecological groups and relations with amount of dead wood. The results are varied, inventory of dead wood ranged from 0,45 to 95 m^3/ha, species richness ranged from 20 to 118 beetles species and abundance of specimens ranged from 50 to 1,002 per research area. Shannon Wiener Diversity Index has reached values from 0.88 to 4.00 and Margalef Species Richness Index has reached values from 11.19 to 42.23. Highest values were obtained for stands infested with *Armillaria* sp.

SESSION 14-P7

Climate sensitivity of rare native tree species in NE-Germany – a dendroecological and ecophysiological approach

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The aim of our study is to identify suitable tree species to increase the biodiversity in NE-German forests under a changing climate. The climate projections for this region predict higher temperatures and less precipitation during the growing season and generally more frequent extreme events (Lasch *et al.* 2002; Lindner *et al.* 1997). In particular we assess the sensitivity of rare native tree species to extreme/prolonged summer drought. These rare and secondary, less studied species include *Taxus baccata*, *Betula pendula*, *Carpinus betulus*, *Prunus avium*, *Acer campestre*, *Malus sylvestris*, *Pyrus pyraster* and *Sorbus torminalis*. In a pot experiment leaf gas exchange, leaf water potential and biomass are assessed on watered and non-watered 3–year old seedlings during the main growing season. In forest plots we collect stand data and extract increment cores for dendrochronology and carbon stable isotope analysis of distinct pointer years. Concerning the focus of dendrochronology we test different approaches to visualise tree ring boundaries. The pointer years were analysed to rank the vulnerability and the potential for recovery of the different species. Carbon stable isotope natural abundance analysis of individual tree rings obtained from increment cores from the forest plots and shoot material from the pot experiment are used to determine the tree species' intensity of the drought response. The results of this study can be employed to shape silvicultural decision-making in forest management to increase tree species richness and forest biodiversity for securing forest function in a changing climate.

SESSION 14-P8

Forest biodiversity enhances abundance of natural enemies of insect pests

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Endemic populations of natural enemies like parasitic wasps are probably most successful in stable forest ecosystems, where they keep plant feeding insect pest populations below outbreak levels. The gypsy goth (GM), *Lymantria dispar*, shows cyclic patterns of abundance and may then severely defoliate oak and other broadleaved forests. In Austria, GM mass outbreaks occur occasionally in small areas, but they collapse within the next year or two. We monitored the parasitoid complex of GM larvae during all phases of gradation in a mixed deciduous oak-hornbeam forest in eastern Austria. In general, parasitism was higher in retrogradation than during culmination and highest during latency. Under non-outbreak conditions, the gregarious braconid wasp *Glyptapanteles liparidis* was the dominant parasitoid that caused over 50 % of GM larval mortality. The adult wasps feed on nectar from a variety of flowering plants in the understory. Suitable food sources increase wasp longevity and fecundity significantly, thereby enhancing the parasitoid's efficacy in controlling the pest population. GM larvae, however, are present only from late spring to early summer, so persistence and survival of the local wasp population depends on suitable alternate hosts which in turn feed on specific food plants (trees, shrubs, herbs). Larvae of *Leucoma salicis* and *Macrothylacia rubi* are possible candidates to bridge the period after GM pupation in autumn and may also serve as overwintering hosts. Other moth species such as *Lasiocampa quercus*, *Euproctis similis*, and *Euproctis chrysorrhoea* could support overwintering together with additional alternate hosts (e.g. *Orgyia antiqua*, *Dasychira pudibunda*). Field data on the relevance of these alternate and overwintering species are still missing. Apparently, the efficacy of parasitic wasps for long-term insect pest regulation depends upon a complex biological balance of a multitude of players present in habitats with high diversity.

SESSION 14-P9

Overyielding of temperate deciduous tree mixtures is maintained under throughfall reduction

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A changing climate in the future with more severe drought events will affect the conditions for forest growth and vitality. Most knowledge on tree species response to drought is based on monocultures, even though many of the forests in the world consist of mixed stands. We aimed to investigate how trees respond to summer drought when grown in a three species mixture. For two subsequent summers canopy throughfall, and subsequently soil water potential, was reduced using sub-canopy roofs in monocultures and mixtures of *Betula pendula*, *Alnus glutinosa* and *Fagus sylvatica.* The overyielding of the mixed stand was not affected by the drought using either above or below ground production, standing fine root biomass or soil respiration as parameters. However, *Alnus glutinosa* was the most negatively affected when growing in monoculture, whereas this species was less affected when growing in mixture. In contrast, *Betula pendula* was most negatively affected when growing in mixture. *Fagus sylvatica* was least affected by the drought and maintained growth over the two years. A water demanding species as *Alnus glutinosa* can perform well in a mixture during drought and not be outcompeted. This is opposite to what is assumed in most models of forest responses to climate change.

SESSION 14-P10

Development of an affordable-priced, automated soil CO_2 flux measurement system

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Carbon stored in soils represents the largest carbon pool of terrestrial ecosystems with global estimates of organic pools of approx. 2,400 Pg. Information on soil carbon dynamics is therefore essential to predict the future global carbon balance. Widespread recognition of the importance of soil CO_2 efflux as a major source of CO_2 to the atmosphere has led to active research in several biomes, including temperate, boreal, tropical, Arctic and deserts, over the last few decades. While there is an ongoing need for further CO_2 efflux measurements, the currently available instrumentation for continuous measurements, i.e. automated soil CO_2 flux measurement chambers connected to an IRGA and equipped with sensors for soil moisture and soil temperature logging (the two single most important factors determining CO_2 efflux rates), is expensive and only offered by a handful of manufacturers. Thus, less well-funded researchers worldwide, but especially those in non-western countries, have currently a very limited access to reliable automated systems. Furthermore, the current, multiplexed systems available on the market often limit the spatial arrangement of chambers, limiting the research set-up, and require excessive cable and tube connections to be installed in the field. In recent years, a range of low cost IRGA sensors has been developed for industrial applications. This fact and the availability of affordable microcomputer platforms such as Arduino should allow to develop new, affordable-priced but equally reliable stand-alone IRGA gas flux systems for in situ studies. In addition, 'modern' features, intrinsically available thru the microcomputer platform, such as wifi connectivity, integration in an ecosystem-of-things, remote control and data access, will reduce the necessity for field trips and thus cost – while the systems will run autonomously (but supervised) for month. We aim to integrate state-of-the-art technology at limited development costs by active collaboration with last-year students and teaching staff of the engineering college HTL Mödling, Austria. We are actively searching for academic partners with experience on the technological aspects of gas flux measurements for a joint proposal (e.g. FFG, Austria) and laboratory and field validation of a prototype.

SESSION 14-P11

Neighbour effects on tree growth in a reforestation project in Costa Rica

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The high tree diversity in tropical forests is ideal to test various ecological theories. Trees in tropical wet climates, potentially grow very fast, with individual growth rates depending on environmental factors, species identity and direct or indirect interactions with neighbouring trees. Neighbouring trees can either compete (for light, nutrients or water) or provide benefits, for instance by shading species that are not adapted to full sunlight. We tested if trees that follow different ecological strategies, specifically pioneer trees versus species regenerating in the understory respond in different ways to competition or facilitation by neighbours. The present study was conducted in a reforestated area where > 100 native tree species have been planted as part of the reforestation project 'La Gamba Biological Corridor' (COBIGA) in the southeastern province of Costa Rica, Puntarenas. The planting took place in 2012–15 and tree growth is being monitored annually by taking diameter and height measurements. In April 2018 precise distance measurements were carried out using a laser-based electronic mapping equipment and crown size was measured for the dominant species. We used measures of tree size and distance to calculate different competition indexes and first tested whether the stand is already dense enough to have neighbour effects. We quantified the position along a successional gradient based on the occurrence of trees of either old growth or secondary forest and tested the hypothesis that species from old-growth forests are favoured by some shading whereas pioneer trees are strong competitors and always negatively affected by shading.

SESSION 15

Freshwater ecology and societal interactions

Chairs: Wolfram Graf, Thomas Hein, Astrid Schmidt-Kloiber

Human river systems in the 21st century (HR21) – a new interdisciplinary doctoral school addressing riverine landscapes as dynamic socio-ecological systems

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Riverine landscapes are complex systems, which provide a multitude of services for human societies. Multiple pressures, driven by both societal processes and natural feedbacks, far-ranging engineering approaches, changes in environmental conditions, and an intense use of often conflicting forms of societal usage, have modified most of these systems worldwide to industrialized riverine landscapes (IRL) shaped by human – environmental interactions. The close, but complex interaction between natural and societal processes and the path and speed of the co-evolution of these two spheres urgently require a socio-ecological systems approach in both research and management. To address this challenge and develop a critical mass in integrated multidisciplinary river science, 19 leading scientists including 4 associated members from four departments of the University of Natural Resources and Life Sciences, Vienna (BOKU), join their disciplinary high-level expertise in the innovative international doctoral school Human-River 21 (HR21). The main aims of HR21 are to address critical knowledge gaps in industrialized riverine landscapes (IRL) and coupled socio-ecological systems research, developing new analytical and modelling tools, train a new generation of scientists in a multi- and transdisciplinary environment and strengthen interdisciplinary Human-River-System research in Vienna and beyond. HR21 targets to provide a new multidisciplinary understanding of the future development of IRL and their effective and sustainable management.

Assessing water ecosystem services within the Hungarian national ecosystem services assessment

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As other countries within the EU, Hungary is also obliged to asses and map its most important ecosystem services. The Hungarian national ecosystem service assessment was started in 2016, a four–years project led by the Ministry of Agriculture and co-financed by the EU. Thirteen ecosystem services (ES) were selected after several steps of involvement (interviews, stakeholder analysis, participatory prioritizing workshops). From the 13 prioritized ES, eight belonged to the regulating ES and half of these referred to water. The high proportion of water-related ecosystem services highlights how important people perceive water related issues. Implementation of the assessment was thereafter divided into six thematic working groups, one of them being the Hydrologic Working Group. Its scope is to assess the ecosystem services erosion control, water purification, water retention (flood control) and maintenance of the hydrological cycle. The interdisciplinary working group consists of hydrologic and hydro-ecologic experts led by ecologists. The first step of the ES assessment is to define the relevant ecosystem condition (EC) indicators. Inclusion of EC into ES assessments and models is vital, if we want to mirror the (undesirable) effects of anthropogenic pressures and make them more easily understandable and communicable towards society. Indicator screening was made jointly for both EC and ES indicators for all hydrologic ES. As many aquatic ES overlap, we overviewed possible indicators for both EC and ES in a matrix. We suggest combining these relevant indicators for certain ES and valuing them in an expert workshop in order to develop a very basic country-wide model, that can include EC values as well as people's perspectives, while the validation of this basic model could be based on smallscale, watershed modelling – an approach that could be useful not only for aquatic ES.

Past, present and future. Changes of floodplain vegetation due to anthropogenic changes and a prognosis-tool to predict effects of revitalization

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Floodplains are biodiversity hotspots and provide numerous ecosystem services. However due to heavy anthropogenic impacts floodplain systems were dramatically altered. This is also true for the floodplain system of the Weiße Elster in the city of Leipzig, where anthropogenic regulations were intensified in the 20th century. Nevertheless, a relatively high proportion of the former floodplain hardwood forest remained in a near-natural state. But as a direct consequence of the regulations and missing dynamics, we already see a change in species composition. For a long-term conservation of the characteristic floodplain biodiversity there is the need for revitalization measures. Here the 'Lebendige Luppe' project aims to restore parts of the floodplain by re-connecting former watercourses, allowing frequent periodic inundations in substantial parts of the floodplain. To be able to predict and evaluate improvements of the ecological state resulting from such revitalization measures, a long-term monitoring was set up including 60 permanent plots. These plots were inventoried for woody and herbaceous vegetation and different environmental variables including light, soil and groundwater. We analyze the spatial and temporal variability of the recent floodplain vegetation and predict future changes of the vegetation caused by different revitalization scenarios. In a first step we use a hydraulic model linking groundwater and surface water to model the recent hydrological situation and predict future changes of hydrology according to different revitalization scenarios. In a second step we use generalized mixed effects models (GLMM) to model the abundance of herbaceous and woody species depending on a set of environmental predictor variables. We especially aim to identify species sensitive to hydrological changes to provide knowledge for decision-making processes for revitalization and conservation projects in floodplains.

A review of hydropeaking mitigation thresholds from scientific literature and national legislation

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Hydropower plants may expose rivers to severe discharge fluctuations on a sub-daily scale, affecting the entire ecosystem downstream of the tailrace, including multiple life stages of single species. Due to the extent of the impact of pulsed-flow operations, global awareness is increasing, as well as hydropeaking research, aiming at mitigating these impacts generally, but also through the establishment of thresholds for the different hydrological parameters. The goal of this study is, therefore, to analyze mitigation thresholds as presented in the scientific literature and established in national legislation or guidelines. In this review, we provide an overview of the present knowledge and consolidate the so-far established mitigation thresholds regarding, for example, flow variation ratio or downramping rate. Furthermore, by analyzing fish according to their life-cycle stages, more accurate thresholds may be established for different hydropower operation periods. Our study allows a comprehensive assessment of the present status of pulsed-flow mitigation thresholds, providing an outlook for future management and operative hydropower measures.

Human-fish conflicts in East Africa: molecular genetic diversity of anthropogenic threatened *Oreochromis niloticus*

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The need for enhancing fish productivity in Africa ultimately triggered the transfer of various fish species to non-native ranges, causing dramatic changes to the indigenous host species. A typical paradigm of fish translocations is that of the East African *Oreochromis niloticus* (Nile tilapia) which has been dispersed in various non-native homes. Despite the shifts, *O. niloticus* currently dominates the non-native environs at the expense of the dwindled indigenous congenerics, a situation worth investigating. The goal of this study was to characterize and compare *O. niloticus* genetic variability from various locales, with the aim of gaining a better understanding of the populations' genetic structure and inter-relationships. Using 40 and 41 microsatellite loci for the combined East African and all native *O. niloticus* populations respectively, we genotyped a total of 667 samples from Uganda, Kenya, Ethiopia, Burkina Faso, and some fish farms. Genetic structure analyses demonstrated three distinct East African *O. niloticus* genetic clusters consistently supported by Fst results. Both genetic structure and migration rates among the studied populations were congruent with the described anthropogenic activities. Many of the waterbodies were explained by several clusters which may be an indicator of restoking activities contributing to the introduction of new genotypes from multiple sources. The main exception was Lake Turkana where the adverse environmental parameters do not favour intensive fishery practices. However, the reportedly low genetic diversity in Ethiopian and West African *O. niloticus* was allied to genetic drift resulting from population fragmentation. Among the fish farms, Rwitabingi was more genetically divergent and it was attributed to multiple sources of immigrants. Overall these results were consistent with the hypothesis that the East African populations particularly, non-natives exposed divergent genotypes.

POSTER PRESENTATIONS

SESSION 15-P1

Response of juvenile salmonids to hydropeaking along a morphological gradient

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Research has shown that juvenile fish are particularly vulnerable to pulsed flow hydropower schemes, leading to drift and stranding of small fish, and ultimately reducing recruitment of the entire population. However, their sensitivity depends on the parameters characterizing the hydropeaking wave (e.g., timing, flow ratio, rate of change) as well as the river morphological status. We, therefore, hypothesize that juvenile fish abundance in fall can be explained by the hydrological and morphological situation in the year before. We utilized a comprehensive national database to assess the response of juvenile salmonids in Alpine rivers, whereby river hydrology ranges from natural flow regimes to extensive hydropeaking, and morphology from natural to channelized. Here we present initial results from the database analysis and examine potential options to mitigate the adverse impact of pulsed flow operations on fish populations.

SESSION 16

Functional ecology of mycorrhizas

Chairs: Douglas Godbold, Ina Meier

Mycorrhizal symbiosis vs. clonality – testing a trade-off across species, phylogeny, and habitats

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Plants evolved various adaptations that allow them to expand the belowground space from which they uptake nutrients. Among these adaptations, mycorrhizal symbiosis and the ability for clonal growth are wide spread. While both ecological traits help plants to gain nutrients from the soil, they involve the cost of supplying carbon, either to the mycorrhizal fungi, or to the growth of the clonal organ(s). On the basis of this cost-benefit relationship it has been proposed that there should be a trade-off for plants to invest in either of these two strategies, but that limited resources disallow for the investment in both. We tested this hypothesis by combining data on mycorrhizal status, clonality, and habitat affinity of approximately 900 Central-European plant species, and subjecting the collated data to comparative analyses at the species level. As hypothesized, clonal species were less likely to be mycorrhizal, and vice versa. However, there was also a large number of species that were mycorrhizal as well as clonal, while few species had none of the two attributes. Within clonal species we observed similar trends, where species with higher clonality (wider clonal spread, and/or higher number of clonal offspring), were more likely to be non-mycorrhizal. We also tested the role of environmental affinities on the mycorrhizal vs. clonality trade-off. Only the preference of wetter habitats was found to interact with the association between clonality and mycorrhizal status. Importantly, none of these described significant associations were evident when we accounted for the phylogenetic relationships between the investigated species by means of phylogenetic regressions. Though a negative association between clonality and mycorrhizal status does exist across species, it does not manifest a general trade-off based on ecological necessity. Rather, constraint driven by the affinity to certain habitats in distinct clades give rise to this relationship.

Reactivity of ectomycorrhizal communities of spruce and beech to recurrent years of severe summer drought

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We analyzed ectomycorrhizal community composition along with functional traits (enzyme activities, morphological traits) to identify mechanisms of drought adaptation in the ectomycorrhizal communities of the two tree species *Fagus sylvatica* and *Picea abies.* Fine root samples were collected at the Kranzberg Roof Experimental Site (KROOF) next to Freising, Germany, where 6 of 12 plots are equipped with retractable roofs to exclude precipitation throughout April–November. Soil samples were taken at the end of the vegetation period in late autumn since 2013 (before the experiment started) and in the years 2014–2017. Results from 4 repeated years of summer drought show differences in the ECM community changes upon drought of spruce and beech which can be attributed to the different drought adaptation of fine roots of the two tree species. Community enzyme activities of seven extracellular enzyme activities remained remarkably stable in the surviving mycorrhizal communities but strongly declined – at the ecosystem level – upon repeated summer drought years because of the decline of vital fine roots. At the morphological level, long-distance exploration types of ectomycorrrhizae with structured rhizomorphs were less affected by decline than all other ECM types suggesting an enhanced capacity of water uptake and transport to increase survival of drought ECM. Moreover, these results add evidence to decline the carbon starvation hypothesis under drought as the extensive mycelia of these plant carbon dependent fungi are still maintained even under severe drought. Overall, both tree species and their ectomycorrhizae show still an enormous drought resistance considering an extreme drought scenario of four consecutive summer droughts at the KROOF sites particularly at the functional level.

Ectomycorrhizal fungi in pine forest at the upper tree line in Montenegro

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Pinus heldreichii H. Christ and *Pinus peuce* Griseb are endemic and relict species to the Balkans and are of high ecological importance. In the past, they have formed a continuous belt of high altitude forests influenced by Mediterranean climate. The gradual degradation of these forests resulted in isolated and small forest stands remaining on sloped and exposed terrains at the altitudes between 1,200 and 2,100 meters asl. *P. heldreichii* grows predominantly on shallow and dry calcareous soils (calcomelanosols), while *P. peuce* – on silicates, i.e. deeper and more developed and moist soils (pseudopodzols). Ectomycorrhizal (ECM) fungi are important components in these forest ecosystems and significantly contribute to the successful regeneration, establishment and growth of the trees, in particular on marginal habitats under harsh environmental conditions. Despite the importance, information on ECM fungi associated with *P. heldreichii* and *P. peuce* is scarce. To get a better understanding on associated fungi and their potential roles, we assessed ECM and other fungi of *P. heldreichii* and *P. peuce* in Montenegro. The methods were identification of fruiting bodies and a DNA-based identification of fungi from the roots. For the later method, fine roots were morphotyped, and selected ECM morphotypes were used for isolation of DNA, amplification by PCR using fungal specific ITS rDNA primers, and subjected to either Sanger or high-throughput sequencing. Soil chemical and physical properties were determined using mechanical and extended chemical analyses. The results revealed high fungal diversity associated with each tree species. The results also showed host and site-specific effects on abundance and composition of fungal communities in fine roots of *P. heldreichii* and *P. peuce*. New knowledge generated in this study will contribute to the development of relevant strategies for management and conservation of *P. heldreichii* and *P. peuce* forests and associated biodiversity.

Mycorrhizas and soil ecosystem function of co-existing woody vegetation islands at the alpine tree line

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Picea abies, *Pinus mugo* and *Rhododendron ferrugineum* co-exist at the alpine tree line, and can have different mycorrhizal communities. The activity and diversity of mycorrhizal fungi are considered to be important factors in regulation of soil function. At a tree line site and a lower elevation site in the Austrian Alps, the community structure of ectomycorrhiza on *Picea abies* and *Pinus mugo* was determined. The activity of surface enzymes was determined on ectomycorrhizal and ericoid mycorrhizal roots. In soils, the activity of a range of enzymes, nitrogen (N) mineralization and biomass decomposition were determined. The community structure of the ectomycorrhizal community of *Picea abies* and *Pinus mugo* differed strongly, but the average activity of surface enzymes of the ectomycorrhizal communities was similar. A lower root surface enzyme activity was determined on *Rhododendron ferrugineum.* Soil N–mineralization under *Rhododendron ferrugineum* was significantly lower than under *Picea abies* and *Pinus mugo.* In soil, the activity of a range of enzymes did not differ at the tree line but differed between the tree line and the lower elevation sites. The different ectomycorrhizal communities on *Picea abies* and *Pinus mugo* and ericoid mycorrhizas on *Rhododendron ferrugineum* support similar ecosystem functions in soil.

POSTER PRESENTATIONS

SESSION 16-P1

The effect of distance from mature oak on the performance of oak seedling and their infection by their root associated EMF

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Seedling establishment is influenced by the presence of con-specifics in both negative (i.e. kin competition) and positive manners, for instance by increasing mutualist abundance. Ectomycorrhiza (EM) is an example for an obligatory symbiosis where seedlings' proximity to con-species plant may increase infection rates by EM fungi. This research aims to test if the distance from a mature oak tree (*Quercus ithaburensis*) influences the colonization of root tips of oak seedlings and its potential effect on seedling performance. We hypothesized that patterns of root-associated EM fungi are distance-dependent and consequently, everything else being equal, seedling performance will decline with distance from mature tree. We collected soil samples along transects of increasing distances from mature oak trees. Each of these samples was then divided to three treatment groups: soil with additional inoculation, soil with autoclaved inoculation (nutrient addition control), and natural soil with no inoculation (control). Then, each of these treated soils samples was mixed with sterile soil and used for growing oak seedlings as a bioassay. We followed the performance of the seedlings under the various treatments, and took measurements once a month (height, diameter and leaf number). We quantified the root infection rate based on root bundles (high density root structures), a feature that has not previously been described for oaks. We found an insignificant trend of decreasing infection rate at the root tips of seedlings with increased distance from a mature oak tree. In addition, larger seedlings had higher infection rates by EM fungi. Moreover, there was no change in root/shoot ratio in the natural and autoclaved treatments, but the inoculated treatment showed marginally significant decrease in root/shoot ratio as infection rate increase.

SESSION 16-P2

Cold adaption in ectomycorrhizal fungi

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The goal of the research was to find out if ectomycorrhizal fungi are able to tolerate cold temperatures up to −20 °C. Therefore we chose divergent kinds of fungi, to see if there are differences concerning the adaption, and froze them after some time growing at approximately 25 °C. All of the ectomycorrhizal fungi that were tested were able to tolerate the cold temperatures and were growing afterwards.

SESSION 17

Ecological and conservation genetics

Chairs: Harald Meimberg, Christian Lexer

Development of 'target capture' markers for ecological and conservation genetics in non-model species

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Rapid recent advances in next generation sequencing technologies increasingly allow ecological and conservation geneticists to query neutral, adaptive, and potentially deleterious genetic variation within and among the gene pools of wild species. While whole genome resequencing is still too costly (and the resulting datasets too costly to analyze) in most non-model species of interest, widely used reduced-complexity sequencing approaches such as RAD-seq have their own, increasingly known drawbacks. Thus, targeted resequencing ('target capture') has emerged as the method of choice for studying many hundreds of individuals for many thousands of Single Nucleotide Polymorphisms (SNPs) in representative sets of genes or genome regions in wild species. In this contribution, we will outline an analytical and 'wet lab' approach to develop hundreds of thousands of 'target capture' markers useful across micro- and macro-evolutionary times scales, using the ecologically and economically important palm family (Arecaceae) as an example. Our focal group of interest is *Geonoma*, a neotropical palm genus including numerous species complexes with unclear species boundaries and striking infra-specific variation, features that are shared by many organismal groups of interest to ecological and conservation genomics. We developed target capture 'baits' for > 4,100 sequence regions, including > 4,000 genes and > 130 non-genic regions, facilitating ecological and conservation genomic studies across evolutionary time scales. The bait set was effective not only for *Geonoma* spp., but also for taxa of three different palm subfamilies with high mapping rates, specificity and efficiency. We will sketch our marker development procedure, with emphasis on aspects of general interest to ecological and conservation geneticists embarking on projects with target capture markers. We will also outline the sometimes neglected issue of copy number variation during genetic marker development.

Microsatellite genotyping options using NGS

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Microsatellites (SSR) have a high potential for ecological genetic investigations and were till recently the method of choice for the field of molecular ecology, the investigation of molecular DNA markers in a ecology context. The advantage of the Markerssystem is based on codominance and the potential for multiple alleles per locus, that increases statistical power for subsequent analyses. SSRs remained the method of choice for many medium through put approaches also after upcoming of snp analysis, a collection of alternative codominant methods that measure the character state at one homologue base position within a locus. SSR genotyping was competitive because of the higher number of alleles than the two typically for a snp locus. This evened out the higher number of available loci per effort to some extent. With upcoming of the next generation sequencing methods we have now a similar situation. Genotyping by sequencing (GBS) approaches, most prominently restriction site associated DNA, RADs, are promising because of the massive amount of loci that can be investigated without the need of prior sequence information and will replace SSR analysis in many applications. However, there are some peculiarities of SSRs as markers that let them remain method of choice for some applications. For example, models where large differences in DNA quality would cause bias using approaches that determine polymorphisms directly from total DNA extractions. In this respect, Polymorphisms in RADs are influenced by the completeness of coverage of homologue restriction sites which decreases with decreasing DNA quality. Because SSRs are based on amplification, this allele dropout is less a problem and very different sources, like scat and tissue samples can be used in one analysis. For this approach NGS can now be used to facilitate data collection and increase throughput.

Genetic conservation areas – a new approach to protect both species and genetic diversity in calcareous grasslands

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Land use change caused an ongoing decline of semi-natural grasslands throughout Europe during the last decades. A comprehensive conservation approach should include not only species diversity, but also the genetic variation of the species within these grasslands. Considering the impact of land use continuity, historically old grasslands may contain populations with a higher level of genetic diversity and may be differentiated from historically younger grasslands. The first aim of our study was to test, whether populations of three common calcareous grassland species in historically old grasslands differ genetically from populations in historically young grasslands. The second goal was to designate genetic conservation areas identifying those populations with a high level of genetic variation. We took leaf samples from 10 historically old and 9 historically young calcareous grasslands across the Swabian Alb in southern Germany. Using Amplified Fragment Length Polymorphism analysis (AFLP), we analyzed 19 populations each of *Campanula rotundifolia* L. s. str., *Asperula cynanchica* L. and *Linum catharticum* L. Based on these results, we will be able to construct a minimal set of populations representing the genetic diversity of the investigated species accurately. These calcareous grasslands will then be a part of a larger conservation framework including species as well as genetic diversity. These so called 'genetic conservation areas' will provide seed material for in situ storage in gene banks, as well as other conservation and restoration measures.

Macro- and microevolutionary drivers of allopolyploid evolution in *Dactylorhiza*

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Recurrent, polytopic origins are widespread among polyploids. These can produce a multitude of genetically, ecologically, morphologically and physiologically distinct populations. Subsequent gene flow, independent assortment, and recombination may produce additional variation that will be sorted by natural selection as a function of local conditions. Our understanding of the ecological relevance of such early processes in young polyploids is still in its infancy. As multiple origins provide natural replicates, sibling allopolyploids are excellent models to uncover mechanisms of adaptation to divergent environments, which are assumed to lead to evolutionary diversification and biodiversity increase. Our study focuses on two sibling polyploids, *Dactylorhiza majalis* and *D. traunsteineri* formed through the unidirectional hybridization between diploids *D. fuchsii* (always the maternal parent) and *D. incarnata.* Using RAD–seq, RNA–seq and multidimensional ecological investigations we characterize the patterns of genomic diversity in these polyploids and specifically investigate the molecular basis of phenotypic divergence between them. We demonstrate that the allopolyploids have distinct measurable ecological preferences, despite hybridization in sympatry suggesting resilience of specific traits. In turn, the ecological differences are driving differential expression of a number of functionally important genes with functions related to both abiotic and biotic responses. Furthermore, our data allows us to address the molecular mechanisms responsible for the observed gene expression divergence. We observe significant constraints on homoeolog expression in the two polyploids but in turn, alternative dominance patterns differentially affecting gene expression between them. This indicates that divergent *trans*, rather than local *cis* effects are broadly driving the phenotypic distinctiveness in these sibling polyploids. Our results add to our growing comprehension of the broader consequences of allopolyploidy, particularly in the context of ecological speciation and to our understanding of this central force behind plant evolution.

Ecological restoration methods on trial – testing seed sourcing concepts using population genetics

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Sowing of seeds to establish plant species of high conservation value has become an essential tool in ecological restoration. To preserve their genetic structure a variety of provenancing strategies have been established recently. Although some of them are already legally binding, biological evidence of such regulations is still mostly lacking. However, to efficiently restore plant communities, thorough knowledge and understanding of the genetic structure within and among populations is essential. We test an existing seed provenancing concept for plant species of calcareous grasslands, a Flora Fauna Habitat (FFH) frequently targeted in ecological restoration. In southern Bavaria three biogeographical units resulting from an altitudinal N–S gradient and edaphic variation have been defined as seed transfer zones (STZs). We study genetic differentiation in seven species representing an abundance gradient from rare to common in that area. A novel NGS-based methodology and bioinformatic pipelines allow us to genotype hundreds of individuals for > 20 microsatellite loci in very short time. Correlating these data with phenotypic variation and biogeography helps inferring the extent of local adaptation and test how far the STZ system is capturing genetic structure or may affect it. First results show that current practice in general is able to preserve genetic structure at least at a small scale, but may not provide a universal solution for all species and habitats at a larger scale. In addition we investigate three representative species of rare arable plants, using the same methodology. These plants have been an important floristic component of the cultural landscapes for millennia. Being dispersal-limited, seed transfer is necessary for restoration in arable plants, but so far there is no concept for seed production and STZs have not been defined yet.

Conserving genetic diversity in a changing world – novel approaches for oat-grass meadows on the Swabian Alb

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Oat-grass meadows on the Swabian Alb are a comparably young anthropogenic habitat, established for hay production. Due to increased fertilization and cutting frequency in recent decades, these habitats, formerly among the most species-rich in Europe, are now drastically declining in quality and quantity. Next to species diversity, the genetic diversity contained in a specific habitat or of a single target species should play an equal role in modern conservation efforts. As genetic variability ensures future adaptability of species to our changing environments, it is an important aspect of biodiversity, calling for its protection e.g. in genetic conservation areas. But this approach poses questions on how to identify targets for genetic conservation areas and incorporate them in a protection network. Therefore we studied several species occurring on the same oat-grass meadows, including the factors shaping their genetic diversity, like land use continuity, historic and present grassland cover, connectivity and human activity in our analysis. By comparing different species in the same habitats, a comprehensive guideline for the establishment of genetic conservation areas can be established. We analyzed 20 oat-grass meadows located on the Swabian Alb, including 10 old grasslands with a long continuous use as grassland (200 years) and 10 young grasslands established on arable fields after WWII. To compare genetic diversity, plant samples of *D. glomerata*, *H. sphondylium* and *T. pratense* were analyzed using AFLP. Our results showed average genetic diversity within the study sites, with low differentiation levels and a high gene flow among grasslands. However the present vegetation structure, historic surrounding grassland cover and human activity are important factors shaping the genetic diversity of the analyzed species. Thus the land use history can be used as one of the factors, when deciding on genetic conservation areas, while parameters like vegetation structure should also be considered.

The role of hybridization in sorting adaptive characters during the colonization of oceanic islands

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Hybridization can play an important role in sorting adaptive characters being this effect more prominent in oceanic islands. Such systems have a higher number of empty niches making selection against hybrids less effective. Multiple colonization events followed by hybridization may result in highly diverse admixed populations containing recombined traits from several source populations/species leading to an increase of adaptive potential. This process may be applied to the colonization of archipelagoes contributing to the sorting of adaptive characters thought different niches. Based on microsatellites and RAD-sequencing data we tested this hypothesis using the *Micromeria* species endemic to the Canary Islands. The tested hypothesis was supported by the three main evidences. First, both RAD–seq and microsatellites support geneflow and hybridization among species of the same and different islands. Second, using phylogenomic approaches, the relationship among some populations is rather related to ecology than species circumscription. This was the case of the *M. canariensis* populations restricted to the laurel forest in Gran Canaria that are closer related with *M. gomerensis* from La Gomera than other conspecific populations. Third, some of the species that are distributed throughout several ecological zones are the most genetically diverse and presents high migration rates with other species in their contact zones. This was the case of *M. hyssopifolia* from Tenerife that is distributed from the coastal desert to the to the wet pine and laurel forests. These results indicate that hybridization contributed to the distribution of adaptations among islands and within islands. The close relationship between *M. canariensis* and *M. gomerensis* indicates that geneflow from Gran Canaria may have contributed to the colonization of the laurel-forest of La Gomera. Introgression from other species to *M. hyssopifolia* may have contributed to the ecological expansion of this species.

Insect diapause is sensitive to climate variability: a meta-analysis

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Global change alters season onset due to rises in temperature and temperature variability. In light of these changes, species persistence depends on the evolvability of phenological traits such as diapause, which may encompass the evolution of mean timing, predictive plasticity or adaptive variance (bet-hedging). In the face of changing mean, predictability and variability of winter onset, it is hence important to assess the repertoire of diapause traits that maximise fitness. We conducted a meta-analysis on studies that measured diapause timing of single invertebrate species along latitudinal gradients. We hypothesized that 1) the timing of diapause closely tracks mean winter onset; and 2) that variability in diapause timing (a putative bet-hedging trait) increases with environmental variability, but decreases with environmental predictability. We found 30 studies (10 invertebrate orders) that measured reaction norms to day length for 174 populations. We calculated the inflection point (critical day length) of these logit-curves and their slopes, as these determine mean timing and temporal variance of diapause. We then estimated mean winter onset, winter variability and predictability for ~ 29,000 climate stations in the northern hemisphere, and correlated these climatic variables with critical day length/slope of the reaction norms. As expected, populations from northern latitudes shift their timing towards earlier diapause. This shift in critical day lengths (49 minutes per 5° latitude) correlated well with the latitudinal cline in day length at winter onset. Contrary to our hypotheses, however, diapause variance was neither explained by winter variability nor by winter predictability. We conclude that insect phenology can readily evolve in response to temperature across insect orders, but that it is vulnerable to changes in climatic variability.

Investigating the population genetic structure of the wild bee *Andrena danuvia* using microsatellites

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Urban habitats can present a surprisingly high level of insect biodiversity and one such species is the wild bee *Andrena danuvia* Stoeckhert, 1950. In Austria *A. danuvia* has been found in Vienna and surroundings, whereas its sister species, *Andrena cineraria* (Linnaeus, 1758), can be found from the Vienna city border throughout all of Europe. They are solitary bees and often congregate in nest aggregates with more than 100 individuals. The ecological similarities, the species status along with the distribution of *A. danuvia*, which is situated like an island in the middle of their sister group with no existing geographical barrier, has left doubts by some experts as to its species status. Our initial aim was to clarify if *A. danuvia* is an actual species or a subpopulation of *A. cineraria.* Furthermore, if the species status of *A. danuvia* could be verified, we would attempt to test hybridization events between both species. And finally, we focused on the nest aggregates of *A. danuvia* and searched for distinctive genetic patterns in the individual colonies. We, therefore, identified eleven nest aggregates of *A. danuvia* within Vienna. Samples of *A. cineraria* were collected along a transect of Austria from east to west. Twenty–two microsatellite markers were successfully applied to more than 300 samples. Genetic structure using cluster and distance methods showed a clear division between these two species supporting the current taxonomic delimitation. Further studies evaluating potential differential foraging behaviors could elucidate possible causes for reproductive isolation and the speciation process of this species.

POSTER PRESENTATIONS

SESSION 17-P1

Biodiversity of the Hkakabo Razi passerine fauna – implications on taxonomy and conservation from molecular genetics

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The Hkakabo Razi region in the northernmost mountains of Myanmar is for its globally small size extremely species-rich and overlaps with three biodiversity hotspots. Recent surveys resulted in scientific descriptions of new bird taxa. We conducted a biodiversity assessment for passerine birds using DNA barcoding and molecular markers. Of the 500 bird species recorded so far we chose 17 candidate species for a comparative study. A larger taxon set was analyzed to verify identification of crucial species in previously published bird lists from the region. We found phylogeographic structure in all but one species. In 14 species, populations from northern Myanmar were genetically distinctive and local mitochondrial lineages differed from those found in adjacent regions by 3.9 to 9.9 % uncorrected cytochrome–*b* distances. Given that genetic distinctiveness of study populations will be corroborated by further differences in morphology and song, many of them will be candidates for taxonomic splits or for the scientific description of new taxa. We highlight also the specific case of the Naung Mung scimitar babbler (*Jabouilleia naungmungensis*) as example for difficulties in nomenclatural assessments. We review competing classifications and consider them in light of morphological and new genetic information. Our results highlight the importance of a well implemented protection mechanism and our results will support the nomination of the site under criterion 9 and 10 of World Heritage Convention. We predict that a great part of undetected faunal diversity in the Hkakabo Razi region will be discovered by future genetic studies.

SESSION 17-P2

Assessing population genetic structure and extinction risk for the Alpine river specialist *Chondrilla chondrilloides*

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Floodplain specialists of alpine rivers are threatened by extinction due to widespread river regulation. Flood protection measures, hydro-electric dams and intensified land use have destroyed large parts of their habitats, now restricting them to short sections along a few unmodified rivers. *Chondrilla chondrilloides* is a flagship plant within this group. Recently extinct from France and Switzerland, most of the few remnant populations are found in north-eastern Italy. While Austria has at least one large and stable stand, the only German population is restricted to < 5 ha within the nature reserve Friedergries near Garmisch. This population has experienced a recent bottleneck, with less than 100 individuals in 2009, but meanwhile recovered to roughly 1,000 plants. Using NGS-based high throughput microsatellite analysis we investigate how far this bottleneck left a signature in the genetic structure. Inferring historical genetic diversity in the area from extinct populations by using herbarium specimens allowed to get a rough proxy to what extent genetic diversity has been lost over time. We successfully tested DNA extraction from herbarium samples > 150 years old to set up a first phylogenetic framework for the species. The results indicate that it is isolated within the Eurasian genus, thus further underlining current conservation priorities. We compared the German populations with those from Austria (Tirolian Lech) and Italy (Fella and Piave) and complemented this by fitness measures and characteristics of its habitat niche. Combining these data with habitat structure at different spatial scales acquired with UAV allowed to assess the local and overall extinction risk of the remaining populations. Habitat analysis so far revealed that the requirements cited in literature need to be refined. As a complementary conservation measure plants were reintroduced to a formerly inhabited site and are continuously monitored.

SESSION 18

Host vector parasite interactions and global change

Chairs: Swen Renner, Alfonso Marzal

Avian Haemosporidia respond indirectly to forest management but less to magnitude of local transmission risk

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Forest birds are subject to a wide variety of human induced land use changes. Alterations of forests result in changes of ecosystem processes and we hypothesize that host-vector-parasite interactions are driven by these changes. Avian Haemosporida have varying effects in avian hosts, including increased mortality and sub-lethal effects, e.g., changes in habitat use, enlargement of organs, modifications in reproduction. A relevant indirect process in host-vector-parasite interactions is the abundance and presence of the Dipteran vectors that are required in the diseases transmission. To understand the different drivers of forest management on the host-vector-parasite interaction, we analyzed simultaneously and spatially explicit all three components of the host-vector-parasite interaction in different settings of forest management and forest environments. In 2014 and 2015, we screened blood of seven common European bird species for Haemosporidians with genetic and morphometric methods and additionally immune response parameters (e.g., H/L-ratio) and body asymmetries. In addition, we analyzed locally sampled vectors. We applied GLMs and SEMs how host-vector-parasite interactions respond to land use for seven common European bird species. We found a high infection prevalence (77.6 %) over all seven species. There were significant differences for both parasite intensity and prevalence between the species, but we did not find an effect of land use within in any species. Structural Equation Modeling shows that the effects of land use and interactions are host-specific and that there are differences also with regards to the different body asymmetries within a species, pointing to complex interactions.

Investigating malaria parasite effects on the circadian biology of wild birds using a new qPCR method

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Circadian rhythms are a core feature of avian physiology, essential for the normal function of biological processes such as the innate immune response to infection. Malaria is often referred to as the 'circadian disease' due to timed, synchronous release of new parasites from host red blood cells during its life-cycle. This rhythmic feature of malaria is well classified in human hosts. However, little is known regarding the relationship between parasite infection and host physiology in birds. We investigated effects of acute malarial infection on the physiology of nestling great tits (*Parus major*) in the wild, with focus on changes in day–night expression levels of immune genes. Blood samples were collected from 130 nestlings from forest nest boxes, sampling siblings at either midday (12:00 EST) or midnight (00:00 EST). To quantify infection intensity of malaria parasites (*Leucocytozoon* and *Haemoproteus* spp.), we developed a new sensitive qPCR method to assess number of gene copies (18S) for each parasite genera from avian DNA. Levels of parasitaemia were determined for individual birds by normalising infection intensity with levels of an avian housekeeping gene (GAPDH). Subsequently, we related parasitaemia to midday and midnight expression levels of anti-malarial immune genes (e.g. TLR4, LY86) and circadian clock regulators (e.g. BMAL1). Physical measures of condition, such as nestling weight, tarsus length and haematocrit, were also included in our analyses. Our study provides a new tool by which infection intensity of Haemosporidian parasites can be accurately quantified from avian DNA. Moreover, our study gives insight into the mechanisms by which malaria parasites can affect physiology and health of their avian hosts in natural environments.

Haemosporidian prevalence, vector abundance, and avian malaria transmission respond to specific forest characteristics

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Land use change is likely the most important driver for biodiversity loss and drives ecosystem processes such as vector-parasite-host interactions. One key component of the triad is the presence of vectors. Avian Haemosporidia are transmitted by vectors of the Dipteran families Culicidae, Ceratopogonidae (notably of the genus *Culicoides*), Hippoboscidae and Simuliidae. The abundance of vectors is mostly affected by temperature, humidity, and consequently through the availability of reproductive habitats. However, the effects of land use on vectors in this interaction triad are not well studied. We captured insect vectors in the southwest and northwest of Germany, within three different forest stand categories (beech natural, old managed beech and young managed beech) in 2014 and 2015. Beech (*Fagus sylvatica*) is the predominant tree species in the forests of Central Europe. We tested (1) whether forest management affects the abundance of female vectors spreading avian malaria parasites and (2) the effects of forest management on the prevalence of parasites within the female vectors. We found a higher number of vector species in the northeastern region, particularly in 2015. Vector abundance was positively associated with leaf litter depth. This is because leaf litter in beech forests offers both oviposition and larval developmental sites for the vectors. Parasite prevalence in vectors was positively influenced by canopy structural diversity and canopy edge, and negatively associated with understory cover, shrub layer, open stem zone, distance to water sources, and relative humidity. We concluded that vector abundance and prevalence in vectors respond differently to forest structural and categorical variables, indicating transmission heterogeneity at local scales.

Host parasite interactions in a world in change: deforestation, biological invasions and avian malaria

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Deforestation and invasive species impose substantial ecological, economic, and social costs worldwide, being a major threat to biodiversity conservation. Avian malaria parasites of the genera *Plasmodium* and *Haemoproteus* constitute an excellent model for exploring factors contributing to the emergence and spread of the disease. Here we first aim to analyze if some species of avian malaria could be invaders in Neotropical birds from Peru. Our outcomes show for the first time the presence of invasive avian malaria *Plasmodium relictum* SGS1 infecting birds in America. Moreover, the identification of factors underlying variation in invasion success would be essential for evaluating invasion risk. We also tested several host-parasite hypotheses accounting for invasion success of house sparrows *Passer domesticus* in a Neotropical area (Peru). Invasive house sparrows from Peru showed lower prevalence and genetic diversity of haemosporidian parasites than sparrows from their natural range (Spain), indicating that the release from their natural parasites may have favored the spread of sparrows in the new area of occurrence. We also showed that Peruvian sparrows had larger uropygial glands and higher anti-bacteria activity on its secretion than sparrows from Spain, suggesting selection driven by pathogens in defensive mechanisms when colonizing new environments. Furthermore, some recent studies have investigated the effects of landscape transformation on avian malaria, showing mixed and inconclusive results regarding the impact of deforestation on the prevalence and genetic diversity of these haemosporidian parasites. We also investigated whether rainforest deforestation can affect this infectious disease in two different locations from Peruvian Amazonas (Reserva Nacional Allpahuayo Mishana and Reserva Nacional Tambobata). We showed that birds from deforested areas had a higher prevalence and higher genetic diversity of blood parasites than birds from undisturbed areas. Moreover, the abundance of arthropod vector from deforested areas was higher than in undisturbed areas. As an overall, our findings show that rainforest deforestation and avian invasions can contribute to the increase of avian malaria infection, thus providing essential information for designing interventions.

POSTER PRESENTATIONS

SESSION 18-P1

Haemosporidia prevalence in *Parus major* nestlings along an urbanization gradient

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Urbanization is changing bird habitats, which may result in increased immune response and other health issues for resident species. The quality of urban habitats can as well influence the prevalence of blood parasites (Haemosporidia), which can increase mortality or cause severe pathological symptoms in birds. However, little is known about how urbanization affects the immune response and body condition of birds and whether *Parus major* nestlings carry a Haemosporidia infection. We evaluated whether Haemosporidia prevalence varies along an urbanization gradient and whether urban habitats along an urbanization gradient affect the *Parus major* nestlings' immune response and body condition. We calculated asymmetries of the tarsus and measured the body mass to determine the body condition. We evaluated the number of leucocytes per 10,000 erythrocytes and calculated an H/L-ratio to measure the immune response. We found that the nestling number per clutch and the mean body mass of nestlings per clutch is highest in forest and lowest in highly-developed areas. In the highly-developed areas, the number of occupied nestboxes was notably lower than in the other urban habitats, suggesting that habitat quality of highly-developed areas might be lower. The results imply that the body condition of *Parus major* nestlings is better in more natural areas even though the number of nestlings is higher. We expect that Haemosporidia prevalence in *Parus major* nestlings living in urban habitats is higher than in forested habitats. By understanding the association between habitat quality and Haemosporidia prevalence along an urbanization gradient, it will be possible to adequately adapt urban environments in a way that is favouring birds' health, which is of enormous value for a functional ecosystem.

SESSION 19

IPBES beyond assessments – ecological research results informing decision-making

Chairs: Aletta Bonn, Stefan Hotes

Towards pathways bending the curve of terrestrial biodiversity trends within the 21st century

David Leclere[1], Michael Obersteiner[1], Rob Alkemade[2,3], Rosamunde Almond[4], Mike Barrett[5], Neil Burgess[7], Stuart Butchart[6,8], Abhishek Chaudhary[9], Sarah Cornell[10], Adriana De Palma[11], Fabrice DeClerck[12,13], Fulvio Di Fulvio[1], Moreno Di Marco[14], Jonathan Doelman[2], Martina Durauer[1], Simon Ferrier[15], Robin Freeman[16], Steffen Fritz[1], Shinichiro Fujimori[1,17,18], Monique Grooten[4], Michael Harfoot[7], Thomas Harwood[15], Tomoko Hasegawa[17], Petr Havlík[1], Stefanie Hellweg[9], Mario Herrero[19], Jelle Hilbers[2], Samantha Hill[7,11], Andrew Hoskins[15], Florian Humpenöder[20], Tom Kram[2], Tamas Krisztin[1], Hermann Lotze-Campen[20,21], Georgina Mace[22], Tetsuya Matsui[23], Carsten Meyer[24,25], Deon Nel[26], Tim Newbold[22], Haruka Ohashi[23], Alexander Popp[20], Andy Purvis[11,27], Aafke Schipper[2,28], Guido Schmidt-Traub[29], Elke Stehfest[2], Bernardo Strassburg[30,31], Andrzej Tabeau[32], Hugo Valin[1], Hans van Meijl[32], Detlef van Vuuren[2,33], Willem-Jan van Zeist[2], Piero Visconti[16,22], Cristopher Ware[15], James Watson[34,35], Wenchao Wu[17], Lucy Young[5]

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Unless actions are taken to reduce multiple anthropogenic pressures, biodiversity is expected to continue declining at an alarming rate. Models and scenarios can be used to help design the pathways that sustain a thriving nature and its ability to contribute to people. This approach has so far been hampered by the complexity associated with combining projections of pressures on, and subsequent responses from, biodiversity. Most previous assessments have projected continuous biodiversity declines and very few have identified pathways for reversing the loss of biodiversity without jeopardizing other objectives such as development or climate mitigation. The Bending The Curve initiative set out to advance quantitative modelling techniques towards ambitious scenarios for biodiversity. In this proof-of-concept analysis, we developed a modelling approach that demonstrates how global land use and biodiversity models can be combined to can shed light on pathways able to bend the curve of biodiversity trends as affected by land-use change, the biggest current threat to biodiversity. In order to address the uncertainties associated with such pathways we used a multi-model framework and relied on the Shared Socioeconomic Pathway/Representative Concentration Pathway scenario framework. We will briefly present the new methods we used in the proof-of-concept analysis, before exposing the main limits and the results. We will then reflect upon limits and potential future improvements to drive an integrated approach to land use that delivers climate, biodiversity and land-degradation-neutrality objectives through the coming policy opportunities across the United Nations Framework Convention on Climate Change (UNFCCC), the Convention on Biological Diversity (CBD) and United Nations Convention on Combating Desertification (UNCCD).

The policy support function of IPBES: how could this be more effectively developed and implemented?

Marianne Darbi[1], Elisabeth Marquard[1]

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To optimize the match between the needs of policy makers and practitioners and the deliverables provided by IPBES, a 'Policy support function' has been explicitly built into its architecture. To reflect on the purpose and potential future deliverables of this 'Policy support function', fifteen experts gathered during an international workshop organized by the German Network-Forum for Biodiversity Research (NeFo, January 2018). They developed recommendations that have been fed into the public consultation for the development of the next IPBES work programme. It seems particularly relevant to strengthen the role of policy support as a core and cross-cutting function. This could involve to set-up a special mechanism on policy support (e.g. via a task force) focusing on procedures, approaches and participatory processes for ensuring effective policy support. The mission of this task force could be to ensure that policy support is more strongly considered during the development of all IPBES products and to facilitate uptake and use of these products. For example, assessments could generally be more tuned to the actual needs of policy makers. This could be achieved by involving policymakers in the development of the first draft of the scoping document, or by including a final chapter in the assessment reports with good practices of examples of implementation under different contexts. With regard to the policy support function in the narrow sense, it is suggested to continue the methodological work started under the first work programme, e.g. via extension of the mandate of the respective expert group. The financial and human resources spent on the catalogue of policy support tools and methodologies should be critically reflected. It will only be perceived as relevant and useful if the process of data entry is transparent, the quality of information high, and its content reliable and up-to-date. Thus, maintenance and appropriate quality control will be among the major tasks.

IPBES-Assessments completed – what next? Examples of German follow-up activities

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The intergovernmental science-policy platform on biodiversity and ecosystem services (IPBES) was developed to enable informed decision-making on biodiversity issues. It does so by assessing and summarizing relevant information and knowledge on biodiversity and ecosystem services and providing it in policy-relevant formats. IPBES hereby strives to provide scientifically based options for safeguarding and sustainably using biodiversity and ecosystem services. The Federal Ministries for the Environment, Nature Conservation and Nuclear Safety (BMU) – which acts as the National Focal Point in IPBES – and of Education and Research (BMBF) have established the German IPBES Coordination Office i.a. to support their work associated with the implementation of IPBES activities and results. The first two IPBES assessments were approved at the fourth IPBES plenary (IPBES–4) in Kuala Lumpur, Malaysia, in 2016. These were the thematic assessment on 'pollinators, pollination and food production' and the methodological assessment on 'scenarios and models of biodiversity and ecosystem services'. Just recently, in March 2018, five further IPBES assessments have been approved at the sixth IPBES plenary (IPBES–6) in Medellin, Columbia. These were the four 'regional/sub-regional assessments on biodiversity and ecosystem services' (Africa, the Americas, Asia-Pacific & Europe and Central Asia) and the thematic assessment on 'land degradation and restoration'. This presentation will reflect on what is being done by Germany on a national and international level to process and distribute findings of the approved IPBES assessments.

The GfÖ and IPBES – exploring synergies for applied ecology

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From an ecological point of view, the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) is carrying out work on the interactions between *Homo sapiens* and its biotic as well as abiotic environment. In its current work programme, IPBES has so far produced two thematic assessment reports (pollination, 2016; land degradation, 2018), one methodological assessment report (scenarios and models, 2016) and four regional assessment reports (Africa; Americas, Asia–Pacific; Europe and Central Asia; all 2018). The reports are expected to provide information that is policy-relevant without being policy-prescriptive. In publishing the assessment reports, IPBES is meeting part of its objectives 1, 2 and 3 to strengthen the science-policy interface regarding 'capacity & knowledge foundations', 'at subregional, regional & global levels' and 'with regard to thematic and methodological issues'. With the first outputs of IPBES becoming available, attention must be extended to the fourth objective to 'communicate and evaluate Platform activities, deliverables and findings'. Members of the GfÖ have contributed to the work of IPBES under the first three objectives, and it is now timely to discuss in what way the Society can contribute also to the fourth objective. The GfÖ statute provides among others that the Society 'represents scientific ecology in the German-speaking area' and 'represents the interests of scientific ecology in the public sphere'. While individual members of the GfÖ are active in this field, the Society as an organization is currently lacking structures to meet the core objective of communicating policy-relevant results of ecological research to non-academic audiences. I discuss potential synergies that can arise from actively using the 'IPBES Brand' in public outreach work of the GfÖ, focussing on elements in the published IPBES reports that can provide topics for studies and events related to applied ecological research at subregional levels.

POSTER PRESENTATIONS

SESSION 19-P1

Mobilising the scientific community to generate knowledge for IPBES processes

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In the period 2016–2018, IPBES has launched seven assessments, its flagship, the global assessment will be launched in 2019. Assessments build on existing scientific and other knowledge on biodiversity and ecosystem services, their interlinkages and their impacts on human well-being, providing an extensive body of knowledge that can form the basis for environmental decision-making. However, assessments also play an important role in highlight gaps in knowledge that need to be addressed to complete our understanding on the interlinkages of biodiversity and ecosystem services, their impacts on human well-being, and the impacts human actions have on biodiversity. Research networks, such as bioDISCOVERY or GMBA, can play a unique role in mobilising the knowledge and expertise needed in assessments, to fill knowledge gaps arising from assessments, and bridging the science-policy gap by facilitating the uptake of assessments in policy and decision-making. In this talk, we outline different activities the research networks undertake to mobilise the scientific community to synthesise existing knowledge for use in assessment, to catalyse research activities that generate new knowledge to fill the knowledge gaps, and to translate the knowledge generated in assessment into decision-making.

SESSION 19-P2

The IPBES policy support function – options for future activities for the next IPBES work programme

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To optimize the match between the needs of policy makers and practitioners and the deliverables provided by IPBES, a 'Policy support function' has been explicitly built into its architecture. To reflect on the purpose and potential future deliverables of this 'Policy support function', fifteen experts gathered during an international workshop organized by the German Network-Forum for Biodiversity Research (NeFo, January 2018). They developed recommendations that have been fed into the public consultation for the development of the next IPBES work programme. It seems particularly relevant to strengthen the role of policy support as a core and cross-cutting function. This could involve to set-up a special mechanism on policy support (e.g. via a task force) focusing on procedures, approaches and participatory processes for ensuring effective policy support. The mission of this task force could be to ensure that policy support is more strongly considered during the development of all IPBES products and to facilitate uptake and use of these products. For example, assessments could generally be more tuned to the actual needs of policy makers. This could be achieved by involving policymakers in the development of the first draft of the scoping document, or by including a final chapter in the assessment reports with good practices of examples of implementation under different contexts. With regard to the policy support function in the narrow sense, it is suggested to continue the methodological work started under the first work programme, e.g. via extension of the mandate of the respective expert group. The financial and human resources spent on the catalogue of policy support tools and methodologies should be critically reflected. It will only be perceived as relevant and useful if the process of data entry is transparent, the quality of information high, and its content reliable and up-to-date. Thus, maintenance and appropriate quality control will be among the major tasks.

SESSION 20

Indicators and monitoring: measure, analyse, and communicate ecological changes and societal implications

Chairs: Johannes Rüdisser, Georg Leitinger

Biodiversity monitoring and ecological indicators for decision-making

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An understanding of how biodiversity and ecosystems respond to environmental change is necessary to guide policy and management seeking to slow the loss of biodiversity. But the use of observations of biodiversity change in decision making at local to global scales is hampered by different factors. It is difficult to monitor changes in biodiversity in a consistent manner across multiple scales; observations need to be transformed into informative and useful indicators, and the changes observed attributed to direct and indirect drivers. Also, the lack of structured and sustained dialog between scientists and decision makers hampers the translation of scientific findings into policy and ecosystem management guidelines. Time series of observations can track the responses of species, communities, and ecosystems to environmental change, and provide insight into the mechanisms underpinning responses to global change. Remote sensing methodologies can close gaps in biodiversity observation data collected on the ground. Observations of biodiversity and ecosystem responses to environmental change allow to identify indicators to monitor change and responses to change. Indicators are useful in comparing different ecosystems and are valuable tools of communication. Although various indicators already exist, there is a need for a new generation of indicators that consider less-studied taxonomic groups and ecosystem functioning, that are standardised across regions and that measure change over multiple time points. bioDISCOVERY, an international scientific network, seeks to integrate observations, indicators, and scenarios to support policy and decision-making for global environmental management. The network supports the decision-making process through synthesis of information from multiple indicators to inform assessments, and the catalysis of new indicators for management and decision support. Here, freshwater and marine indicators are of particular interest, as well as remotely sensed biodiversity indicators that contribute to the EBV framework.

Diurnal and seasonal changes of acoustic diversity and its direct and indirect drivers along a land-use gradient in grasslands

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Soundscape ecology is a newly emerging scientific field. It aims to understand how sounds from various sources can be used to understand coupled natural-human dynamics across different spatial and temporal scales. It has a high potential for large scale ecosystem monitoring, especially if combined with other remote sensing tools. The soundscape of a habitat is directly and indirectly a result of various biotic, abiotic and anthropogenic factors. Vocalizing animals contribute to the biophonic component with different taxonomic groups (e.g. birds, Orthoptera) having characteristic seasonal and diurnal patterns. The acoustic niche hypothesis postulates that a higher organismic diversity should result in a higher acoustic richness and complexity. Land-use intensity affects biodiversity in various ways and therefore could have an indirect effect on acoustic diversity. Abiotic factors such as temperature and rain as well as noise from nearby roads and machinery have been shown to influence the calling behavior of vocalizing animals and therefor are hypothesized to have additional indirect effects on acoustic diversity. To test this conceptual framework we established autonomous recording systems on a total of 300 plots in grasslands and forests established as long term research plots along a land-use and biodiversity gradient by the German Biodiversity Exploratories. The aim within this project is to establish acoustic richness indices as a functional tool to study the correlations between different organismic groups, vegetation structure and their sensitivity to changes in land-use intensity. We applied structural equation modelling to test the above proposed hypothesis. Here we present results from the grassland plots for May 2016–July 2016, covering the month with the main biological activity. We will discuss the feasibility of the soundscape approach for ecosystem monitoring, its current advantages and limitations.

Using long-term satellite records for monitoring forest health under climate change

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Forest cover approximately 30 % of the terrestrial Earth surface and thus are of great importance for global biochemical cycles, the climate system, and human well-being. Yet, there are rising concerns that forest health might be negatively impacted under climate change. Assessing changes in forest health under climate change is, however, challenging as only few data sources track forest changes over time spans long enough to infer climate change effects. Furthermore, existing data sources are difficult to compare across larger regions, as sampling and measurements protocols might vary widely. We here propose to use long-term satellite records, defined as combined satellite time series spanning more than 30 years, to monitor forest health in space and time. We demonstrate the power of long-term satellite records by reconstructing mortality trends between 1984 and 2016 over approximately 30 mill ha of temperate forests in Europe. On average, 0.79 % of the forest area (approx. 237,000 ha) was affected by natural or human-induced mortality annually. Mortality increased significantly over time (+2.37 % yr^{-1}), resulting in a doubling of forest mortality over the past three decades. Our study thus does not only show the potential of long-term satellite records for monitoring forest health consistently across space and time, but it also highlights the profound changes in forest mortality across Europe, which will have important implications for biodiversity conservation and forest carbon storage.

Bark stripping rate as an indicator to monitor red deer populations.

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Wild ungulates, including red deer, have become abundant in Wallonia (Belgium) as well as in many temperate European forests. Their ecological and economical impacts, notably bark-stripping, are widely documented. Instead of inaccurate and time consuming census of deer populations, forest managers argue for sets of validated indicators to monitor their impact on the environment, including the damages on timber production. Number of bark stripped trees may vary considerably from year to year and between sites and the reasons of these variations are not yet fully understood. This study aimed to identify and assess the effects of determinant factors on damage probability. A systematic sampling inventory was realised from 2004 to 2016 on sensitive stands (8–36 years old stands of *Picea abies* (L.) H. Karst). More than 52,000 trees and 3,500 sampling plots where observed each year in 82 kha of forest divided into 64 blocks facing contrasted red deer densities. Annual climate, red deer population densities and landscape indicators were computed at block level based on pre-existing data sources. Yearly bark-stripping probability was estimated using a generalized linear mixed model. Population densities, number of froze days, of heavy precipitations and snow cover proportion showed significant and positive effect on bark-stripping. The availability of close agricultural lands was the only landsape variable having significant effect but the error structure had to be handle by application of a random effect. Standardisation of climate effect on bark peeling rate produced a more stable indicator over time than raw bark-stripping rate. That indice was strongly correlated (R^2 = 0.67) with abundance indices derived from spotlight counts in a forest block where red deer numbers have been significantly decreased during the study period. Our findings suggested that bark stripping rate can provide useful informations not only on economic damages but also on changes in deer populations.

Meta-genomic monitoring of water resources with PuntSeq

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While the improvement of water quality and the monitoring of pathogenic contamination of freshwater resources have already been recognized as a UN Millennium Development Goal, the impact of climate change, increased weather perturbations and worldwide urbanization on the composition of pathogenic communities will add another level of complexity. We have developed a real-time meta-genomics pipeline for rapid and cheap assessment of the microbial community of freshwater resources. The pipeline includes all necessary steps from water sampling over DNA extraction and sequencing to downstream bioinformatics analyses. We employ the Oxford Nanopore Technologies MinION device for DNA sequencing, which has already been used for pathogen surveillance in other contexts, most famously for Ebola virus monitoring in West Africa, and allows for direct data assessment in the field due to its transportable nature. To test our meta-genomics surveillance pipeline, we founded the pilot project 'PuntSeq' to provide an in-depth resolution of the microbial landscape of our local river, the Cam. Although people obtain serious infections from the Cam's water every year, an information and research framework that targets the involved microbial culprits is still lacking. We sequenced the microbial community at ten different locations along the Cam and analysed the corresponding physical parameters. This allowed us to determine the presence of bacteria down to the genus level, assess their pathogenicity, and cross-relate the microbial community composition with environmental information. To make use of the portability of our devices, we ultimately aim to design a sequencing lab with which people around the globe can analyze the meta-genomics of their water sources *in situ*. 'PuntSeq' was founded as a citizen science project and all of our results are being made accessible through various public engagement efforts, a wide range of media and open-access publications.

Land-use changes in alpine regions: effects on the aesthetic value

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Land-use in the alpine region has undergone a mayor transformation process in recent decades. In 1860 land was mainly used for agriculture and forestry. Since that time there is a strong shift from agrarian and forestry use towards the use for tourism. On the example of the municipality of Sölden, this study shows the effects that land-use change has had on path networks and the aesthetic value of the landscape over the past 150 years. Originally, the roads and paths were primarily used to cultivate the agricultural areas. High alpine paths therefore only were constructed on mountain passes. The result shows that the purpose of the use of the paths has shifted significantly, and that valorisation mainly took place on higher elevated spots, particularly in aesthetically attractive landscapes. The altered accessibility has also increased the aesthetic value of higher altitudes, while the land use change in lower areas tends to have a negative impact on the attractiveness of the landscape.

Biomass production from alpine grassland – an ecosystem service mapping integrating the A1B emission scenario in the European alpine space

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In the Alps, grassland ecosystems provide the basis for grassland farming where local conditions like climate and slope steepness inhibit the cultivation of crops. Drivers such as technical achievements in agriculture and climate change are influencing the flow of biomass production from grassland. In this work, our objective is to identify the impact of a transforming Alpine climate on the provision of the ecosystem service (ES) *Biomass Production from Alpine Grassland* at the municipal level. Our mapping approach incorporates the A1B emission scenario to model the behavior of the indicators *supply* (fodder production of grassland, from colline to alpine level) and *flow* (de facto used fraction of *supply*) by taking into account variations in temperature and precipitation. To enhance the quantification of the *supply*, we developed a new growth function for intensive grassland in the Alpine space. The quantification of the supply was based on a biophysical assessment, where regional yields were calculated via growth functions based on the length of the growing season. Furthermore, the regional yield was refined according to site parameters, such as precipitation during the growing season and sum of radiation. The *demand* (amount of energy needed by forage feeding livestock) was derived from agricultural census statistics and takes into account herd composition, age class energy requirements and performance needs of milk production. This indicator was drawn to compute grassland yield energy budgets for two points in time, and thus to identify regional surpluses and deficits in the delivery of the ES *biomass production from Alpine grassland.* Our results indicate strong regional distinctions concerning the sensitivity to drivers: the southern and eastern parts of the Alpine space experience a loss in the ES, whereas low-altitude pre-Alps show an increased potential for the ES provision under the A1B climate change scenario. We recommend these findings to regional and cross-national decision-makers for the elaboration of a climate change adapted grassland management framework.

POSTER PRESENTATIONS

SESSION 20-P1

Assessing ecosystem services: the importance of distinguishing among supply, flow, and demand

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The concept of ecosystem services (ES) differentiates between supply, flow and demand. ES supply is usually defined as the capacity of ecosystems to provide a ES regardless of this being actually used, whereas ES flow refers to the actual level of use. Demand for ES represents the amount of a service required or desired by society. Hence, the quantification and mapping of these three aspects requires different indicators, various data sources, and diverse modelling approaches. Although the development of ES indicators has advanced considerably during the last decade, most studies focused on ES supply disregarding demand and/or flow. This contribution therefore aims at illustrating the importance of distinguishing among supply, flow, and demand. In addition to discussing suitable indicators for selected ES, we examine the spatial relationships among supply, demand, and flow in the Alpine space area. Our results reveal important supply-flow-demand mismatches across landscapes, i.e. more natural mountain regions are hotspots of ES supply, whereas high demand is mostly associated with highly urbanised areas or intensively used agricultural areas in the lowlands. Furthermore, our results indicate that the level of supply or demand, or a combination of both often determines the actual use, but other drivers such as infrastructure or marketing may also influence the level of flow. Hence, ES assessments that include the three aspects can contribute to an enhanced understanding of ES and inform decision-making to support the development of sustainable management strategies. This is particularly important at the regional and cross-national level in order to account for the dependence of the benefitting lowland areas from service providing mountain areas.

SESSION 20-P2

Resilience through synergies between agriculture and tourism for two contrasting trajectories in the Tyrolean Alps

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Multifunctional farming has various ways to integrate with the tourism sector. The empirical case is provided by the two villages of Obergurgl and Vent, both parts of the municipality of Sölden in the Tyrolean Alps. They provide a unique opportunity to study the interdependencies between agriculture and tourism over a long period. First, both villages exhibit a long history of tourism. Second, they have chosen two distinctly different development trajectories, one focusing on winter tourism with skiing while the other profiles as a mountaineering village. Third, both were part of a large 'Man and Biosphere' (MAB) project between 1973 and 1979 which studied the structural change from agriculture to tourism. This provides a baseline against which long-term changes and effects can be measured. The study applies sociological and ecological perspectives on resilience and investigates, if/how provision of ecosystem services (ES) has changed. Here, modelling the provision of ES covers a broad range of methodological approaches and is based on sociological and/or ecological indicators. This allows spatial mapping of historical ES provision as well as the evaluation of the resilience of the social-ecological system in a future environment. Therefore, the study provides deeper scientific insights into interlinkages between agriculture and tourism. The combination of different forms of integration of the two sectors with different communal development trajectories, assessed over a period of 35 years will provide a comprehensive picture of factors impacting on social-ecological resilience and reveals indicators which have to be monitored to ensure future ES provision.

SESSION 20-P3

Predicting the distribution of released Oriental white stork (*Ciconia boyciana*) in central Japan

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With the rapid decline in stork (*Ciconia*) populations, reintroduction programs have been carried out in some breeding territories. The first reintroduction of the Oriental white stork (*Ciconia boyciana*) in Japan occurred in 2005. But as the species' natural wetland habitats are declining, the birds now prefer to forage in rice paddies. Thus, restoring the paddy-dominated landscape is key for further success in the reintroduction program. In addition, a quantitative method is urgently needed to assess how much suitable habitat is available and where it is located. In this study, we identified environmental factors that affect the distribution of the Oriental white stork and produced the first predictive spatial distribution map using 2–year satellite tracking data of reintroduced individuals. The Maximum Entropy (MaxEnt) approach was used to model the species' distribution at the landscape scale (1 × 1 km grid cells). We identified six relevant environmental variables. Our results highlight the proportion of area of rice paddies as alternative wetland habitat as the most influential variable affecting the distribution positively. Landscape diversity represented by a complexmosaic of paddies and forest is also important for the species, as total length of paddy–forest edge also had a positive effect on habitat suitability. Our predictive distribution map provides valuable information for conserving habitat suitable to maintain the Oriental white stork population in Japan, and our findings suggest that urbanization should be regulated and farmers should receive assistance in maintaining paddies.

SESSION 20-P4

Estimating nesting plant preference of harvest mouse in Yato environment using UAV at Kanagawa Prefecture, Japan

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This research investigated the preference of nesting plant by harvest mouse *Micromys minutus*, in an abandoned Yato used for cultivation, at Fujisawa city, Kanagawa prefecture. At first, Investigation was mainly vegetation research of Yato bottom using small UAV and ground survey. Nests were found by searching the grasslands of Yato bottom thoroughly, and the nest positions were plotted using GPS. To find the relationship between vegetation of Yato bottom and harvest mouse's nesting location, zero-inflated model was used to analyze the data. As a result, harvest mouse in this research area preferred Amur silver-grass, Japanese silver-grass and low-height Poaceae hydrophytes. In grasslands with higher Amur silver grass percentage had higher nesting rate. However if vine species run over these tall grasses, it was not chosen as a nesting location. This research showed that harvest mouse nesting location is predictable, by finding distribution characteristics of tall grass using small UAV. Recently, abandoned paddy fields are often reused as natural parks in Japan. This study, estimating nesting location of harvest mouse from vegetation of the landscape, can be used for conservation programs that need consideration of continuity of grasslands.

SESSION 21

Learning from protected areas for an ecosystem-oriented management of forests

Chairs: Rupert Seidl, Simon Thorn, Christian Ammer

Conflict resolution in national park planning and management: what can we learn from the case of the national park Schwarzwald?

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For decades the national park Schwarzwald has been a dream for nature protection enthusiasts. However, its recent history (since establishment in 2013) is also full of emotional conflicts amongst environmentalists and protected land experts. Species conservation was, in part, not compatible with the protection of dynamic environmental processes. During the facilitation of the conflict resolution process by the offices of the state of Baden-Württemberg, the public was not only informed of the conflict but could take part in discussing the value of protected areas. The participation process aimed to create recommendations for national park authorities both prior to the declaration as a national park, and up to the present, when management plans for paths and roads must be devised. The basis of an informed discourse is mediation and participation. This requires an interaction between experts and citizens where diverging beliefs, values, fears, and interests of all participants (forestry, tourism, hunting, different environmental groups, NGO's, and citizens) come to the table. The participation process must merge with the political planning process to ensure the recommendations – as an outcome of the participation process – matter. Success factors can be shown from international studies and various environmental conflict resolutions in Germany. Ultimately, the aim is to create increased trust between citizens and natural protection experts to improve the facilitation process of establishing natural protected areas.

Impact of drought stress on forest dynamics in two environmentally sensitive protected areas

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Drought is known to have a large influence on forest health and to be one of the most important factors triggering both temporary declines and the mortality of susceptible species in temperate forests. Tree ring analysis gives a long-term perspective of tree growth and stand dynamics, and allows determination of environmental stresses. The focus of this study was to evaluate the impact of drought stress on long-term growth trend and stability of two divergent forests located within protected areas in the inner Alpine dry valley of the Inn River (Tyrol, Austria): a xeric Scots pine forest developed on a postglacial rock-slide area (Tschirgant-Bergsturz; c. 750 m asl) and a grey alder dominated riparian forest (Mieminger and Rietzer Innauen; c. 635 m asl). At the xeric site evaluation of long tree ring series (> 150 yr) of *Pinus sylvestris* revealed a stepwise growth decline of trees predisposed to die and increasing drought sensitivity in recent decades. The riparian forest stands, which are locally invaded by *Pinus sylvestris* and *Picea abies*, are situated on rarely flooded alluvial terraces and are exposed to extreme seasonal fluctuations of the water table (> 2 m). At some sites growth of *Alnus incana* is severely constrained by water supply leading to reduced stand height, pronounced top-killing and crown-thinning. However, drought stress causes only temporary growth reductions and no distinct decrease in long-term trend of basal area increment was detected. In summary, whether xeric sites within dry inner Alpine valleys might gradually become treeless or be replaced by more drought tolerant tree species like *Quercus* spp. and whether conifers can further spread within the riparian forest will depend on the duration, intensity and frequency of extreme weather events, e.g., drought, heat-waves and flooding in the future. The research was funded by the Austrian Science Fund (FWF; P22280–B16, P25643–B16) and Tiroler Naturschutzfonds.

Differential response of rare and dominant species separate successional trajectories in anthropogenically disturbed forest

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Originally developed for vegetation, successional theory has been applied to multiple taxa, including beetles, bryophytes, and lichens. However, continuing or additional natural and/or anthropogenic disturbance may hamper successional changes of communities towards a pre-disturbance state, or – in an extreme case – may lead to the transformation from one ecosystem to another, e.g. transition of forest to grassland. Here, successional trajectories of areas with additional disturbance move away from those of single disturbance ultimately resulting in a non-/different forest ecosystem. We used an extensive large data set of eight taxonomic groups, including vascular plants, bryophytes, beetles, and birds sampled in early successional stages of a forest affected by windstorm and experimental logging. Specifically, we tested if the strength of community divergence or convergence between successional trajectories of logged and unlogged plots varies with underlying relative abundance of species. If stochasticity is a major driver, we predict that community convergence or divergence between logged and unlogged plots appears largest when focusing on rare species, i.e. neglect dominant species. The presence, frequency, and distribution of species life history-traits present in local community is increasingly discussed to explain community changes over the course of succession.

Biodiversity patterns in a natural forest reserve: effects of deadwood amount and distribution on saproxylic species

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The natural forest reserve Sihlwald in Switzerland, which is dominated by beech, has been protected since 2007 after having been intensively used for timber production for over 500 years. In landscapes dominated by managed forests, such reserves are important for the promotion of natural dynamics and habitat structures. Deadwood is an essential habitat for biodiversity in forests, it is strongly affected by management and it should thus be considered in forest management plans. Therefore, it is necessary to understand how deadwood influences the manifold species that depend on it (saproxylic species). In this study, we sampled the communities of saproxylic beetles, wood-inhabiting fungi, bryophytes and lichens on 70 plots that were independently selected along two gradients: deadwood amount and connectivity. We evaluated if species richness and community composition can be best explained by deadwood amount and distribution, other forest structures or environmental variables, and at which scale effects can be found. A forest inventory that has been repeated four times since 1981 further allows us to relate the present biodiversity to the forests history and its development. Our first results show that the deadwood amount in the surrounding landscape has a strong influence on saproxylic beetles, wood-inhabiting fungi and bryophytes, while the connectivity was less important. In contrast to that, the species richness of lichens was not influenced by the availability of deadwood in the surroundings. The results of this study contribute to a better understanding of biodiversity patterns in temperate forests. We expect that our analyses will provide relevant information towards improved conservation measures that could be applied in forest management to help preserve biodiversity.

Restoring forests by bark beetle outbreaks – implications from mountain forest flagship species

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Intensive human use altered European mountain forests over the last centuries, resulting not only in a loss of biodiversity and old-growth forest structures, but also in an enhanced vulnerability against natural disturbances. Although forest managers have tried to supress natural disturbances, such as windstorms, wildfire and outbreaks of insect pests, climate change has led to increasing frequencies and intensities of natural disturbances in European mountain forests during the last decades. The impacts of natural disturbances on forest stands and the following succession can vary greatly and consequently species responses are difficult to predict. This talk illustrates impacts of bark beetle outbreaks on three species of conservation concern in a landscape frequently affected by natural disturbances. We investigated the response of the foraging activity and roost selection of barbastelle bats (*Barbastella barbastellus*). A combination of acoustic surveys, radio telemetry, and airborne light detection and ranging (LiDAR) was used to characterize forest structure and *B. barbastellus* habitat use on different scales. In the same study area, we analysed the response of capercaillie (*Tetrao urogallus*) and hazel grouse (*Tetrastes bonasia*) to bark beetle outbreaks. We combined a 23–year time series of aerial photography with LiDAR data to quantify present-day forest structures as well as stand disturbance history to test the effects of natural disturbances on the probability of grouse presence as mediated by changes in forest structure. Our results highlight the potential of post-disturbance biological legacies for maintaining and restoring habitat for species of conservation concern.

Habitat size is the crucial factor for protecting the wetland orchid *Dactylorhiza majalis*

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We examined long-term population trends to assess which factors jeopardize populations of the endangered wetland orchid *Dactylorhiza majalis*. We tested for effects of between-year climatic variation, management regimes and habitat size. To this aim, census data between 1975 and 2016 were assembled for 51 populations from nature reserves in Brandenburg, NE-Germany, and complemented by current vegetation surveys. The majority of populations (76 %) were stable or increased during the study period. Habitats were mostly Calthion grasslands. However, habitats were drier, shadier and richer in nutrients than expected for *D. majalis*. We identified small habitat size as a key reason for declining populations. Current management regimes – grouped as early mowing, late mowing, grazing – appeared equally suitable for preserving populations. Climatic factors had overall no strong influence on population sizes, although positive effects were detectably for warmer and wetter springs. Our results suggest thus far no substantially increased vulnerability of *D. majalis* to climate change in Brandenburg. They highlight, however, that conserving *D. majalis* depends in particular on preserving and developing large, suitable habitats.

Does carbon sequestration matter for managers of protected areas?

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Ecosystem Service oriented management strategies in Protected Areas are hampered by different perceptions of their importance between scientists and park managers. One such example is carbon sequestration which is highly prioritized by scientist as a mitigation measure to abate further climate change. Managers consider such regulation services less important because they have to address cultural services to a large extent like education, protection of cultural heritage, and recreation. In a series of modelling applications in the National Park Kalkalpen (NPK), a 200 km^2 forest landscape in Austria and part of the UNESCO world heritage 'Ancient and Primeval Beech Forests', we have studied regulation services and how they may be affected by climate change. By exemplifying that todays and future forest's capacity to sequester carbon is a result of past legacies (e.g. historic forest management), we were able to link cultural and regulation services. Moreover, we showed that the decrease of ungulate density by means of hunting, an extremely important cultural good, is significantly reducing the post-disturbance loss of carbon. These findings are applicable by the park managers in their daily work and intensify communication between scientists and practitioners, which is needed to improve ecosystem service oriented management strategies.

How does human influence modulate natural disturbance patterns across the temperate forest biome?

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Increasing evidence suggests that forest disturbances are changing in response to global change, yet the patterns of disturbances still remain incompletely understood. Quantifying within-biome variation of natural disturbance patterns and examining how human land-use modulates these patterns is thus of critical importance. Recent progress in remote sensing of forest change delivers consistent information on forest disturbances at the global scale, enabling large-scale comparative analysis of disturbance patterns. However, attributing disturbance agents from remote sensing data and distinguishing between natural and anthropogenic disturbances remains challenging. To overcome this limitation, we focused on 50 strictly protected areas and their surroundings to contrast disturbances in unmanaged systems with disturbances in coupled human and natural systems. Our study landscapes are distributed throughout the temperate forest biome, covering five continents and representing a total area of 3,970,922 ha. We combined remote sensing data on recent (2001–2014) disturbances with in-depth ecological context information from local experts. Our objectives were to quantitatively describe recent disturbance patterns, identify factors explaining within-biome variation in disturbance, and contrast this variation between protected areas and their surroundings. Our results indicate that global disturbance patterns in the temperate biome are highly variable, and co-vary with disturbance agents and traits of prevailing tree species. Disturbances in protected areas were smaller and more complex in shape compared to their surroundings. Yet, this signal of human land-use disappeared in areas with high recent natural disturbance activity, suggesting that large natural disturbances can override the effect of human land-use and dominate landscape patterns in forest ecosystems.

POSTER PRESENTATIONS

SESSION 21-P1

Improving forest conservation through GPS-tracking of cattle and horses in an extensive wood pasture in southwest Germany

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For centuries, wood pasture ecosystems were an important landscape element in Southwest Germany. Today, wood pasture systems are rare due to the legal separation of agriculture and forestry and the trend of land use intensification. Modern wood pastures can be key management tools in enhancing the biodiversity of wooded ecosystems. In an extensive wood pasture (34 ha) on a floodplain in southwest Germany (NSG Taubergießen), robust cattle (Salers) and horses (Konik, Icelandic horse) are used to achieve nature conservation goals such as increased structural diversity and lighter forest stands. Here, GPS-tracking was used to study the movement patterns and behaviour of four cattle and two horses. Their positions were logged from December 2017 to January 2018 with the aim of analysing the potential of GPS-collars in monitoring spatial behaviour. Pasture use was visualized and compared to the structures and characteristics of the pasture's forest stands. Animal behaviour was classified into 'resting', 'walking' and 'grazing' using a random forest classification algorithm. All animals spent five times longer in the older, more open forest stands, than in the younger, denser stands, but horses and cattle differed in space use and behaviour. Results show the horses were more active and covered longer distances, with a higher concentration of tracks on existing roads and trails. While horses covered 6.8 km/day, cattle covered 4.4 km/day, on average. Cattle were more influenced by supplementary feeding, with cattle walking 64 % of that average on days preceded by feed days, as compared to the horses at 86 %. GPS-tracking provides opportunities for further research on the behaviour of cattle and horses in wood pastures by enabling the gathering of accurate information on daily and seasonal herd movement and pasture use. This aids in making decisions concerning herd management, animal welfare and silvicultural practices.

SESSION 22

Nature conservation and restoration – from science to practice

Chairs: Nina Farwig, Bruno Baur, Martin Dieterich

A conceptional framework and practical guide for choosing target species for biodiversity sensitive urban design

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Recent research has highlighted the significance of cities for biodiversity, making them important places for conservation in their own right. Current conservation approaches in cities are mostly defensive, by focussing on remnant pockets of natural areas within the urban area, or by trying to protect particular species where they occur in the built environment. The disadvantage of these approaches is that they are vulnerable to further urban development and do not create habitats where these do not exist anymore. An alternative strategy is to make wildlife an integral part of urban development, to create new habitat in the built up area. Several examples for such a strategy exist, such as the method Animal-Aided Design, that combine urban design with wildlife conservation and allow particular species to live in cities. Here we address the challenge of choosing target species for such biodiversity sensitive urban design. The starting point of our conceptual framework is the observation that many species may live in a particular city, not just those that already live there. Thus, it is the regional species pool that needs to be searched when target species for a particular urban development project are sought, which can be obtained from geo-referenced species data. The available habitat types on and around the development site and migration barriers then limit the species numbers to the local species potential. In the next step, the potential of the site for each species is analysed – how can it be upgraded to host species given the planned development and the life-history traits of the species? For the final choice of target species, traits related to the human-animal interaction should also considered. We suggest that experts make some recommendations, but that there is a participatory process such that stakeholders will be involved in species selection. We will illustrate the framework with examples.

Effect of land-sparing and land-sharing measures on honeybee nest populations: an individual-based modelling approach

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The intensification of agriculture and the associated decline in biodiversity have an impact on honeybees. The effects on honeybee population development were investigated with landscape scenarios using the models BEESCOUT and BEEHAVE. Based on a typical crop rotation of a region in Brandenburg, Germany (business-as-usual scenario), landscape scenarios with increased diversification under the approach of land-sharing (i.e. catch crops, mix cover crop and the permanent culture of cup plant) and land-sparing (i.e. flower strips) were developed. The influence of different pollen and nectar quality of the catch crops buckwheat and phacelia and the mix cover crop winter rye/hairy vetch as well as their combinations on the number of bee individuals was modeled. Besides the quality of forage supply, variation effects of the proportion of crop or flower strips in the agricultural area were taken into account in the respective scenarios. The scenarios with the implementation of buckwheat, phacelia and the winter rye/hairy vetch mix cover crop show an increase in the honeybee population over the 12 years, in which the crop rotation was modified. The number of individual bees rises when the cup plant covers 2 % of the agricultural area. However, the honeybee population remains at comparable level even when the percentage cover of cup plant exceeds 8 %. Evenly distributed flower strips with a high pollen and nectar quality lead to an increase of bee population, but a low quality of forage supply results in a negative population development. Both, land-sparing and land-sharing scenarios had positive impacts on honeybees, whereby it appeared that the quality of the forage supply could have a greater effect than the quantity. In a next step, combined landscape-scale effects of land-sharing and land-sparing measures will be examined.

Understanding farmers' perceptions of ecosystem services to improve biodiversity conservation and research communication

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Ongoing expansion and intensification of land use at the expense of habitat diversity at landscape scales pose a major threat to biodiversity and related ecosystem services. The initiation of agri-environment schemes as well as numerous conservation and research projects, environmental teaching and education measures, seek to counteract this trend and negative impacts on agricultural sustainability and biodiversity conservation. However, little is known about the perception and appreciation, as well as the effectiveness of such measures in applied fields, and the training of conservationists and landscape ecologists. This persisting 'research implementation gap' appears to limit the potential of conservation research in practice. From April to July 2018, we conducted a widespread survey in Germany and Austria to assess the diverse perceptions of land users, farmers, decision-makers, students and early-career scientists on these topics. So far, more than 200 participants have responded to the survey. We will present an early analysis and overview of their perceptions on the importance and impact of biodiversity and associated ecosystem services, as well as different forms and communication pathways of available information sources (e.g. scientific vs. popular articles and journals; direct vs. indirect communication) for both productivity and protection of agricultural landscapes, and their own versus general decision-making processes. These first results of our survey provide valuable insights into various perceptions of biodiversity conservation and ecosystem service management measures in a European land use context. We will discuss how such social surveys and findings can be used to improve the planning and implementation of agro-ecological conservation studies and measures, and provide examples of effective communication of scientific knowledge within and beyond research projects to fill persistent gaps in this field.

How to close the science-practice gap in nature conservation?

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Professionals working in practical nature conservation and management depend on up-to-date knowledge on the protection of biodiversity and the conservation or restoration of ecosystems and habitats. Which kinds of information sources are important to professionals and which ones do they use in their every-day work? Answering these questions and knowing more about the information sources used in conservation practice should help to improve the exchange between science and practice. We therefore conducted a survey to identify the information sources used by Swiss professionals in nature conservation, including the forest sector. Experience-based sources of information (e.g. personal experience, exchange with colleagues or experts and field trips) are more important for and more often used by professionals in nature conservation than evidence-based sources (e.g. various print products such as fact sheets, specialized journals in national languages and targeted books). In contrast, English articles from international scientific journals are hardly ever consulted by practitioners. It is thus important that scientists personally engage as experts, and take time for direct personal contact and exchange with practitioners (e.g., by offering field trips). Given that practitioners have little time in their daily business for searching and implementing new scientific knowledge, short, audience-targeted and synthetizing publications in national languages or specialized websites should be provided. These measures are key to reduce the gap between science and practice in nature conservation.

Ecological interrelation between carnivores and ground-nesting bird communities in a Special Protection Area in Brandenburg, Germany

Christian Fiderer[1], Ulrich Zeller[1]

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In this study, we examine the spatial and ecological interrelation between different carnivore species (Carnivora, Mammalia) and ground-nesting bird species in a Special Protection Area (SPA) in Brandenburg, Germany. Between August 2015 and June 2017, we carried out camera- and live trapping of carnivores and combined these data with a bird mapping to calculate predator-prey spatial overlap. Spatial data were complemented by an investigation of raccoons' (*Procyon lotor*) and red fox' (*Vulpes vulpes*) feeding behavior via an analysis of scats. Camera- (4,684 trap nights) and live-trapping (2,543 trap nights) of carnivores revealed that the SPA hosts virtually all terrestrial carnivore species that occur in Germany. Raccoon, red fox, and domestic cat (*Felis silvestris* f. catus) showed highest levels of relative abundance. We used GPS-telemetry for a detailed analysis of spatial behavior of raccoons (n = 9) and red foxes (n = 5) over a 20–months period, conducting one of the first GPS-telemetry studies of raccoons in Germany. Similar dimensions of total home ranges for both species initially assume a comparable level of predatory potential on ground-nesting birds. However, spatial distribution patterns recovered a strong difference between the two species: raccoons showed a clear preference for reed swamps and shrub swamps, clustering along the fringes of water bodies, while red foxes were more evenly distributed and showed a preference for deciduous forests and reed swamps and a pronounced level of migratory activity. Both species consistently avoided open lands. Overlap between carnivores' core areas and bird locations assume a high potential impact of raccoons (and to lower extent of red foxes) on water-associated bird species, while the impact of carnivores on grassland birds appears not as important. Dietary analysis of carnivores confirmed species-specific spatial patterns. While 31.7 % of raccoon scats (n = 60) contained remains of birds, this number was clearly lower in red fox scats (18.6 %, n = 51). Most scats of raccoons contained insects, mollusks and fruits. Red fox scats most frequently contained small mammals, insects and large mammals (carrion). In summary, our study highlights the need for a differentiated view on the potential impact of these two carnivores on the endangered bird species in this region.

Intensity-dependent impact of sport climbing on vascular plants and land snails on limestone cliffs

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Limestone cliffs in the Jura Mountains harbour species-rich plant and animal communities including rare species. Sport climbing has recently increased in popularity in this habitat and several studies have reported damage to cliff biodiversity. However, so far how damage levels vary with climbing intensity has not been investigated. We evaluated the effects of climbing intensity on the diversity of vascular plants and land snails in 35 limestone cliff sectors in the Northern Swiss Jura Mountains. Mixed-effects models were used to examine whether species richness of plants and land snails differ between cliff sectors with low and high climbing intensity and unclimbed cliff sectors (controls) taking into account potential influences of cliff characteristics (aspect, cliff height, rock microtopography). At the cliff base, the best fit model revealed that plant species richness was affected by climbing intensity and cliff aspect. Plant species richness was reduced by 12.2 % and 13.1 %, respectively, in cliff sectors with low and high climbing intensity compared to unclimbed cliff sectors. On the cliff face, plant species richness was only influenced by climbing intensity (species richness reduction by 24.3 % and 28.1 %). Combining data from cliff base, face and plateau, the best fit model revealed that land snail species richness was only affected by climbing intensity (species richness reduction by 2.0 % and 13.7 %). In both organism groups, species composition was increasingly altered by increasing climbing intensity. Our study provides evidence that even low climbing intensity reduces cliff biodiversity and that damage becomes more pronounced with increasing climbing intensity.

GIS and remote sensing analysis of land cover change in Kopaonik National Park (Serbia)

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During latest decades, natural ecosystems in mountain environments have been increasingly exposed to different human influences, both globally and in Serbia. There are six main ski resorts in Serbia (Kopaonik, Zlatibor, Stara planina, Divčibare, Goč, Brezovica) and environmental degradation is present in all of them. The oldest and the greatest ski resort in Serbia is situated in the area of Kopaonik National Park, located in one of the floristically richest mountains in Balkans. The aims of this study were to detect and to analyze land cover changes in the area of National park for the period 1984–2016, using GIS and remote sensing techniques. The results showed significant changes in land cover, which can be corelated with intensified human activities. The greatest increase in land cover areas was registered in the category of open spaces with little or no vegetation – more than 90 %, while the greatest decrease was recorded in the category of natural grassland – more than 40 %. The greatest habitat loss and fragmentation were registered in the area of ski resort. However, in the former agriculture areas abandoned by local population, results showed current processes of natural revegetation and forest cover increase.

POSTER PRESENTATIONS

SESSION 22-P1

An online inquiry reveals: communication between scientists and practitioners in conservation urgently needs to be improved

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There is no doubt that an effective implementation of scientific results into conservational practice is still missing. This implementation gap has been raised by several studies with a broad range of suggestions how to close it. Assuming that the gap is also residing in the Ecological Society of Germany, Austria and Switzerland (GfÖ) we are presenting the results of an online empirical study that we performed among the scientific members of the society. With the help of an anonymous inquiry using a mixed approach (qualitative and quantitative questions) we analyzed the scientific profile of the involved researchers in relation to what they thought about implementation (e.g., necessity, contact to practitioners, deficits, reasons and possible ways out of the dilemma). Of the total number of 153 feedbacks (15.3 % of addressed scientists) there is about one third of the researchers devoted to basic and one third to applied research while another third is in routine with both. While merely all (98 %) clearly opted for an improved exchange with practice the frequency of explicit contact to practitioners is much larger when researchers are with applied projects. Thirty-five percent of the latter contacted practice more than once a month in contrast to people in basic research with only rare contact. Interestingly, more contact does not necessarily lead to more implementation since only 8 % of the researchers found their results frequently implemented in practice. An in-depth-analysis identified 'communication' as a key-problem related to 'communication of results' as well as to 'culture of communication' as such. We focus on this problem and give perspectives for the evident need of improving mutual understanding.

SESSION 22-P2

Decline of *Arnica montana* in montane *Nardus* grasslands despite extensive conservation efforts – the role of habitat microstructures

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The ongoing decline of the endangered plant species *Arnica montana* L. in species-rich *Nardus* grasslands, both highly protected by the EU Habitats Directive, receives high attention from both science and conservation practice to maintain remaining populations in a favourable status. The observed species' decline within properly managed habitat sites goes beyond already identified deterioration effects such as eutrophication. Considering *Arnica's* todays clumped distribution in montane *Nardus* grasslands, we suppose microstructures as an important controlling factor in its decline pattern and lacking generative reproduction in otherwise homogeneous habitat sites. To explore the importance of habitat microstructures, we address the research question if habitat microstructures are an influencing factor in *Arnica*'s decline process, present population size and occurrence pattern, and hypothesise that short swards dominated by *Nardus* grassland character species are positively associated with species' presence. We surveyed plots with locally isolated *Arnica* populations and its potentially colonisable direct neighbourhood in the Rhön Mountains (Germany) in equally managed sites regarding habitat and community structures and site conditions at micro scale. Results indicate a distinct relationship between site conditions and specific co-occurring species and *Arnica* presence and absence plots, respectively. For example, presence plots are associated with low herb cover and canopy height, while absence plots are associated with competitive tall-growing species. The results suggest that near distant habitat areas, which would be potentially re-colonisable for *Arnica montana* at habitat scale, provide currently less suitable conditions at micro scale. Implications for conservation and habitat management arise from an enhanced understanding of declining patterns of this important target species and highlight the need of a management to promote diverse habitat structures at micro scale.

SESSION 22-P3

Seed fire tolerance of herbaceous species from the temperate zone depends on their hydration status

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In Romania and Hungary, grassland burning is recently very frequent during spring and autumn. The main cause is that more and more people do not manage their land in a traditional way anymore. As a simple and fast solution, farmers regularly use fire to remove shrubs and the accumulated biomass. Previous research showed that fire may have a negative effect on seed germination of native herbaceous plants. The question of our study is how hydration status of seeds influences their post-fire germination. We chose sixteen species from four families (Asteraceae, Brassicaceae, Poaceae and Fabaceae) and divided theirs seeds into three groups. The first group remained dry, the second was hydrated and the last one was the control. The first two groups were heat treated on 100oC for 5 minutes, which simulated burning. After the treatments, the seeds were germinated. Based on the results of statistical analyses (GLM), we found that through all the species, heating decreased the germination of hydrated seeds compared to dry seeds and the control. Having investigated the response of each species separately, we figured out that from the 16 species 9 did not tolerate heating, when their seeds were moist, and germinated in lower percentage than the control. The reaction of dry seeds was different, heating reduced seed germination of only one species (*Lepidium campestre*). Based on our results, uncontrolled and regular burning represents a threat for several herbaceous species, because during the burning period their seeds are hydrated and therefore fire seriously damages them. Thus, instead of uncontrolled frequent burning, we suggest the revitalization of the traditional management in European temperate grasslands.

Forest fires analysis using remote sensing techniques: a case study in East Serbia

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Forest fires have a significant impact on the humans and environment and remote sensing techniques play an important role in forest fire management. As an environmental monitoring tool, remote sensing allows us to observe nature before, during, and after the fire occurrence. In the past decades, large forest fires were registered in South and Southeast Europe, including Serbia. Several extensive fires occurred in the area of Svrljiške Planine and Stara Planina Mountains (East Serbia) in July 2007. The aims of this study were to detect and analyze damage caused by fire and land cover change in this area from 2007–2017. Atmospherically corrected Landsat 5 & 8 data were downloaded via USGS Earth Explorer application. Machine learning Random Forest (RF) algorithm for pixel based supervised classification was employed to obtain six different classes: artificial area, bare soil, water, agricultural area, pasture, and forest. Results showed remarkable changes in two classes – decrease of pastures for 23.74 % and increase of forests for 20.86 %, which can be explained by natural revegetation. The analysis for other classes did not show significant oscillations.

SESSION 22-P5

Ecological interrelation between carnivores and ground-nesting bird communities in a Special Protection Area in Brandenburg, Germany

Christian Fiderer[1], Ulrich Zeller[1]

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In this study, we examine the spatial and ecological interrelation between different carnivore species (Carnivora, Mammalia) and ground-nesting bird species in a Special Protection Area (SPA) in Brandenburg, Germany. Between August 2015 and June 2017, we carried out camera- and live trapping of carnivores and combined these data with a bird mapping to calculate predator-prey spatial overlap. Spatial data were complemented by an investigation of raccoons' (*Procyon lotor*) and red fox' (*Vulpes vulpes*) feeding behavior via an analysis of scats. Camera- (4,684 trap nights) and live-trapping (2,543 trap nights) of carnivores revealed that the SPA hosts virtually all terrestrial carnivore species that occur in Germany. Raccoon, red fox, and domestic cat (*Felis silvestris* f. catus) showed highest levels of relative abundance. We used GPS-telemetry for a detailed analysis of spatial behavior of raccoons (n = 9) and red foxes (n = 5) over a 20–months period, conducting one of the first GPS-telemetry studies of raccoons in Germany. Similar dimensions of total home ranges for both species initially assume a comparable level of predatory potential on ground-nesting birds. However, spatial distribution patterns recovered a strong difference between the two species: raccoons showed a clear preference for reed swamps and shrub swamps, clustering along the fringes of water bodies, while red foxes were more evenly distributed and showed a preference for deciduous forests and reed swamps and a pronounced level of migratory activity. Both species consistently avoided open lands. Overlap between carnivores' core areas and bird locations assume a high potential impact of raccoons (and to lower extent of red foxes) on water-associated bird species, while the impact of carnivores on grassland birds appears not as important. Dietary analysis of carnivores confirmed species-specific spatial patterns. While 31.7 % of raccoon scats (n = 60) contained remains of birds, this number was clearly lower in red fox scats (18.6 %, n = 51). Most scats of raccoons contained insects, mollusks and fruits. Red fox scats most frequently contained small mammals, insects and large mammals (carrion). In summary, our study highlights the need for a differentiated view on the potential impact of these two carnivores on the endangered bird species in this region.

SESSION 22-P6

A fast localization and marking technique for wading bird nests exemplified with the Northern lapwing

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Nests of the Northern lapwing (*Vanellus vanellus*, L. 1785), a ground-breeding bird, are endangered by farming regimes on arable land, which take place at the same time as the birds breeding season. To protect nests from destruction, they need to be localized and marked. Despite availability of modern technology, still the marking, localization and monitoring requires time- and labor-intensive ground-based field work. Here, we evaluate, how simple range-finder devices in combination with photograph-based distance-detection can be combined with the traditional ground surveys for the localization and discovery of bird nests. Within the experiment, we tested three types of rangefinders, in fields varying in vegetation height and density. At the start of each survey, we measured the distance from the car to each nest and took a photograph. Marking landmarks on each photograph ensured clear orientation of differently experienced field workers. Moreover, when approaching each nest, the field workers were able to measure their distance to the car, enabling distance estimates to the nests. The general discovery success rate of nests was 96.8 %. On average one nest was localized and discovered within 6 minutes. Vegetation height and density increased the searching time, but did not influence the discovery rate. The type of range-finder device influenced searching time and path length, but not the discovery rate. In addition to that, the method does not depend on environmental influences and is easily learnable to untrained volunteers or novice field workers. We believe this method to be applicable in any nature conservation facility to realize a Northern lapwing survey regime that comes with reduced fieldwork effort – fast, simple and still at low cost. Moreover, the method has the potential to be easily adapted for the detection of other wader species nests and to be generalized as standard survey method in the protection and conservation of ground-breeding birds.

SESSION 22-P7

Habitat use of red kites (*Milvus milvus*) in human-shaped landscapes during different breeding phases

Theresa Spatz[1], Dana Schabo[1], Christian Gelpke[2], Claudio Grefen[1], Simon Ostermann[1], Michael Riess[1], Chris Lindner[1], Sascha Rösner[1], Nina Farwig[1]

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Land use intensification is one of the main drivers of global change with consequences for biodiversity. Highly mobile animals such as birds of prey that act on large spatial scales are particulaly affected by human-induced modifications of the landscape. The distribution and availability of suitable foraging habitats and resources largely determines the fitness and survival of individuals as well as population dynamics. In consequence, populations of many threatened raptors such as the red kite are declining in these human-shaped landscapes. With approximately 50 % of the red kite's world population breeding in Germany, the country has a special responsibility for its protection and preservation. It is therefore essential to understand how and during which breeding phase land use intensification impacts the habitat use of red kites. We selected 20 nest sites along a gradient of land use intensity. At each of these nest sites, one breeding bird was equipped with modern GSM–GPRS transmitters. We will combine spatially and temporally highly-resolved movement data with detailed land use data to (I) determine the activity ranges of red kites during three different phases of the breeding season – (a) occupation of nest sites, (b) breeding and chick rearing, (c) post-breeding. We will (II) analyze differences in land use composition between activity ranges of differerent birds and (III) identify land use types that serve as important foraging grounds for red kites during the three phases. Thus, our findings will shed light on the complex habitat use patterns of these highly mobile animals during different breeding phases. As such we will provide insights into an optimal spatio-temporal distribution and composition of foraging grounds that can in turn enhance the long-term population dynamics of the red kite.

SESSION 23

Novel tools and data for quantifying the impacts of global change on ecosystems

Chairs: Rupert Seidl, Cornelius Senf, Florian Hartig

Structural uncertainty in forest gap models: friend or foe?

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Forest gap models (FGMs) are a key tool to better understand, assess and project decadal to centennial-scale forest dynamics. Despite their success, many questions regarding appropriate model formulations remain unresolved, and few FGMs have found widespread application across Europe. The aim of this study was to revisit, assess and increase the internal consistency of the forest gap model ForClim, a FGM originally developed to simulate tree species composition in the European Alps. We simultaneously scrutinized the formulations of the three core demographic processes tree establishment, growth (including the light regime) and mortality, applying a pattern-oriented modelling (POM) approach. We developed a set of alternative process and parameter representations making use of various data sources. We tested all combinations of the standard and alternative formulations (> 500 model versions) against a comprehensive set of patterns across a wide range of site conditions, for both managed and unmanaged stands, and for both decadal as well as centennial-scale projections. The most accurate model versions differ considerably across applications and study sites, and model performance can be substantially improved for an application while adapting one process only. Yet, to improve the general robustness of model projections under a broad set of applications in time and space, all core processes and applications of interest should be considered during model development so as to avoid overfitting and allow for the detection and revision of structural shortcomings and parameterization problems. Instead of aiming at the development of one best model version, we suggest to develop a set of meaningful model versions, to rigorously test them, and to apply the most promising ones simultaneously ('ensemble simulations') to account for uncertainties in model structure and parameters.

Simulating intra-annual carbon dynamics of beech using different phenological data and modelling approaches

Katarína Merganicová[1,2], Tomáš Hlásny[1,3], Zoltan Barcza[1,4,5], Tomáš Bucha[3], Dora Hidy[5], Milan Koreň[2], Daniel Kurjak[2], Ján Merganič[2], Martin Mokroš[1,2], Zuzana Sitková[3], Katarína Střelcová[2]

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Phenological development affects both intra and inter-annual carbon cycling in ecosystems by driving main physiological processes, such as photosynthesis, growth, carbon allocation, etc. Traditionally, phenological phases have been observed terrestrially based on the visual assessment of a tree state. However, recent advances in the acquisition of ecological data using modern technologies enable fast and objective assessment of phenological patterns at various spatial scales. In our study we applied remote sensing, terrestrial laser scanning, and digital repeat photography to derive canopy phenological development of a common beech temperate forest stand and compared it with visually determined phenological stages. We further examined the impact of different sources of phenological data on the simulated ecosystem dynamics using the version of Biome–BGC model called Biome–BGCMuSo (Hidy et al. 2016). In the applied model version, phenological development, plant mortality, and soil processes are simulated in more detail than in the original Biome–BGC. The enhanced phenology module enables to divide the growing season up to seven phenological phases based on heat sum, while the original phenology module of Biome–BGC accounts only for the onset of the growing season driven by a critical soil temperature constraint and the beginning of leaf senescence in deciduous ecosystems. We tested the match between the internally generated phenology using the two above-mentioned sub-models and phenology derived from the mentioned external sources. We were interested in the accuracy with which spring and autumn phenological transitions are predicted by the two phenology sub-models, and we examined the options for improving model performance by supplying the observed phenology patterns from external sources. Such an investigation strives to explore the options for more extensive utilisation of data acquired by modern data acquisition methods in ecological research.

Tree species site suitability as a combination of occurrence probability and growth

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The Happy Tree Index (HTI) was developed as a measure of site suitability of forest tree species which considers occurrence probabilities and additionally growth responses as proxies for viability and vitality (Märkel & Dološ 2017, Forests). With projections for current climate and climate change conditions, the HTI helps improve climate change impact assessments for forests. Species distribution and growth models were calculated and combined into one measure. The simple calculation method of the HTI makes it easy to integrate more aspects of site suitability. The six most frequent tree species according to German national forest inventory data were used including repeated measurements. Comparing modeled occurrence and growth revealed considerably differing patterns of the two responses for some species. The combination of occurrence probability and growth led to new patterns of site suitability represented by the HTI. The HTI was used to identify regions which are estimated to experience the greatest negative climate change impact under consideration of current stands. To identify these regions, we aggregated species-specific expected negative development of site suitability for stands where a tree species was currently important. In managed forests, these regions may serve as priority regions for climate change adaptation. This work provides a more comprehensive view on tree species site suitability in biogeographical modeling and helps assessing climate impact on forests.

IPS-SPREADS – a new simulation tool for the risk assessment of the European spruce bark beetle (*Ips typographus* L.)

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From 2030, more than 75 % of the Saxon Switzerland national park (NLP) area will be left without human intervention. Despite its high topoclimatical diversity (e.g. cliffs and canyons), a mass outbreak of the European spruce bark beetle (*Ips typographus* L.) (BB) is reasonable due to a high amount of non-native spruce tree plantations (*Picea abies* (L.) KARST.) (ST) resulting from past forestry. First signals of this threat have been detected recently. Due to the division into two parts and the need for open land management inside the NLP, it is impossible to provide a buffer zone at the NLP border, which could hinder a spread out of the NLP to the surrounding forests used for wood production. The latter imposes a conflict between conservational and economic interests as observed in other regions before. An adaptive risk assessment, which considers possible climate and management scenarios, is thus urgently needed. Such a risk assessment can be done with model-based prediction tools like a predisposition assessment system published by Netherer & Nopp-Mayr (2005). This system was integrated into IPS (Infestation Pattern Simulation), a spatially explicit individual-based model (IBM) which describes the dispersal of an BB population within a forest, where weakened STs in the simulated world are searched and accordingly infested by the BBs. With this new model (IPS–SPREADS), possible influences of climate and management scenarios on the infestation as well as the endangering situation of the STs in real forests can be investigated by importing GIS data. We present IPS–SPREADS based on simulation experiments (1) to reproduce the past infestation development in the Saxon Switzerland NLP and (2) to evaluate future management strategies to decrease the infestation risk. Both advantages and basic principles of the IBM developed in NetLogo will be highlighted and the potential for the transmission of the model results for predictions on landscape level will be discussed.

Using demographic trade-offs and a simple forest model to understand and predict tropical forest dynamics

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Tropical forests worldwide suffer from human alterations, e.g. through climate change or timber extraction, with profound consequences for biodiversity and carbon retention. To understand and predict how forests change in response to these drivers, we need an understanding of the demographic strategies of the tree species and their response to resource availability. I explore how demographic strategies of 282 tree and shrub species in the tropical moist forest of Barro Colorado Island, Panama, combine to determine forest dynamics. I apply the PPA (perfect plasticity approximation) model that simulates height-structured competition for light based on growth and survival of each species in four canopy layers. Model parameters were derived from a PCA of species-specific growth, survival, and recruitment rates to capture essential dimensions of demographic variation. The model was parameterized for each species separately or for up to five virtual species representing different demographic strategies (fast, slow, long-lived pioneers, short-lived breeders, intermediate). When all five strategies were included, the model correctly reproduced observed old-growth forest structure and species composition, as well as species' maximum sizes. The model also correctly predicted the dynamics of secondary forest (as compared to chronosequence data) although it was parameterized only based on demographic rates observed in old-growth forest. Slow species and long-lived pioneers accounted for most of the biomass in old-growth forest, while fast species dominated the early succession (< 70 years). The PPA is a simple model that is easily parameterized from inventory data without any need for manual parameter tuning. It allows to scale up from demographic rates of individual species to community structure and dynamics and is thus a promising tool to predict consequences of anthropogenic impacts on tropical forests worldwide.

Soil water hydrodynamics in individual-based mangrove stand modelling – a new strategy to face changing environments

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Individual-based models of plant communities mainly describe intra- or interspecific interaction processes in a framework of an invariant abiotic environment. Competition for belowground resources is often represented in the form of abstract concepts that limits plant available resources and growth. Without accounting for resource flow and balancing, a description of feedbacks on the soil and associated resources is hardly possible in models. Hence, the validity of available models remain limited to stationary conditions. Using example of mangrove ecosystems, we want to employ a new modelling strategy, which ensures coupling of mechanistic mangrove growth with numerical ground water models. From the perspective of a mangrove tree, water use and transpiration will lead to a salinisation of the root zone. This will affect water availability for all present plant individuals. Hydrodynamic soil processes like density differences due to different salinities and boundary conditions like fresh-water influence or tides lead to flow processes in the soil matrix and form – in combination with the plant water use – the salinity distribution in the stand. From the ecological point of view, we will explain the formation of mangrove zonation and the development of a mangrove stand under changing environmental conditions (e.g. restoration or sea level rise). For ground water modelling, the understanding of the origin of visible stand patterns may enable a model-based identification of unknown soil parameters.

Scaling vegetation dynamics: a novel approach for modeling vegetation transitions across large spatial scales based on deep learning

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Terrestrial vegetation is of crucial importance for human well-being and provides a wide variety of ecosystem services to society. To tackle global issues such as climate change or biodiversity loss, managers increasingly demand tools that allow the prediction of vegetation dynamics at large spatial scales. While dynamic vegetation models with a faithful representation of demographic processes exist at the local to landscape scale, addressing larger scales with the fine spatial grain required to answer management questions remains challenging. We here introduce a new framework for Scaling Vegetation Dynamics (SVD) that at its core utilizes deep neural networks (DNNs). Deep Learning is an emerging branch of machine learning, currently revolutionizing computer vision, natural language processing, medical diagnosis, and many other fields. In the context of SVD, a DNN learns a representation of vegetation dynamics from data provided by remote sensing or high resolution process based vegetation models (PBM). The DNN is trained to predict the probability of transitions between discrete vegetation states contingent on the current state, the residence time, environmental drivers (climate and soil conditions), and the spatial context (i.e., the state of neighboring cells). In addition, a density distributions of relevant ecosystem attributes (e.g., total ecosystem carbon or biodiversity) is linked to each vegetation state, which allows the impact of vegetation transitions on these attributes to be quantified. In this contribution we introduce the conceptual approach of SVD and show results for an example application where we train SVD on landscape level simulations of a PBM in the Austrian Alps. More broadly we discuss aspects of applying deep learning in the context of ecological modeling.

Using random forests to identify composite early warning signals of population crashes

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Predicting population dynamics is a major goal in population ecology. A suite of early warning signals of such collapses has been identified using bifurcation theory. Some success has been achieved in identifying populations that are bound to collapse; however, the reliability of such signals are dependent on the specific system and underlying drivers: although the behaviour of these signals is well described for systems that go through a bifurcation, less is known for systems that follow a gradual decrease. Here, we test the usage of a random forest, a machine learning algorithm, to predict population dynamics. Random forests can efficiently combine signals, thereby potentially improving predictive power. We test the approach on simulated data from an individual based model, data from a microcosm experiment, and field data from a population of pairie voles. We show that combining multiple signals improves predictive power. Due to the computational efficiency of random forests, we could include more candidate signals in our search. These signals included both the conventional early warning metrics that stem from bifurcation theory (such as autocorrelation at lag–1 and skewness) as well as more ecological en evolutionary indicators of the state of a population (such as genetic variation, selection pressure and average body size). Finally, we used permutation testing to identify which underlying signals contributed most to the predictions. We found that trait-based signals were especially informative in the microcosm experiment and the field data. However, their contributions depended on the amount of data as wel as the forecast horizon. The identified signals provide a basis for future empirical work. Furthermore, by applying the random forest to more real world data we hope to construct even more reliable predictors of population crashes in the future.

Determining species' ranges using point locality data from data sharing networks – mining for false-positives

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Natural history collections and other sources have been mobilizing an enormous amount of point locality data, and are sharing them via large databases such as the Global Biodiversity Information Facility (GBIF). These data are potentially of high value for assessing the status of and changes in species distributions, but various shortfalls, errors and biases compromise a wider use. Elucidating how accurate these data represent the geographic range of a species, is therefore of eminent importance. False-positives, i.e. putative records from locations outside of the native range, are a common problem and may cause geographical bias in species' range estimation, and thus need to be systematically searched-for and eliminated, which is often a time-consuming task. Here we present an approach to determine false-positives in occurrence data using North American *Ephedra* species as a model. To standardize data cleaning, we utilized a data cleaning cycle of the data mining process CRISP–DM, and a set of different tools (e.g. spatial and analysis R packages, Analysis ToolPak of MS Excel). This cleaning environment allowed us to identify common false-positives located at e.g. botanical gardens or herbaria, duplicate records, or other anomalies (e.g. switched LON/LAT values, or insufficient accuracy of occurrence points at coastlines). The toolset was adjusted during the trials to increase data accuracy. As a 'gold standard' for species ranges and to compare aggregator data with it, we created multiple layers from valid *Ephedra* occurrence points, each layer being built from a single source (field observations, literature, Google Street View imagery). The gradual improvement of the toolset and the development of a 'gold standard' led to the removal of c. 90–95 % of false-positives in four data cycle iterations, compared to 20 iterations at the beginning of our exploration of the data. In our case study, the data cleaning process led to a more accurate representation of *Ephedra*'s geographic range. We conclude that an integrated cleaning environment, along with accurate and well-developed 'gold standards', supports fast and systematic data cleaning and helps to eliminate false positives.

Sampling biodiversity with autonomous sound recordings

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Autonomous sound recording techniques have gained considerable traction in the last decades, but the question remains whether they can replace human observation surveys to sample sonant animals. Here we show the results of several studies and projects focusing on autonomous sound recording methods. We demonstrate with a meta-analysis that bird surveys using autonomous sound recorders perform as well as surveys using point counts. We present different recorder and microphone types and also an online platform for processing soundscape recordings. We underline the previously neglected importance of sound detection spaces on acoustic sampling surveys. To address this, we propose a method for estimating bird detection distances in sound recordings and how to use them for distance sampling. We finally balance advantages and disadvantages of sound recording methods and present some of the unique possibilities offered by acoustic biodiversity sampling.

Movement ecology meets roads

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The 'landscape of fear' represents relative levels of predation risk that reflect the level of fear a prey (e.g. roe deer) experiences in different parts of its home range. For deer living in habitats with road infrastructure, the road itself should provoke such a level of fear. Deer should have to learn how to deal with the road situation in its area of use. Consequently, compared to little effective prevention and protection measures (like warning signs or reflectors), one could argue that the game animal itself – it's so called experience – is responsible for being more or less vulnerable to road kills. If this hypothesis is true, wildlife vehicle collision (WVC) mitigation measures should additionally focus on the 'hidden' component of roe deer experience. In our study (financed by the German Ministry for Transport and Digital Infrastructure), we will consider roe deer movement histories that finalize in WVCs. We are in the fortunate position to have access to accident sites of 73 GPS-collared roe deer individuals across Europe (http://eurodeer.org/) that died collared during a vehicle collision compared to data of 73 not damaged and randomly chosen control individuals (roe deer as well as red deer). We will apply a decision tree approach for deriving behavioral patterns of game species that result in WVCs or not. Thereby, attributes such as age, sex, road crossing experience of the animal during the last 30 days before the final position, the final GPS-coordinate inside of a specific kernel area (experience of the deer inside of this area) as well as additional factors such as time, site or land use are taken into account. Subsequently, we are able to compare these learned rules with the output of a second analysis integrating WVC-sites reported by the police in Bavaria in Germany from 2010 till 2017 in parallel to land use, infrastructure and traffic data. Such a comparison might reveal additional rules of animal behavior for improving BigData predictions.

A model ecosystem analyzer (TUMmesa) for a new generation of community experiments

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Anthropogenic global change is occurring with increasing intensity, affecting ecosystems and human societies at different scales. Thus, the development of experimental facilities for controlled studies on different scenarios is an important step for understanding the impacts of climate change on species and ecosystems. The model ecosystem analyser (TUM*mesa*) is a facility for studying community dynamics and ecosystem or physiological processes under strictly controlled environmental conditions. As a basis for future research, a full-scale test was conducted to evaluate the full potential and homogeneity of TUM*mesa.* We performed an experiment over 8 weeks to study effects of different water supply and light conditions on biomass production and reproduction of barley and beans within and between the eight climate chambers. We used these important crops, as previous studies reported climate change to have significant impacts on their productivity. In all chambers, we planted barley and bean in a factorial design with two factors, i.e. position (corner and center of each chamber) and water supply (low and normal). Two levels of light (natural and high intensity) were tested in two consecutive periods. Therefore, homogeneity of climatic conditions within and between chambers was tested. Although plant varieties responded differently to drought stress, no position effects were observed when comparing plant responses within and among chambers. These results confirm that the climate chambers of TUM*mesa are* homogeneous, therefore the replication of experiments across chambers should not be influenced by any chamber effect. We emphasize that TUM*mesa is* an important gain for the scientific community since it allows for controlled ecological experiments to investigate effects of climate change on plant performance and its interactions with habitat degradation, fragmentation and other species.

POSTER PRESENTATIONS

SESSION 23-P1

A cross-European evaluation of empirical mortality models in a dynamic vegetation model

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Tree mortality is one of the biggest challenges for the projection of future forest development. Since mechanistic (i.e. process-based) mortality models are still restricted to relatively small scales due to the limited understanding of complex physiological processes, empirical (i.e. statistical) mortality models derived from forest inventories are increasingly used in dynamic vegetation models (DVMs). Previous studies have shown that simulated forest dynamics critically depend on the mortality formulation, especially under climate change scenarios. The effects of various types of published empirical mortality models, however, have not been investigated comprehensively in a DVM framework. Here, we investigated the behavior of seven inventory-based mortality models for *Pinus sylvestris* across Europe within the DVM ForClim under present climate and different future climate scenarios. Our results show strongly diverging mortality patterns among the seven models for the long-term simulations. Based on their behavior, we identified two distinct groups of mortality models, which were associated with model structure, but not with geographic origin of the data. The decisive difference was whether models treated competition directly via a competition index or indirectly via a response to altered tree growth. The growth-based models yielded overall better performances when comparing long-term simulations with empirical data and were less prone to extreme behaviors under future climate change scenarios. Overall, we conclude that special attention should be payed to the structure of the mortality formulation when exploring global change impacts in a DVM framework. We suggest using growth-based mortality models rather than models relying on a competition index, particularly when simulating no-analogue conditions under a changing climate.

SESSION 23-P2

Meta-genomic monitoring of water resources with PuntSeq

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While the improvement of water quality and the monitoring of pathogenic contamination of freshwater resources have already been recognized as a UN Millennium Development Goal, the impact of climate change, increased weather perturbations and worldwide urbanization on the composition of pathogenic communities will add another level of complexity. We have developed a real-time meta-genomics pipeline for rapid and cheap assessment of the microbial community of freshwater resources. The pipeline includes all necessary steps from water sampling over DNA extraction and sequencing to downstream bioinformatics analyses. We employ the Oxford Nanopore Technologies MinION device for DNA sequencing, which has already been used for pathogen surveillance in other contexts, most famously for Ebola virus monitoring in West Africa, and allows for direct data assessment in the field due to its transportable nature. To test our meta-genomics surveillance pipeline, we founded the pilot project 'PuntSeq' to provide an in-depth resolution of the microbial landscape of our local river, the Cam. Although people obtain serious infections from the Cam's water every year, an information and research framework that targets the involved microbial culprits is still lacking. We sequenced the microbial community at ten different locations along the Cam and analysed the corresponding physical parameters. This allowed us to determine the presence of bacteria down to the genus level, assess their pathogenicity, and cross-relate the microbial community composition with environmental information. To make use of the portability of our devices, we ultimately aim to design a sequencing lab with which people around the globe can analyze the meta-genomics of their water sources *in situ*. 'PuntSeq' was founded as a citizen science project and all of our results are being made accessible through various public engagement efforts, a wide range of media and open-access publications.

SESSION 23-P3

Climatic turning point of European forest tree species

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The predicted climate change is influencing the dynamics of European forests. In order to assess climate change impacts on forests, scientifically based projections of forest development are required. The Climatic Turning Point (CTP) represents those climatic conditions that determine a dominance shift of two examined tree species (Mette et al. 2013 Ecosphere; Dološ et al. 2016 For Ecol Manag). It therefore takes into account not only the influence of climate on species, but also the relative competitive strength between two species. This method provides insight into competition dynamics and makes it possible to identify climate-induced heat and drought stress boundaries between species. To model the CTP, today's dominance patterns are related to several environmental variables. The CTP approach allows climate change projections to be made to assess future dominance patterns. In this study, empirical models were developed which estimate the influence of climate and soil variables on the relative competitiveness of several European forest tree species. Previous studies emphasize the need to cover the ecological niche of a tree species as completely as possible by using wide-ranging species information. Thus, national forest inventory data from multiple European countries were used. The project contributes to a better understanding and assessment of climate change impacts on European forests. The results identify both weak and strong competitors under current climate and climate change conditions. This information can be useful for the adaptation of European forests to climate change.

SESSION 23-P4

A common metric for ecology: a standardized phytometer to disentangle climate, soil, and species contributions across gradients

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Disentangling the many environmental factors driving primary productivity is a central goal in community ecology. Controlling for multiple of these influential factors while allowing for natural variation in others is a difficult task, particularly along biogeographic gradients. Despite these challenges, isolating drivers of primary productivity is critical in improving our understanding of vegetation dynamics in the face of global change. Recent advances in addressing this concurrence of factors include the emergence of coordinated experimental protocols and common metrics. In response to this, we developed a living reference system, or a phytometer, that can act as an integrative proxy for the multitude of drivers of plant productivity, and implemented it across a pan-European gradient to demonstrate its efficacy. The gradient of aridity occurring at the 18 sites in 11 European countries which conducted the here presented phytometer approach, was the strongest predictor of community biomass. But the relativized local soil effect was most strongly correlated to phosphor availability. Phytometers have been a recognized tool for ecologists for nearly a century, with the term first being introduced by Clements and Goldsmith in 1924. This phytometer approach can stand alone or serve as an add-on to existing studies, providing a background rate for the expected contributions of climate and soil effects separately and more effectively linking processes studied in coordinated and non-coordinated experiments alike. The strength in the here presented approach is its ability to disentangle three major drivers of productivity (soil, climate and biodiversity) by standardization of them following a standardized protocol while still offering the opportunity to incorporate add-on studies.

SESSION 24

Origin and development of steppe habitats

Chairs: Karl-Georg Bernhardt, Karin Tremetsberger

Origin and evolutionary history of the Eurasian steppe belt

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The Eurasian steppe stretches across 8,000 km from the Hungarian basin and the Danube delta in the west to the Amur basin in the east, and has some smaller exclaves in Middle Europe and northeastern Asia. The aim of the lecture is to provide an insight into origin and development of the Eurasian steppe belt based on presently available information. In this context, we will firstly go into general aspects like steppe climates and characteristics, comment on current steppe classification systems, and deal with the origin of grasses and grassland biomes in general. Proxies of relevance to steppe palaeoenvironmental reconstructions will be addressed, and we then focus on the climate/landscape history of the Eurasian steppes from their origin in the Miocene to their present status quo. Challenges as historical molecular footprints in present-day genomes, the correlation between phylogeographic studies and steppe histories, the problem of steppe refuge areas during warm and cold phases, and biogeographic dynamics of steppe taxa will be outlined.

Population genetics of *Stipa glareosa* (Poaceae) along gradients of climate and land use in Mongolia

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Grazing effects on dryland plants have been widely studied, reflecting the importance of livestock husbandry as the main land use in some the world's largest terrestrial biomes. However, there is a lack of studies on population genetics of drylands plants in general, and of those addressing grazing effects in particular. To determine if and how grazing has impact on genetic structure of dryland species, we worked in the steppes of Mongolia that represent some of the finest extant examples of temperate grasslands. We chose the keystone grass *Stipa glareosa*, and employed nine polymorphic Simple Sequence Repeat (SSR) markers for the first characterization of its genetic structure. We assessed genetic fingerprints of 200 individuals of 6 populations in Mongolia, which were sampled along a large scale-climatic gradient (100–170 mm mean annual precipitation). Nested within this gradient, subpopulations were sampled along local transects representing five different grazing intensity levels. Our study species showed rather low levels of genetic diversity within populations (mean proportion of polymorphic loci = 46.4 %, mean expected heterozygosity, He = 0.09). AMOVA analysis revealed a modest genetic differentiation between populations (9 % of variation) and among subpopulations within different grazing levels (11 %), while high differentiation was observed between individuals (80 %). This implies high gene flow (Nm = 7.0) along both small-scale grazing and large-scale climatic gradients. Principal Coordinate analysis (PCoA) also revealed a low degree of genetic differentiation among populations of different grazing condition. Instead, correlations between environmental factors and genetic diversity were strong, especially with respect to altitude and latitude. Results suggest that climatic constraints have stronger effects on genetic structures of *S. glareosa* populations, while smaller scale differences in grazing disturbance matter to a more limited extent. There is, however, no evidence for fragmentation and severe genetic depauperation in the populations of Mongolia.

Phylogeographical history and intraspecific genetic diversity in Pannonian and Western Pontic steppe grasslands

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In the last century, the area of steppe grasslands has decreased tremendously due to changing land use. The remaining patches of European dry grasslands are important refuges for many species. However, little is known about their biogeographical history and the local continuity of their species composition. Potential source areas for the (re-)colonisation of the Pannonian region from glacial refuge areas are assumed in the Western Pontic region, along the Black Sea coast and/or on southern slopes surrounding the Hungarian Plain. Therefore, we ask if characteristic steppe grassland species, representing mostly rare habitats in Central and Southeastern Europe, show varying patterns of genetic structure and diversity, i.e. a diverging response to glacial survival, postglacial expansion and/or recent decline. In a preceding classification of Pannonian *Festuco-Brometea* grasslands, characteristic species of *Brometalia erecti*, *Festucetalia valesiacae*, and *Stipo-Festucetalia pallentis* were determined based on a comprehensive set of relevés. We selected 12 character species for our cpDNA sequence analyses. Here, we compare results for *Filipendula vulgaris*, *Trifolium montanum*, *Astragalus onobrychis*, *Salvia nemorosa*, *Linum tenuifolium* and *Poa badensis*. We identified different patterns of intraspecific genetic structure and diversity throughout the Pannonian and Western Pontic region. There are species representing the Pannonian and Western Pontic steppe grasslands as distinct units, harbouring moderate to high haplotype diversity. In contrast, other species showed less genetic structuring and accordingly also overall lower intraspecific diversity. In summary, our results indicate that patterns of genetic diversity and phylogeographical history differ across dry grassland orders investigated. However, analyses of 1–2 additional species per group will reveal a more detailed picture of potential refuge areas and migration routes across the Pannonian and Western Pontic region.

More than an appendix – populations of inner-alpine steppe species are more divergent (and conservation relevant!) than anticipated

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Winter cold steppes occur mainly in the continental interior of large land masses and on the lee side of high mountain ranges. The steppes of the inner-Alpine valleys and the Eurasian steppes share many animal and plant species. The majority of them are continuously distributed from Central Asia to Eastern Europe, to the west they are restricted to a few, especially continental areas. This suggests that these disjunct steppe occurrences did not develop independently but were once associated with the Eastern European ones, thus ensuring a direct exchange of species. For a long time it was unclear whether steppe species in the alpine dry valleys are relics that were pushed back to the few remaining steppe areas by post-glacial reforestation or whether long-distance dispersal is the main reason for their fragmented area. In respect to the traditional hypotheses the following questions will be addressed: (1) What are the links between Alpine populations and other populations from Eurasia? (2) What are the implications for the conservation of steppe biota in Europe? A next-generation sequencing technique (restriction site associated DNA sequencing) and plastid DNA sequencing were used to elucidate phylogeography and migration history of six steppe species sampled from Europe and western Asia (insects and plants). In addition species distribution models were used to get information on the spatiotemporal dynamics of steppe biota since the last glacial maximum. We demonstrate that the inner-Alpine steppe biota are not a mere appendix of their Pannonian and Pontic distribution. Quite on the contrary, the inner-Alpine steppes harbored genetic lineages that were largely divergent from the eastern populations. Our findings highlight the evolutionary significance of the inner-Alpine steppe biota. We emphasize the importance to view the Alpine steppes as independent entities in future grassland conservation.

Genes documenting history: uncovering the phylogeographic patterns of *Camelina* Crantz

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Stretching 8,000 km from the Pannonian basin and the Danube delta in the west to the Manchuria region in the Far East and reaching up to a 1,000 km in width, the Eurasian steppe belt is the vastest grassland region in the world. However, despite its sheer size, little is known about the onset, development and florogenesis of the Great Steppe. Molecular markers have greatly enhanced our understanding of the history of the Eurasian steppe belt, as they have a much higher resolution and are not as biased as pollen records, macrofossils, palaeosoil studies and isotopic analyses. These molecular methods were applied widely to infer the history of some phylogeographic regions in North and South America. Nevertheless, only a handful of phylogeographical analyses of the Eurasian steppe belt have been carried out, possibly due to its vastness and overall inaccessibility – including literature, as most of it is in the Russian language and published in journals unknown to western scientific communities. As a part of our research, we carried out a multi-gene phylogenetic analysis of *Camelina* – a taxon of a high agricultural value, with its origin in the Irano-Turanian region – by using Maximum Likelihood optimisation in RAxML and Bayesian Inference approach. *Camelina* consists of eight species that are found across three different biogeographical units – the whole Eurasian steppe belt from the Pannonian basin in the east to Amur River in the west, southern areas of the Kazakh Steppe, or in cold steppes of Turkey and adjacent areas. Our study uncovered several genetically distinct intraspecific lineages that are geographically separated and inferred potential hybridisation zones and polyploidisation events. Furthermore, we carried out a time estimation analysis using Bayesian optimisation in BEAST to put the development of temperate grasslands of Eurasia into a time frame and to identify ages of intense speciation (or lack thereof) due to climate and geographical changes or stasis.

Species of the Central Asian steppe section *Rhizomatosa* of the genus *Allium* were from the beginning at evolution of steppe vegetation

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The genus *Allium* is one of the largest genus in the family of Amaryllidaceae and comprises over 1,000 species, and the number is still increasing (Govaerts et al. 2018). Based on molecular sequence data, Friesen et al. (2006) presented a new intergeneric classification system and subdivided the genus into sections. For some sections, phylogenetic position of species within the sections remained unresolved. This was also the case of sections *Caespitosoprason* N. Friesen and *Rhizomatosa* Egorova. These two sections are confined to central Asia, where they inhabit steppe habitats. We conducted phylogenetic analysis of most taxa of sections *Caespitosoprason* and *Rhizomatosa* with the nuclear marker ITS and three different chloroplast markers (*trn*Q–*rps*16, *trn*L–*trn*F and *rpl*32–*trn*L spacers). Taxonomical remarks, identification key and distribution maps for all species of section *Rhizomatosa* Egorova (including all species of section *Caespitosoprason*) are presented. A new discovery of *Allium bellulum* in the Katun Valley (Altai, Russia) is compared with the other two known localities from Tuva, Russia, and the Buchtarma Valley, Kazakhstan, and the disjunctive distribution is discussed. Divergence time estimates of the species of the section *Rhizomatosa* are in good agreement with the origin and climate/landscape history of the central Asian steppe

About the polyploid complex in genus *Allium* L. subgenus *Reticulatobulbosa*

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As one of the largest genera in the family of Amarylidaceae, *Allium* contains over 1,000 species and the number is still increasing (Govaerts et al. 2018). Based on molecular sequence data a new classification was made by Friesen et al. (2006). Within this work not all subgenera have been completely studied concerning the phylogenetic positions of all their species. One of them is the subgenus *Reticulatobulbosa* with its multiple polyploid-complexes in South Siberia (Friesen 1992). Especially *Allium strictum* s.l. with its polyploid complex in the Altai Mountains is particularly difficult to investigate whereas *Allium lineare* L. is a clear diploid. In the first approach 218 accessions of *Reticulatobulbosa* were investigated for parsimony informative characters on the two nuclear genome regions ITS (Blattner et al. 1999) and ETS and the two chloroplast genome regions *rpl*32–*trn*L$^{(UAG)}$ and rps16–trnQ (Shaw et al. 2007). The accessions were arranged based on the ploidy-levels determined by flowcytometry and ideograms. ITS and ETS trees showed a mixed grouping of ploidy-levels and species. Based on rDNA sequences two major groups named 'Lineare' and 'Strictum' were identifiable. Trees based on cpDNA marker regions resulted in numerous polytomies. Preliminary findings show evidence of a younger evolutionary process. Remarkable is that 1) all groups with mixed species and ploidy-levels in the ITS-tree have a clear area of distribution and only hexaploid individuals of *A. strictum* s.l. can be found in Europe; 2) all polyploidy levels of *A. strictum* s.l. have definable ecotypes and clear morphological characters in opposite to *A. lineare* and in contrast to previous mentioned molecular markers. ISSR fingerprints of an *Allium amphibolum* Ledeb. population (subgenus *Reticulatobulbosa*) show a correlation to ecotypes as well.

POSTER PRESENTATIONS

SESSION 24-P1

The role of ancient burial mounds in enhancing the biodiversity of Central-Asian steppes

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Ancient burial mounds (called kurgans) of the Eurasian steppes are man-made habitats that link the protection of historical heritage and biodiversity. Kurgans have the potential to harbour rich plant diversity due to their long time undisturbed status and the micro-habitats associated with their special topography. In our study we assessed whether kurgan micro-habitats (northern-, southern slope and the surrounding ditch) harbour different species pools and functional groups compared to the surrounding steppes. In addition, we studied the effects of different grazing regimes (non-grazed, moderately grazed and heavily grazed) on the vegetation of the micro-habitats. We studied altogether 9 kurgans embedded in extended steppe vegetation in northern Kazakhstan. We analysed the differences in the species composition of four habitats under three grazing regimes using Generalised Linear Mixed Models, PCA ordination and indicator species analysis. We found that due to the special habitat conditions vegetation of the micro-habitats harboured unique vegetation differing also from the vegetation of the steppes. We identified 16 steppe specialist plant speciess confined to kurgan micro-habitats, which suggest that the vegetation of the kurgans harbour a special species pool which contributes to the maintenance of the landscape scale diversity of the steppes. Lack of grazing livestock did not have a detrimental effect on the vegetation due to the harsh arid climate and due to the grazing of small mammals. Steppe vegetation was well-adapted to extensive grazing, although heavy grazing supported ruderals and a decline in steppe specialists. We found a significant interaction between grazing intensity and habitat type: heavy grazing supported ruderals and suppressed steppe specialists especially on the slopes. We highlighted that kurgans play an important role in maintaining plant diversity of the extensive Central-Asian steppes by increasing environmental heterogeneity.

SESSION 24-P2

Functional traits of a Mongolian grassland species influenced by grazing and precipitation

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The Mongolian rural economy relies mainly on animal husbandry. Forage provision is a key ecosystem service there and biomass production is generally driven by moisture availability and land-use intensity. The aim of our study was to investigate the effects and interaction of grazing and precipitation on growth performance of Mongolia's main biomass producer: *Stipa krylovii* Roshev. We focused on changes in the plant traits canopy height, plant width, specific leaf area (SLA), chlorophyll fluorescence (F_v/F_m), performance index, and individual biomass along a precipitation and grazing gradient in Mongolian rangelands. We hypothesized plant trait values to increase with increasing precipitation, but decrease with increasing grazing intensity. All measured traits showed under almost all grazing intensities a unimodal value distribution along the precipitation gradient. As expected, canopy height, plant width, and aboveground biomass decreased with increasing grazing intensity. But SLA increased, probably as defense against herbivores. Lowest stress (F_v/F_m) and highest vitality (performance index) was found under intensive grazing, which is an indication for compensatory photosynthetic growth of *Stipa krylovii.*

SESSION 24-P3

Phylogeography of plants representing the order Festucetalia valesiacae in the Pannonian and Western Pontic region

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We are basically interested in the biogeography and conservation of Central European dry grasslands, which are important habitats for many species. However, little is known about their large-scale history and the local continuity of their species composition. Although potential source areas for the (re-)colonisation of the Pannonian region are diverse, but we assume that species representing a specific vegetation type within the Pannonian *Festuco-Brometea* grasslands (more) likely share a common history. Therefore, we ask whether characteristic steppe grassland species of the Festucetalia valesiacae show varying or similar patterns of genetic structure and intraspecific diversity. Genetic variation was analysed based on cpDNA sequences (*atp*IH, *rpL*16, *rpL*32). Characteristic species of the Festucetalia valesiacae were selected based on a previously published phytosociological classification covering our study region (Willner et al. 2017 Appl Veg Sci). Here, we compare results for *Astragalus onobrychis*, *Eryngium campestre*, *Salvia nemorosa*, and *Stipa capillata*. We identified patterns of intraspecific genetic structure and diversity throughout the Pannonian and Western Pontic region. However, at the time of this abstract, we could not finally verify, if those patterns are all species-specific. Nevertheless, unexpectedly, first results obtained for *Astragalus onobrychis* do not confirm a large-scale genetic diversity gradient, with higher intraspecific diversity in the continental east (i.e. in the 'true steppes') and reduced genetic diversity in the Pannonian region. In contrast, populations from the Dobruja, the Ukraine and adjacent southeastern Russia were exclusively monomorph.

SESSION 24-P4

The Central Asian genera *Dontostemon* and *Clausia* (Brassicaceae)

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Species of *Dontostemon* Andrz. ex C. A. Mey. and *Clausia* Korn.Tr. are characteristic Eurasian steppe elements. The genus *Dontostemon* comprises twelve species. It is a Central and East Asian genus distributed primarily in Mongolia, Russia and China; they prevail arid regions, mainly in steppe, desert and mountain habitats. Some prefer alkaline soils. The five species of the genus *Clausia* occur in Russia including the European part of it, in N Kazakhstan, Mongolia, and China. The two genera are the only genera in tribe Dontostemoneae. Ploidy levels are shown by flow cytometry data and chromosome counts. To elucidate phylogeny and evolutionary and biogeographic history of the species, we sequenced the nuclear ribosomal ITS and chloroplast *trn*L–F regions. Phylogenetic analyses revealed the close relationship of *Dontostemon* and *Clausia*, and a lack of significant resolution of deeper nodes. Divergence times were estimated using BEAST, relying on published ITS substitution rates. Ancestral areas were reconstructed using LAGRANGE. Comparison of distribution areas with phylogenetic trees and divergence time estimates (using BEAST), and interpretation of the results against the history of the Eurasian steppe belt, showed that diversification in the developing steppe habitats was the main driving force in the evolutionary history of *Dontostemon* and *Clausia*. Origin of the two genera is Asia, with *Clausia* later extending its range to Eastern Europe. Three radiation periods are obvious: Origin and onset of diversification began in the lower and middle Miocene; main radiation at the end of the Miocene/lower Pliocene, and a young radiation during the Quaternary.

SESSION 24-P5

Phylogenetic analysis of the steppe plant *Kraschenínnikovia ceratoides*

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Krascheninnikovia ceratoides (L.) Gueldenst. (Chenopodiaceae) is a steppe plant with two subspecies, *Krascheninnikovia ceratoides* subsp. *ceratoides*, which is widespread in the Eurasian steppe, and *K. ceratoides* subsp. *lanata*, which is present in North America. *Krascheninnikovia is* a species characteristic for in the Eurasian steppe and can also be found in enclaves in Austria (on loess) and Spain (on soils rich in gypsum and nitrogen). To understand the history and development of the Eurasian steppe, we investigated differences on DNA level, which can reflect the phylogeographical history. Therefore, we sequenced several loci like ITS and ETS. First results indicate that the species could have spread from Central Asia – for one thing to the west, to Spain, and for another to the east, to North America. In Central Asia several lineages exist, which could be connected to differentiation in glacial refugia and secondary contact. Of the two main linages one consists primarily of diploid individuals, while the other consists primarily of tetraploid individuals. The fossil-calibrated gene-trees can also be used to estimate the age of the species. It is probably several million years old and may have existed during the Pleistocene glacial age (Günz, Mündel, Riß, Würm). Furthermore, we identified the level of ploidy of the individuals. While in the literature diploid, triploid, tetraploid and hexaploidy individuals have been reported, we were only able to find diploid and tetraploid individuals. The diploids were found in the USA, Kazakhstan and Mongolia. The tetraploids were located in the west of Mongolia.

SESSION 24-P6

How to withstand Pleistocene climatic changes in the steppe? A case study in *Hypochaeris incana*

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Besides changes in temperature, the Pleistocene climatic oscillations also brought about changes in local water supplies, thereby profoundly influencing plant growth. It is assumed that the northern part of the Patagonian steppe in South America was colder, but at the same time more humid than today during the glacial periods. In the interglacials, the Patagonian vegetation had to adjust to warmer, but drier conditions. We studied changes in growth associated with polyploidy in the Patagonian and Subantarctic plant *Hypochaeris incana* (Asteraceae), a self-incompatible perennial herb with leaves arranged in a rosette. The species has a wide distribution from the southern tip of the South American continent to the northern Patagonian steppe area and occurs in two cytotypes. It is mainly diploid in the south and mainly tetraploid in the north. In a mixed ploidy population in the northern Patagonian area, we investigated vegetative and reproductive growth parameters and established clone sizes with microsatellites. We then assessed how these parameters are associated with the ploidy of the plants and their direct environment. Our results suggest that the tetraploids may be better suited to cope with the dry conditions of today's steppe, despite the fact that the diploids did better with respect to some parameters of growth and reproduction (e.g., number of rosettes, number of heads, fruit set). The tetraploids, however, were superior particularly in two features: First, they had more living heads than the diploids at the end of the summer in the two years of observation. Second, the tetraploids have the ability to form large clones via underground stolons, with genets more than 90 m distant, a feature not encountered in the diploids. These features seem to favour the tetraploids over the diploids, as a previous phylogeographic study suggested that the diploids have repeatedly been supplanted by their tetraploid descendants in the northern Patagonian region.

SESSION 25

Physiological plant ecology in a complex changing world

Chairs: Maaike Bader, Ansgar Kahmen, Arthur Geßler

Above- and belowground processes shaping tree resilience to drought

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Drought is a major environmental threat to plants, causing severe limitations at different scales of plant organization and function. The ability to resist the drought impact and recover after drought release determines the overall response of plants to this environmental threat, which is fundamental to the recent concept of plant and ecosystem resilience. While past studies provide a large body of information on drought-induced limitations of plant growth and function, little is known about processes counteracting these limitations during drought and after drought release. Using a set of lab and model ecosystem experiments, in combination with molecular and eco-physiological approaches, we studied the above- and belowground responses of young beech, oak and poplar trees to cycles of soil water shortage and rewetting or to osmotically imposed steady-state drought. In these experiments, we show not only the well-known limitations which trees experience under drought conditions, but also the mechanisms that trees may activate in roots and leaves to minimize the adverse effect of drought on plant water relations and molecular function and compensate for the loss of photosynthetic carbon gain. The obtained response patterns also suggest a close coupling of root and leaf function after drought release, in that increasing root metabolic activity triggers the subsequent recovery and stimulation of photosynthetic activity in leaf organs. From this observation, we propose that the maintenance and recovery of root function play a key role in tree resilience to drought.

Partial mycoheterotrophy in orchids

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Interspecific mutualisms are some of the most important and widely studied species interactions in ecology and due to their abundance, mycorrhizae qualify as their classical and prime example: The absolute majority of vascular land plants engage in mycorrhizae where soil fungi and plant roots participate in a bidirectional exchange of mineral soil nutrients and water for carbohydrates fixed from atmospheric CO_2 through photosynthesis. Fully mycoheterotrophic (FMH) plants lack chlorophyll but have the ability to obtain carbon from fungi and thereby reverse the usual direction of plant-to-fungus carbon flow in mycorrhizae. Initially mycoheterotrophic (IMH) plants rely on carbohydrates supplied by fungi for successful germination and seedling establishment but then become (putatively) autotrophic as mature plants. Partially mycoheterotrophic (PMH) plants may be predisposed to an exploitation of their mycorrhizal fungi also at adulthood due to their first, IMH ontogenetic stages. Stable isotope natural abundances ($\delta^{13}C$, $\delta^{15}N$ and $\delta^{2}H$) together with N concentrations complemented by the molecular identification of mycorrhizal fungi are the state-of-the-art tools to differentiate PMH and FMH from autotrophic plants. Mycoheterotrophic strategies have been detected in several plant families however they are very abundant in the orchid family. Here, we focus on four main objectives contributing to the general understanding of the complex ecology of the trophic mode of partial mycoheterotrophy in the Orchidaceae: (1) The drivers of isotopic enrichment in the orchid genus *Epipactis*, (2) the presence of PMH species in meadow orchids associated with rhizoctonia fungi, (3) the percentage of organic matter gain in rhizoctonia-associated orchids using an improved methodological approach and (4) the light-dependency of partial mycoheterotrophy in rhizoctonia-associated orchids.

Aquatic micro-ecosystems and their use in investigating a complex world

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Ecosystems are subject to dramatic changes, both natural and increasingly, man-made. The full consequences of these changes for the diversity, stability and functioning of ecosystems are difficult to predict, especially because ecosystems are complex, contain a multitude of interactions and provide multiple functions that can hardly be investigated simultaneously. Here, we present small natural ecosystems which can be used as observational and experimental model systems to study the effect of environmental change on entire communities and the functions they provide. These aquatic micro-ecosystems form in tree holes and bromeliad plants, but also in man-made structures such as flower pots and graveyard vases. Protozoan and arthropod communities colonize the habitats, sometimes comprising rare specialists or potentially disease-carrying mosquitoes. We show here that these aquatic micro-ecosystems can be used to study effects of environmental change on entire communities for example by transplanting them along natural environmental gradients such as mountain slopes. We have furthermore found that such systems may detect anthropogenic changes such as altering forest management or urbanization intensity. In addition, artificial analogues of aquatic micro-ecosystems have proven useful as simple experimental systems providing similar evidence of environmental change as their natural counterparts. We conclude that aquatic micro-ecosystems are both, interesting and important habitats in themselves (especially in managed forests and cities) and useful model systems for studying effects of changing environmental conditions on entire communities. They could furthermore be used as relatively simple indicator systems of anthropogenic change in a complex world.

Carbon starvation of epiphytic orchids from tropical cloud forests at warm temperatures

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Because of the annually stable climate at tropical cloud forests, plants that are specialized to this ecosystem are often very sensitive to climate change. Especially, epiphytic orchids are considered to be extremely sensitive to the anticipated future rise in temperature. Within two experiments, we investigated the consequences of increasing temperatures on the CO_2 gas-exchange and the carbon reserve household in different species of the two orchid genera *Masdevallia* and *Dracula*. 10 different species from each genera, were subjected to three different temperature treatments in phytotrons: i) a constant temperature treatment, ii) a slow temperature ramp (+0.75 °C every 14 days), and iii) a fast temperature ramp (+1.5 °C every 14 days). Plant status, leaf gas-exchange was and non-structural carbohydrates (NSC) concentrations were analyzed regularly throughout the experiment. In all investigated species, net-photosynthesis declined strongly at daytime temperatures above 29 °C, and became negative at daytime temperatures between 32 and 34 °C. Because leaf respiration increased only moderately in this temperature range, the observed fast decrease of net-gas exchange was likely caused by a decline of the photosynthetic reaction. Closer analyses of light-response and A/Ci curves of photosynthesis suggested a malfunctioning of the photosynthetic dark reaction. The decline of photosynthesis was accompanied by a fast depletion of leaf starch reserves and plant death, giving strong experimental evidence for carbon starvation. Such an extreme sensitivity against warm temperatures is surprising, but new in situ measurements at the natural habitat of these orchids confirmed the extremely constant temperatures throughout the year, with maximum temperature peaks well below 30 °C. The exceptionally high vulnerability of the photosynthetic apparatus of *Masdevallia* and *Dracula* orchids already at mild heat stress confirms that these epiphytes will be highly endangered by climate warming.

Taller individuals of *Senegalia mellifera*, an encroacher shrub in African savannas, show better physiological adaptions towards drought stress

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Semiarid savanna systems are being rapidly transformed worldwide by woody plant encroachment, especially in southern Africa. Regardless of the drivers behind woody plant expansion, this transition is related to a disturbed balance between coexisting trees and grasses. Currently less evident is the importance of individual variation of these trees (and the intraspecific trait variability therein) for the dynamics of the savanna plant community, especially under increasing water limited conditions of climate change. Due to climatic conditions and climate change, precipitation occurs seasonal and highly variable in the study area, it is critical to understand how encroacher species endure periods of severe water stress. Intraspecific variation in tree mortality due to drought stress, depending on the size of an individual, is of particular relevance here. The physiological drought adaption of *Senegalia mellifera*, an encroacher shrub in Southern Africa, was examined by measuring and assessing plant functional traits (turgor loss point (π_{tlp}), relative water content at turgor loss (RWC_{tlp}), apoplastic fraction (a_f) and specific leaf area (SLA)), via the pressure-volume approach. In addition, the carbon nitrogen ratio (C/N) was compared between leaves and branches, as well as put in relation with the SLA. 84 individuals of different sizes were sampled. All functional traits showed a linear response towards the size of the individuals. Taller individuals had lower π_{tlp} and SLAs, while the RWC_{tlp} and af increased with size. Individuals with lower π_{tlp} are able to endure desiccation of soils for a longer time, since they are able to extract water even from very dry soils. Additionally, the π_{tlp} was lowered and the RWC_{tlp} increased, with increasing time after the last rainfall, which suggests a direct adaptive response, of traits regarding drought tolerance, towards the amount of water in the soil. Therefore, taller individuals are better adapted towards drought stress.

POSTER PRESENTATIONS

SESSION 25-P1

Determination of drying and rewetting cycles of moss-dominated biocrusts using a novel biocrust wetness probe

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On the upper few millimetres of soil surfaces, stress tolerant cyanobacteria, green algae, mosses and soil lichens form biological soil crusts. As rootless poikilohydric organisms, the photosynthetic activity of biocrusts strongly depends on moisture supply from dewfall, fog and/or rainfall. Differences in microclimatic conditions and water holding capacity of biocrusts, and, at least partly, in chemical properties of soils can explain the formation of spatial patterns of different biocrust types. The duration of soil surface wetness is most important for the physiological activity of biocrusts, and for the formation of different types of biocrusts on the landscape level. A novel biocrust wetness probe (BWP) allows in situ measurements of the water content of biocrusts or the uppermost soil region, assessed by means of electrical conductivity measurements with two 5 mm copper alloy pins serving as electrodes. We measured the changes of biocrust wetness within moss patches compared to the microclimatic conditions at the site in a post-mining area and on tree stems. Furthermore, a calibration equipment was developed to relate BWP raw data (in mV) to water amounts in the top soil. As low-cost sensors BWPs are well suited for the continuous monitoring of spatio-temporal water contents of biocrusts and cryptogams. Linking the measured biocrust wetness with ecophysiology measurements and microclimate will allow more detailed modelling of biocrust activity under field conditions.

SESSION 26

Plant populations facing environmental change

Chairs: Niek Scheepens, Christian Lampei

An ecological and genomic study of phenotypic responses to climate change in the widely distributed species *Silene vulgaris*

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Understanding species' ability to cope with climatic changes is crucial when predicting the future performance of ecosystems. However, detailed information about plant adaptation and its genetic basis remains scarce. For an assessment of plant adaptation to climate change we employed the model organism *Silene vulgaris* and examined its phenotypic traits. Seeds were collected from 25 European populations and grown in a greenhouse mimicking a possible climate change scenario: with two temperature (18 °C, 21 °C) and three precipitation (36 mL, 40 mL, 46 mL) regimes. ddRAD sequencing was used as a genomic approach examining the genetic variation of populations. Phenotypic traits showed ample variation among populations and responded strongly to the applied treatments. Temperature mostly affected flowering time and biomass-related traits, whereas water regimes did not influence flowering time at all. Although populations differed significantly in their traits, their treatment response was not significantly different. ddRAD sequencing revealed two major genetic groups within the European populations. One group consisted of South and West European populations, whereas the other group included central and North European populations. Although genetically distinct, the two groups did not show different responses to the experimental treatments. Our results suggest that *S. vulgaris* has the potential to meet changing climatic conditions through phenotypic plasticity regardless of its genetic background. For a realistic assessment of climate change impacts on ecosystems widely-distributed species should thus be frequently included in further research studies.

Inter- and intraspecific variation in response to nutrient fluctuations in annual plants

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Driven by global environmental change and land use change, plants may experience temporal fluctuations of soil resource availability. Previous experimental studies found that species and populations within species may differ in their response to environmental variability, yet so far no study has tried to bring these two aspects together to look at both inter- and intraspecific variation in responses to fluctuating nutrient supply. We carried out a greenhouse experiment to look at the effect of nutrient fluctuation which included changes in overall nutrient mean and variability and a competition treatment. We used 11 common annual species with seed material from different origins to test for both species differentiation and intraspecific variation**.** Our results showed both inter- and intraspecific variation in response to nutrient variability treatments. In response of aboveground biomass, four species favored high variability, one favored low variability, and six responded neutrally. Within four species nutrient variability induced significant origin variations. The general positive effect of nutrient variability on aboveground biomass across species was modulated by nutrient mean and competition. Our study suggests that nutrient variability may drive species turnover and population shifts in grassland communities**.**

Leaf traits track adaptation of vascular plants to climate along a 1,200 km latitudinal gradient in Western Siberia

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In order to follow their climatic niche in a changing climate, many species migrate northwards. However, this requires adaptation to climate-independent factors that change with latitude. Our knowledge about the relative importance of these environmental factors along potential migration routes is still poor. Here we present results from a comprehensive survey of ecophysiological leaf traits of 350 plant samples from 19 sites of zonal vegetation across a 1,200 km latitudinal transect along the Ural Mountains in Western Siberia. We observed a strong decline in leaf $\delta^{13}C$ with latitude, indicating that southern plants had to cope drought stress and had higher intrinsic water use efficiency (WUE). This effect was observed within and across species. Also leaf mass per area (LMA), Chlorophyll and Carotenoid content decreased simultaneously. Together these results indicate considerable shifts in ecophysiological leaf traits along the latitudinal gradient in Central Eurasia under scenarios of future climate change that will require a high degree of plasticity or adaptation in plants to track their climatic niche.

Migration lags during climate change driven range shifts can accelerate population spread

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Climate change is redistributing biodiversity worldwide. The ability of species to shift their ranges fast enough to track their moving climatic niches is crucial for their persistence. Range expansions are driven by population spread, which depends on both species' fecundity and dispersal capacity. Climate change causes species to shift their ranges *along* climatic gradients (namely latitudinal and elevational gradients), along which fecundity is not constant but follows a hump-shaped or other non-linear functions. However, most theoretical studies of population spread have assumed spatially homogenous fecundity across the landscape, which limits their value for understanding to climate-change driven range shifts. Accounting for the heterogeneous spatial structure of fecundity along climate gradients has interesting implications for population spread that have not been fully considered so far. We built a mathematical model of an annual plant population spreading along a temperature gradient in response to warming. In our model, *per capita* fecundity in the absence of competition is a Gaussian function of temperature (assuming no local adaptation to climate). We use computer simulations to show that, when climate velocity exceeds initial spread velocity, populations at the range limit become increasingly closer their climatic niche core. This results in a fecundity boost at the range limit and a consequent acceleration of spread that can enable some species to ultimately track their shifting climate. We also show that the interaction between the magnitude of inter-annual climatic variability and dispersal capacity determine the life history strategy that maximizes spread velocity and the probability of population persistence. These findings can help improve our understanding of how life history and landscape characteristics mediate range dynamics under climate change.

POSTER PRESENTATIONS

SESSION 26-P1

The role of seed bank in habitat restoration in a changing climate

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Seed bank has a crucial role in the conservation of plant communities under unfavourable conditions. Climate change will affect directly or indirectly soil seed banks worldwide, but our knowledge about its effect on soil seed bank is scarce. Our aim was to evaluate the effect of climate change on the soil seed bank and its potential to buffer climatic changes. For this we performed a literature research in the ISI Web of Science and found 4 papers which evaluated the direct effects of climate change, i.e. temperature increase and precipitation change, on the soil seed bank. The direct effect of climate change will also change disturbance regimes, i.e. fire, drought and flooding frequency, severity and timing, so we reviewed 38 papers which studied this indirect effect of climate change on the soil seed bank. According to the reviewed studies persistent seed bank can support passive restoration in wetlands and frequently disturbed habitats. In case of stable, less disturbed habitats the soil seed bank is not enough to support passive restoration because its transient characteristics and therefore, active restoration activities are needed. Climate change has to be considered in the planning of future restoration projects and we suggest the use of native species that can tolerate forecasted changes.

SESSION 26-P2

Between light and litter – seed germination and early establishment of the subdominant wetland plant *Valeriana dioica*

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Valeriana dioica is a subdominant species of wet meadows, nowadays dependent on regular suppression of the main competitors (in form of moderate land use). It is endangered in many parts of Central Europe, incl. lower Austria. Although it is a perennial herb building short stolons, generative reproduction is essential for its population. Germination and early establishment of seedlings is expected to be most crucial limiting the successful colonisation of appropriate sites. We studied the effects of light, temperature and stratification on germination success of *Valeriana* seeds and the effect of litter of different competitors (small sedges, forbs and reed) on early establishment of seedlings. We compared several populations of maternal plants differing in vegetation composition and density (light availability) of the growing site. Our findings show, that *Valeriana dioica* is able to germinate without light. Under high summer temperatures it shows a high germination rate independent of cold stratification. At low temperatures, the germination rate was significantly higher only after stratification (conditions expected in spring). Litter produced by dicotyledonous forbs is at same layer thickness less hampering for the seedlings, than litter of small sedges or grasses. Seeds produced by populations under shading show a lower germination rate, than these of populations under good light conditions. However, our hypothesis that light stress of maternal plants would change the seed morphology (e.g. producing light weighted seeds with long plumes to increase the chance of long-distance dispersal) could not be confirmed. *Valeriana dioica* is more strongly limited by litter layer than by light competition of the maternal plants. Our findings confirm the observation, that it builds more dense and vital populations at forb-dominated wet meadows than at small-sedge reeds although the shading by tall forbs (e.g. *Filipendula ulmaria*) is much stronger than by small sedges.

SESSION 26-P3

Rapid evolution in novel environment: a multispecies approach

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In the course of climate change, it is becoming increasingly important to understand rapid evolution that allows organisms to adapt to new environment. This is especially valid in plants, since their ability to migrate is mostly limited to seed dispersal. Here we study rapid evolution across many plant species. As a model system, we use propagation of wild plant for restoration purposes. 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. After the transfer from natural populations to on-farm propagation, plants face novel environment with new selection pressures. For instance, intraspecific competition replaces interspecific competition, resource stress is not as severe and heterogeneous as in nature due to fertilization and watering, there is usually pest control, and fitness is ultimately determined by the number of seeds at the time of harvest, rather than across the entire life cycle as in the wild. These conditions might lead to plant adaptation within few generations. Commercial cultivation of native plants for seed production thus represents an unintended real-time evolutionary experiment. We use the seeds of generations F0 to F4 to grow plants of these different generations side-by-side in a common garden. As these plants will all experience the same environmental conditions, this will allow us to compare heritable phenotypes, and thus to infer evolutionary changes that may have taken place across generations.

SESSION 26-P4

Repeating historic vegetation and soil surveys to understand the role of anthropogenic nitrogen deposition on vegetation change

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In contrast to other biomes, research on vegetation change in Central Europe suggests that anthropogenic nitrogen (N) deposition is the most influential driver of this process. Since the second half of the 20th century, N emissions from agriculture and use of fossil fuels increased seven- to nine-fold worldwide, and disproportionally in Europe and North America. These emissions have the potential to strongly modify the terrestrial N cycle, as they result in substantial increases in the amount of biologically reactive N in natural environments. In Germany, about 75 % of the endangered plant species are confined to N–poor soils, facing the risk of competitive exclusion by plants better able to utilize high N amounts. However, specific limits, until which ecosystems are resilient to anthropogenic N deposition, i.e. critical loads remain to be determined. Here, we focus on near-natural forest ecosystems in the German federal state of Thuringia. We make use of historic paired vegetation and soil surveys dating from 1950 to 1965. These are used as reference conditions before the onset of high anthropogenic N deposition due to industrial recovery and agricultural intensification after this period. By resurveying a large number of historic plots, we expect to understand the influence of anthropogenic N deposition and other environmental factors on single species, but also on vegetation composition as a whole. This is crucial for the conservation of biodiversity and the prediction of future changes in vegetation composition and ecosystem functioning.

SESSION 26-P5

The petaloid geophytes of Aydın (West Anatolia) including remarks on their ecological preferences

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This study was carried out to determine the petaloid geophytes of Aydın (West Anatolia) which is one of the major cities in the Aegean region of Turkey. As a results of the field work and herbarium studies conducted in different herbaria of Turkey, as well as the literature studies a total of 174 taxa belonging to the 52 genera and 10 families were determined in Aydın province. Among 174 taxa, seven are endemics (4 %) while *Ornithogalum exaratum* is new for Turkey and eleven taxa new for Aydın. The required confirmations were made on the presence of *Narcissus serotinus* and *Tulipa clusiana* in Turkey. Our results also indicated that six exotic taxa collected from the research area during this study have not been listed in the last plant check-list of Turkey. According to our results 12 commonly cultivated exotic petaloid geophytes are present in Aydın whereas 12 native petaloid geophytes are cultivated and selling in neighborhood markets. The floristic analysis of the research area showed that Orchidaceae (14 genera, 57 taxa) and Asparagaceae (11 genera, 32 taxa) are the two families having the largest number of petaloid genera and species. As far as the number of taxa within the genus are considered *Ophrys* (22 taxa) and *Orchis* (19 taxa) are the two genera having the largest number of taxa. Within the vegetation types maquis and forests are the two vegetation types having the largest number of petaloid taxa, respectively. The chorotype analysis of the floristic list showed that 86 taxa (54.08 %) are Mediterranean or East Mediterranean, 6 taxa (3.77 %) are Euro–Siberian, 5 taxa (3.14 %) are Irano–Turanian or Irano–Anatolian, 46 taxa (28.91 %) are biregionals and 16 taxa (10.06 %) are pluriregional and wide-range chorotypes. Among the 174 petaloid geophytes of Aydın, 24 are threatened. The threat categories of these taxa as follow: LC (13 taxa), VU (2 taxa), EN (2 taxa), NT (1 taxon), NE (1 taxon) and CR (1 taxon). Among the 164 native petaloid geophyte species of Aydın, 70 species (42.68 %) are bulbous, 48 species (29.26 %) are tuberose, 24 species (14.63 %) rhizomatous and 22 species are (13.41 %) cormose. The ninety percent of petaloid geophytes flowers in spring, whereas the rest in autumn. Among the 164 petaloid geophyt species that naturally occur in research area, 45 species grow only on limestone, 44 species grow only on metamorphic rocks and 75 species grow on both geological substrates.

SESSION 27

Plant, animal and habitat diversity in farmland: monitoring and strategies for conservation

Chairs: Kathrin Pascher, Stefan Schindler, Thomas Wrbka

First results for science, policy and farmers from the Swiss farmland biodiversity monitoring programme ALL-EMA

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ALL-EMA is the program for monitoring biodiversity in the farmland of Switzerland. The main objectives are: (1) to know the dynamics of species and habitat diversity in farmland; (2) to evaluate the contribution of ecological focus areas (EFA) to farmland biodiversity and (3) to combine the data with additional information to identify levers for improving the efficiency of agroecological policies. In ALL-EMA, 170 1 x 1 km landscape units distributed across Switzerland are sampled within five years and will be re-visited to measure change over time. Habitats are recorded in plots on a regular grid. Vegetation plots are sampled on 10 percent of the habitat plots with a focus on the habitats of interest. A second series of vegetation plots is dedicated to EFA. We present three preliminary results for science, policy and practice: (1) A national land use intensity model map based on habitat mapping; (2) Target species richness of EFA compared to the surrounding farmland; (3) 'EFA meadows lose species under the EFA management' – can this statement from farmers be understood by investigating vegetation types of EFA? The land use intensity model showed the significant influence of topography and remote sensing variables. We will further test the model for its use in application or policy. The comparison of EFA with the surrounding agricultural area showed that EFA host more target species than the surrounding area. The species loss observed by farmers on meadows managed as EFA (no fertilizer and late cut) probably occurs on vegetation types that correspond to medium intensity meadows on fertile soils and standard fertilization. Despite permanent grasslands, these stands will hardly evolve towards species rich grasslands simply under late cut and without fertilization. Instead, farmers should obtain guidance on how to promote biodiversity best under the current measures. Based on these preliminary results, ALL-EMA will obviously be able to deliver information for science, policy and farmers.

Progress towards a national farmland biodiversity monitoring in Germany

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Given that around 50 % of landcover in Germany are under agricultural use, existing biodiversity monitoring programmes with a focus on nature conservation issues, such as the monitoring of common breeding birds and the high nature value baseline-indicator, do generate data from agricultural landscapes or fields. Those data are undoubtedly valuable but they cannot be counted towards a specific farmland biodiversity monitoring because the data are of little use for informing about failure or success of agri-environmental policy at the national or EU level. What is urgently needed still is the implementation of a national biodiversity monitoring scheme specifically designed for informing policy about the trends of biodiversity change in agriculture but also about the cause of change and the development of the pressures driving the change. One of the first and important steps towards the implementation of a specific farmland biodiversity monitoring scheme is a nationwide characterization of the farmland types existing in Germany and an agreement on the goals of biodiversity conservation specific for each of the farmland types. Those goals would have to account for the multifunctionality or multiple ecosystem services that are provided by the respective farmland types. Trade-offs between targets of biodiversity conservation and harnessing of ecosystem services need to be negotiated among stakeholders for identifying the indicators most appropriate for the goals of the respective farmland types. The current debate about the causes and impacts of the loss of insect biomass in Germany has opened widely a political window, providing the chance for establishing a farmland biodiversity monitoring which includes approaches looking into the causal relationships between development of farming systems and biodiversity associated to farmland habitats. This paper will review the progress made towards the establishment of such a monitoring scheme.

Regionally differentiated responses of farmland birds to levels of agricultural intensity

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Birds are among the best monitored groups of wildlife in Europe and most frequently used as indicators of farmland biodiversity. Intensification of agricultural practices has caused a severe decline in farmland birds over the past decades. Recently the loss of insect biomass has dominated the narrative, and this loss should have a direct impact on those birds depending on insects for reproduction. While data on insect abundance are lacking, we use percentage cover of crops (winter grains, oil seeds, maize and root crops) characterised by intensive cultivation practices (large fields, narrow crop rotations and high pesticide applications) as proxy for a likely lack of insects. We hypothesise differences in bird population trends between species depending on insects for their reproduction (N = 14) and those that are entirely herbivorous (N = 2) or raptors (N = 2). Moreover we test for differences between regions characterised by different levels of agricultural intensity; intensity of livestock husbandry and arable land. Monitoring data from the Common Breeding Bird Survey in Lower Saxony (Germany) were used, covering 205 monitoring sites (1 km^2). For spatially and temporally explicit data on intensive crops; data from the European Integrated Administration and Control System (IACS) were employed. Generalized mixed models were applied to test for differences in trends between bird groups, relations to intensive crops and regions between 2005 and 2015. Numbers of breeding birds relying on insects for reproduction showed a significant decline whereas herbivorous birds and raptors were stable over the 11 years. In the regions dominated by a high proportion of maize among the intensive crops the negative impact was most prevalent on insect feeding birds. In contrast in the least intensive regions maize even had a beneficial impact. In order to induce a trend reversal, measures should be taken, that account for both bird and insect habitat requirements.

Landscape composition, configuration, and trophic interactions shape arthropod communities

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Increasing landscape heterogeneity of agroecosystems can enhance natural enemy populations and promote biological control. However, little is known about the effects of landscape heterogeneity on arthropod communities in rice agroecosystems, especially in combination with trophic interactions, at different spatial scales. We examined for the first time how landscape heterogeneity, measured by four independent metrics of landscape composition and configuration at three spatial scales, affected species abundance and species richness within four functional groups, and the abundance of the most common species at 28 sites in the Philippines. Additionally, we examined the influence of trophic interactions among these functional groups. We found that both the compositional and configurational landscape heterogeneity in combination with trophic interactions determine the rice-arthropod communities. Herbivore abundance decreased with increasing landscape diversity. The abundance of parasitoids and species richness of both parasitoids and predators increased with the structural connectivity of rice bunds. Fragmentation of the rice landscape had a negative effect on arthropod communities except for highly mobile predatory arthropods. Abundance of common predators and detritivore species decreased with shape complexity of rice patches. Trophic interactions, measured as the abundance of prey (herbivores and detritivores), outweighed the importance of landscape heterogeneity for predators. In contrast, parasitoids responded positively to configurational landscape heterogeneity but were unaffected by prey abundance. Our results show that landscape heterogeneity and trophic interactions had different effects on different functional groups. While predator abundance was solely driven by the availability of prey, all other functional groups in the rice-arthropod community were significantly affected by the composition and configuration of surrounding landscape features. Landscape management to improve biodiversity and biological pest control in rice agroecosystems should promote a diversity of land uses and habitat types within 100–300 m radii to reduce the presence of pests. Additionally, maintaining smaller rice patches and the structural connectivity of rice bunds can benefit the natural enemies of pests in rice. Future research should focus on the temporal and spatial manipulation of rice fields to maximize the effects of biological control.

Drivers for farmland biodiversity change in Austria: analyses of two data-sets of BINATS I and II

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Alterations of environmental conditions due to land use, change of habitat types, habitat quality and patch sizes, fragmentation, and climate change are proposed to be the main drivers for loss of plant and animal species diversity and abundance in farmland. In the Austrian biodiversity monitoring program BINATS II (BIodiversity-NATure-Safety) we survey habitats, vascular plants, grasshoppers and butterflies in 100 test areas (625 x 625 m) at 1,000 test circles (r = 20 m). Comparing these data with the BINATS I data set of the four indicators – sampled ten years ago for the first time – we aim to identify the impact of these drivers on farmland biodiversity. In BINATS I, we identified correlations of species richness of vascular plants, butterflies and grasshoppers with habitat diversity, landscape patch shape complexity as well as proportion of grassland habitats. Contrastingly, all three taxa showed a negative correlation with the proportion of cultivated land. Concerning climatic gradients an unexpected correlation of plant species richness with decreasing mean annual temperatures was detected. Land use intensity increased with favourable climatic conditions, hence, compensating potential positive effects of climate on biodiversity. However, this trend was not visible concerning grasshoppers and butterflies. Decadal change of farmland biodiversity will be calculated subsequent to the survey of BINATS II finished in autumn 2018. Based on first observations, we assume that land use intensification (pesticides, cultivation of only a couple of crops), disappearance or contraction of field margins as well as habitat destruction cause diversity loss of plants and insects which again provokes cascading effects on food webs.

Austrian farmland biodiversity monitoring – 'ÖBM Kulturlandschaft': combining remote sensing and field surveys

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The Austrian biodiversity monitoring ÖBM-Kulturlandschaft has a focus on habitat and species diversity in Austrian cultural landscapes (including alpine pastures). The stratified random selection of the sampling sites is based on the 1 km^2 grid of Statistics Austria with a minimum of 50 % of agricultural area. 100 nested sampling plots are arranged hierarchically (i) remote sensing based landscape survey: 3 x 3 km^2–landscape plots, (ii) habitat mapping: 625 x 625 m^2 test areas; and (iii) organismic surveys in test areas: 10 test circles (r = 20 m) for vascular plants, grasshoppers and butterflies. The survey is conducted during two years with mapping 50 test areas each. The repetition of surveys should take place every three to five years. Survey methods for organismic groups are closely aligned with those applied in the monitoring project Biodiversity-Nature-Safety (BINATS, Pascher et al. 2011 Env Sci Eur) that focusses on maize and oilseed rape cultivation areas. The recording of habitat types is based on the Red Lists published by the Environment Agency Austria. Remote sensing data will imply phenological characterizations of the habitat types and detection of changes in ecosystem functions (e.g. NDVI) and ecosystem structure (e.g. land cover). The baseline survey is conducted in the years 2017/18. Preliminary results from 2017 are that 69 species of grasshoppers, 103 species of butterflies, and 1,299 taxa of vascular plants were detected. Average species richness was 10.6 ± 4.6 for grasshoppers and 10.5 ± 4.7 for butterflies per test area, and 3.9 ± 2.9 for grasshoppers and 2.8 ± 2.2 for butterflies per test circles.

SESSION 28

Pollinator ecology

Chairs: Bärbel Pachinger, Sophie Kratschmer, Dominique Zimmermann

Landscape change impacts on the diversity of pollinators in Uruguay

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Worldwide dramatic land-use changes affect human-insect relationship, pollinators' diversity and reduce the provision of pollination services in agricultural productive landscapes with harsh consequences for human food supply. Managed honeybee hives are often the only solution for farmers to ensure crop pollination. As an example Uruguayan landscapes are currently subjected to expanding afforestation and intensive agriculture, especially soy plantations for the globalized market. Studies on related impacts on insect health and their pollinating services are lacking. We assess impacts of land-use changes on insect pollinator abundance and diversity. We determine interacting pressures on pollinators and underlying processes and mechanisms on landscape scale in order to develop pollinator friendly land-use approaches for a multifunctional, biodiverse and sustainable productive rural landscape. We integrate pollinator specific parameters and evaluation approaches into the existing RuralFutures long term monitoring network and apply standardized data acquisition methods to systematically record data in different land-use types across Uruguay. We generated a database of all appearing Hymenoptera species and present their geographical distribution. Secondly, we established a correlation analysis to measure the association between appearance of these species and the ground flora within the selected monitoring plots, focusing on a comparison between modified and natural habitats. This relation is being discussed on a land-use level to create a link between sustainability approaches, landscape heritage conservation and enhancement of regional diversity and local identity in order to develop perspectives on multifunctional productive rural landscapes.

Past and potential future effects of habitat fragmentation on plant-pollinator and host-parasitoid networks

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Habitat fragmentation is a primary threat to biodiversity but how it affects the structure and stability of ecological networks is poorly understood. Here, we studied plant-pollinator and host-parasitoid networks on 32 calcareous grassland fragments, covering a size gradient of several orders of magnitude and independent amount of additional habitat availability in the surrounding landscape. We find that additive and interactive effects of habitat fragmentation at local (fragment size) and landscape scales (additional habitat in 1,750 m radius) directly shape species communities by altering the number of interacting species and indirectly their body size composition. In turn, the number of interacting species and their body size determine interaction network structure, i.e., nestedness and modularity. We simulate species coextinctions to evaluate how current network structure relates to network robustness to species loss under potential future habitat fragmentation and discover that the structure-stability relationship depends on species sensitivity to coextinctions and capacity for adaptive partner switches, which differ between the mutualistic and antagonistic interaction partners. In plant-pollinator interactions, nestedness and modularity can have a stabilizing and destabilizing effect, respectively. However, the stabilizing role of nestedness in plant-pollinator communities disappears under lower pollinator sensitivity or adaptive partner switches. In contrast, high modularity always stabilizes host-parasitoid networks regardless of the assumed parasitoid sensitivity to host loss or capacity for host switching. In conclusion, while plant-pollinator communities may cope with future habitat fragmentation by responding with opportunistic partner switches to species loss, past effects of fragmentation on the current structure of host-parasitoid networks may strongly affect their robustness to coextinctions under future habitat fragmentation.

Impact of inundation regime and meadow management on wild bee communities and bee-flower networks

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In this study wild bee communities on flood-prone meadows were compared with those on rarely inundated sites in the Donau-Auen National Park. Flower-visiting bees were sampled on 32 meadows between April and August 2016. Altogether 92 wild bee species interacting with flowers of 62 plant species were recorded. Mowing activities and strongly related to that, abundance of feeding plants were the main drivers altering wild bee activity density and diversity. Counter to expectations, the flooding regime had no significant impact on observed individual numbers and species accumulation curves suggest that species richness was higher on meadows which are more regularly flooded. As a potential driver of this pattern, a significantly higher bee differentiation diversity on annually flooded meadows could be identified. Since bees are predicted to be vulnerable to floods, it follows that bee assemblages must have recovered following the last unusually severe summer flood in 2013. To obtain further insight into the functional characteristics of the observed bee communities in relation to pollination, three network metrics, which were derived from a bipartite plant-bee interaction matrix, were analyzed. None of the network indices was affected by the flooding regime. Hence it is concluded that, although floods may have strong effects on wild bee populations in the short term, stable and diverse bee communities are restored only after a few years. These findings underline the exceptionally high value of floodplain areas as habitat for wild bees and reinforce earlier studies in which other insect groups seemed to show a low resistance but high resilience towards flooding. The observed resilience surely highly depends on the surrounding landscape, which acts as a starting point for recolonization processes. Hence it is important to consider biodiversity on a landscape scale beyond the limits of the nature reserve.

Fruit quantity and quality of strawberries benefit from enhanced pollinator abundance at hedgerows in agricultural landscapes

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Animal pollinators are in a serious decline due to habitat loss, isolation and landscape fragmentation, putting pollination services to crops at risk. Hedgerows have been repeatedly emphasized as landscape elements that provide nesting and food resources, that connect fragmented habitats and that could thus facilitate crop pollination. However, the beneficial and potentially also detrimental impacts of hedgerows on crop pollination remain poorly studied. Here, we analysed the interacting effects of pollinators and herbivorous pollen beetles (*Meligethes* spp.) on fruit quantity and quality of strawberry phytometer plants located at forest-connected hedgerows, isolated hedgerows and on grassy margins without any hedgerows. Moreover, we identify fruit quality parameters that are related to insect pollination including commercial grade and value, sugar-acid-ratio and grey mold (*Botrytis cinerea*) infection. Higher pollinator abundance increased strawberry weight, whereas pollen beetle abundance reduced berry weight. Berry weight was significantly reduced by 29 % at isolated hedgerows and 32 % at grassy margins, compared to berries at connected hedgerows. Plants placed at forest-connected hedgerows produced more high quality fruits (90 % classified as 'marketable'), whereas only 75 % of fruits from plants at isolated hedgerows, 48 % of fruits from plants at grassy margins and 41 % of fruits from self-pollinated control plants where classified as marketable. Increased habitat connectivity through hedgerows enhanced the commercial value of strawberries. Pollinator abundance was highest on phytometer plants at forest-connected hedgerows, lowest on grassy margins and intermediate at isolated hedgerows. Pollen beetle abundance on phytometer plants was not affected by hedgerows. Our study highlights the importance of hedgerows and habitat connectivity for promoting pollination services in agricultural landscapes, with economically important benefits for crop quantity and quality.

Enhancing strawberry pollination with social bees by choosing the right species and colony size

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Bees in agroecosystems are important pollinators for many crops. But interactive effects between flowering resources for pollinator visitation may alter bee's foraging preferences. While social bees can be distracted from minor crops such as strawberries by increased flowering of surrounding mass-flowering resources like oilseed rape (OSR), solitary wild bees can be facilitated by competitive release. Social bees are commonly used as additional pollinators in agricultural landscapes but high densities can negatively affect wild bees. Hence, optimized pollinator management of social bees is needed to increase pollinator efficiency by reducing negative implications on wild bees. Therefore, we investigated the potential use of managed honeybees (*Apis mellifera*) and bumblebees (*Bombus terrestris*) varying in colony size by analyzing collected pollen via next-generation sequencing and light microscopy. We expect 1) higher flower constancy of honeybees compared to bumblebees and 2) higher amounts of strawberry pollen collected by small compared to large colonies. Preliminary results of light microscopy show that honeybees have greater flower constancy in strawberries compared to bumblebees with increasing values over time. Surprisingly we found only little amounts of OSR pollen collected by honeybee pollen foragers although it was a highly available mass-flowering resource at this time. Nevertheless, honeybee nectar foragers seem to use OSR much more often. Using next-generation sequencing we will identify potentially competitive plants which have been used as pollen resource apart from strawberries. Furthermore, our results suggest that forager from small colonies collect more strawberry pollen compared to large colonies. So far, we recommend small honeybee colonies to improve the efficiency of pollination management with social for minor crops.

POSTER PRESENTATIONS

SESSION 28-P1

Determining habitats to enhance wild bee diversity in agricultural landscapes

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Wild bees provide a valuable ecosystem service by pollinating crops and wild plants in agricultural landscapes. Agricultural intensification is known to be a major driver for the decline of wild bees. The project BINATS 2 (BIodiversity–NATure–Safety) assesses the biodiversity of representative indicators in Austrian agrarian regions. Wild bees are recorded additionally to the indicators habitat structure, vascular plants, grasshoppers, and butterflies in 100 test areas. During two consecutive years, these indicators are sampled in 50 test areas in maize (2017) and 50 test areas in oil-seed rape cultivation regions (2018). Within each of the 625 x 625 m test areas habitat structures are mapped. Plant and animal indicators are recorded in ten randomly selected test circles (40 m diameter) per test area. Wild bees are sampled by a semi-quantitative method on two centre crossing 40 x 2 m transects in each test circle. The wild bee fauna is assessed once per test area, which enables a snapshot of the species inventory during maize and oil seed rape florescence, respectively. Additionally, 30 of the 100 test areas are sampled three more times between April and August during the survey year to evaluate the situation of wild bees in the Austrian agrarian region. In 2017, we recorded 192 wild bee species in the Austrian maize cultivation region. Common species were *Andrena flavipes*, *Bombus lapidarius*, *B. lucorum/terrestris*, *Halictus simplex* and *Lasioglossum pauxillum.* We also observed rare species like *Pseudapis diversipes*, *Halictus tectus* and *Lasioglossum pressithorax*, a new species for Austria. Our data will further identify relevant habitat structures which enhance wild bee diversity in agro-environments and their occurrence in different agricultural land-use systems.

SESSION 28-P2

REGRASS – Re-established grasslands to promote wild bee biodiversity and pollination efficacy

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Bee mortality has become a widely known phenomenon over the past years. As wild bees are particularly significant pollinators their decline will severely adversely affect several habitats including agricultural crops. A loss in bee species diversity and abundance would also threaten the existence of a majority of insect pollinated plant species worldwide. In European agricultural landscapes not only the usage of pesticides but also diminishing food resources and breeding sites account for the disappearance of wild bees throughout the area. In 2008, the EU stopped subsidizing set-aside grasslands in agricultural areas. Since then the amount of extensively managed meadows and fallows has decreased drastically. We investigate bee abundance and species diversity as well as pollination success in newly established grasslands and adjoining winter cereal fields in Lower Austria over three consecutive years. We analyze movement patterns of wild bees from existing meadows to re-established grasslands and cereal fields. Moreover, we compare already existing meadows and re-established grasslands with subsidized biodiversity fields (ÖPUL). These fields are part of Austria's Agri-environmental Programme to promote appropriate agriculture for the environment and the protection of natural habitats. First trends show that our newly established grasslands present a valuable food source for bees perhaps due to high flower supply. In the first year we found 36 wild bee species in the re-established grasslands, 20 species in the meadows and 11 species in subsidized biodiversity fields. In contrast, for honey bees subsidized biodiversity fields seem to be the most attractive food source, most probably because of a high abundance of *Medicago sativa*. Results from the following seasons will be most interesting as we expect gradual changes in the plant species compositions in our newly established grasslands.

SESSION 28-P3

Using DNA metabarcoding for simultaneously examining the functional diversity of plants and wild bees

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DNA barcoding has evolved into a standardized genetic method for differentiating species and is now applied to every branch on the tree of life. Next generation sequencing technologies are not only a sensitive and powerful tool for whole genome or single amplicon sequencing, but also for the metabarcoding approach. Single specimens are detectable in bulk samples with various mixtures of tissues and organism fragments. The aim of our study is to establish an approach where both, the functional diversity of plants and one of the most important pollinators, wild bees, are evaluated. We achieve that by sequencing the pollinator and the collected corresponding pollen at the same time. This is carried out by amplifying the barcoding markers for animals and plants in the same PCR reaction. For this, we first established a reference database of Illumina DNA barcodes of wild bees and of pollen. The DNA barcoding markers CO1 for wild bees as well as portions of the trnL–trnF and rbcl for plants were amplified using universal primer pairs in multiplex PCRs. Using this approach, the direct connection between plants and wild bee species can be shown by barcoding bees and adhered pollen simultaneously. Some of the possible applications of such an approach are: the detection of ecological speciation of pollinators based on their foraging behavior; the designation of bees as oligo- or polylectic; the evaluation of ecological restrictions of wild bees based on the plant distribution in certain habitats, such as cities.

SESSION 28-P4

Using machine learning to predict ecological interactions from traits

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Finding interactions between species is of importance for understanding ecological systems. In other fields, predicting these links is achieved by matching their traits. We require high predictive models to forecast interactions. Compared to traditional statistical methods, machine learning models achieve higher accuracy and are more independent of pre-assumptions about the system. However, choosing the right machine learning method remains a challenge due to the variety of available algorithms. By using different mechanisms, they vary in their ability to learn from patterns in the data. Beside predictive analysis, it's also of great interest to interpret these black box models and in particular detect the underlying interacting traits. We tested the performance of several supervised machine learning models (support vector machine, k-nearest-neighbor, random forest, naive bayes, deep neural network, and convolutional neural network) by fitting them to two real datasets, a plant–pollinator with binary interactions and a plant–hummingbird with interaction counts. We also implemented a simulation to compare the models' performances directly and to examine their interpretability. We validated their performance by removing species and all their interactions. Random forest achieves the highest performance for both real data sets. Our results show that the performance depends strongly on the proportion of positive interactions and the sample size. We show that separating the main effects from interactions is complicated. The artificial neural networks were not able to outperform significantly the random forest maybe due to the sample sizes of the real datasets and the lacking complexity in the simulation. Further research should focus on developing techniques to interpret black box models to overcome the mismatch between high predictive power and causal inference.

SESSION 28-P5

Fly communities of alpine meadows now and in the past (pre–1900)

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Changes have taken place on alpine meadows for centuries by change in both climate and land-use. At the same time, mountainous insect communities are known to host a high number of fly species, many of which are flower visitors and important pollinators. Knowledge on their distribution and their flower visiting choices is still far from complete. Especially in alpine regions where they become more important as pollinators, it is important to study community changes. The biologist Hermann Müller collected pollinator-plant data from 1874 to 1879 at multiple sites in the Alps and we resampled these same sites in 2016 and 2017. We compare fly-pollinator diversity and composition from the Alps from our recent expeditions with the pre–1900 period. For this work in progress, we give an overview of the data and the differences between both periods, changes across elevational gradients, and a first attempt to link these changes to climate and land-use changes. We discuss what the consequences of changes in this fly community are on other flower visitors.

SESSION 28-P6

On the possibilities of care-crafting in the Anthropocene: bees, beekeepers, and 'bee people'

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Through the realm of small-scale beekeeping the aim of this paper is to explore the intertwined ideas of living with shared ecological vulnerability, engaging in creative collaboration amidst capitalist entanglements, and the creation of caring relationships arising from environmental crisis. This paper will probe the potential of anthropology, political ecology, and multi-species thinking for re-imagining sustainable links between plants, bees, farmers, markets, industrial agricultural lobbies, and regulatory bodies on an environmentally damaged planet. By questioning how to cultivate more caring for bees across unlikely groups, the bee will be used as a symbol in the practical negotiating of the current global environmental crisis. Moreover, this will illustrate how the space between bees and humans is shifting in these catastrophic times and in turn, necessitates creative, unusual responses. This paper will present the usefulness of new kinds of caring multi-species relationships birthed from shared ecological and economic vulnerability, and their sustainability in community-based agricultural and social networks. Lastly, an exploration of the concepts of place and obligation will occur in relation to land, bees, ancestors, future generations, consumption, and one's own expectations within an ecologically fragile modernity

SESSION 29

Scales and heterogeneity in ecology

Chairs: Katrin M. Meyer, Kerstin Wiegand, Matthias Fritsch

Fairy circles may form without termites: Australian evidence from drone-based image analysis and soil excavations

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Fairy circles are extremely ordered round patches of bare soil within arid grasslands of south-western Africa and Western Australia. Their origin is disputed because correlations with various biotic and abiotic factors like soil toxicity, abiotic gas, termites, ants or microbes may partly occur. Another source of the controversy is the fact that genuine fairy circles are sometimes mixed up with other non-related grassland gaps that have different spatial patterns. In this study we shed some new light on the spatial properties of fairy circles and how they differ from typical termite-created gaps. We demonstrate how the heterogeneous spatial patterns, the small diameters and the skewed size distributions of termite gaps do not match the fairy circles. Furthermore, with a systematic landscape survey and more than 150 soil excavations we demonstrate that in circa 90 % of these diggings no hard pavement termitaria were found that could inhibit plant growth. In our key research area we even found 100 % absence of pavement termitaria in all excavations, demonstrating that the fairy circles may form completely without termite intervention. This fact is substantiated by the observation that small, immature grassland gaps are initiated without any evidence of termite activity. We argue that partial correlation does not imply causation and that an absence of termite data rejects termites as being the ultimate cause of fairy circles. Finally, our analyses of soil texture and compaction provide evidence that clay contents and soil hardness were highest in the fairy circles as well as adjacent to them in the large bare-soil areas where no grasses are growing for hundreds of meters. The 2.6 to 2.8 times higher clay contents in these two areas, as compared to the matrix vegetation, indicates that the source of the clay is not termite mounds but abiotic processes that are related to intense rainfall events, particle dispersion, erosion, and mechanical crust building.

We measure to know: from plot to landscape scale

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Earth observation, remote sensing, and proximal sensing are seen to provide high-resolution data for a great variety of scientific disciplines. Although applicable for ground truthing, plot-scale data covering a broad range of environmental parameters are still a prerequisite for most functional ecological studies. Moreover, detailed surveys at plot-scale have tremendous capabilities for upscaling purposes in a broad range of modelling frameworks, commonly accepted in landscape ecological research since long. Ordinary least squares (OLS) regression models and artificial neural networks are valuable to fully exploit the information of 'local' data and are seen as powerful methods to upscale ecosystem processes and functions. However, there are some issues impeding the progress of this type of landscape scale models: (1) established statistical correlations do not necessarily reflect causal links, (2) increasing availability of ready-to-go low-cost remote sensing data with high resolution. Additionally, misleading use of the terms 'parameter', 'variable' and 'indicator' in context with ecosystem processes and functions leads to fundamental problems for the comparability of bottom-up and top-down approaches. Here we present various upscaling techniques from ecosystem and landscape research in the Alps, thereby elucidating opportunities and challenges, as well as possible improvements of sampling design by using historical land-use/land-cover trajectories. Complemented by top-down studies using indicators from remote sensing data to analyze specific target process (e.g. land-surface temperature as indicator for evapotranspiration and/or energy balance), a broad range of scaling issues are presented to promote discussions and to contribute to the growing demand for scale-explicitness in ecological research.

Scale dependency of the heterogeneity-diversity relationship in forests

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Environmental heterogeneity is expected to promote the diversity of species by increasing the number of available niches (heterogeneity-diversity hypothesis). Although the positive relationship which was initially suggested by habitat-heterogeneity hypothesis was supported by a meta-analysis across plants and animals, the heterogeneity-diversity relationship is still under debate (e.g. positive, negative, or unimodal). Recently, theoretical and empirical data support the view, that increasing environmental heterogeneity leads to a decrease in the amount of suitable area available for single species, which in turn makes stochastic extinction of species more likely. Therefore, habitats characterized by intermediate levels of environmental heterogeneity should host the highest level of species richness compared to habitats characterized by low and high levels of heterogeneity. However, the shapes of the heterogeneity-diversity relationships were rarely compared among animal groups of different body size. The difference among the mean body size of multiple taxonomic groups might cause the different shape of the relationships among taxa, since body size might influence the animals' perception of environmental heterogeneity and the amount of effective area available. The spatial grain of the analysis can also influence the shape of the heterogeneity-diversity relationships, even the direction of the relationship. We will present if the relationship between animal species diversity and horizontal heterogeneity and the heterogeneity level at which area-heterogeneity trade-off occurs are dependent on the spatial grain of the heterogeneity analysis and the average body size of the taxonomic group. We will employ the field survey data, airborne lidar data, and satellite data (Sentinel 1 and 2) to scale up our environmental variables from the local scale to the landscape scale.

Detection, strength and implications of conspecific negative density dependence

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The phenomenon of conspecific negative density dependence (CNDD) in trees and the role of this mechanism for maintaining species diversity have featured prominently in ecological thinking at least since Janzen and Connell published their seminal work in the early seventies. Since then, many studies have set out to prove CNDD from the local to the global scale using both observational and experimental data. Despite this vast body of research, however, there is now agreement about the strength of CNDD and its dependency on species rarity or forest attributes. Arguably, this ambiguity is driven by differences in the spatial scale of the analysis, as well as in the underlying concepts of CNDD and statistical methods used. For example, in a recent comment, we showed that some previous results about CNDD were driven by biased statistical methods and inadequate methodological assumptions. Here, we review available approaches for detecting CNDD, summarize the evidence of existing studies and evaluate their reliability to provide a more conclusive view on the current understanding of negative density effects. In addition, we evaluate to which degree local effects of close-by conspecifics scale up to the level of forest stands or even landscapes and thus support the CNDD-biodiversity hypothesis.

Spatial and temporal scales confound tests of stable coexistence, but identify underlying mechanisms

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A primary goal of community ecology is to identify mechanisms that are responsible for maintaining coexistence. However, depending on the spatial and temporal scale of measurement, species may seem to stably coexist even if they cannot, or actually stable communities may appear unstable. Characterizing the stability of coexistence in systems with spatial or temporal structure is therefore notoriously difficult. To address this problem, I demonstrate a three-stage, empirically tractable approach for leveraging the scale-dependent nature of stability to identify underlying mechanisms. First, for an unknown system of interacting species, I quantify the stability of coexistence across spatiotemporal scales using two commonly applied metrics: species responses to perturbations, and their ability to invade when rare. This yields a multivariate distribution of metrics which I refer to as a stability 'fingerprint'. Second, I generate fingerprints for a series of models with known underlying mechanisms. Lastly, I compare fingerprints from unknown systems to those from known models. To validate this approach, I use it to analyse empirical dynamics from an old-field successional time-series, and simulated dynamics from five models based on mechanisms that are commonly hypothesized to influence coexistence: metapopulation dynamics, disturbance, feedbacks, species interactions, and neutral drift. Stability fingerprints revealed substantial variation in perceived stability across spatiotemporal scales. Based on this variation, it was possible to successfully classify randomly chosen simulations of all five models, and to characterize potential mechanisms underlying the successional dynamics. These results suggest that multi-scale stability analysis may be an effective tool for identifying underlying coexistence mechanisms.

Stability of the n-species Lotka-Volterra model: new methods, results and implications for species diversity

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Community assembly and consequently biodiversity patterns are influenced by species interactions and nonlinear dynamics. Both are covered by the classical, simple Lotka-Volterra interaction model. For few species its equilibrium behavior has been studied explicitly since decades, for more species by stochastic simulations and often restricted to specific interaction matrices.

We present new results about the stability of the equilibria of a generic LV model with many species based on a combination of theoretical derivations and simulations, give some examples how stability depends on the model parameters characterizing the community and discuss potential implications for species diversity on different scales.

POSTER PRESENTATIONS

SESSION 29-P1

A lingua franca for neutral landscape models: developing a classification approach to advise their future usage

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Neutral landscape models (NLMs) simulate landscape patterns based on theoretical distributions and can be used to systematically study the effect of landscape structure on ecological processes. NLMs are commonly used in landscape ecology to enhance the findings of field studies as well as in simulation studies to provide an underlying landscape. So far there is no framework that provides guidance which of the models in the diverse variety of NLMs available can be applied in which specific context (having the same properties as the landscape to be used against as null model, or mimicking a certain landscape for a simulation model). Historically they were divided into the three categories i) random, ii) hierarchical or iii) fractal. However, we think that a more methodological approach to advise their usage is needed. This is based on the fact that their simulation becomes more and more accessible and as such, if they are used there is in most cases no justification why a specific model was used. Our aim is it to classify NLMs based on a set of landscape metrics that are sufficient to describe the configuration and composition landscapes over spatial scales. Therefore, we used the R package NLMR that offers 16 different algorithms to simulate NLMs and performed a parameter space exploration. This parameter space exploration used the Latin Hypercube Sampling as sampling technique. The parameters obtained there we used to simulate the neutral landscapes and were classified with 18 different landscape metrics. We used a principal component analysis to obtain clusters of NLMs that cover a similar range of landscape metrics. These clusters can then be used to guide the application of NLMs in future studies.

SESSION 29-P2

Abundance and spatial patterns in neutral communities – contrasting the species and the lineage perspective

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Surprisingly, few attempts have been made to link the factors defining species abundance with that of spatial distribution. However, spatial patterns might leave signals of underlying mechanisms and thus of explanations of why some species are abundant while others are rare. Results from a spatially continuous IBM provide evidence that – under the assumption of neutrality and similar dispersal – differences in the abundance between species should be mostly refelcted in the frequency of cluster centers whereas the spatial dimension and individual number within clusters hardly correlates with species abundance. This result is reversed if we take a lineage perspective, i.e. consider the distribution of individuals of same ancestry. We further note that the location of clusters may over very long time remain stable, centered around the location of the founding individuals and that foundation of new clusters is a rare event. Deviations from these predicted pattern can, for example, indicate past disturbane-colonization events.

SESSION 30

Social ecology: the need for an integrative perspective

Chairs: Marion Mehring, Thomas Kastner

Social-ecological dynamics of ecosystem services

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The concept of ecosystem services claims to bridge between biodiversity and society. The concept has proved its success at least since the application in the IPBES – Intergovernmental Platform on Biodiversity and Ecosystem Services Framework as well as the various national ecosystem service assessments. Currently, the framework of ecosystem service supply and demand plays a crucial role in research. However, social-ecological dynamics of ecosystem services, i.e. the interaction between societal processes (demand) and biodiversity (supply), have only recently gained attention within ES research. We claim that there are not only interdependent temporal and spatial dynamics between ES supply and demand, but also a social dimension which needs to be considered. This oral contribution presents a critical reflection on the current research of ecosystem service supply and demand. Against the background of our conceptual framework of social-ecological systems, we argue that there is a functional relation between ecosystem services supply and demand influencing each other. Presenting two studies i.e. from Socotra Archipelago, Yemen and from Sahel regions in Senegal and Mali, West Africa, we illustrate that the society behind the demand of ecosystem services is highly interrelated with ecosystem services supply. With this presentation we seek to contribute to the present debate on ecosystem service supply and demand in order to better understand the nature-society interaction in terms of dynamics of use of ecosystem services.

The stock-flow-service nexus: new directions for socio-ecological transformation research

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A transformation toward sustainability requires far-reaching changes in the patterns of societies' use of biophysical resources. Current socio-metabolic research traces flows of energy, materials or substances to capture resource use: input of raw materials or energy, their fate in production and consumption, and the discharge of wastes and emissions. This approach has been successful in bridging social and natural sciences in inter- and transdisciplinary analyses of society-nature interactions. It has yielded important insights into eco-efficiency and long-term drivers of resource use. However, socio-metabolic research has not yet fully incorporated material stocks or their services, hence not fully exploiting the analytic power of the metabolism concept. This presentation argues for a material stock–flow–service nexus approach focused on the analysis of interrelations between material and energy flows, socioeconomic material stocks ('in-use stocks of materials') and the services provided by specific stock/flow combinations. It builds on recent empirical efforts showing, among others, that the fraction of the global socioeconomic material inflows added to stocks each year has risen from 20 to over 50 %, suggesting the emergence of global 'stockpiling' societies. Currently, socioeconomic material stocks are in a similar magnitude as the standing biomass of plants on land, and they have grown in unison with GDP for over a century. The paper argues that analyzing the interrelations between stocks, flows and services will allow researchers to develop highly innovative indicators of eco-efficiency and society-nature interaction. By focusing on services rather than measures of economic activity such as GDP, the stock-flow-service nexus allows identifying novel options for sustainability transformations. Because stocks can be mapped with high resolution using data from remote sensing, the stock-flow-service nexus provides new data and indicators to analyze the importance of spatial structures of societies' organization beyond current metrics such as nighttime lights. We therefore argue that the stock-flow-service nexus will open new research directions for understanding of the biophysical foundations of sustainability transformations.

Coupling models to understand social-ecological systems

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Modelling approaches have become increasingly popular to understand the complexity of social-ecological systems (SES). In the light of the Anthropocene, especially the dynamics of humans as a key part of SES come to the fore. A popular modelling technique to address this central task is agent-based modelling (ABM), where agents represent humans and their impact on their environment. Yet, recent approaches often rely on highly simplified assumptions about human decision-making that mainly account for economic motivations. In order to capture these complex dynamics, we propose an integrated modelling approach which combines the strengths of a spatially explicit ABM, namely the integration of feedbacks among human actors and between them and their (natural) environment and the high temporal and spatial resolution, with the strengths of Bayesian networks. The latter strengths are first and foremost, the ability to integrate even highly disparate underlying data while accounting for uncertainty. We present an example from the Cuvelai-Basin at the border between Namibia and Angola, where people rely on various traditional, but often unreliable, water sources. Consequently, many households are extremely vulnerable to the constantly recurring droughts. In some areas, modern water sources can substitute or relieve traditional sources. Still, households weigh these fee-based alternatives with regard to a lot of different factors. Besides environmental factors, the household's socio-economic status and the behaviour of neighbours also influence the decision-making. Our results show the importance of drought severity and duration, but also highlight the influence of the households willingness for cooperation and mutual support. Since we know from our surveys that the willingness and capability to support each other decreases with the occurrence of consecutive droughts, climate change is likely to become a serious threat that affects ecological as well as social structures.

Farmer's decision-making and land use intensification: developing an integrated socio-ecological agent-based model of the Enns valley

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Intensification of land use is an important facet of land use change in the past decades and centuries. Intensification has allowed the reduction of per-capita land requirements for food production, despite growing calorie and animal product intake, but at the expense of decreasing productivity (the ratio of input to output fell in energetic terms). Nevertheless, land-use change research still needs to pay more attention to processes of agricultural land intensification especially focussing on decision-making processes driving land management. In this paper, we present the proposal of an integrated agent-based model that aims to simulate the intensification of land use. Intensification refers to both socioeconomic inputs into agro-ecosystems (work, machinery, energy and fertilizers) and outputs from agro-ecosystems to society (harvest of cropland and grasslands or ecosystem services). Changes in intensification result from individual decision-making processes of farmers, consumers and other actors. Biophysical and socio-economic framework conditions are the main drivers and constraints for the option space for each of these decisions This model endogenously represents (a) decisions of relevant actors, (b) spatially explicit changes in land use and land cover and (c) socioeconomic as well as ecological stocks and flows of substances like nitrogen (with adequate spatial as well as temporal resolution. Aim of the model is to explore possible future developments resulting from predicted changes in (a) external economic and political drivers such as food and energy prices, agricultural subsidies or various kinds of regulation, (b) external biophysical drivers such as changes in temperature or precipitation, (c) internal social, political or economic choices such as food preferences or cooperation between farmers.

Towards a qualitative assessment of cultural and natural values of national natural heritage sites in Germany

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In Germany, over 70,000 ha of land share a history of military use that is currently curated by the German Federal Environmental Foundation (DBU). These relicts of former military usage build the foundation of the National Natural Heritage conservation site (Nationales Naturerbe NNE) in Germany. The sites distributed across Germany host diverse and unique landscapes of high cultural and natural value for society and science. With an interdisciplinary team of historians, geographers, landscape planners, and biologists we investigated how to assess the cultural and natural values of three case study NNE sites across Germany. We examined the dynamics of ecosystem services over the last 150 years and related cultural practices and land use changes with the capacity and actual use of ecosystem services. Our results show that among the three study sites, the dynamics of land use change varied considerably. Open landscapes underwent the most dynamic changes whereas forest as a category of land use remained relatively constant over time. Under the assumption that moderate land use changes provide high capacities for certain ecosystem services, we compared the capacity of the heritage site with the actual use of selected ecosystem services. Interestingly, our participatory mapping revealed an intense use of open landscapes and a less intense use of forests. The dichotomy of capacity and actual use of these landscape categories is discussed. To conclude, our results inform the understanding of the conservation of natural and cultural assets as one aspect of 'heritage' and provide first insights into the importance of integrating an historical dimension in the assessment of cultural and natural values of National Heritage sites in Germany.

Land use elements and attributed ecosystem services: an archetype approach to land use evaluation at the North Sea coast

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The ecosystem services approach has been introduced as a decisive concept to include ecosystem functioning in land use planning and stakeholder driven sustainable development processes. Nevertheless, early integration of stakeholders in participatory processes in the nexus of ecosystem services, climate adaption, and land use management is still demanding. The aim of this study is to identify stakeholders' perceived connection between land uses and ecosystem services in a German North Sea region. The stakeholders are decision-makers who represent societal sectors of water management, agriculture, nature conservation, regional policy and tourism. With their diverse interests they strongly agreed independently on the relevance of close to 1/3 of 342 land use elements-ecosystem services attributions (19 land use elements, 18 services), whereas there was a disagreement on 2/3 of the possible attributions. In case of agreements, general service projections are possible, whereas disagreements render them impossible, because consensus on the value of land use elements for a certain service cannot be achieved. Disagreement can result primarily from sector's views or individual's views. If agreements across different sectors can be identified, archetypes in land use-ecosystem relationships can be found on the regional level. In case sector-wise disagreements occur, these relationships may show trade-offs of interests. We found that disagreements were mainly individual and not associated with the represented sectors. This indicates that individual knowledge on service outputs of multiple land uses differed strongly among stakeholders, particularly regarding regulatory services. The archetypes became foundation of scenario development, showing possible future land management and spatial planning actions. The study has demonstrated potentials of using the archetype approach in combination with the socio-ecological context to support transdisciplinary decision-making processes.

Community-based ecotourism at Jiuzhaigou national reserve and perceptions of management programs in administrative and local communities

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Community-based Ecotourism (CBET) is promoted in protected areas of developing countries as a strategy for biodiversity conservation and poverty alleviation. The success of CBET management programs relies on coordination between key stakeholders, such as park administrative staff and local communities. The impact of these programs and relationships between staff and locals were often only assessed from the perspective of local communities. This study addresses both, the perspectives of local park inhabitants and administrative staff, through a survey in Jiuzhaigou National Nature Reserve. This reserve is a key protected area for the conservation of giant panda in China and is therefore of outmost importance for the national biodiversity strategy. Both qualitative and quantitative approaches were used to survey 200 local Tibetan villagers and 80 administrative staff members. The results indicate that both staff members and locals support the existing ecotourism development plan (EDP), but locals criticize the sustainable management policies (SMP). Younger, better-educated and higher income interviewees were generally most supportive of the EDP and SMP. The relationship between staff members and locals was perceived as uncoordinated with a lack of trust being mentioned as a major issue. The local community is empowered in economic and environmental dimensions, but not in social, psychological and political dimensions. The CBET program generates economic income, but creates problems like inequality of benefit distribution, insufficient social infrastructure, loss of cultural identity, ecological degradation and participation as tokenism. Key factors that hinder the success of CBET are prevalent top-down approaches, a mixture of property and operation rights, single sources of funding creating dependencies, and the lack of management capacity. This study provides empirical evidence for issues and limitations of policy implications under CBET programs in protected areas.

Ethnoecology and the cultural niche

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Ethnoecology is the interdisciplinary science concerned with analyzing and interpreting the origins, evolution and the functions of ecological traditional knowledge (TEK) in a certain socio-cultural system. The interplay between traditional ecological knowledge and the members of the society is known as socio-ecological system. TEK are socially transmitted among generations and are responsible for the development of the cultural niche from previous generations. The cultural niche construction is related to environmental modification in order to solve the adaptive problems a society face. The ethnoecologist is interested in knowing the ecological traditional knowledge of a certain society and understanding the different variables responsible for the cultural niche construction. In this context, ecological traditional knowledge in Albanian society are expressed in their perceptions and cultural practices in relation to nature. More specifically, in their perceptions and cultural practices regarding mountains, rivers, Oret, vegetation etc. These perceptions and behaviors are responsible for the socioecological system which is an integrated part of the sociocultural system as a whole. The traditons in relation to nature are most present in those areas where cultural practices have not been modified by today's ways of living. They risk being lost due to consumism and the poor communication and relation between humans and their natural habitat.

Bird species richness increases life satisfaction across Europe

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Nature's contributions to people are both important topics in international politics and development. Therefore, research with the aim to explore natures' influence on human well-being has increased over the last few decades. However, this research has predominantly relied on very vague descriptions of nature, for example green or blue space. The contribution of specific nature components such as biodiversity or specific landscape features to human well-being has largely been unexplored, especially on larger spatial scales. In this study we explore the relationship between nature and human well-being at a European scale, focusing on biodiversity measures, such as species richness for birds, mammals, megafauna and forest trees as well as different macro-ecological and geographic indicators as landscape attributes. Human well-being of European residents was measured as life satisfaction, a well-established measure for human well-being, derived from European Quality of Life Survey. Our analysis provides the first evidence of a direct relationship between biodiversity and human well-being across Europe. We show that bird species richness (measured as area weighted mean) is positively associated with life satisfaction. This means, that an increase in bird species richness across Europe might potentially lead to an increase in life satisfaction. And this increase in life satisfaction can be up to 1.3 times higher than a comparable increase in personal income. Our findings highlight that humans benefit from bird species richness. Overall, our study opens up a new avenue for macro-scale research on biodiversity's effect on human well-being and provides important input for bird conservation and policy makers in Europe.

Residential greenery as a tool for improving human well-being

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The urban population has grown rapidly in the recent decades. The socio-economic studies conducted by the world health organization confirm the global need for humans to live in a sustainable and healthy urban environments. Urban green infrastructures offer many ecosystem services that demonstrably improve citizen’s health status. Especially green areas surrounding buildings, defined as residential greenery, are very useful to guarantee healthy conditions in particular in districts with lower social index status and less mobility. The main objective of this trans-disciplinary study is to develop long-term and at the same time feasible strategies to increase the physical and mental status of citizens. The study compares three different but typical European cities, Berlin (Germany), Krakow (Poland) and Turin (Italy). The focus here is on characterization and analysis of residential greeneries within the main common European building types regarding biodiversity and social interactions by broad literature research and a SWOT analysis. Samples areas were deeply studied (e.g. vegetation features) and citizens were involved in order to understand their expectations of the new residential greeneries (questionnaires). Based on a SWOT analysis the improvement strategies are finally presented.

SESSION 31

The need of long-term data for taking nature's pulse

Chairs: Mark Frenzel, Jörg Müller

Unlikely biodiversity benefits through reduced Nitrogen deposition in European forests until 2030

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Nitrogen (N) and sulphur (S) deposition are considered responsible for a substantial decline in plant species richness and for altered community structures in terrestrial habitats worldwide, but pressure is decreasing in some areas. In Europe (EU28), overall emissions of NO_x declined by more than 50 % while NH_3 by less than 30 % between the years 1990 and 2015, and a further decrease in N deposition can be expected with even lower emission targets in regulations such as the EU National Emission Ceilings Directive. Studies investigating the potential benefits for biodiversity taking into account lags in soil recovery have yet to emerge. Here we use ecosystem research sites from LTER-Europe and the International Cooperative Programs of Integrated Monitoring and Forests under the LRTAP Convention with high quality long-term data on deposition, climate, soil recovery, and understory vegetation. A dynamic soil model coupled to a statistical plant species niches model is applied with site-based deposition (Current Legislation Scenario from EMEP, scaled with site specific measurements) and climate scenarios (ensembles of 12 downscaled RCP4.5 and RCP8.5). We use indicators of N deposition effects such as the change in the occurrence of oligophilic, acidophilic, and cold-tolerant species to compare the present with projections for 2030 and 2050. Our results show that air pollution abatement will not render a broad scale benefit to forest habitat's understory vegetation in the near future.

How does different arable management affect soil organic carbon, nutrient cycling and crop parameters in Austria?

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Long-term field experiments are indispensable to quantify the effects of changes in arable soil management such as tillage, mineral fertilisation as well as organic amendments including compost applications and the management of crop residues on different soil and crop parameters. The Austrian Agency for Health and Food Safety (AGES) runs long-term field experiments since more than 30 years. Most of these field experiments are part of LTER Austria and focus on various agro-ecological research questions. Selected arable management practices under study are: – Tillage systems (conventional, reduced, minimum); – mineral fertilisation (nitrogen (N) and phosphorus (P) fertilisation in different amounts); – organic amendments (different composts: biowaste compost, green waste compost, cattle manure compost and sewage sludge compost; management of crop residues: incorporation, removal) The results indicate that the maintenance of soil organic carbon (SOC) at the investigated sites is only possible, if tillage is reduced to a minimum and crop residues (cereal grain straw, maize stover, sugar beet leaves) remain on the field. 18 years of compost application resulted in a significant increase of SOC compared to mineral fertilisation. SOC decreases occurred in the long-term with frequent tillage (two times a year and more). This is also the case, if crop residues are removed every year, or if crops without or only few residues (e.g. silo maize, potatoes) dominate the crop rotation, even though the residues normally remain at the field. The above mentioned arable practices lead to a clear differentiation of soil nutrient parameters, e.g. plant available nutrients (P, K, Mg), cation exchange capacity, total nitrogen and the nitrogen mineralization potential. The effects of different arable management practices on crop yields and quality were also investigated. Data from these long-term field experiments have been used for data mining and modelling of primary productivity. These long-term experiments are of pivotal importance as living laboratories, where research questions from different fields can be examined. Furthermore, they offer a unique opportunity to learn about long-term effects of management practices on soils and crops.

A global meta-analysis of long-term insect community changes shows lots of variation, but no net decline

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Recently, a number of studies have indicated dramatic declines in insect abundances in nature reserves in several European countries, instigating significant alarm. It remains unclear, however, just how prevalent these declines are, or whether any anthropogenic drivers can be attributed to them. We compiled a global database of trends in abundance of terrestrial and aquatic arthropod communities monitored over periods of 10 years or more. The database presently includes 124 separate studies with over 2000 unique locations. All continents except Antarctica are represented, but the majority of data come from Europe and North America. Overall, we find that at the global scale, increases in total abundances of arthropods are as frequent as declines, resulting in no net change across the entire dataset. A more detailed analysis indicates that in large, relatively pristine reserves, insect abundances are relatively stable, whereas severe declines are common in agriculturally dominated landscapes, in particularly in Europe. Strong climatic warming in boreal and alpine regions, as well as nature restoration, were associated with increasing insect abundances. Our results show that strong changes in insect abundances are rarely natural, but are associated with a variety of global change drivers. Given the importance for insects as food source for higher trophic levels, as well as for ecosystem functioning, stemming declines in insect abundance should be a top priority for nature conservation.

¼ century of water beetle monitoring reveals changes in diversity and community composition

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With increasing temperature due to climate change species have already begun to respond by e.g. shifting or reducing their distribution range. Climate change might affect especially organisms with patchy resource needs like water beetles. In order to assess the current state of adephagous water beetle communities, we monitored water beetle communities (Dytiscidae, Haliplidae, Noteridae) from 1991 to 2017 in 33 ponds in in southern Germany. We used time-standardized catching with hand nets in three periods; between 1991 and 1995, 2007 and 2008 and in 2017. During the whole sampling period we captured a total of 85 water beetle species with 19,000 individuals at a total of 148 plot dates. Species diversity decreased, constantly over the three time steps. Also community composition showed significant differences between the three time steps. We used a thorough documentation of environmental factors like water temperature, nitrogen content and ph together with information on mean body sizes, distribution and temperature preferences to link changes in diversity and community composition to these factors. We will present the most important factors in this talk.

Bee community patterns in agricultural landscapes – do they change in the long run and does it matter?

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Wild bees play an important role as pollinators in many habitat types. They are rich in species but difficult to access in terms of monitoring and identification. Moreover, long-term data about insect communities are scarce, although these are nowadays highly requested in the light of recently reported insect decline. About 60 % of the area of Saxony-Anhalt (Germany) is covered by agricultural fields. This emphasizes the importance to focus on insect communities in agricultural dominated landscapes. We monitored wild bees in Saxony-Anhalt in six landscapes of 4 x 4 km varying in local weather conditions and land use. In each landscape 16 combined flight traps were installed. The time series started in 2001–2002 and was continued from 2010 onwards. These activities are embedded in ongoing work within the long term monitoring project TERENO (TERrestrial ENviromental Observatoria) which is part of the LTER (Long Term Ecosystem Research and Monitoring) network. We interpret our findings with respect to (a) temporal trends of composition and dominance structures of wild bee communities and (b) the capacity of wild bee communities to provide pollination services within the selected landscapes by analyzing overall bee abundance and the diversity of species traits relevant for pollination.

Bridging the gaps by tea – a simple approach to collaboration in ecosystem science

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In order to study ecosystem processes as well as to analyze environmental changes and develop appropriate mitigation measures 'big data' involving comprehensive datasets collected over multiple temporal and spatial scales and diverse ecosystems is needed. Comparisons of existing data across sites and making sound conclusions are generally challenged due to unsatisfactory data quantity and quality. Hence, there is general consensus on the need for harmonized data in ecosystem research. In this context, global research infrastructures are seen as one of the key elements to foster the harmonization in ecosystem research and as a source for unique understanding. However, a 'usual' distribution pattern in sampling strategy creates a risk of data hot spots in some areas on the one hand and persistent data gaps in other areas on the other hand. This will lead to high uncertainty in process understandings and thus inappropriate answers to the grand challenges. One way to overcome the limitation around high-instrumented infrastructures is to combine them with dense and highly distributed studies and experiments as it is realized within the TeaComposition initiative, a global litter decomposition study. The TeaComposition initiative is an excellent example of collaboration and data sharing as well as an example on how to make best use of legacy datasets combined with a simple 'add-on' approach. Within the TeaComposition initiative we use a standardized and low-cost method, in the form of household tea bags (Rooibos and Green tea), for studying long-term plant litter decomposition rates and its drivers. So far, 570 terrestrial and 350 aquatic sites across 9 biomes around the world are involved in the TeaComposition initiative, with > 80,000 tea bags being deployed. We could show that litter quality was the predominant controlling factor in early stage litter decomposition, explaining about 65 % of the variability in litter decomposition at a global scale. The effect of climate was not litter specific and was of significance only under unfavorable decomposition conditions or when data were aggregated at the biome scale. This initiative underlines the importance of collaborative effort between experimentalist and observers essential for addressing complex ecosystem processes.

POSTER PRESENTATIONS

SESSION 31-P1

Biodiversity Exploratories: 12 years of functional biodiversity research

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Since 2006, the German Research Foundation (DFG) funds three exemplary large-scale and long-term research sites in Germany, the Biodiversity Exploratories. Their aim is to address the relationships between land use, biodiversity and ecosystem processes in real landscapes. For this purpose, we established 300 field plots (so-called Experimental Plots, EPs). 100 of them are located in each of the three regions and they are half in forest and half in grassland. For more complex research, subsets of 150 plots (Medium Intensity Plots, MIPs) and 57 plots (Very Intensive research Plots, VIPs) were selected. Plots differ in land-use intensity and in every region the plots represent gradients from low to high land use intensity, in both forest and grassland. Currently, 10 core projects build the backbone for research in the Biodiversity Exploratories as they maintain the infrastructure and conduct long-term comparative monitoring of central biodiversity and ecosystem process measures. Further 34 contributing projects expand the framework with their individual research on the causes and consequences of biodiversity change. They conduct comparative studies and manipulative experiments on a multitude of plots. Due to the common plot design, data are comparable and therefore compatible for ecological synthesis. All in all, the Biodiversity Exploratories platform presents a great perspective to study the causes and consequences of biodiversity change, which are of highest fundamental relevance in ecology.

SESSION 32

The role of plant diversity for other trophic levels: insights from biodiversity experiments

Chairs: Michael Staab, Anne Ebeling

Effects of tree species diversity on trophic interactions between herbivores and their predators

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Plant diversity is known to affect a wide range of ecosystem processes including plant growth and insect pest resistance. Consumers such as mammalian herbivores too have been shown to modify insect herbivory by triggering changes in host plants. However, few studies have investigated whether consumer effects interact with plant species diversity effects on a focal plant. To unravel consumer–diversity interactions, we recorded both the presence and intensity of winter browsing by moose and insect chewing damage during the following growing season on silver birch in the Satakunta forest diversity experiment in SW Finland. In this experiment tree species richness is manipulated by planting monoculutres and 2–, 3–, and 5–species mixtures of Norway spruce, Scots pine, Siberian larch, silver birch and black alder. Although browsing on birch by moose was not affected by tree species richness, moose browsing altered the direction of tree diversity effects on insect herbivory on birch. Unbrowsed trees experienced lower insect chewing damage in mixed stands whilst browsed trees suffered more insect chewing damage in diverse stands. Reduced insect herbivory in mixed-species plant stands can be attributed to more effective top-down control by predators with increasing plant diversity. Using dummy caterpillars, we have examined bird predation in a gradient of tree species diversity in the Satakunta forest diversity experiment. At the neighbourhood scale, birds preferentially foraged on focal trees surrounded by a higher diversity of neighbours. However, predation rates did not increase with tree species richness at the plot level and were instead negatively affected by tree height variation within the plot. Our studies at the Satakunta forest diversity experiment highlight the importance of spatial scale and trophic interactions in interpreting tree species diversity effects on ecosystem functioning in forest ecosystems.

Tree identity rather than tree diversity impacts herbivores and predators

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Understanding biodiversity effects of trees on higher trophic levels is important in conserving biodiversity throughout the food web. Not only tree diversity per se, but also identity of trees making up the forest community can have strong effects on higher trophic levels. Patterns arising from tree diversity at forest level may differ from responses of communities associated to individual tree species. We studied the effects of tree diversity and forest composition on communities of leaf miners and bark-dwelling. To accomplish this, we sampled these arthropod communities in temperate forest plots varying in tree diversity and forest composition. By using abundance, species richness and diversity at plot level and by using these response variables for the individually sampled focal tree species, we can disentangle responses at a plot level from responses of communities associated with individual tree species. We find that the forest composition and tree identity are more important than tree diversity effects. We show that communities on different tree species respond differently to forest composition. These results can also explain the tree identity effects on a plot level. We will also discuss comparisons and differences between the different trophic levels in their response. Our findings emphasize the importance of species identity making up the community. It also highlight the importance of understanding mechanisms underlying biodiversity effects on higher trophic levels.

Revealing the effects of tree diversity on consumer-mediated ecosystem functions – insights from the Kreinitz experiment

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The functioning of ecosystems has been shown to depend on biodiversity, while the underlying mechanisms are subject to current research. In this context, in the Kreinitz tree diversity experiment research has focused on exploring the spatial and temporal dynamics of consumer-mediated ecosystem functions. The 13 years old Kreinitz experiment is among the oldest tree diversity experiments worldwide and covers a diversity gradient spanning from 1, 2, 3, and 5 to 6 tree species. The species pool comprises two deciduous species with fast decomposing litter (*Fraxinus excelsior*, *Tilia cordata*), two deciduous species with slow decomposing litter (*Fagus sylvatica*, *Quercus petraea*), and two coniferous species (*Picea abies* and *Pinus sylvestris*), adding up to six indigenous species in total. The Kreinitz experiment is one of the few tree diversity experiments in which trees are randomly planted within plots, i.e., allowing to analyze the effects of different local neighborhoods. Several studies in Kreinitz were able to demonstrate the important influence of tree diversity on important ecosystem functions mediated by several trophic levels. For instance, it could be shown that tree diversity decreases insect herbivory on oak. Relatedly, another study revealed the positive impact of local tree diversity on ecosystem functioning by decreasing the level of fungal pathogen infection of trees. Taken together, these results suggest that trees are better protected against antagonists in more diversity tree stands. Moreover, additional work has shown significant tree identity and functional composition effects on earthworm communities, which is likely to influence decomposition processes. Current studies in Kreinitz concentrate on tree diversity effects on decomposition as well as the microbial soil community. This includes a study linking relationships between tree diversity and ecosystem functions to distinct spatio-temporal dynamics of microbial decomposer activity. First results indicate that tree diversity enhanced soil microbial biomass.

Plot level but not local neighborhood tree diversity increase leaf litter ant diversity

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Ants are ubiquitous arthropods in forest ecosystems and play a substantial role in ecosystem functioning. In (sub)tropical forests, nearly half of all ant species are associated with brown food webs in the leaf litter. However, it is largely unknown how litter ant diversity is related to small scale variation in the environment. Several tree diversity experiment studies have shown that diversity at the producer level increases the diversity of associated organisms in other trophic levels. Most past research has focused on the diversity of primary consumers. Organisms inhabiting the leaf litter layer, which are important components for nutrient cycling in forests, are little studied. In order to fill these research gaps, we investigated leaf litter ants within the BEF-China tree diversity experiment. We assessed how plot and neighborhood tree diversity affect various components of litter ant diversity (taxonomic, functional, phylogenetic). Unsurprisingly, ant diversity was positively related to habitat quality, measured as leaf litter cover. However, contrary to our expectations, we found that plot level tree diversity had a stronger influence on ant diversity than small-scale neighborhood tree diversity. This indicates that even for small and less mobile organisms in the leaf litter, bottom-up effects of tree diversity only begin to occur at relatively larger scales (plot level), emphasizing the importance of diverse and mixed forest stands for supporting arthropod community diversity.

Tree genetic diversity increases arthropod diversity in willow short rotation coppice

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Most plant diversity experiments manipulate interspecific species diversity, which ignores that intraspecific genetic diversity within a species can also be an important component of biodiversity. Willows grown in short rotation coppice (SRC) are a promising bioenergy cropping system that has been expanding in the last decade. Increasing the number of willow genotypes in SRC can potentially enhance species diversity in the associated arthropod community, which may promote ecosystem functions within plantations. Therefore, to study the role of plant genetic diversity (GD) in SRC, we established a replicated common garden diversity experiment comprising genetic monocultures and mixtures of two, three and four different Salix genotypes used in commercial SRC. We sampled arthropods and examined the effect of GD across trophic groups, to test if the use of genotype mixtures increases arthropod richness and abundance. Species richness of total arthropods and of herbivores increased significantly with increasing GD, regardless whether data were pooled per plot or analysed on tree level. However, effects varied among willow genotypes as positive correlations between GD and different trophic groups were genotype-specific. We show that establishing and managing commercial willow SRCs with a mixture of varying genotypes can help to increase arthropod diversity within a bioenergy system that is a promising renewable energy source.

Climate, not tree diversity, drives insect herbivory in forests at a global scale

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Increasing the diversity of tree species in forest stands can lead to both associational resistance or susceptibility to insect herbivores. Despite decades of research, the development of a predictive framework of associational effects remains elusive. Several studies report that plant-insect interactions may change along large scale climatic gradients as a result of direct effects on herbivores or indirect effects on plant investment in chemical defenses. However, the potential role of climate in mediating associational effects has been overlooked. We measured leaf insect herbivory and leaf chemical defenses in birch (*Betula pendula*) in twelve long-term tree diversity experiments belonging to the Tree Diversity Network (TreeDivNet, *http://www.treedivnet.ugent.be/*). Experiments covered temperate and boreal biomes, spanning a 16° latitudinal gradient. We modeled the response of chemical defenses and herbivory as a function of tree diversity and climate and explored whether the leaf insect herbivore responses were mediated by leaf traits. Our results do not support the view that there is a general effect of tree diversity on insect herbivory. Instead, we show that, at a global scale, mean annual temperature is the main driver of herbivory independently of stand diversity, age and density. The variability of strength and direction of associational effects among sites is partly mediated by variability in leaf chemical defenses. Further work is required to elucidate factors underpinning the dependency of the biodiversity-resistance relationships to environmental context in forests.

Mycorrhiza in tree diversity-ecosystem function relationships: conceptual framework, experimental implementation, and first results

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The widely observed positive relationship between plant diversity and ecosystem functioning is thought to be driven by complementary resource use of plant species. Biotic interactions among plants and between plants and soil organisms are suggested to drive key aspects of resource use complementarity. We present a conceptual framework for integrating biotic interactions across guilds of organisms, more specifically between plants and mycorrhizal types, to explain resource use complementarity in plants and its consequences for competition and multitrophic interactions. Our overarching hypothesis is that ecosystem functioning increases when more plant species associate with functionally dissimilar mycorrhizal fungi, because different mycorrhizal types will increase coverage of habitat space for and reduce competition among plants. We introduce a recently established field experiment (MyDiv) that uses different pools of tree species that associate with either arbuscular or ectomycorrhizal fungi to create experimental gradients in tree species richness and mycorrhizal associations. Moving beyond the plant-centered view of previous experiments, MyDiv explicitly focuses on essential ecosystem functions related to soil as well as higher trophic levels, which are often neglected in biodiversity-ecosystem functioning studies. We present first results, where we studied the effects of tree diversity and mycorrhizal types on higher trophic levels and related functions, such as leaf pathogen infestation and herbivory rates as well as soil microbial and invertebrate community structure. The effects of the experimental treatments differed between the multitrophic response variables, including opposing trends. These insights exemplify the importance of ecosystem functions driven by higher trophic levels as affected by plant diversity and, thus, deepen our mechanistic understanding of cascading effects of resource use complementarity by trees through above-belowground food webs.

Environmental conditions affect the probability of seed dispersal or predation through changes in slug behavior

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Many plant species do not have a specialized dispersal mechanism and seeds are usually dispersed by gravity. Whether they will be dispersed or predated when encountered by granivores depends on the interplay between animal behavior and seed traits that affect their durability during gut retention. Especially when considering changing environmental conditions that might affect animal foraging behavior, these interactions are likely crucial for predicting plant population responses to global change. We used a model system with legume seeds and slugs as opportunistic generalist granivores under dry and wet conditions to assess whether these affect slug behavior and therefore influence dispersal and/or predation rates. We further analyzed how interactions between slug (size) and seed traits (size, oil and protein content) determine seed fate. The system was set-up in a cage experiment with either dry or wet surface conditions. The slugs' behavior was recorded continuously over 48 hours with time-lapse cameras. Slugs in the wet treatment moved more and for longer distances, which increased the chance of the ingestion of seeds but also accidental seed dispersal through exozoochory. When slugs ingested seeds, larger seeds were more likely to be dispersed (up to 30 m) than smaller seeds, which were digested during the long gut retention time. Slugs in the dry treatment showed stronger homing behavior, returning to their shelter more often and spending more time there. This increased the likelihood of directed dispersal to the shelter when seeds were ingested and later defecated. Under changing climate conditions with predicted drier summers in continental Europe, our results indicate decreased seed predation but also decreased dispersal by slugs. However, if dispersal is directed to moist microhabitats through homing behavior, it might facilitate improved germination conditions for some seed species.

Plant diversity moderates consumer functional diversity and trophic interaction structure

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The effect of changes in biodiversity on ecosystem functioning (i.e. the BEF relationship) are understood predominantly from investigations within single trophic levels, such as plants. Although species in higher trophic levels contribute to key ecosystem services (e.g. pest control), our understanding of how changes in plant diversity propagate through multitrophic communities remains limited. We sought to elucidate the mechanisms underlying shifts in the structure and functioning of consumer communities using functional trait and food-web approaches. Using highly-resolved arthropod community and trophic interaction data from a 15-year grassland biodiversity experiment (The Jena Experiment), we show that plant diversity increased consumer functional diversity and modified trophic interaction structure. Increases in consumer functional diversity were observed for herbivores, omnivores and predators. Further, plant diversity altered the representation of different consumer traits, including a shift in herbivorous taxa towards more smaller and specialised species. The subsequent changes in the number and identity of realised feeding links meant that plant diversity affected emergent food-web properties, including connectivity, robustness and the occurrence of network modules. Together, shifts in consumer diversity and energy flow patterns are likely responsible for observed shifts in ecosystem functions, such as increased predation at high plant diversity. By linking community composition to ecosystem functioning, our findings represent an important step towards mechanistically understanding BEF relationships in multitrophic communities.

Plant diversity-driven changes in consumer stoichiometry have consequences for reproductivity

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High plant diversity increases the abundance and diversity of the associated fauna. A potential mechanism could be plant diversity-driven changes in the elemental composition of consumers with consequences for their reproductive output. N and P concentrations in plant matter have been shown to decrease with plant diversity and could potentially increase the stoichiometric mismatch between plants and consumers. However, the effects of plant diversity on the stoichiometry of consumers and the consequences for their reproductivity are largely unexplored. Here, we use the framework of a grassland biodiversity experiment (The Jena Experiment) to test how plant diversity affects the stoichiometry of consumers from multiple trophic levels. As model organisms, we used three common species with generalist feeding habits: the herbivorous slug *Deroceras* sp., the omnivorous ground beetle *Harpalus rufipes*, and the carnivorous ground beetle *Pterostichus melanarius*. 138 plots with experimentally manipulated plant communities (1 to 8 species mixtures) were enclosed to limit in-between plot movement. Five beetles per species were marked, released in the plots, and recaptured after 25 days. Additionally, ambient slugs were sampled from each plot. We analyzed the relative C, N, and P content in gut-free sample material and additionally counted the number of eggs in female ground beetles. The direction of the effect of plant diversity on consumer molar C : N, C : P, and N : P ratios differed between the organisms: all three ratios increased in the omnivore, which could indicate a shift in its diet towards more plant matter. The ratios slightly decreased in the carnivore and were unaltered in the herbivore. Additionally, the number of eggs in female omnivores decreased with increasing C : P ratio. Such a reduction of the reproductive output of a common generalist species might be a mechanism how species rich plant communities limit the abundance of generalists and support species-coexistence.

SESSION 33

Understanding and projecting plant phenology shifts

Chairs: Andrey Malyshev, Constantin Zohner

A European phenological database, PEP725, www.pep725.eu

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'Phenology – the timing of seasonal activities of animals and plants – is perhaps the simplest process in which to track changes in the ecology of species in response to climate change.' (IPCC 2007) PEP725, the Pan-European Phenological Database, is a European research infrastructure to promote and facilitate phenological research. Its main objective is to build up and maintain a European-wide phenological database with an open, unrestricted data access for science, research and education. So far, 20 European meteorological services and 6 partners from different phenological network operators have joined PEP725. In many European countries, phenological observations have been carried out routinely for more than 50 years by different governmental and non-governmental organisations following different observation guidelines. Therefore, data is stored at different places in different formats. This has been hampering large-scale studies as one has to address many network operators to get access to the data before one could start to bring them in a uniform style. www.pep725.eu has been developed to solve these problems by offering a single entry point to more than 11,800,000 phenological records, all of them classified according to the so called BBCH scale. The first datasets in PEP725 date back to 1868; however, there are only a few observations available until 1950. Having accepted the PEP725 data policy and finished the registration, the data download is quick and easy and can be done according to various criteria, e.g., by a specific plant or all data from one country. www.pep725.eu also displays a map of near-realtime phenological observations from a few countries with real-time monitoring. PEP725 is funded by EUMETNET, the network of European meteorological services, ZAMG, who is the acting host for PEP, and the Austrian ministry of science, research and economy.

Sensing the optimal time for leaf-out: a probabilistic plea for photoperiod and for temperature

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When is the perfect time for leaf-out? In other words what time allows minimal risk of damaging frosts while maximizing the growing season. This goal is crucial for deciduous, perennial plants inhabiting temperate and higher latitudes. Early emerging leaves not only ensure enough carbon uptake, especially in the understory, but also keep competing neighbors in check. By all evidence we have so far, only two environmental cues are perceived by trees to sense the optimal time for leaf-out: temperature and photoperiod. Using different combinations of these cues, several strategies have evolved in relation to species-specific traits such as freezing resistance and recovering time after a damaging frost event. Here, using long-term series of temperature and phenological observations we compare the efficiency of these two extreme strategies (*i.e.* relying only on one of these two cues), for avoiding frost while maximizing growing season length. Within a conceptual framework we discuss how reliable each strategy is to target this perfect timepoint, for different species across latitudes and elevation.

Spring frost under global warming: is the risk of damaging frosts increasing in Switzerland and Germany?

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Winters and early springs are predicted to become warmer in temperate climate under continued global warming, which in turn is expected to promote earlier plant development. In contrast, there is no consensus about how the occurrence of late spring frosts will change. If the frequency and the severity of late spring frosts remain unchanged in the future or advance less than spring phenology of plants does, vulnerable plant organs (young leaves, flowers or dehardened buds) may be more exposed to frost damage. Using long-term series of phenological observations and temperature in Switzerland during the period 1975–2016 we show that the risk that emerging leaves are exposed to frost has not changed at lowlands due to a similar advance in the last spring frost event and in the leaf-out date. However, at elevations higher than 800 m, this risk has slightly increased due to stronger phenological advance. Using long-term series of temperature from Germany and Switzerland up to 1864, we also show that the damaging spring frost that occurred in April 2017 was unprecedented in term of previous accumulated heat. Yet, in spite of this exceptional event, our results suggest again no significant change in the risk of damaging frosts over the last 150 years in lowlands of Switzerland and Germany.

Patterns in flowering phenology change along elevational gradients and relate to leaf functional traits

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Patterns in flowering phenology, i.e. first and last flowering day and flowering duration can have ecological and economic effects in natural and agricultural landscapes. Changes in flowering patterns can impact future community compositions since e.g., increasing flowering duration increases a plant species' chance to get pollinated and perform better under warmer conditions whereas changed flowering times and decreased flowering duration might in turn increase the susceptibility to a mismatch with pollinator species. However, changes in plant phenology due to changing temperatures are highly species specific, and so far it is not clear, why. To analyse changed patterns in flowering phenology we monitored the flowering phenology of 29 herbaceous species on a weekly basis along two elevational gradients ranging from 700–1,700 m asl in two consecutive years. The study was located in the northern limestone alps near Garmisch-Partenkirchen where temperature decreases –0.55 °C per 100 m asl. We monitored plant populations every 100 m increase in elevation and up to three populations per elevational band. From this data we determined first flowering day, last flowering day and flowering duration of each species. To test whether eco-morphological leaf traits (specific leaf area (SLA), leaf dry matter content (LDMC), leaf N and C content, stable isotope composition namely $\Delta^{13}C$ as well as stomatal pore area index (SPI)) are linked flowering patterns and drive species specific responses, we measured those in parallel for the same populations at peak flowering. We found that first flowering day is earlier if elevation is lower i.e. mean annual temperatures are higher whereas as was the last flowering day in early flowering species whereas late flowering species did not change last flowering day with temperature. However, there was an overall increase in flowering duration with an increase in temperatures. Especially leaf nitrogen was shown to be associated with stronger changes in the first flowering day along the elevational gradients and LDMC was associated with longer flowering duration. These findings give further insight into the species specific changes in phenological patterns and thus plant performance and distribution under changing climate regimes and their ecological impact on natural and agricultural landscapes will be discussed.

Timing is not everything: key bud dormancy variables affecting budburst dates

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Tree species which develop deep bud dormancy tend to have their bud burst later than species with lower winter bud dormancy depth. The timing of peak bud dormancy depth has rarely been compared among tree species, yet earlier peak bud dormancy may lead to earlier budburst. The relationships among peak bud dormancy depth, the rate of loss in bud dormancy and spring bud burst dates are also unclear. I have tracked temporal changes in bud dormancy depth of three adult trees of six tree species growing within 200 m of each other from August to March. Every three to four weeks tree bud dormancy depth was estimated by taking twig cuttings from each tree and quantifying the days required for bud break under optimal growing conditions in climate chambers. A running mean of bud dormancy depths for each set of three sampling dates was used to estimate the date of peak bud dormancy depth of each tree. Change in bud dormancy depth per time was calculated for each tree, starting with the estimated date of peak dormancy. Spring budburst dates were recorded for branches closest to the sampled branches. Interestingly, peak bud dormancy timing varied up to two months among the species. Spring budburst dates could be predicted using seasonal bud-dormancy changes in excised twigs with an error of 3.6 days (+/−0.8 SE) using species-specific budburst probability curves. Species and trees with higher peak bud dormancy lost bud dormancy faster. For species with similar peak dormancy dates, higher dormancy depth resulted in later budburst while for species with similar bud dormancy depth later peak dormancy dates resulted in later bud break. Therefore, the independent effects of timing and depth of peak bud dormancy should be considered in explaining and projecting species-specific bud break dates.

POSTER PRESENTATIONS

SESSION 33-P1

PhenObs – botanical gardens as a global phenological observation network

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Climate-driven changes in phenology are affecting ecosystems in fundamental ways. Despite the recent attention paid to phenological research, substantial gaps in our understanding still exist, such as the leaf and fruit phenology of herbaceous perennial plants. We aim to fill this gap of knowledge by establishing a new international network of botanical gardens to monitor and analyze different phenological stages on a large set of herbaceous wildflower species in a controlled setting. As results are relevant to the society, our project provides an excellent opportunity to attract citizens as volunteers, and introduce them to botanical and climate change research. Main questions are: what are the drivers of variation in plant phenology in herbaceous species across the growing season and in response to climatic variation? Can plant phenology be predicted from species' trait composition, provenance, position and extent of the distribution range and species' phylogeny (as proxy for their eco-physiological adaptation)? What are the implications of this variation with respect to species performances and assembly, biotic interactions as well as ecosystem processes and services under changing land-use and climate?

SESSION 33-P2

Global warming leads to more uniform spring phenology across elevations

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One hundred years ago, Andrew D. Hopkins estimated the progressive delay in tree leaf-out with increasing latitude, longitude and elevation, referred to as 'Hopkins' bioclimatic law'. What if global warming is altering this well-known law? Here, based on ~ 20,000 observations of the leaf-out date of four common temperate tree species located in 128 sites at various elevations in the European Alps, we found that the elevation-induced phenological shift (EPS) has significantly declined from 34 days.1,000 m^{-1} conforming to Hopkins' bioclimatic law in 1960, to 22 days.1,000 m^{-1} in 2016, i.e. –35 %. The stronger phenological advance at higher elevations, responsible for the reduction in EPS, is most likely to be connected to stronger warming during late spring as well as to warmer winter temperatures. Indeed, under similar spring temperatures, we found that the EPS was substantially reduced in years when the previous winter was warmer. Future climate warming may further reduce the EPS with consequences for the structure and function of mountain forest ecosystems, in particular through changes in plant-animal interactions, but the actual impact of such ongoing change is today largely unknown.

SESSION 33-P3

Inferring climate effects on vegetation phenology using long-term satellite records

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Phenology is a key indicator of vegetation response to global climate change. Yet, our understanding of the underlying functional relationships is limited. This knowledge gap can in parts be attributed to missing consistent long-term phenological observations. Using long-term satellite records, covering more than 30 years of continuous observations, might help overcoming this challenge. Consequently, we here present a study shedding light on the spatiotemporal drivers of European beech (*Fagus sylvatica*) and Norway spruce (*Picea abies*) phenology in a mountainous ecosystem in southern Germany, utilizing long-term satellite records. Spatial variation in green-up was driven by local scale topographic variation, in particular elevation (3 days 100 m^{-1}). Assessment of the temporal variation indicated a substantial trend towards earlier green-up (−0.5 days yr^{-1}), which was linked to changing pre-season temperature (−2.6 [−4.38 to −0.47] days $°C^{-1}$). However, we found only limited evidence for winter chilling effects in our mountainous ecosystem. Our approach based on long-term satellite records allows for assessing the spatiotemporal patterns and drivers of vegetation phenology for regions and scales yet hardly explored by the phenological community. As such, our approach will help refining process-based models of vegetation phenology, which in turn will improve prediction of vegetation response to global climate change.

SESSION 33-P4

Does climate warming alter phenological variation within species?

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Global warming is advancing spring leaf unfolding and flowering, and experimental studies as well as long-term monitoring on woody species show striking among-species differences in the speed of these shifts. Whether global warming might also be affecting within-species synchrony in leaf-out or flowering is unknown. Here, we use climate-manipulation experiments and Pan-European long-term observations on up to 20 herb, shrub, and tree species to study the effects of warmer temperatures on inter-individual (within-population) synchrony in leaf-out and flowering. Warmer pre-leaf-out or pre-flowering temperatures significantly reduced in situ leaf-out and flowering synchrony, increasing inter-individual variation in leaf-out or flowering times within species by up to 55 % (11 days) or 51 % (23 days), respectively. Experiments on European beech showed that individual leaf-out and flowering dates are mainly (to ~ 40 %) explained by genetic differences in photoperiod sensitivity among trees. Individuals without day-length limitation strongly advanced leaf unfolding, whereas day-length-sensitive individuals were less able to respond to short winter conditions, resulting in an overall reduction in phenological synchrony. Loss of inter-individual synchrony under global warming will have consequences for herbivores, pollinators, and possibly gene flow.

SESSION 34

Water in plants – mechanisms, fluxes and experiments from the leaf to the ecosystem

Chairs: Ansgar Kahmen, Henrik Hartmann, Thorsten Grams

The isotope composition of water in the stems of trees does not necessarily equal the isotope composition of the trees source water

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The isotope composition of water in the stems of trees carries important information. This information can be used to estimate the origin of source water of trees and it serves as starting point for the interpretation of the oxygen and hydrogen isotope composition of plant organic compounds. These applications rest on the belief that the water extracted from the stems of trees is identical in its isotopic composition to the trees source water. Recently, there have, however, been indications that this assumption might not be true. In a series of greenhouse experiments, we tested if isotope fractionation occurs (i) during the water uptake by the root and (ii) during the upward transport of water in the xylem of trees. We used 1–2 m tall saplings from seven different temperate tree species in our experiments. We found that indeed no fractionation occurred during the uptake of water by the roots. However, we found clear indications that both hydrogen and oxygen in stem water become slightly enriched in ^{2}H (5 ‰ m^{-1}) and ^{18}O (0.6 ‰ m^{-1}) with progressive upward flow of water in the stems. This enrichment could be the result of stem evaporation or because of the exchange of xylem water with enriched phloem water. We also found that water directly extracted from the conducting tissue (i.e. the xylem) was depleted in ^{2}H by up to −15 ‰ compared to parenchyma and whole stem water. For oxygen, we did not observe such differences among different stem tissues. We speculate that the exchange of ^{2}H depleted metabolic water between xylem and parenchyma cells caused this depletion. Our study has important implications for interpreting the isotope composition of stem water. It shows that stem water does not necessarily equal the isotope composition of source water and that these deviations need to be considered in the interpretation of stem water isotope data of trees.

Hydraulic redistribution – a crucial water exchange process among Central European tree species

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Hydraulic redistribution (HR) is the passive flux of soil water through plant roots along a soil-water-potential (ψ) gradient. Its influence on the water balance of plants and ecosystems depends on interactions between soil processes and plant physiology. This contribution comprises field and greenhouse experiments to trace and quantify HR among Central European tree species under drought. In a split-root greenhouse study HR by *Acer pseudoplatanus*, *Castanea sativa*, *Fagus sylvatica*, *Picea abies*, *Pseudotsuga menziesii* and *Quercus robur* was tested. Trees were planted with one individual (split-root plant) having its roots divided between two pots with an additional tree each. A ψ gradient was established between the pots and HR was observed by stable isotope labeling. Split-root plants redistributed labeled water from the moist to the dry side – where it was found in the drought stressed plants (DPs): 61 % of the water in their roots originated from the roots of the split-root plants. The use of HR water by DPs was assessed in real-time through laser spectroscopy of the transpiration water. In a mixed *Fagus sylvatica–Picea abies* stand in southern Germany (Kranzberg forest, kroof.wzw.tum.de) HR by 70–year old *Fagus sylvatica* trees was studied on six throughfall exclusion plots. Via plastic tubes labeled water was applied to deeper (30–50 cm) soil layers and HR was traced by sampling of soil and plant tissue. 2 % of the applied water was redistributed to the finer roots in the dry topsoil and also reached the rhizosphere where it was potentially available to other trees. HR plays a crucial role in the water balance of Central European trees and displays an important water source for drought stressed plants.

How does the $\delta^{18}O$ of atmospheric water vapour influence the $\delta^{18}O$ of water and assimilates in plants?

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The oxygen isotopic composition of atmospheric water vapour ($\delta^{18}O_V$) influences the oxygen isotope ratio of leaf water ($\delta^{18}O_{LW}$). However, the velocity of this process and how this signal is ultimately incorporated into assimilates such as sugars and starch are barely understood. In several greenhouse and field experiments, we pulse-labeled up to 140 plant species of different life forms (including trees, grasses, herbs, succulents, and epiphytes) with ^{18}O–labeled water vapour for several hours by simulating a fog event. Subsequently, we extracted water and assimilates from different plant tissues and measured potential leaf traits. We found that leaf water was instantly ^{18}O–labelled and that isotopic equilibrium between leaf water and water vapour was reached after c. 5 h in c. 50 % of all studied plant species, while the other half was almost or not in equilibrium. $\delta^{18}O_{LW}$ variations were mainly dependent on the water pool size (i.e., leaf succulence and thickness) and leaf tissues (i.e., leaf lamina and main vein, twig phloem and xylem). Moreover, we observed that the ^{18}O–label was quickly incorporated and differently partitioned into individual sugars (e.g., sucrose, glucose, fructose, and sugar alcohols) and starch. However, the ^{18}O–label incorporation into assimilates varied strongly among the different plant species and life forms, which has substantial implications for (paleo-)ecophysiological and hydrological studies. Our results advance our understanding of how the $\delta^{18}O$ of plant material and thus biomarkers are shaped, clearly demonstrating that soil water (i.e., source water) is not the sole source for $\delta^{18}O$ of plant material. Thus, we recommend measuring $\delta^{18}OV$ in future isotope-based studies on plant-water relations as it reflects an essential parameter of the hydrological cycle. We also show that water vapour labeling can be easily applied and also combined with $^{13}CO_2$–labelling to investigate and compare the allocation of different elements (O, H, C) in plants.

Water and lipid isotopes in mangroves suggest increased reliance on intermittent water sources at high salinity sites

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The tropics are important for global climate dynamics, yet relatively little is known about past change in this region, partly because of lack of suitable archives like tree rings and ice cores that have permitted high-resolution, continuous records at higher latitudes. A new paleoclimate proxy that allows quantitative reconstructions of salinity and rainfall rates is based on the hydrogen isotope ratios ($^2H/^1H$ or D/H) of sedimentary mangrove lipid biomarkers. This approach relies on observations that apparent $^2H/^1H$ fractionation between surface water and mangrove leaf lipids increases (lower ε_{app} values) with surface water salinity in nine species of mangroves growing at diverse sites throughout the Indo-Pacific and Caribbean. The mechanisms that cause lower ε_{app} values at high salinity remain unclear. Field studies including xylem and leaf water isotopes from mangroves growing along estuaries and in marine lakes are consistent with increased reliance on alternate water sources – such as rainwater runoff or dew – as surface water salinity increases. Since freshwater is depleted in ^2H relative to saline water, use of alternate water sources by trees in high salinity water could result in leaf lipids that appear more ^2H–depleted relative to surface water than in trees growing at low salinity sites. In order to test this hypothesis, we grew five species of mangroves at six salinity treatments in the greenhouse for three years. Opposite to field studies, ε_{app} values did not decrease with salinity in the greenhouse. Since cultivated mangroves were limited to one water source with relatively constant $^2H/^1H$ among treatments and over time, this result suggests that alternative fresher, ^2H–depleted water sources at high salinity are important for the overall decrease in ε_{app} values at high salinity. This study enhances the interpretation of mangrove leaf lipid $^2H/^1H$ values down sediment cores by improving our mechanistic understanding of the controls on these values

Water sources of bigger bushes: a risk for groundwater recharge and ongoing bush encroachment in an African semiarid savanna?

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Groundwater recharge is the most difficult component of the hydrologic cycle to measure in semiarid regions. Extremely small recharge fluxes, fluctuating rain events and often-unknown effects of vegetation exacerbate the problem. Both, climatic conditions and vegetation are currently subject to significant changes in many semiarid regions around the world. It includes altered precipitation patterns with more heavy rain events and changes from open vegetation into bush and thicket. In this study, we investigated how individuals of an important encroaching woody plant in southern African savannas might affect these processes of groundwater recharge and disturbed coexistence between grasses and bushes. We wanted to know whether differently sized bushes of *Acacia mellifera* (blackthorn) use water from different sources (rain, soil water, groundwater) and how this use changes during the growing season. A special focus was set on heavy rain events. Study site was a commercial cattle farm in the semiarid Kalahari in Namibia (MAP 250 mm). The measurements took place from the end of the dry season 2016 to the middle of the rainy season 2017 and comprised 8 rain events. We selected 15 differently sized individuals of blackthorn and sampled their xylem water with a Scholander pressure bomb. We used stable isotopes as markers of water partitioning, since rain, soil water in different depths, groundwater and plant water differ in their natural signature of O and H isotopes. Big blackthorn bushes use the same water sources as small bushes. During a rain event, little rainwater is directly used. Instead, main water sources of blackthorn reside in deeper soil layers, with stronger rain events causing higher depths of use. Bushes prefer deep layers even after a heavy rain event when soil water is also high in shallow depths. Our results suggest a short phase of intense competition with shallower rooting grasses only if rain amounts are low. Independent of size, some bushes do compete with groundwater recharge. They use water that would normally go into the groundwater over time. Nevertheless, the bush in general seems not much of a threat for groundwater recharge in this semiarid savanna system.

Effect of organic farming on soil hydraulic properties and plant water relations

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Conventional high-input farming systems in Europe are often regarded as unsustainable with severe environmental impacts on biodiversity, soils, water and climate. Low-input approaches, typically referred to as organic farming practices, have been proposed as alternative farming systems with reduced environmental impact. The DOK trial is the world's oldest long-term field trial, in which organic and conventional farming systems are being compared since 1978. This experiment has shown that organic farming practices can, among many other effects, dramatically improve major structural properties of the soil, such as aggregate and percolation stability (Mäder et al. 2002 Science). What remains unclear is, whether these changes in structural soil properties also influence ecohydrological properties of organically managed farming systems and potentially improve the water relations of organically grown crops. We therefore investigated if soil hydraulic properties (i.e. matrix potential, infiltration rates, soil moisture and water holding capacity) and consequently plant water relations (i.e. midday water potentials, stomatal conductance and stable C and O isotope ratios) are affected by forty years of organic farming. We performed our investigations for almost two years on the two crop species winter wheat and soy bean. Against our expectations, organic management practices did not significantly affect soil hydraulic properties nor plant water relations under ambient climatic conditions. In future work, we will address if these patterns prevail also under extreme drought conditions.

Hydrological niche segregation of plant functional traits in an individual-based model

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Water is one of the major drivers determining distribution and abundance of plant species. Namely, plant species' presence and location in the landscape can be explained using metrics of soil water because plant species are restricted to a species-specific range of soil water conditions, i.e. their hydrological niche. However, little is known about the specific traits that determine the hydrological niche of a plant species. To investigate the relationship between plant functional traits, community structure and hydrological niche segregation, we developed a generic individual-based model PLANTHeR which describes plant functional trait abundance as a function solely of soil water and individual behavior. An important innovation is that there are no *a priori* defined trade-offs so that the model is neither restricted to a certain set of species nor scaled to a specific ecosystem. We found that plant functional traits and their combinations (plant functional types – PFTs) were restricted to specific ranges of soil water potentials. Furthermore, the intensity and direction of functional trait trade-offs and correlations were determined by water stress intensity. Most interestingly, the correlation intensity between traits representing competitive ability and traits promoting colonization ability changed in a unimodal fashion across a complete soil water gradient from water logging to drought. Our results suggest that soil water largely governs the functional composition and diversity of plant communities. This has consequences for predicting plant species' response to changes in the hydrological cycle due to global change.

Xylem plasticity: tracheid and pit architecture of *Pinus sylvestris* growing on a dry and a humid site

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Tree hydraulics are based on xylem structures and function. In conifer xylem, tracheids provide mechanical and hydraulic functions, with pits playing a central role for hydraulic efficiency and safety. Pits represent the main water transport resistances and they are crucial for embolism avoidance. In the present study, the plasticity in tracheid and pit architecture of *Pinus sylvestris* was analysed. Wood cores (2 per tree) were extracted from trees growing at a dry site (Tschirgant) and at a humid site (Mieming), both located in the Inn valley west of Innsbruck. On the first core, year ring series were measured with TSAPwin™ Scientific (ver. 4.80e RINNTECH). This core was also used to measure tracheid parameters (diameter, cell wall reinforcement) via light microscopy (Olympus BX41, Olympus, Austria) and ImageJ1.45 software (National Institutes of Health, USA) after preparation of cross sections. Radial sections prepared from the second core were analysed using scanning electron microscopy (SEM model XL 20, Philips, The Netherlands). Tracheid and pit parameters were measured on selected year rings. Mean year ring width was 726 ± 15 µm at the dry and 2,724 ± 135 µm at the humid site. Most xylem anatomical parameters were similar at both sites, only the torus to porus ratio (2.07 ± 0.02 and 1.78 ± 0.02), the torus overlap (i.e. [torus diameter–porus diameter]/torus diameter; 0.52 ± 0.01 and 0.43 ± 0.00) and the valve effect (i.e. [margo–torus]/torus x torus overlap; 0.22 ± 0.00 and 0.19 ± 0.00) differed between the humid and the dry site. Despite pronounced differences in growth, as indicated by year ring widths, xylem anatomical properties hardly varied between sites. Small differences were found in relative pit measures, which might enable slightly increased hydraulic efficiency at the dry site. The overall low plasticity in studied tracheid and pit dimensions indicates their architecture to be important in tree hydraulics.

Monitoring dynamics changes in water – and dry matter content of leaves, fruits and stems by means of a mobile NMR sensor (NMRS)

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Dry weight, fresh weight, dry matter content and water content are some of the most basic parameters to describe plant growth and water status. They have in common that they are easy to determine gravimetrically and destructively, but are remarkably difficult to measure and monitor in the living plant. In this context, Nuclear Magnetic Resonance (NMR) can help: it can directly and quantitatively detect protons in water and organic compounds, and is able to distinguish between liquids and solids. Unfortunately, NMR is known to be expensive, useful only in the laboratory, and difficult to use. Or is it? In this contribution we introduce a novel class of affordable, mobile NMR device that in their simplest form can be used as an on-line sensors to measure water- and dry matter content, in objects varying in size from pine needles and cereal leaves, to tree trunks and fruit. The devices can be operated in the field, and allow automated, uninterrupted measurements over periods of weeks, with a time resolution of less than a minute. With the addition of some hardware they can also be turned into mobile NMR imagers, capable of measuring flow. We will demonstrate these measurement modalities by means of experiments on a number of model subjects and problems: water storage in the stems and leaves of mangrove exposed to shock wise changes in soil salinity; the dynamics of dry matter deposition and seed water relations during the course of seed filling, and in imaging mode, the detection of air embolism formation in trees exposed to drought.

Plant water use strategies under drought conditions: new insights from lysimeter studies in alpine grasslands

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Alpine grasslands are biodiversity hotspots and provide multiple ecosystem services (i.e. water provisioning and grassland productivity/forage production). In a future climate change scenario, where precipitation patterns are expected to change, it is necessary to understand the effect on water balance fluxes in order to manage efficiently future grasslands. Water balance is influenced by abiotic factors, as well as by the water-use strategies of present vegetation. It remains questionable to which extent plant water-use strategies can buffer negative consequences of drought periods for these ecosystems. To assess the reaction of Alpine grasslands to varying drought conditions, different types of grassland ecosystems were investigated in a garden experiment at the long term socio-ecological research (LTSER) site 'Stubai Valley', Tyrol, Austria. In addition to local grassland types from the Stubai Valley characterized by the Northern Central-European climate, soil-vegetation monoliths from an inner-alpine dry valley, the Matsch Valley in South Tyrol, Italy, belonging to the LTSER platform 'Val Mazia/ Matschertal' were investigated. Water balance analyses were performed using high precision lysimeters (Smart Field lysimeters®, SFL, METER Group) with 0.3 m in diameter and depth, containing respective soil-vegetation monoliths from both sites. Additionally, seed mixtures commonly used when recultivating grassland at both sites have been selected and grown directly in the lysimeters on standardized soils. Different treatments were applied: moisture (long-term precipitation amount and frequency) and drought (with periods of no precipitation). Water balance was assessed and the measurements of stomatal conductance for species abundant in all grassland types were used to calculate plant transpiration by porometer-based upscaling. The analysed species were classified in three functional groups: herbs, legumes and grasses. Results showed that commonly used seed mixtures for reseeding or recultivation lack specific adaptations which make mature grassland ecosystems more resilient to drought. However, responses to drought revealed marked differences between site-specific grassland types, functional groups and even within species adapted to different environmental conditions. To a certain degree it remains debatable whether more frequent droughts will lead to a shift to better adapted plant communities or plants can initially adapt to drought physiologically / morphologically (i.e. as ecotypes).

Effects of continuous and pulsed deficit irrigation on the metabolome of wheat flag leaves

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As one component of global climate change, intensified drought periods are predicted for certain regions in the near future. Changes in the intensities and frequencies of precipitation probably not only affect the growth of plants, but also their chemical composition. In a greenhouse experiment, we investigated how different traits of wheat (*Triticum aestivum*) are affected by continuous *versus* pulsed deficit irrigation. Plants grown under deficit irrigation received 40 % of the water provided for control plants, either every other day (continuous deficit irrigation) or every eight days (pulsed deficit irrigation). Plant biomass, chlorophyll fluorescence and water use efficiency were determined at two time points during plant development. Moreover, (semi-)polar metabolites in the flag leaves including benzoxazinoids, which are characteristic specialised metabolites in wheat, were screened using an eco-metabolomics approach. The maximum quantum yield of photosystem II was not affected by deficit irrigation. Aboveground biomass was reduced under deficit irrigation, particularly if deficit irrigation was applied in a pulsed manner. Plants under drought showed higher water use efficiencies, especially under continuous deficit irrigation. The concentrations of many metabolic features in the flag leaves were higher in plants grown under deficit irrigation, with these effects being stronger for pulsed compared to continuously watered plants. Interestingly, at the first time point the pool sizes of two benzoxazinoid glucosides were higher in plants of the pulsed deficit irrigation treatment. This study shows that deficit irrigation has profound impacts on various traits of wheat, with these effects depending on the frequency of watering. These findings might be relevant for irrigation scheduling in agricultural fields. Moreover, the metabolic effects of deficit irrigation on flag leaves probably modify interactions of the plants with their antagonists.

Combining field experiments and simulation modelling to assess the effect of rainfall frequency on a common dryland biocrust lichen

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Biological soil crusts (biocrusts) are poikilohydric communities consisting of mosses, lichens, cyanobacteria and other microorganisms that live on the soil surface. They play an important role at the ecosystem level because they protect the soil, influence the redistribution of water, and impact the carbon and nutrient cycle. Biocrusts have been found to be sensitive to changes in precipitation frequency, although they are desiccation tolerant and adapted to extreme conditions. Despite their importance for ecosystem functioning especially in drylands, they have rarely been included in ecosystem models. We will combine a field experiment with a simulation study to assess the long-term impacts of different rainfall frequency patterns on the common biocrust lichen *Diploschistes diacapsis*. In the field experiment, we found that *D. diacapsis* indeed responds differently to two rainfall frequency patterns despite receiving the same overall water amount. We will use this experiment together with literature data to parameterize a global-scale process-based lichen and bryophyte model and will simulate the dynamics of *D. diacapsis* at the local scale. Our study shows the potential of combining short-term experiments with long-term simulation experiments to upscale local estimates to the ecosystem level.

POSTER PRESENTATIONS

SESSION 34-P1

Links between moisture-induced metabolic changes in *Brassica napus* seed material and the corresponding virgin oils

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The chemo-sensory properties of virgin rapeseed (*Brassica napus*) oil are crucial for the acceptance of this niche product on the market. Improper storage of the seeds can adversely affect oil quality in terms of chemical and sensory traits. We investigated moisture-induced metabolic changes in the stored material and linked them to chemo-sensory properties of the virgin oils pressed from this material. Seeds were kept moist for one to four days and metabolite profiles of stored material and the resulting oils measured with several complementary analytical platforms. The sensory quality of the oils was assessed by trained testers. Under moist conditions, several amino acids and hexoses accumulated in the seed material within one day. These metabolic changes are probably due to a breakdown of seed storage compounds. Glucosinolates are specialised defensive metabolites of Brassicales. Aliphatic glucosinolates were less affected during moist storage, whereas the concentrations of indole glucosinolates increased. This increase could be due to the higher availability of their precursors, i.e., amino acids and glucose, and probably indicates the transition from mechanical to chemical defence. Moreover, pronounced shifts in the volatile profiles of the resulting virgin oils occurred along with moist seed storage. Specifically, the concentrations of several volatiles increased. These metabolic changes are probably related to the moisture-induced metabolic processes found in the seed material. In parallel, the sensory quality of the oils decreased as indicated by assignments of off-flavor attributes at the expense of characteristic sensory attributes of virgin rapeseed oil. Our results revealed that even short seed storage under moist conditions adversely affects virgin rapeseed oil quality. As the changes are probably irreversible, this study highlights that permanent seed storage under optimal conditions is crucial for the production of high quality virgin rapeseed oil.

SESSION 34-P2

Coping with drought in agriculture – investigation of wheat-aphid interactions under different drought regimes

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In a changing environment, where frequencies and amounts of irrigation become an increasing obstacle in agriculture, investigations of consequences for crop systems are crucial. One of the world's three most important crops with a high annual yield and extensive acreage is wheat. Guaranteeing high yields despite unfavorable cultivation conditions is especially important with regard to the growing world population. Besides increasing abiotic stress, such as drought, crops also have to cope with various pests. In Europe the English Grain Aphid (*Sitobion avenae*) is a major pest on wheat. An infestation leads to a loss in yield, because aphids preferably suck on young plants and developing ears, where they ingest the nutrient-enriched phloem sap. Thus, stress-induced changes in plant quality also have an impact on crop pests, which leads to investigate the interactions between wheat and pests in a changing environment. We studied how continuous (cd) and pulsed drought (pd) influence the phenotype, biomass and phloem sap composition of summer wheat plants compared to well-watered control plants (ctr) in a climate chamber experiment. Furthermore, we investigated the effects of drought stress treatments on aphid population growth and survival as well as the combined effects of drought and aphid treatment on plant traits. Under both drought conditions the total biomass was reduced in all plants compared to ctr plants. Especially in pd plants generative biomass and the number of ears was drastically reduced. On ctr plants aphid populations grew bigger compared to cd and pd plants, whereas on pd plants 50 % of the populations were dead after one week. The relative composition of phloem exudates was affected by both the drought stress treatment and aphid feeding to different extents. The results are discussed in the context of the 'plant stress hypothesis', postulating that aphids perform better on drought-stressed plants and the 'plant vigor hypothesis', which argues that herbivores rather benefit from feeding on well-watered, vigorous plants. The outcome of our study contributes to our knowledge about wheat-pest-interactions under stress and provides information to perhaps ameliorate agricultural praxis under climate change conditions.

SESSION 34-P3

Water relations in a Mediterranean ecosystem: a fresh perspective on the two-water-worlds hypothesis

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Plant invasion can strongly alter ecosystem water balance particularly in water limited ecosystems where competition for water is high. We investigated water relations in a Mediterranean cork-oak woodland encroached by the native shrub *Cistus ladanifer* under severe drought. We combined stable isotope sampling of ecosystem water pools (precipitation, groundwater, soil water profiles, plant xylem water of the dominant oak (*Quercus suber*) and the shrub invader with observations of soil water contents and sap flow. In particular, we tested the 'two-water-worlds' hypothesis, which postulates low connectivity between bound and mobile soil waters and preferential root-water-uptake of bound soil water sources, based on dual water isotope observations of soil water profiles and xylem waters. Specifically, we tested the pool-weighted impact of potentially isotopically distinct water pools for hydrological cycling, the influence of species-specific water use and the degree of eco-hydrological separation. Stable water isotopes in shallow soils were evaporatively enriched during dry-down periods, but enrichment faded strongly with depth and upon precipitation events. Despite clearly distinct water sources and water use strategies, both species displayed a highly opportunistic root-water-uptake pattern. Our results do not support two critical assumptions of the 'two-water-worlds' hypothesis: Neither did we find evidence for low connectivity between bound and mobile water nor preferential root water uptake of bound water sources. Moreover, pool weighting the contribution of evaporatively enriched soil water reveals only minor annual impacts to ecosystem water cycling (~ 11 % of bulk soil water and ~ 15 % of transpired water). These data clearly show that a pool-weighted analysisis required, taking the eco-physiological adaptations and distinct water use strategies of each species into account. These clearly indicate that the high water use of the invader and drought synergistically reduced ecosystem transpiration and the resilience of the dominant oak. Thus, invasion of water spending species and recurrent extreme droughts may synergistically cause critical drought tolerance thresholds of key-stone tree species to be surpassed, corroborating observed higher tree mortality in the invaded ecosystems.

SESSION 34-P4

Effect of monsoon failure on tree water use in Himalayan montane forests

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The Himalaya is an important source of water for the Indian subcontinent where the summer monsoon rain maintains lush forests on the southern slopes. Yet historic periods of monsoon failure over one or more years are known. Climate change can alter the intensity, duration and spatial distribution of monsoon rains and may result in episodic regional drought. This would affect forests and their ecosystem services in the mountains as well as downstream. To investigate the effect of monsoon failure on Himalayan forests, we established throughfall exclusion experiments in two forests in Bhutan: at Pangsho (2,350 m asl) dominated by oaks (*Quercus grifithii* and *Q. lanata*), and at Tashigang (3,200 m) dominated by conifers (*Tsuga dumosa*) and *Q. semecarpifolia*, both with *Rhododendron arboreum* in the understory. Rainfall was excluded by plastic sheets covering areas of 25 x 29 m at a height of 2 m and soil water flow by trenches. Sapflow was measured on a total of 58 trees in two rainfall exclusion and two control plots in each of the two sites over more than one year. Water use was reduced in all species and more so in the wetter but cooler forest at Tashigang than in the drier and warmer forest at Pangsho. Though trees showed obvious effects of drought stress, they generally recovered after the drought stress, suggesting a certain resilience of the forests to even extreme drought. Throughfall exclusion experiments are not perfect simulations of monsoon failure as they do not change vapor pressure deficit and sunshine, and a certain amount of water flow into the plots at deeper soil layers is difficult to avoid. Yet the experiment permits to investigate the response of local tree species to drought and to the drivers of water use. Combined with physiological measurements at the leaf level it will serve to model the response of trees to extreme drought and help to understand potential effects of climate change on Himalayan forest ecosystems.

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