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150 years of Ecology – lessons for the future

46th Annual Meeting of the Ecological Society of Germany, Austria and Switzerland

Gesellschaft für Ökologie e.V. (GfÖ)

Philipps-Universität Marburg, 05 – 09 September 2016

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Preface

Dear colleagues and friends, dear guests,

I am happy to welcome you to the 46th *Annual Meeting of the Ecological Society of Germany, Austria & Switzerland* (GfÖ) at the *Philipps-Universität Marburg*. After 2007, this is the second time that Marburg hosts the annual meeting of the GfÖ. Our university was founded in 1527 as the first Protestant academic institution worldwide. Presently, we host more than 25.000 students, 12% of whom have an international background. Most scientific disciplines, with the exception of the engineering sciences, are represented at the *Philipps-Universität Marburg*. They are organized in 21 faculties. The *Faculty of Biology* consists of ten departments, representing four broad research fields: (1) Ecology, Nature Conservation, Biodiversity; (2) Molecular Cell Biology and Plant Physiology; (3) Animal Development and Physiology; (4) Microbiology and Genetics. There are also close ties to the *Faculty of Geography*, members of which are also active in the scientific committee of our conference.

The motto of this year's meeting, "150 years of ecology - lessons for the future", was inspired by an important anniversary. In 1866, *Ernst Haeckel* coined and defined the term "*Oecologie*" in the second volume of his treatise on the "*Generelle Morphologie der Organismen*". He clearly envisaged the research protocol of ecology at the crossroads between physiology, phylogeny and biogeography. However, the anniversary of the term "*Oecologie"* is not the only important anniversary in 2016. As GfÖ president Volkmar Wolters pointed out to me, 2016 is also the 250th birthday of *Thomas Robert Malthus*. Although he was no ecologist - he worked on macroeconomics - his growth model inspired Darwin to develop his theory of speciation and therefore had a profound impact on ecology. These anniversaries show that current ecological research is based on achievements and insights gained well before computers and electronic data sources became available. I hope that our meeting will provide opportunity to look back on the development of ecology, reminding us that our work is being facilitated by the genius of our predecessors.

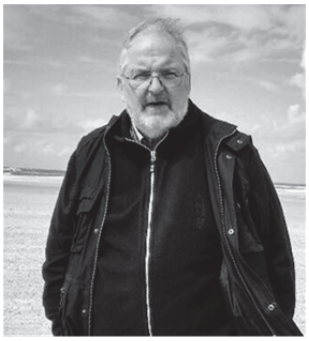
I would like to thank the many people who have contributed to the successful organization of the meeting here in Marburg. First of all I would like to mention Juliane Röder, Dana Schabo and Martin Brändle who have been the core organizers of the meeting, together with Heike Kuhlmann. Furthermore, I would like to express my gratitude to the keynote speakers for providing us with a comprehensive framework concerning recent developments in ecological sciences as well as the chairs of the various sessions for suggesting inspiring topics and for organizing the sessions.

Finally I would like to mention that Marburg is a lovely medieval city with many possibilities for sightseeing. Thus, we hope that the meeting in Marburg will offer a stimulating atmosphere not only for discussions during the conference, but also for personal exchange with colleagues whilst strolling through Marburg's narrow streets.

Roland Brandl

Faculty of Biology
Animal Ecology
Philipps-Universität Marburg

Dear friends and colleagues,



I warmly welcome you to the 46th Annual Meeting of the Ecological Society of Germany, Austria & Switzerland. It is being hosted by the University of Marburg – just nine years after hosting the 37th GfÖ Meeting. Our society is very grateful to all the local people involved for their willingness to accept again the enormous burden of organizing such a large and diverse conference. Our friends in Marburg have done a great job in designing an exciting and highly up-to-date program.

Building on last year's meeting in Göttingen "*Ecology for a Sustainable Future*", our motto in 2016 is "*150 Years of Ecology – Lessons for the Future*". One and a half centuries after Ernst Haeckel created the term 'Ökologie', driven by the ideas of Darwin, ecology has become a rigorous science that can be proud of its achievements, but still faces enormous challenges. Rarely has Haeckel's definition of ecology as the "*Economy of Nature*" been as timely as today – almost one year after the adaptation of the Sustainable Development Goals (SDG) by the United Nations. Of course, the objectives of our discipline go far beyond investigating the global environmental problems directly or indirectly caused by human beings. However, my remark in 2015 that sustainability will only be reached when the route to each individual SDG makes use of the best ecological knowledge available has lost nothing of its topicality.

As a vital starting point for learning our lessons for the future, the meeting in Marburg will give us the chance to reflect upon the progress we have made in the past and – even more importantly – to identify the many unsolved scientific questions that still confront us. As the organizers have nicely written in their introduction to the Marburg meeting: Where are we? What have we learned? What are the gaps? What are the challenges? I am looking forward to discussing these and other issues in the ancient but nevertheless youthful city of Marburg - the oldest Protestant university in the world.

Volkmar Wolters

President of the GfÖ

Keynote lectures

MONDAY 13:30 – AUDIMAX (+2/0010)

Past, present and future macroecology and biogeography: 200 years of large-scale pattern and process in ecology and evolution

Susanne Fritz[1,2]

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Macroecology deals with large-scale patterns of abundance, distribution, and diversity across multiple species, to identify general principles underlying the structure and function of ecological systems (definition after Blackburn & Gaston 2003). Compared to ecology as a whole, macroecology is a young discipline, since the term macroecology was officially coined as late as 1989. However, many patterns and processes that are commonly studied in macroecology were described and postulated much earlier: classic biogeography has long been concerned with patterns such as species distributions and elevational diversity gradients, going back to early naturalist explorers such as Alexander von Humboldt and Alfred Russell Wallace. I will show some prominent examples of historical research that can be classified as macroecology today, and contrast historical scientific findings to current updates of the classic patterns.

I will also endeavour to give an overview of the main challenges faced by macroecology now and in the near future. In 2012, the macroecology Special Interest Group of the GfÖ published a forum paper called: "What's on the horizon for macroecology?" We identified the main challenges as i) integrating the past, ii) considering local processes and fine-grain variability, iii) generating and tapping new data sources for large-scale but high-quality datasets, and iv) utilizing more sophisticated statistical methods to account for biases inherent to large-scale sampling. I will use recent studies to assess whether and how these challenges are being addressed, and to identify future directions that will enable real progress in the fields of macroecology and biogeography.

TUESDAY 08:30 – AUDIMAX (+2/0010)

Harnessing the potential of satellite remote sensing research in the face of global environmental change

Nathalie Pettorelli[1]

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Global environmental change is a growing threat to the Earth's biological diversity, potentially leading to detrimental impacts on ecosystem services and human well-being, particularly for the world's most marginalized and impoverished communities. Our ability to monitor the state of biodiversity and the impacts of global environmental change on our natural capital is fundamental to designing effective adaptation and mitigation strategies. This requires the scientific community to assess spatio-temporal changes in the distribution of abiotic conditions and in the distribution, structure, composition and functioning of ecosystems. The potential for satellite remote sensing (SRS) to provide key data has been highlighted by many researchers, with SRS offering repeatable, standardised and verifiable information on long-term trends in biodiversity indicators. SRS permits one to address questions on scales inaccessible to ground-based methods alone, facilitating the development of an integrated approach to natural resource management, where pressures to biodiversity, biodiversity state and consequences of management decisions can all be monitored. Here I will provide an interdisciplinary perspective on the prospects of SRS for ecological applications, reviewing established avenues but also highlighting new research and technological developments that have a high potential to make a difference in global change ecology and environmental management. I will also discuss current barriers to the ecological application of SRS-based approaches, and identify possible ways to overcome some of these limitations.

TUESDAY 14:00 – AUDIMAX (+2/0010)

After the hype: A 'reality check' for trait-based functional biodiversity research

Christian Wirth[1,2]

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Trait-based approaches in functional biodiversity research rest on the assumption that individual traits capture important biological and ecological mechanisms and thus represent means to generalize across species (and their idiosyncrasies) when predicting and analyzing plant and ecosystem functioning. In recent years, this development has been fueled by an explosion of trait information available via on-line databases (e.g. www.try-db.org). The concept has been applied to a wide range of processes, levels of integration (organ, individual, population, community, ecosystem) and spatial and temporal scales. Using examples of experimental, observational and modelling studies I will present a critical assessment of trait-based approaches in functional biodiversity research and their heuristic value. I suggest that that advances in the field can be expected from approaches that (i) consider process hierarchies of trait-function relationships, (ii) carefully explore the joint operation of different facets of functional biodiversity, and (iii) design new real-world and virtual experiments to progress from correlative prediction to causation.

WEDNESDAY 08:30 – AUDIMAX (+2/0010)

The interaction between global change and ecosystem functioning

Rien Aerts[1]

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Global change factors such as atmospheric nitrogen deposition, global warming and changes in precipitation patterns may have a tremendous impact on ecosystem functioning. On the other hand, ecosystems may have a strong impact on the regional and global climate. Due to recent advances in molecular ecology and Earth System Modeling (ESMs) these interactions between global change and ecosystem functioning can now be studied from the molecular level to the whole Earth System ('from microbe to globe''). This will be illustrated by data from case studies in cold biomes. Particular attention will be paid to the partitioning of carbon fluxes between organic matter decomposition (almost continuous, low rates) and fires (low frequency, high carbon losses) and to the plant traits thay underly these fluxes. Finally, it will be shown have remote sensing data of plant traits can be used to predict these fluxes at large spatial scales

WEDNESDAY 14:00 – AUDIMAX (+2/0010)

Community structure across trophic interfaces

Thomas Lewinsohn[1]

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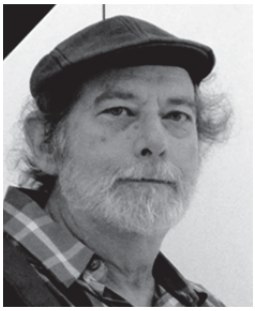

The investigation of ecological interactions in communities was initially pursued along two avenues: first, describing entire food webs, which comprised predator-prey or consumer-resource relations, which largely ignored parasites and decomposer webs. Second, performing detailed studies of the interactions of a few selected species, sometimes through experiments, regardless of other species with which they cooccur and may also interact. Whereas studies of entire food webs are very laborious and suffer from problems such as uneven taxonomic resolution, detailed results on particular interactions allow hardly any extrapolation or prediction of community-wide interaction patterns. The focus on a particular trophic (or nontrophic) interface overcomes to a large extent these limitations. I will present a selective overview of community-wide studies which, in the last two decades, have investigated plant-herbivore and host-parasite interactions as well as mutualistic (e.g. plant-disperser) interactions. Interaction patterns can be inspected and modeled in several ways. The application of complex network theory has offered insights into the structure and underlying processes at these interfaces. New concepts of specialization allow further elucidation of the organization of interactions. To conclude, I will consider possibilities of extending such approaches to multiple trophic interfaces, with prospects for further breakthroughs enabled by genomic and other tools.

THURSDAY 08:30 – AUDIMAX (+2/0010)

Who serves whom in Nature? Lessons from contemporary ecological approaches to linking ecosystem services to societal well-being.

Shahid Naeem[1]

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The study of the interface between an organism and its biotic and abiotic realms, an approximation of Haeckel's definition of ecology, concerns three classes of traits; (1) an organism's environmental requirements, (2) its environmental impacts, and (3) its responses to environmental change. Contemporary ecology has moved away from its historical roots in population-based research to trait-based research because these three classes of traits collectively form the logical link between organisms and environment, a link difficult to establish using population-based approaches. Traits are also more readily quantifiable than population parameters, such as intrinsic rates of increase and carrying capacities, and traits provide means of scaling biological processes from the molecular to the biosphere. I provide three examples derived from studies of a temperate forest, an arctic tundra, and birds of the Solomon Islands, all of which illustrate the critical importance of an ecosystem's biodiversity to its functioning. This work is part of a global body of modern ecological research that points to the extraordinary importance of biodiversity to environmental processes and, by extension, how nature serves society. As the modern environmental paradigm continues to shift in this direction, however, in which all organisms, all dimensions of biodiversity, and all ecosystems are reconfigured to serve society, the consequences of this shift merit closer examination. Trait-based research argues that the more stable approach to securing societal well-being, now and into the future, may not be one in which nature serves humanity. Rather, the converse, in which humanity sees itself in the service of nature, may better secure our environmental future in a time of unprecedented global change.

Public

lecture

TUESDAY 06 SEPTEMBER, 20:00 – AUDIMAX (+2/0010)
OPEN TO THE PUBLIC – FREE ADMISSION!

Der Haeckel-Faktor. Oder: Wie Darwin und Wallace die Evolution entdeckten.

Dr. Matthias Glaubrecht[1]

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In seiner explizit auf Darwins Theorie Bezug nehmenden „Generellen Morphologie“ benannte Ernst Haeckel vor 150 Jahren erstmals „Ökologie“ als Disziplin, die die Beziehungen der Organismen untereinander und zu ihrer unbelebten Umwelt erforscht. Seitdem verfügen wir über einen Begriff für Faktoren, die jenen evolutiven Wandel vorantreiben, der wenige Jahre zuvor – im Juli 1858 in London – unter höchst bemerkenswerten Umständen erstmals öffentlich vorgestellt wurde. Unabhängig von Charles Darwin (1809-1882) hatte auch der britische Naturforscher Alfred Russel Wallace (1823-1913) fernab im Indomalaiischen Archipel mit dem Prinzip der natürlichen Selektion den entscheidenden Mechanismus der Evolution erkannt. Ein Aufsatz von Wallace wurde gemeinsam mit einem Auszug der bis dahin unpublizierten Ideen von Charles Darwin verlesen und anschließend veröffentlicht. Doch seit dessen epochales Werk „Über die Entstehung der Arten“ im darauf folgenden Jahr erschien, gilt meist allein Charles Darwin als „Vater“ der Selektionstheorie, während Wallace in dessen Schatten blieb. Bis heute sind Wissenschaftshistoriker damit beschäftigt, die erstaunlichen Ereignisse um die Entstehung dieser Theorie zu rekonstruieren, die zu einer bahnbrechenden Revolution im Denken führte. Was oft als Zufall, Zeugnis der Großmut zweier bedeutender Forscher oder Koinzidenz aufgefasst wurde, ist für andere einer der ungeheuerlichsten Vorgänge der Biologie-Geschichte. Dank vergleichender Auswertung erst unlängst publizierter Dokumente lassen sich die dramatischen Ereignisse um die Entdeckung der Evolutionstheorie aus wissenschaftshistorischer Sicht rekonstruieren und vor dem Hintergrund unseres aktuellen Verständnisses von Ökologie und Evolution beleuchten.

Abstracts

Session 1 – Frontiers of Macroecology

Chairs
Dr. Christian Hof
Dr. Marlee Tucker
Prof. Dr. Holger Kreft

Session 1-O1 - Integrating physiology and ecology at the macroscale to better understand species' responses to global change

Christian Hof[1], Joel Methorst[1], Imran Khaliq[1,2]

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[2]Ghazi University, Dera Ghazi Khan, PK

To understand whether and how species and ecosystems are able to respond to global change is still one of the major challenges in macroecological research. Over the recent decades, macroecology has developed powerful tools to study species' responses to anthropogenic impacts. Here, I will discuss several avenues of how our analytical and predictive abilities of biotic responses to global change may be improved by integrating data and approaches from different areas of ecological research. As examples, I will present recent studies on (1) how thermal trait data from physiological experiments may help to better understand relationships between species distributions and ambient climatic conditions and (2) the relationships between species' thermal tolerances and empirical dispersal abilities (i.e. two key response pathways of species to react to climate change). I will highlight the need for and the opportunities of more and better integration among (sub)disciplines of ecology and biogeography in order to improve our understanding of macroecological patterns as well as the potential effects of global change threats on species and biodiversity.

Session 1-O2 - Improving Species Distribution Models: How to account for biological traits and land-use change

Joel Methorst[1], Christian Hof[1]

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A variety of different approaches exist in order to study the effects of climate change on species. Creating Species Distribution Models (SDMs) is probably the most common approach. However, this method usually fails to consider species specific biological traits or land use change, even though there is the overall consensus that these factors can determine how well species will cope with global

change. In this study we therefore introduce an improved SDM approach, where we not only use climate data but also information on the species' physiology. For this purpose, we create a unique parameter termed "metabolic suitability". Additionally, we account for dispersal ability and land use change in our analysis. Our results highlight strong variations in predicted future range size, depending on the factors considered in the analysis. Based on climate and physiology our models predict a strong range increase in the future. However, as soon as we account for land use change and dispersal ability our predictions show that the future range might suffer from severe area loss. So far, there has not been any study with comparable methodology and thus our approach may have the potential to become a new tool in order to assess species' vulnerability to climate change.

Session 1-O3 - Elevational shifts at rear edges are more sensitive to climate warming than at leading edges

Sabine Rumpf[1], Karl Hülber[1,2], Niklaus Zimmermann[3], Stefan Dullinger[1,2]

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Recent climate warming has triggered range shifts of species along latitudinal and elevational gradients. Two major processes involved in range shifts are the colonization of new terrain at cool range margins, or so-called leading edges, and the extinction of populations at warm range margins, also termed rear edges. Empirical efforts in documenting recent range shifts have, however, mainly concentrated on the leading edge or on species' optima and have much less frequently considered the dynamics at rear edges. It has been speculated that extinctions may inherently take a longer time than colonization processes, especially in long-lived species. As a corollary, relatively stable rear edges could actually buffer negative warming effects on species distributions to a certain extent, at least for a period of transition. A consistent summary of the empirical evidence on possible differences among elevational leading and rear edge dynamics under recent climate warming has, however, not been provided so far. We tried to fill this gap by a thorough search for and analysis of the data published on elevational range limit shifts of mountain species from re-visitation studies since the beginning of the last century. Concentrating on studies that document shifts of both upper and lower range margins for the same species in the same area, we extracted and analyzed 910 records of a wide range of biota from 19 re-visitation studies distributed around the world. Taken together, our results do not support the expectation that rear edges have been more resilient against recent climate warming than leading edges, at least not along elevational gradients. By contrast, rear edges have not only moved upwards faster and in closer correlation with climatic trends, but also without a significant time lag. This evidence suggests that

asymmetry of boundary shifts will rather accelerate than delay population decline and eventual extinction of mountain biota.

Session 1-O4 - The eco-evolutionary dynamics of range expansions - theoretical and experimental insights

Emanuel Fronhofer[1,2], Florian Altermatt[1,2]

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[2]University of Zurich, Department of Evolutionary Biology and Environmental Studies, Zurich, CH

Understanding and predicting the (macro)ecological and evolutionary dynamics of range expansions is of great ecological and economical interest. While theoretical and comparative work has advanced significantly over the last years, some of the most basic predictions concerning evolutionary changes during range expansions and their feedbacks on macroecological dynamics and patterns remain to be tested experimentally. Central predictions that remain to be tested include that range expansions select for increased dispersiveness at range margins, that population density decreases from range core to range margin due to trade-offs between dispersal and competitive ability and that invasions into fitness-relevant gradients will lead to stable range borders, to name a few examples. In order to provide causal evidence in favour or against these predictions we studied range expansions theoretically and experimentally using microcosm landscapes and protists as model organisms. While we find that range expansions indeed select for increased dispersal at range margins we do not find that population densities decrease from range cores to ranges margins. We also find that expansion dynamics are disturbingly insensitive to gradients in local mortality. Our results show that a number of theoretical predictions concerning rapid evolutionary changes during range expansions do not hold true, even in simple microcosm landscapes. We link these erroneous predictions to the fact that resource dynamics are typically ignored and competition for resources is often captured by misleading, non-mechnistic models.

Session 1-O5 - Paradise burns: projecting the survival of 26 Proteaceae species under changing climate and fire regimes

Alexander Kubisch[1], Jörn Pagel[2], Frank Schurr[2]

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[2]University of Hohenheim, Stuttgart, DE

Species are nowadays not only confronted with rapid changes in climatic conditions, but often they are also additionally challenged by changing disturbance

regimes. One such regime is defined by recurring wild fires in Mediterranean-type ecosystems like the Cape Floristic Region in South Africa. In this study we aim to project the survival of plant species adapted to wild fires under potential future conditions. To do so, we perform range-wide population viability analyses for 26 South African shrub species (Proteaceae) that use data-driven demographic models. We calculate the mean time to extinction under current and future climatic conditions and investigate the influence of changing fire frequencies. Our results show a wide range of responses with large inter-specific variation. They can in part be explained by species traits such as average plant height or the ability to resprout after fire. Such a combination of large-scale empirical data, derived niche estimates and stochastic population modelling opens a new route to projecting future survival, range shifts and community composition.

Session 1-O6 - Dissecting global turnover in vascular plants

Christian König[1], Patrick Weigelt[1], Holger Kreft[1]

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This study aims to provide the first global assessment of species turnover in vascular plants across geographic settings, taxa and functional groups. We analyzed a dataset of 496 vascular plant checklists, containing 420,000 occurrence records for about 98,500 species. We calculated pairwise floristic similarities (βsim) for subsets based on geographical setting (mainland, islands, different island types), taxonomic group (angiosperms, gymnosperms, pteridophytes), and functional group (trees, shrubs, herbs). For each subset, we analyzed the decay in similarity along geographical distance using generalized linear models and assessed the relative importance of geographic distance vs. environmental conditions using generalized dissimilarity models. Overall, turnover rates were lowest for pteridophytes and herbs, and highest for gymnosperms and shrubs. Environmental variables generally explained a larger amount of compositional variation than geographic distance, but the relative importance differed strongly among subsets. Unexpectedly, turnover among islands was lower than among mainland units and predominantly driven by differences in environmental conditions, whereas mainland turnover was about equally dependent on geographic distance and environmental conditions. This contrast was – to different degrees – consistent across taxonomic and functional groups. We conclude that turnover on global scales is strongly impacted by dispersal and environmental filters imposed by the geographical setting. The strength of filtering processes is directly proportional to the amount of homogenization of realized species assemblages within a given setting. In addition, our results indicate that species groups are differentially successful in passing filters, depending on group-specific characteristics such as dispersal ability or environmental tolerance.

Session 1-O7 - The same, only different: analysing the world's grassland heterogeneity in terms of productivity and beta diversity

Samuel Hoffmann[1], Lauchlan H. Fraser[2], Jason Pither[3], Anke Jentsch[4], Marcelo Sternberg[5], Martin Zobel[6], Reinhold Stahlmann[1], Carl Beierkuhnlein[1]

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Ecological studies have been evolving for about a hundred years. So-called Coordinated Distributed Experiments (CDE) are recently discussed in ecology. The Herbaceous Plant Diversity Network (HerbDivNet) applied an ecological CDE in order to address the lack of investigations that consider grassland diversity at the global scale. Grassland is one the Earth's major ecosystems and is enormously contributing to the human well-being by ecosystem functions and services that depend on biodiversity. Beta diversity is heterogeneity in species composition and can be defined in many ways. It is an essential component of the concept of biodiversity. Discovering causes for differences within and between species assemblages is thus crucial for the understanding and the conservation of biodiversity and ecosystem functions or services, from which we profit. But beta diversity of the world's grassland is poorly examined. Therefore, we analysed beta diversity of the global grassland ecosystems by using the HerbDivNet data set. Former studies revealed that biomass production determines beta diversity by stochastic or deterministic, ecological processes, whose relative importance alters along the productivity gradient. Stochasticity and determinism are the main concepts of two contrasting, yet fundamental theories in ecology, the neutral theory and the niche theory, respectively. By relating biomass production, heterogeneity in biomass production, species richness and climatic parameters to thirteen beta diversity metrics, which are distinguished into four groups of distinct theoretical computation and practical meaning, we identified drivers and causes of grassland beta diversity worldwide, which can be assigned to one of both theories. Statistical methods included robust linear regression, the Mantel test and variance partitioning. Results showed that both stochastic and deterministic processes influence species composition of the Earth's grassland ecosystems. However, findings depend on the applied definition of beta diversity. Hence, we recommend taking advantage of the diversity of beta diversity concepts in order to unravel

ecological mechanisms generating species assemblages in future studies. Moreover, a large part of heterogeneity in species composition could not be explained at all. We finally suggest other unconsidered factors of grassland beta diversity worldwide to be incorporated into further research.

Session 1-O8 - Scale matters or not - What drives scale-dependence of ecological patterns?

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Scale-dependence is still an unresolved topic in ecological research. Many ecological responses to environmental stressors on small spatial scale are reported to strongly differ from the responses occurring on macro-scale. However, understanding about how and why ecological patterns are scale-dependent or not is largely lacking so far. Here we propose that the strength of abiotic links between scales as well as the level of biotic noise on small spatial scale drives scale-dependence of ecological patterns. More specifically we hypothesize that strong cross-scale links between micro- and macro-environmental drivers and low environmental noise on small spatial scale will go along with high cross-scale similarity, thus, low scale-dependence of ecological patterns. This hypothesis is confirmed by a first study we conducted in spring fens, environmentally stable, wetland ecosystems characterized by tight cross-scale links between micro- and macroclimatic conditions. Here we observed high cross-scale similarity of species temperature niche characteristics across the seven orders of magnitude of investigated spatial scale ranging from local to continental scale. Further tests of this hypothesis for other ecosystems which differ in terms of abiotic cross-scale links and small-scale environmental noise might help to increase our general understanding about scale-dependence in ecological systems. This understanding is crucial to assess future responses of ecosystems to the ongoing, rapid changes of environmental conditions induced by human activity.

Session 1-O9 - Machine learning allows unprecedented insights into factors driving riverine biodiversity patterns across large scales

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Biodiversity patterns are driven by multiple environmental factors that mutually interact across nested spatial scales. However, most biodiversity studies subjectively select a handful of these factors as explanatory variables to avoid over-parametrization. This comes with the risk of a priori discarding a pivotal factor. Random forest, a machine learning algorithm, enables to analyze a large number of variables and even all their higher-level interactions without causing the statistical problem of over-parametrization. Using a random forest approach, we aimed at understanding the relative importance of comprehensive environmental factors at nested spatial scales on macro-scale biodiversity patterns with an unprecedented precision. We built random forest models for α- and β-diversities of 518 riverine macroinvertebrate communities across Switzerland using 79 predictor variables and all their interactions. Our models explain about 60% of the variance in species richness, which is nearly doubling the prediction power compared to most of the similar precedent studies. In addition, we found that only a few explanatory variables play pivotal roles in explaining the biodiversity patterns. For instance, the five most important variables, including elevation and land use, contributed to >50% in the model's respective power to explain species richness of a target taxonomic group. In contrast, most of the other variables including 29 variables that explain local habitat conditions contributed far less (<1%). We demonstrate that riverine biodiversity patterns are strongly determined not by local factors but by a few landscape scale factors, highlighting the significance of an appropriate inclusion of explanatory variables at the appropriate spatial scale. We conclude that our approach may help to increase predictability in biodiversity studies in general, which were hitherto often limited by a low proportion of variance explained.

Session 1-O10 - Colour lightness of dragonfly assemblages across North America and Europe

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Dark-coloured ectotherms absorb energy from the environment at higher rates than light-coloured ectotherms. The thermal melanism hypothesis (TMH) states that this physical mechanism links the colour lightness of the body surfaces of ectotherms to their thermal environment and hence to their geographical distribution. Studieson different insect taxa in Europefound support for this prediction of the TMH. However, whether these results hold also for other biogeographical regions remains unclear. Here, we quantify and map the colour lightness of dragonfly species in North America and directly compare our results to

previously published findings for Europe. We estimated the colour lightness of 152 North American dragonfly species from published illustrations, compiled their distribution data from the literature and combined all these data with six biologically relevant environmental variables. We evaluated the importance of phylogenetic autocorrelation for the spatial variation of mean colour lightness of dragonfly assemblages (grid cells of approximately 50 km × 50 km size) by repeating all analysis also for the phylogenetically predicted component of the colour lightness of species and the species-specific deviation from this prediction. We also accounted for spatial autocorrelation with autoregressive error models. All statistical approaches showed that dragonfly assemblages from both continents consistently tended to be darker coloured in regions with cold climates and lighter coloured in regions with warm climates. Regression slopes, however, were significantly less steep and the amount of variance explained by environmental variables was lower for North America than for Europe. Our results highlight the importance of colour lightness for the distribution of dragonfly species, but they also indicate that idiosyncrasies of the continents modify the general pattern.

Session 1-O11 - Comparing the macroevolution of body mass in large mammals between two Neogene continents

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Because body size connects with many other aspects of a species, broad-scale patterns of body size variation can shed light onto the underlying processes that have shaped the world's biodiversity. In this study, we combine the macroevolutionary and biogeographic perspectives to investigate whether body size variation can be associated with differential origination and/or extinction rates in different faunas, thus directly linked to the regional dynamics of biodiversity. We took advantage of the fossil record, serving as a direct window to the evolutionary history, and applied a Bayesian analytical approach to an extensive body size dataset of Neogene large herbivores (971 species in the orders Artiodactyla and Perissodactyla) in Europe and North America. We reconstructed the temporal patterns of body mass evolution in each order on each continent independently, using species-specific origination and extinction times estimated from distributions of fossil occurrences. We found increases of body size through time in three out of

our four focal assemblages, and all three showed significant increases in minimum size through time, so that the clade-level pattern is most likely driven by selection for large bodies, rather than a bounded diffusive process. We then assessed whether changes in body mass are linked to clade-specific diversification dynamics by comparing different trait-correlated birth-death models. The common trend of body size increase seems to have been generated by different processes in different clades and regions. We found a significant correlation of body size with species origination rate in Artiodactyla in Europe, but with extinction rate in Perissodactyla in North America; both results further support the idea of a driven evolution towards larger body sizes. Notably, further sampling effort is unlikely to alter the patterns, as we did not find larger bodies associated with higher preservation rates in any of our groups. Collectively, our results highlight the value of investigating macroevolutionary dynamics in a biogeographic context. Because evolution takes place in environmental templates provided by different regions, further integration of the temporal and spatial dynamics can provide a deeper understanding of body size evolution.

Session 1-O12 - Morphological distinctness in birds: linking phylogeny and geography to identify processes shaping trait distributions

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Understanding the processes that influence the distribution of morphological diversity is a relevant issue in ecology and evolution. While recent studies have focused either on the evolution or diversity of morphological characteristics in specific taxa that have colonised new regions or habitats, few have attempted to combine these two aspects. Here, we investigate and contrast ecomorphological diversity across 489 species in eight avian clades based on measurements of 9 morphological traits that reflect ecological niches. We combine previous approaches by testing for correlations of species-level ecomorphological distinctness with phylogenetic history and geographic distributions within and across clades. Previous attempts to understand morphological diversity have not compared this consistently among multiple clades. We compare a set of radiations of approximately the same size, thereby standardizing the morphological diversity for the number of species. Though most clades show some degree of phylogenetic signal, we find no unifying pattern across clades when considering the correlation between ecomorphological and phylogenetic or geographic distinctness. However, we did observe a positive correlation across all eight groups, showing that in general ecomorphologically distinct species are also more isolated on the phylogeny. Furthermore, we found a negative correlation between

ecomorphological and geographic distinctness in most groups for which ecomorphological distinctness of species could not be explained by the phylogenetic structure of the clade. These results imply that morphological diversity has not accumulated at equal rates in different phylogenetic lineages, and that competition between lineages that co-occur could lead to higher morphological distinctness independent of phylogenetic relatedness. Our findings contribute to untangling the evolutionary and ecological processes that influence the distribution of species in morphological space.

Session 1-O13 - Linking long-term climate stability, species pools and forest productivity

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Variation in terrestrial net primary productivity (NPP) is thought to be driven by large-scale gradients in temperature, precipitation and growing season length as well as by stand characteristics such as standing biomass and plant age. Alternatively, findings from biodiversity experiments also suggest a positive effect of species richness on NPP. As local species richness is controlled by the size of regional species pools, we hypothesize an indirect effect of historical climate on NPP via its species pool effect. Testing this idea using Structural Equation Modelling and data from across Northern Hemisphere forests, we explore (1) whether Quaternary climate instability reduces forest NPP via a negative effect on the size of regional tree species pools, and (2) how important this effect is relative to contemporary climate and stand characteristics. Our study uses range maps of all tree species in North America and Europe to construct species pools, climate data from different time periods across the Quaternary and the present, as well as plot-scale data on NPP, stand biomass and age. Preliminary results indicate a separate effect of species pool size on forest NPP but that the form of the relationship differs among biogeographic regions. This suggests that considering both biogeographical and ecological drivers of NPP will allow for improved predictions of how climate change affects this important ecosystem function.

Session 1-O14 - Tropical niche conservatism does not explain high *Rhododendron* richness in tropical and subtropical China

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High tropical diversity is often linked to tropical niche conservatism hypothesis which assumes that most extant groups originated in the tropics, and are unable to disperse into cold climate due to niche conservatism. Given this hypothesis, we predict that tropics should harbor older species lineages and winter coldness should strongly limit their dispersal into temperate regions. Here, using *Rhododendron* distribution data, we aim to assess the determinants of their richness pattern and ultimately evaluate whether tropical niche conservatism can explain their higher diversity in tropical and subtropical China. We compiled distribution data for all *Rhododendron* species in China and estimated species richness at 50×50 km spatial resolution. We performed bivariate regressions to evaluate the effects of environmental variables on species richness followed by stepwise regression to select the best predictors. Age of each species was estimated from dated phylogeny constructed using 9 chloroplast and 7 nuclear genes. We found that the variables of habitat heterogeneity and climate seasonality were consistently the strongest predictors of species richness. The contribution of winter coldness was nearly 4 times lower than variables of either of the above categories. Species occurring in tropical and subtropical China were much younger (< 10 Myr) than those occurring in northern China. Our results indicate that higher tropical diversity of *Rhododendron* does not appear to be influenced by evolutionary history but rather driven strongly by contemporary climate. Although tropical niche conservatism has been widely acknowledged for higher tropical diversity, none of its explicit assumptions including the time-for-speciation effect seem to fit this group. The formation of landscape with a wide variety of habitats (e.g. subtropical valley, temperate slopes and alpine peaks) all clustered closely together in south-west China, might have fostered species existence by providing diverse niche space, promoting speciation by isolation and offering shelter and refuges during quaternary glaciation. We conclude that species diversity pattern at large spatial scale is predominantly determined by variability in climate and habitat.

Session 1-O15 - Why do biotic interactions between plants and animals matter for macroecology?

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Plant-animal interactions are pivotal for structuring ecological communities across the majority of terrestrial ecosystems. Although these interactions mostly occur at relatively small spatial scales (i.e. within ecological communities), it is likely that plant-animal interactions influence the large-scale distribution of species and will also play a crucial role for species' range shifts in response to climate change. The analyses of biotic interactions from a macroecological perspective requires the integration of methodological approaches from different ecological disciplines.

Here I will first show that the functional diversity of fleshy-fruited plant and frugivorous bird communities matches along elevational gradients in the tropics, suggesting a high degree of trait matching between interacting species groups at large spatial scales. Hence, future range shifts of species may depend on those of their interaction partners. To address this notion in more detail, I will present results from a collaborative study of pollination and seed-dispersal interaction networks across central Europe. Here we link the biotic specialization of plants and animals in these networks with their vulnerability to projected changes in climatic conditions. The results of these analyses suggest that biotic specialists are most prone to future changes in climatic conditions. Moreover, plant extinctions under climate change are likely to trigger co-extinctions of specialized animal partners, whereas the opposite effect is less likely to occur. In summary, these studies highlight that biotic interactions are essential for understanding the large-scale distribution of species and the responses of plants and animals to future conditions.

Session 1-O16 - Intrinsic and extrinsic drivers of mammalian movement: a global signal of the human footprint.

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Understanding the causes and consequences of animal movements is important because they are critical for species' survival, as well as having direct and indirect effects on ecosystem structure and function. The increasing human population, land use changes and habitat fragmentation is altering animal behaviour. How animal movements are changing due to anthropogenic landscape changes has to date only been explored on small scales (e.g., within a single species). In this study we have attempted the first comparative analysis to estimate the global effect of anthropogenic landscape changes on mammalian movements. We were interested in whether and to what extent mammalian movements will be limited in areas of higher anthropogenic impact due to the presence of artificial barriers that may restrict and alter animal movements. In collaboration with more than 100 co-authors and data contributors, we compiled a data base of tracking data across 49 mammalian species to examine the effect of humans on animal movements. We calculated straight-line displacements across various temporal resolutions (1 hour to 7 days) for 49 mammalian species and annotated these data with extrinsic variables human footprint and NDVI, and the intrinsic variables body mass and diet guild. We then compared movements among individuals to examine how the environment influenced movement patterns. Overall, we found a negative relationship between displacement and human footprint. Mammals living in areas of low human footprint moved more on average more than mammals living in

areas of high human footprint. We also found a positive effect of body mass and a negative effect of resources on displacements. Our results suggest that not only mammals with greater displacements may be avoiding areas with greater human footprint, but that the human footprint is actually altering the behaviours of mammalian displacement worldwide.

Session 1-O17 - Modelling land-use effects on European plant diversity using a countryside SAR approach

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Land use is considered a major threat to global biodiversity and thus needs to be considered in models of biodiversity change. Species-area relationships (SARs) are widely used to predict biodiversity changes at regional to continental scales, but are often based on the simplistic assumption that land use leads to complete habitat loss and thus dramatically overestimates species loss. SAR approaches that consider the conservation value of the countryside have recently become available, but have been limited to smaller study regions. Here, we present an improved, broad-scale countryside SAR-approach for vascular plants and illustrate it at the example of Europe.

We proposed a new approach to parameterize a countryside SAR: We first predicted plant species richness pattern at a 50 x 50 km² resolution using a biome-specific SAR and compared spatial patterns with those from the Atlas Flora Europaeae. We then used these predictions as a baseline to predict changes in species richness distributions due to land use using the countryside SAR. Overall, the biome-specific SAR can predict spatial patterns of plant species richness from the Atlas Flora Europaeae reasonably well. Using the countryside SAR it is possible to predict past and future changes in the distribution of plant species richness due to land use. It highlights regions with predicted large species losses and thus can be used to make suggestions where conservation efforts at broad-scale should be

targeted. This very flexible approach to predict changes in biodiversity due to land use especially overcomes unrealistic assumptions of previous model approaches about constant or general negative effects of land use and allows the study of scenarios and trade-offs resulting from national and international policy changes.

Session 1-O18 - Similarity to resident alien species increases establishment success: evidence for invasional meltdown?

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Darwin's naturalization hypothesis states that dissimilarity to native species may benefit alien species establishment due to empty niches and reduced competition, although conversely relatedness to the resident community could facilitate establishment due to similar adaptations to environmental conditions. In this study we investigate for the first time if biotic similarities to previously established alien species, instead of native residents, influence establishment success of new invaders, focusing on permanent grasslands across France as a receding ecosystem of great conservation importance. Biotic similarity is quantified by both phylogenetic and trait distance between more recently introduced alien species and alien species with longer minimum residence times occurring in the same vegetation plot. We estimated the joint probability of establishment across 82 alien species and 7800 vegetation plots in function of these biotic similarities and other covariates, including distances to native residents, minimum residence times and climatic variation. We found that biotic similarity to previously established alien species consistently increased establishment success of more recently introduced alien species, whereas biotic similarity to natives showed mixed results. Consequently, similarity of new to already established invaders facilitates invasions and may contribute to invasional meltdown. A better understanding of biotic interactions among multiple invaders will improve multi-species management decisions and assist in the conservation of permanent grasslands.

Session 1-O19 - Understanding historical dynamics to predict the future: Global spreading dynamics of alien species over 500 years

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In recent years, an increasing number of global data sets of alien species ranges were compiled, and the pictures of the worldwide distribution of alien species are currently emerging. However, these pictures show the cumulative number of alien species, which is the result of a centuries-long history of introducing new alien species. To understand the current distribution of alien species, we need to investigate the historical dynamics of alien species spread. I will present the newly compiled database of the years of first records of alien species, encompassing over 40,000 first records in a region worldwide of more than 15,000 species from various taxonomic groups. Using this database, we show that the number of alien species consistently increased during the last 500 years for all taxonomic groups and on all continents, and for most taxonomic group even the rate of introduction increased until recently. The timing of steepest increases and the shapes of accumulations differed among taxa and continents. We analysed the dynamics of emerging alien species, defined as those, which have never been reported as established alien species before. Emerging alien species pose a significant challenge to biosecurity, which often relies on known alien species. In theory, one would expect that the proportions of emerging alien species should decline due to the depletion of the source pool of potential invaders. In reality, the proportion of emerging alien species declined much slower than expected and even remained constant for the last 150 years in some taxonomic groups, which can be explained by the overwhelming increase in the number of released individuals and species. The proportion of emerging alien species to all alien species is surprisingly high with every third first record related to an emerging alien species. Our study suggests that the pools of potential invaders is far from being depleted and that we have to expect many new alien species in the future.

Poster presentations

Session 1-P1 – Response of vegetation distribution to climate changes in China from the Last Glacial Maximum (LGM) to 2080

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How climate change affects vegetation distribution is one of the central issues of global change ecology and has important implications for assessing carbon budget of terrestrial vegetation. Construction of vegetation maps under historical, contemporary as well as future climate scenarios is essential to understanding the dynamics of vegetation distribution. Here, using species distribution models (SDMs), we explored the climatic determinants of contemporary vegetation distribution and reconstructed the distributions of Chinese vegetation in the last glacial maximum (LGM, 18,000 14C yr BP) and middle-Holocene (MH, 6000 14C yr BP). We then predicted future vegetation distributions under two climate scenarios as well as evaluated the vegetation changes in Chinese nature reserves. Our results indicated that mean temperature of coldest quarter (MTCQ) has the highest explanation power for the distribution of most vegetation types in China. The dynamics of vegetation distribution since the LGM reconstructed by SDMs were largely consistent with those based on pollen data, suggesting that SDMs can serve as a useful tool in studying vegetation dynamics and its response to climate changes. Based on our results, the nature reserves in China will face vegetation change of up to 37% in the future. Specifically, temperate bunch grass steppe, temperate deciduous forest, taiga forest, alpine meadow and alpine tundra tend to shrink in most nature reserves. This may seriously disrupt several ecosystems and hence, expose the vulnerable species to higher extinction risk. Studies on vegetation distribution under global climate change such as this will greatly facilitate management planning of protected areas to conserve rare and threatened species at the regional as well as global scale.

END OF SESSION 1

Session 2 – Applied ecology and evolution: nature conservation and restoration

Short title: Nature restoration and conservation

Chairs
Dr. Anna Lampei Bucharova
Dr. Andreas Ensslin
Dr. Walter Durka
Prof. Dr. Thomas Fartmann
Prof. Dr. Bruno Baur
Prof. Dr. Martin Dieterich

Session 2-O1 - Preserving functional traits and trait variation in ex situ conservation programs: lessons from botanic garden collections

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The preservation of endangered species ex situ in botanic gardens and gene banks has become an important pillar of species conservation programs. However, previous studies have shown that particularly cultivation of plants for many generations can decrease the genetic diversity and also the fitness of the ex-situ collection due to the effects of inbreeding and genetic drift. Moreover, changes in selection regimes may result in shifts of important functional traits and potentially also reduce trait variability. Functional traits and their heritable variation have not only been invoked as a pivotal feature of a population to adapt to rapidly changing environments (evolutionary potential), they are also considered as an important element for the proper functioning of the whole ecosystem. In order to test whether ex situ collections can preserve functional traits and the evolutionary potential of the wild populations, we compared the several functional traits (e.g., germination rate, performance and reproductive success) and their variability in 12 plant species conserved in the living collections of the Botanic Garden Meise, Belgium with those of wild populations. Furthermore, to investigate the plants' ability to cope with environmental stress, we also compared the plants' response to drought stress. Our study will provide important information about potentials and limits in ex situ collections which are crucial to provide best-suited plant material for restoration programs.

Session 2-O2 - Experimental test on the performance of an ex-situ cultivated plant species under natural in-situ conditions: influence of time since divergence and cultivation conditions

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To fight against global species loss, ex-situ cultivation of plants in botanic gardens has become an established tool. However, the cultivation process involves the risks of genetic drift and selection to artificial conditions, which may result in a poor performance of ex-situ cultivated species under natural conditions. By conducting an extensive reciprocal transplant experiment with five well-documented ex-situ conserved species involving eight Botanic Gardens in Germany and their wild source populations, we tested whether ex-situ cultures show reduced performance in the wild due to adaptations to their novel environmental conditions in Botanic Gardens. Moreover, we analysed whether increasing time of cultivation and the conditions in the ex-situ collection had an influence on the difference between wild and garden plant performance in the field. Molecular genetic analyses were performed to assess the genetic differentiation of the ex-situ from the wild populations. Preliminary results with the dry grassland species Carlina vulgaris show increased biomass and earlier flowering time of the ex-situ cultivated populations under common garden conditions, but not under natural conditions in the field sites. ALFP analyses confirmed genetic differentiation between botanic garden populations and their wild origin. Based on the observed shifts in phenotypic and genetic traits between ex-situ and wild populations, we suggest a minimal time of ex-situ cultivation with a maximal possible population size and a near natural cultivation with overlapping generations and self rejuvenation as an adequate method to preserve genetic integrity of ex-situ populations.

Session 2-O3 - Evolution in cultivation: the effect of seed propagation ex situ on plant traits

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The growing number of restoration projects worldwide, leads to increasing demand for seeds of native species. Seeds are collected in the wild and either directly used

on a target locality, or serve as a source for the establishment of cultivation on specialized farms. These propagated seeds are then used for restoration projects. During cultivation, plants face a new environment in comparison to their natural populations. There is a considerable danger, that plants in cultivation face selection and consequently loose original adaptation to natural conditions. Despite the propagation method is designed to maintain as much natural diversity as possible, the effectivity of this measure was never really tested. Here, we focused on evolutionary change of six common grassland species during cultivation. We have sown seeds of all the species and up to five consecutive generations per species (from wild collected, up to the fourth cultivation generation) into one common garden experiment. This allows us to directly compare the plants traits and track evolutionary processes from generation to generation. Cultivation conditions impose selection on germination timing and phenology traits. With increasing time in cultivation, the proportion of early germinated seeds increased in some species. Further we detected shifts in onset of flowering or budding across generations and species. However, the direction of these shifts was species dependent. The strongest effects were detected in a self-pollinated species. At the time of abstract submission, the experiment was still running, but will be finished until the conference and we will present the full results including impact of cultivation on fitness of the plants.

Session 2-O4 - The German plant conservation network ‚WIPs-De' - integration of ex situ and in situ plant species conservation

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In view of the dramatic decrease of plant biodiversity, ex situ cultivation in Botanical Gardens and collection and storage of diaspores in seed banks contribute to halt the extinction of plant species worldwide. They are fixed in the Target 8 of the Global Strategy for Plant Conservation (GSPC). The German Strategy on Biological Diversity is implemented in the German National Biological Diversity Programme. The German plant conservation network (WIPS-De) is part of that programme. It is a network of the Botanical Gardens of Berlin, Karlsruhe, Osnabrück, Potsdam and Regensburg and the University of Education Karlsruhe. The WIPS-De project combines three nationwide conservation modules: First, the collection and storage of diaspores of 15 target species across Germany, second, the establishment of ex situ cultures and the propagation of selected populations, and third, reintroduction projects and the support of small populations. The WIPS-De network established a standard for ex situ cultivation practice of endangered wild plant species. To preserve genetic diversity, it recommends both adequate broad sampling in the wild and a sufficiently large number of individuals in

cultivation. During cultivation, unconscious selection and hybridization must be avoided to safeguard genetic identity. For reintroductions, it is often difficult to decide between the use of exclusive offspring material from small local populations and mixtures from several populations of different size from a wider region. In this regard, there is only scarce experience available to base decisions on. We suggest a simple experimental reintroduction protocol which is appropriate to obtain much wider experience in this field.

Session 2-O5 - To do or not to do: Using non-local genotypes for restoration projects

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In roadside verge restoration projects the use of non-local seed provenances of naturally occurring herbaceous species has been common practice. Risks associated with this usage are (1) hybridization between non-local and local provenances, (2) genetic swamping leading to a potential loss of adaptation and natural selection, (3) maladaptation resulting from artificial selection leading to higher mortality and/or reduced performance, (4) outbreeding depression. Thus, from 2020 onwards nature conservation proposed that for restoration projects exclusively local seed sources should be used (BNatSchG §40-1, 2010). However, the introduction of novel genotypes could also raise species' population genetic diversity. This could be beneficial (1) in times of global change, (2) if surrounding populations are already genetically impoverished, and (3) to counteract genetic erosion by restoring genetic variation. We conducted population genetic comparisons between local and non-local populations of *Daucus carota*, *Leucanthemum vulgare,* and *Pimpinella saxifraga* several years after population establishment. Two species featured very low differentiation among the local and non-local provenances, while one (*P. saxifraga*) was strongly genetically differentiated with almost no admixture between local and non-local genotypes. We conclude that the introduction of non-local seed provenances in the course of landscape restoration did not jeopardize regional species persistence by contributing to inbreeding or outbreeding depressions and we could not detect any measurable adverse population genetic effects. Based on these results, we see no obvious objections to the current practice to use the tenfold cheaper, non-local seed material for restoration projects for common and widespread species.

Session 2-O6 - Advancing insights into the potential of assisted colonization: monitoring introduced forest herb species for 18 growing seasons

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Land-use change is a major determinant of biodiversity loss in plant communities. The effects are particularly evident in forests, where the distribution and abundance of forest understorey plant populations are known to bear the imprint human land-use history for decades to millennia. In many landscapes throughout Europe, the majority of forests are actually growing on abandoned agricultural land. In these 'post-agricultural forests', the understorey plant species need to (re)colonize after the forest vegetation was completely removed during the period of cultivation. Since typical forest plants have extremely low dispersal abilities (dispersal limitation), assisted colonization of their populations has been put forward as a relevant management option. However, the environmental legacies of the former land use may additionally hamper the establishment of the species in these forests (establishment limitation) and completely wipe out the restoration efforts. Here we will show the long-term (18 growing seasons) results of an introduction experiment where seeds and adults of ecologically very different forest plant species were introduced in ancient and post-agricultural forests. While the results after two years showed remarkably successful establishment, these conclusions had to be nuanced after eight growing seasons, when (some) species started to suffer from the persistently altered environmental conditions. Today, after eighteen years, novel disturbances such as the ash dieback and their impact on the introduced populations force us to adjust our conclusions again. Clearly, a long-term dataset on assisted colonization puts the potential of such restoration approach into the right perspective. Early results are contradicted by long-term dynamics and new disturbances put the populations on unforeseen trajectories.

Session 2-O7 - More harm than good? Assisted migration of foundation species

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With ongoing climate change, many plant species may not be able to adapt rapidly enough and some conservation experts are therefore considering translocating warm-adapted ecotypes to mitigate effects of climate warming. Although this strategy, called assisted migration, is intuitively plausible, most of the support comes frommodels, whereas experimental evidence is so far scarce. Additionally, translocating of plant ecotypes might have consequences for interacting organisms. First, to address plant performance during climate change, we carried out a multispecies common garden experiment during the summer heat wave. We

compared the performance of regional ecotypes with plants from a locality with long-term summer temperatures similar to what the plants experienced. We found either no difference in performance between regional and warm-adapted plants, or regional plants outperformed warm-adapted ones – despite the elevated temperature. Second, we evaluated how strong might be the effect of plant origin on biotic interactions. Using data from common garden, we show that herbivore abundance is affected by plant ecotype identity up to four times, and the abundance of higher trophic level, parasitoids, even up to nine times. To be sure how common are effect sizes of such magnitude, we gathered information from over 30 studies comparing herbivore performance on plants from different populations. Mostly, plant origin affected herbivore performance by tens of percent (median 37%), but in 20% of the comparisons were larger than three times, and the magnitude increases with geographical distance between populations. Based on our results, we cannot advocate assisted migration as a universal measure to help plant populations to adapt to climate change, since we found no evidence that transfer of warm-adapted ecotypes will improve population performance. Moreover, plant origin might very strongly affect biotic interactions with unpredictable consequences.

Session 2-O8 - Genetic rescue of critically endangered plant species as a tool for grassland restoration

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Habitat fragmentation and degradation of grassland habitats have been so severe in Western Europe that many of their typical plant species only remain as a few, often small and isolated, populations. These populations are susceptible to genetic, environmental and demographic stochasticity and are likely to express low reproductive success, reduced gene flow, inbreeding depression, and genetic erosion, threatening their long-term persistence. The usual ecological management practices that aim at restoring habitat quality may not be sufficient for ensuring sustainable population persistence, especially in the absence of a persistent soil seed bank and when they are already too rare for producing enough seeds for conventional hay transfer. Their restoration must therefore go through genetic rescue (e.g. allo- or auto-reinforcements, restoration of connectivity by corridors). In the frame of the EU LIFE project “Herbages” (http://www.life-herbages.eu) that aims at improving the conservation status of priority grasslands in Southern Belgium, genetic rescue experiments have been started in autumn 2013 for four grassland species that are critically endangered in Belgium: *Arnica montana*, *Campanula glomerata*, *Dianthus deltoides* and *Helichrysum arenarium*. The aim is to increase the effective size of remaining populations (reinforcement) and restore extinct populations (reintroduction) in order to improve connectivity in the

landscape. Here we present (i) the experimental design applied, which comprises an estimation of the quality of target and source populations (including genetic diversity and structure), and an assessment of soil seed bank composition of the target sites, and (ii) the first results of the demographic survey (e.g. survival, floral production, reproductive success) aiming at estimating the viability of the transplanted populations, and of the experimental estimation of fitness of the progeny, in order to test for inbreeding or outbreeding depression.

Session 2-O9 - Genetics, biotechnology and assisted colonization as key tools to secure the survival of the climate relict tree *Zelkova sicula* in Sicily

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Organisms whose distribution range have shrunk due to climate changes over geologic time scales, in addition to populations of species that persisted in isolated enclaves of suitable environments surrounded by areas with inhospitable regional climate, are referred to as climate relicts. The survival of such organisms is challenging, especially when related to the potential impact of future climate change scenarios. Plants can respond to new conditions through phenotypic plasticity, migration or adaptation over multiple generations. In case of failure of one or all of these three strategies, decline or extinction is expected. Small, isolated and low-dispersing populations are often limited in their genetic adaptive potential and may be unlikely to naturally shift their ranges in response to changing environmental conditions. In such cases human-mediated translocation (*e.g.* assisted colonisation) could represent one of the most effective strategies to enhance species conservation. We implemented an integrated conservation strategy aimed at improving long-term conservation of *Zelkova sicula*. This relict tree endemic to Sicily is currently known from two unique populations and is at the brink of extinction. Individuals from the two populations showed inter-population genetic diversity, whereas identical genetic profiles were detected at intra-population level (probably resulting from suspected sexual sterility and clonal propagation). Production of plants through vegetative multiplication represents the only tool for out-from-nature reproduction of selected individuals. The produced plantlets are devoted to translocation actions, which still has a pioneering relevance at regional and national level. According to recent studies, in addition to biogeographical and palaeoecological data, more mesic conditions are inferred to better meet the ecological requirements of *Z. sicula*, hence preventing the

recurrent events of summer drought stress occurring in the present habitat. Therefore, three out of 17 surveyed sites were selected in the meso-/supra-Mediterranean belts of Sicily, within forest communities dominated by mixed summer-green broadleaved deciduous trees. New populations are expected to be able to better cope with climatic constraints due to the forthcoming climate changes.

Session 2-O10 - Habitat-specific differences in the population dynamics of the endangered steppe plant species *Astragalus exscapus*

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We studied the population dynamics of *Astragalus exscapus* in 22 populations in central Germany from 2009 to 2013 focussing on habitat differences. Despite from its rarity, *A. exscapus* occurs in a relatively broad variety of vegetation types that can be roughly divided in 'dry grasslands' and 'semi-dry grasslands'. We further divided the study populations in four environmental types: pioneer grasslands = PG, dry grasslands = DG, Semi-dry grasslands = SDG, intermediate grasslands = IG by characteristics like vegetation height, litter cover or heat-load. Population growth rate (λ) and other demographic properties like elasticities were calculated for each population and year using integral projection models (IPMs). Stochastic growth rates (λ) derived from the yearly population growth were considerably higher than 1 in seven, about 1 in six and considerably smaller than 1 in nine populations, so more than 40 % of the study populations are declining and may eventually go extinct. Five of the nine declining populations were located in semi-dry grasslands, while five of the seven growing populations were located in dry grasslands. Consequently, population growth was higher in dry than in semi-dry grasslands. The four environmental types differed strongly in their population growth rates. While populations of the PG and the IG type were considerably growing or at least stable, DG and SDG populations were often declining. A life-table response experiment (LTRE) revealed, that overall vital rates related to fecundity i.e. recruitment of juveniles made the largest contributions to differences of population growth between the four environmental types, followed by survival and growth of individual plants. Habitat specific population dynamics like in *Astragalus exscapus* should be considered in plant conservation.

Session 2-O11 - Reintroduction of three rare and endangered species into steppe grasslands in Thuringia, Germany

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Reintroductions of rare and endangered plant species are an important element of the Global Strategy for Plant Conservation and are getting steadily more attention by research. Despite an urgent need for research identifying reasons for success and failure of reintroductions, scientifically designed reintroduction studies in Germany are still scarce. We conducted reintroductions of three steppe plant species (*Astragalus exscapus*, *Pulsatilla pratensis* and *Scorzonera purpurea*) in the Thuringian Basin, Germany, in order to investigate whether reintroductions can protect these rare species, and if characteristics of source and target habitats, and the size of the source populations can influence reintroduction success. For each species juvenile plants were planted out in spring 2010 (*S. purpurea*) and autumn 2011 (*A. exscapus*, *P. pratensis*), respectively, with about 900 individuals for *P. pratensis* and *S. purpurea*, and even 2200 individuals for *A. exscapus*. Survival, flowering, and growth were monitored annually until 2015. During this time, 56 % of reintroduced plants of *S. purpurea*, 54 % of *A. exscapus*, and 66 % of *P. pratensis* survived. Generalised linear mixed models revealed that *S. purpurea* and *A. exscapus* survived significantly better on south-facing slopes, while target habitat had no effect in *P. pratensis*. *P. pratensis* and *A. exscapus* survived better in plots with lower vegetation height. *A. exscapus* had also higher survival rates in plots with lower proportions of herb layer and litter cover. In general, reintroduction success for all three species was best when competition by surrounding vegetation or dead biomass was low. While target habitat characteristics had a significant influence on reintroduction success, size of the source populations had no positive effect. The survival of more than half of reintroduced *A. exscapus* and *S. purpurea* and about three quarters of *P. pratensis* demonstrate that reintroductions can be an effective measure to prevent the species' extinction.

Session 2-O12 - Restoration of grasslands: From mowing and grazing regimes to gardening?

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At present, everywhere in Europe attempts are made to restore species-rich semi-natural grasslands. For over 10 years in-depth vegetation analysis is taking place in a Special Area of Conservation (SAC) in the Eastern Ore Mountains nearby Dresden in Saxony, Germany. Two project sites received a mixture of practical restoration approaches and scientific field experiments in the past 20 years. Both sites were mapped in the Natura 2000 system and with detailed vegetation types. Our results show, that the general grassland matrix improves stepwise. Intermediate states may remain for many years. Today, the target-communities are covering significantly less area than the former intensive grasslands which still dominate large parts of the project sites. At the Geisingberg-sites (about 180 ha) 32 permanent plots have been sampled up to seven times with a full Braun-Blanquet relevé (5x5m) between 1993 and 2013. For the development analysis 208 relevés

were included in a detrended correspondence analysis (DCA). The gradient of all relevés equals to 4, the mean turnover in 20 years is approx. 2. Similarly, 75 permanent plots ate the Oelsen-sites (about 160 ha) have been treated. The development direction varies depending on initial state. The improvement of the grasslands in general does not guarantee the restoration success in terms of all historically verified species occurances. Hence, the research focus switched from general regeneration measures to measures tailored for the requirements of single plant species. Maintenance measures as practiced include in-vitro breeding, watering, small-scale topsoil-removal, liming. How can we reverse this trend towards gardening in nature conservation?

Session 2-O13 - Restoration ecology meets Functional community ecology: Assessment of restoration success of semi-natural grasslands

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Species-poor grasslands in Saxony-Anhalt were restored by applying four different methods of species introduction: hay transfer and application of threshing material, combined with and without additional sowing of a regional seed mixture, starting in 2009. We assessed the restoration success by focusing on the development of species composition and diversity calculating the number and cover of target species. Furthermore, we explored the potential to additionally use functional community composition to assess restoration success as community weighted means (CWM) and functional diversity (FD) of species traitsmight offer mechanistic insights into restoration processesnot captured by traditional evaluation criteria. Transfer of hay and the sowing of threshing material increased the target species number. However, there were only slight differences with respect to the establishment of target species between hay transfer and sowing of threshing material. However, additional sowing had a positive effect on target species' number and cover. We found that the analysed meadow was also restored functionally. Comparing the CWMs of the restoration site with a local reference, most of the trait values approached the reference indicating a positive trajectory. Furthermore, we found steadily increasing FDs. The species newly introduced to the restoration site differed in establishment success. We asked to which degree the establishment success depends on species traits and whether there are traits that are relevant for particular restoration methods We found that in particular traits related to dispersal had an important influence on the establishment success. For various traits, we found significant trait-by-method and trait-by-year interactions, indicating that different traits promoted establishment under different conditions. We conclude that both species diversity and functional

diversity can be restored through hay transfer or sowing of threshing material. Sowing additional species supported the restoration process. Including functional trait analysis in restoration ecology does not only complement traditional evaluation criteria but also allows insights of why restoration measures are successful or not.

Session 2-O14 - Soil inoculation steers restoration of terrestrial ecosystems

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Many natural ecosystems have been degraded due to human activities and need to be restored in order to protect biodiversity. However, restoration can take decades and restoration activities are often unsuccessful, because of abiotic constraints (e.g. eutrophication, acidification) and unfavourable biotic conditions (e.g. competition or adverse soil community composition). A key question is what manageable factors prevent transition from degraded to restored ecosystems and what interventions are required for successful restoration. Experiments have shown that the soil community is an important driver of plant community development, suggesting that manipulation of the soil community is key to successful restoration of terrestrial ecosystems. Here we examine a large-scale six-year old field experiment on ex-arable land and show that application of soil inocula not only promotes ecosystem restoration, but that different origins of soil inocula can steer the plant community development towards different target communities, varying from grassland to heathland vegetation. The impact of soil inoculation on plant and soil community composition was most pronounced when the topsoil layer was removed, whereas effects were less strong, but still significant, when the soil inocula were introduced into intact topsoil. Therefore, soil inoculation is a powerful tool to both restore disturbed terrestrial ecosystems and steer plant community development.

Session 2-O15 - Human impact on vegetation in National Park Kopaonik, Serbia

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Human influence on mountain ecosystems in Serbia has been increasing in the last decades. Main impact refers to agriculture, settlement abandonment, forestry, mining, waste disposal, unsustainable building and winter tourism. Kopaonik Mountain is one of the centers of mountain flora of different origin and age in the Central Balkans. Its highest parts are established as National Park in 1981. Within the territory of the protected area, winter tourism has been developing rapidly in the last 30 years, turning Mt. Kopaonik into the largest ski resort in Serbia today. To measure human-induced changes on the distribution of natural vegetation, we mapped plant communities and tourist infrastructure using aerial images and vegetation maps from the period 1985 to 2015. The obtained results revealed remarkable changes in the distribution and significant loss of vegetation cover of subalpine coniferous and shrub communities caused by land uses such as development of tourist facilities, ski trails, road building, and urbanization. The preservation and protection of the National Park's natural resources is of high priority, and therefore substantial efforts should be given to identify the most affected vegetation types and promote restoration in these areas.

Session 2-O16 - Effects of mire restoration by drainage ditch impoundments on dragonflies

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Intact or near-natural raised bogs and fens are important habitats for a specialised flora and fauna. However, around the world mires are strongly threatened, especially by drainage and peat extraction. The aim of our study was to investigate the role of secondary mire water bodies (former peat extractions ponds and impounded drainage ditches) and primary (natural) mire ponds on dragonflies in southern Bavaria (Central Europe). In total, we recorded 36 autochthonous dragonfly species, 17 of them were endangered and 12 were typical mire species. Densities and constancy values of the mire specialists *Aeshna juncea, Leucorrhinia dubia, Leucorrhinia rubicunda* and *Lestes virens* and were similar or higher in secondary habitats than in primary ones. Concerning the other mire species, *Somatochlora arctica* had its maximum constancy and density in impounded drainage ditches, *Coenagrion hastulatum* and *Sympetrum danae* in peat extraction waterbodies. *Leucorrhinia pectoralis* occurred only in peat extraction waterbodies. *Aeshna subarctica, Leucorrhinia albifrons* and *Nehalennia speciosa* were restricted to primary habitats. This studies clearly showed that secondary water bodies can be important habitats for dragonflies in mires. This is even true for impounded drainage ditches.

Session 2-O17 - Using life-history traits to predict arthropod responses to grasslands management amid species pool influences

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To maintain the characteristic biodiversity of semi-natural meadows, regular management by mowing is required to avoid vegetation succession. However, differences in the pool of species occurring at a site complicate the identification of processes shaping communities under different management regimes. We developed a trait-based framework to test the effects of three different mowing regimes over several groups of grassland arthropods over a large number of sites. We use literature data on phenology (time of adult activity) and larval substrate (soil, vegetation or outside the meadow) to identify which species are most likely to benefit from the changes in management. Mowing regime was manipulated by delaying the first possible mowing date by one month or leaving an uncut grass refuge on 10-20% of the field in comparison to control meadows (first cut after June 15 and no refuge left). Arthropod communities were assessed 3-5 years after the regimes were installed. Here we only tested for differences between the regimes before the first cut of the year. The various arthropod groups showed contrasting responses to the mowing regimes: we found positive carry-over effects of delayed mowing on the abundance of day-active butterflies, parasitoid wasps and sawfly larvae. Positive effects of refuge partitioning were found on Lepidoptera larvae, whereas no effects were found on ground beetles, rove beetles, wild bees or hoverflies. Using the trait-based approach, we found that species whose larvae develop in the vegetation, and species with a phenological peak in July benefited most from the alternative mowing regimes. No effects were found on species with soil dwelling larvae. We conclude that delayed mowing and refuge apportioning have lasting effects on biodiversity and can easily be implemented within the agri-environment scheme framework. A trait-based approach as developed here can help understanding if and how species will respond to changes in grassland management.

Session 2-O18 - Dynamics of two reintroduced populations of the Blue-winged grasshopper *Oedipoda caerulescens* over 21 years

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Restoration of a site, especially in highly fragmented landscapes, mostly benefits mobile generalist species. For less mobile species, reintroduction, i.e. the intentional movement and release of plants and animals inside their indigenous range from which they have disappeared, is an increasingly used tool to re-establish populations in restored habitats. We assessed the long-term success of a project in which the Blue-winged grasshopper *Oedipodus caerulescens* was reintroducedto a nature reserve, an alluvial gravel area where the species went extinct in the 1960ies.Im summer 1995, we released 110 individuals (50 females and 60 males) and another 204 individuals (101 females and 103 males) into two gravel patches with sparse vegetation. In the following two years, individuals of *O. caerulescens* were found in increasing numbers 40–80 m around the release points. In the third year, the top soil was scraped down to the gravel pad in four areas and the pipe trench of a cable duct crossing the nature reserve was filled with sandy gravel. Grasshoppers used this belt as dispersal corridor to colonize the new patches. Nine years after reintroduction, *O. caerulescens* reached a high abundance both in the release sites and the four newly created patches, while the dispersal corridor was already overgrown by dense vegetation. Surveys 20 and 21 years after introduction showed that the abundance of the Blue-winged grasshopper declined strongly in the established subpopulations and moderately in the two release sites, owing to natural succession of the habitat. To maintain high-quality habitat for *O. caerulescens,* we suggest a rotational management program that maintains early successional stages.

Poster presentations

Session 2-P1 - Does the symbiosis with arbuscular mycorrhizal fungi play a role in the decline of *Arnica montana*?

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Arnica montana is a characteristic plant species of nutrient poor grasslands of Central Europe. Although protected by law, populations have been declining strongly over the last decades, especially in lowland regions compared to montane habitats (> 500 m.a.s.l.). Observations in the field revealed the mycorrhizal colonization of *A. montana* roots in the montane regions to be distinctly higher than the infection rate in the lowlands. Thus, we propose that the symbiosis might act as a further player in the decline of *A. montana* on lowland sites. To study the relationship between *A. montana* and arbuscular mycorrhizal fungi (AMF), we conducted a greenhouse experiment. We used four factors to analyze symbiosis related processes in a full-factorial design, resulting in a sample size of seven per factor combination. The factor "inoculation" referred to the inoculation with the

fungal species *Rhizophagus irregularis* resulting in AM (presence of AMF) and NM (absence of AMF) plants. The factor "origin" differentiated seeds of lowland and montane regions in our study area Hesse, Germany, while the treatment "water supply" separated the plants by water availability (two levels). The "nutrient availability" factor was split into four groups with nitrogen and phosphorus contents being manipulated. The plants were measured weekly and harvested after three months. We recorded dry weight of roots and shoots, leaf area, nutrient content in leaves and mycorrhizal colonization. Results show that *A. montana* is facultatively dependent on AMF as the NM plants were viable, but smaller. Interestingly, in the NM treatment the plants from montane regions were overall much larger than the lowland plants. Moreover, the mycorrhizal growth response and the colonization rate were higher in the lowland plants than in the ones of montane origin which may indicate that the symbiosis is of higher relevance for the fitness of plants of lowland populations than of those of montane sites. The findings suggest that mycorrhizal colonization could play a role in the decline of *A. montana* in lowland regions.

Session 2-P2 - Population genetics accompanying ex situ - in situ conservation efforts of the endangered Globeflower (*Trollius europaeus*) in the ‚Rothaar-Mountains‘

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Starting from Alpine glacial refugia Globeflower (*Trollius europaeus* L.) has successively been colonizing suitable habitats in Central Europe and became a native grassland component in our cultural landscapes. Today, especially in peripheral areas,*T. europaeus* populations are threatened mainly due to an intensified use of grassland. Fragmentation as well as habitat loss and degeneration have driven the Globeflower populations in the „Rothaar-Mountains” (North-Rhine-Westphalia) to an alarming level of decline. As part of a long-term conservation measure, the Botanical Garden of the University of Marburg launched an ex situ - in situ management to increase population sizes again (see Poster by Saxler et al.). The question arises as to the success of these conservation efforts while the genetic background of the managed populations is still unknown. In this study, we therefore focused on population genetics of selected populations that are included in the ex situ – in situ management in order to assess their conservational genetic status, particularly to identify signals of inbreeding or genetic drift. For this purpose we developed two additional nuclear microsatellite markers and added them to the already available set of five. In the long run, the results of this study will contribute to create a management guide for *T. europaeus*

in the "Rothaar-Mountains" on the basis of a genetically accompanied ex situ and in situ conservation management.

Session 2-P3 - Genetic structure in natural and restored populations of a calcareous grassland plant – the case of *Buphthalmum salicifolium*

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Calcareous grasslands are a Natura2000 habitat that benefits from restoration measures in several parts of Europe. Plant species used for restoration are successfully introduced by hay transfer or direct seeding, while the success of restoring genetic population structure is less well understood. *Buphthalmum salicifolium* (Asteraceae) is a perennial forb of calcareous grasslands, which has been used in numerous restoration projects in the lowlands around Munich. Here, the nature reserve „Garchinger Heide" serves as a reference for natural calcareous grasslands. Our study included 39 restored and 10 natural populations in southern Bavaria and one cultivar as outgroup. Twelve microsatellite markers were designed and tested on over 700 plants. The results indicate small-scale geographic differentiation among natural populations of the study species, even within the currently used seed transfer zones. Moreover, the genetic structure of the restored populations differs from that of the natural source populations. Interestingly, the restored populations showed higher genetic diversity than the natural populations, and no evidence for inbreeding depression or genetic bottlenecks. The cultivar represented the highest overall divergence underlining the risk of introducing potentially maladapted genotypes. Our results call for more studies on genetic structure of plants used for restoration, and the need to modify current guidelines in relation to the seed source used for grassland restoration.

Session 2-P4 - LIFE for *Minuartia*

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Minuartia smejkalii is postglacial **e**ndemic species bounded to serpentine, whose worldwide distribution is limited only on two SCI areas in the Czech Republic. In the

last 5 years the population size decreased by about 65%, some local populations went extinct. The main reason for this decline is forestry (formation of dense shaded pine forests with high cover by litter and high humus layer). In these conditions, serpentine plants are quickly suppressed and replaced by competitively stronger common plants. Plant collection is also a problem in both areas. Current starting LIFE project is aimed to suppression of these negative factors and setting up sustainable and feasible management. During the project, both sites will be revitalized by combination of various management practices including large scale forest grazing. In selected areas, enhancement of population size will be realized by seed sowing and transplantation of juvenile plants. Further, self-sustainable ex-situ population will be established to be used for plant reintroduction. Prior establishment of the ex-situ population, genetic analysis and breeding experiment will be done to ensure conservation of maximum genetic variability and at the same time to avoid outbreeding depression. Further, we will create a specific conservation program. *The rescue planting of rare species in the private garden* based on Swiss methodology to motivate and involve local residents in species protection. Working group for this program will be established to solve emerging problems (e.g. how to regulate trade of seedling and their spread to other regions) and to select other species to be included to this program. Recently, we are looking for organization/persons, dealing with similar issues as this project (e.g. revitalization of serpentine sites, forest grazing, ex-situ conservation, reintroduction, motivation of locals) to be able to discuss the project or who will be interested in the program of Rescue planting in private garden.

Session 2-P5 - Combining habitat suitability models and spatial graphs for more effective landscape conservation planning: a methodological framework

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In response to the negative effects of habitat fragmentation on biodiversity, ecological network conservation and restoration has become a central objective in biodiversity conservation planning. Evaluating landscape functional connectivity for species and mapping ecological networks are key steps towards effective implementation of relevant actions, but both remain challenging. Habitat suitability models (HSMs) and spatial graphs are thought to provide conservation practitioners with useful information for landscape planning, but these spatial modelling methods are limited if they are considered independently from each other. To tackle their respective drawbacks, we propose to combine HSMs and spatial graphs in a four-step methodological framework: (i) collect and prepare input data, (ii) model habitat suitability using MaxEnt to obtain a map of the species Habitat Suitability Index (HSI), (iii) transform the HSI map into spatial graph inputs using GIS, (iv) perform spatial graph connectivity analysis using Graphab. The outputs of this species-specific and quantitative approach are maps of the species

ecological network ranking habitat patches and dispersal linkages in terms of their importance for habitat availability and landscape connectivity. This prioritization identifies locations where conservation biologists and landscape planners should focus their conservation and restoration efforts. The proposed framework is illustrated with a case study on the woodlark (*Lullula arborea*) in a Mediterranean area, and alternatives and limitations of the method are discussed. We anticipate that the quantitative-based graphical outputs of the proposed framework can valuably support landscape planning decision-making, complement local expert opinion, and help federate various relevant stakeholders at territorial scale.

Session 2-P6 - Is the passive dynamic river restoration approach an efficient tool to achieve the good ecological status?

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The intensive use of the European rivers during the last centuries has led to profound changes in the physico-chemical properties, river morphology and aquatic faunistic communities. Rectifying these changes and improving the ecological state of all surface water bodies is the central aim of the European Water Frame Directive (WFD) and for many rivers restoration measures are the main tool to achieve this goal. As the cost-effectiveness of all measures is crucial to the WFD implementation, the passive river restoration approach has become very popular over the last decades. But while the costs of this approach are minimal, not much is known about the long-term effectiveness of passive river restorations. The research presented here provides essential and in-depth data about the effects of two such restoration measures on the riverbed morphology of a large river of the lower mountain region in Germany (type 9.2). More than 7,500 TRiSHa data sets were collected in three consecutive years and the results show a high spatial and temporal diversity and dynamic for all analyzed morphologic parameters – ranging from the riverbed sediments and organic structures to the distribution of 32 choriotopes. The structures and their dynamic depend on the character of the study area (free-flowing or impounded), the location of the study sites within the research area (main channel or restored side channel) and on the occurrence of major flood events. These results show the potential of the passive restoration approach for creating diverse riverbeds, but also the limitations of impounded river sections. These differences in the morphological development also influence the aquatic fauna and the ecological quality and thus have to be taken into consideration when formulating the expectations of any passive river restoration.

Session 2-P7 - Not to harm: seed harvesting in wild populations

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

Session 2-P8 - Rangeland degradation assessment in Kyrgyzstan: Vegetation and soils as indicators of grazing pressure in Naryn Oblast

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Rangelands occupy more than 80% of the agricultural land in Kyrgyzstan. At least 30% of Kyrgyz pasture areas are considered to be subject to vegetation and soil degradation. Since animal husbandry is the economic basis to sustain people's livelihoods, rangeland degradation presents a threat for the majority of the population. We present for the first time an ecological assessment of different pasture types in a remote area of the Naryn Oblast, using vegetation and soils as indicators of rangeland conditions. We analysed the current degree of utilization (grazing pressure), the amount of biomass, soil samples, and vegetation data, using cluster analysis as well as ordination techniques. Winter pastures (*kyshtoo*) are characterized by higher pH values (average of 7.27) and lower organic matter

contents (average of 12.83%) compared to summer pastures (*dzailoo*) with average pH values of 6.03 and average organic matter contents of 21.05%. Additionally, summer pastures show higher above-ground biomass, and higher species richness and diversity. Our results support the hypothesis that winter pastures, which are located near settlements, suffer from over-utilisation, while the more distant summer pastures are subjected to much lower grazing pressure.

Keywords: animal husbandry, biomass, classification, grazing management, montane and alpine steppes and meadows, ordination, plant communities.

Session 2-P9 - Dynamics of Collembolan communities in correlation with vegetation and temperature changes during 20 years of succession

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The successional dynamics of collembolan communities of a rubble and debris dump in Bremen, Germany were studied for a period of twenty years from 1980 till 2000 in two experimental plots. One plot (SUC) was left undisturbed for natural secondary succession, the other one (REC) was recultivated with rotary-tilling and sowing of grass. The mean density varied between 3800 and 118667ind. m^{-2} in SUC and between 5667 and 91942 ind. m^{-2} in REC. In the two sites individual numbers peak occurred in the first decade, thereafter it decreased. Number of species increased from 9 to 29 in SUC and from 17 to 32 in REC and the alpha diversity calculated as number of species, Shannon-Wiener and Simpson-index increased in both comparable sites of different successional age. Within the second decade in the two sites, yearly species turnover rate profoundly decreased between 1990 and 1994 indicating the lowest change with 100% complete similarity in species composition. In the earlier years, the change in species composition presumably was slower and more irregular. With 66%, the dominance similarity (Renkonen index) of collembolan communities in the two sites was greatest six years after the beginning of succession.During twenty years of succession, total abundance and species composition were considerably affected by vegetation cover and annual mean temperature. Negative correlation of total abundance with annual mean temperature was found profoundly in REC more than in SUC. Positive correlation of total abundance with vegetation cover was found in the initial years of succession in the two sites.

Session 2-P10 - Protection of caves in Serbia

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This study reviews current state and legal framework of karst protection in Serbia. Limestone terrains in Serbia cover 8,414 km^2 or 9.5% of its territory. Caves are protected as follows: within general nature protection, within protection of speleological objects as parts of larger protected regions, and as natural monuments. Conservation measures are given together with the list of legally protected caves. Main threats to speleological objects and implementation problems are discussed. Concerning their scientific, natural and cultural values, caves and other speleological objects require more practical protection and advanced research.

END OF SESSION 2

Session 3 – Biodiversity on the move: integrating movement ecology and biodiversity research

Short title: Integrating movement and biodiversity

Chairs
Dr. Ulrike Schlägel
Dr. Antje Herde
PD Dr. Niels Blaum

Session 3-O1 - Movement-mediated biodiversity in a changing world

Ulrike Schlägel[1], Antje Herde[1], Niels Blaum[1], Florian Jeltsch[1], BioMove RTG members[1,2,3,4]

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Biodiversity trends due to anthropogenic environmental change are varied. While we experience an overall loss of species, individual communities and metacommunities may increase or decrease in diversity, depending on spatial scale, landscape configuration and composition, and species interactions. Many of the processes that shape community composition and allow species coexistence are mediated by animal movement and in particular the movement of individuals, which have different motivations, vary in their strategies, and respond to differing local environments. Yet many existing theoretical approaches in biodiversity represent movement phenomenologically, e.g. by assuming basic dispersal kernels or space-use patterns. We present a framework for future research interfacing movement ecology and biodiversity research. Our framework merges concepts from movement ecology and coexistence theory and embeds them in community assembly. With this, we embrace an ongoing paradigm shift from a classical view that focuses on species' averages towards an individual-based perspective in biodiversity research.

Session 3-O2 - Choosing the right tool for the job: Range vs. occurrence distributions for quantifying animal space use

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Understanding animals' space requirements is a core goal of movement ecology and is a key reason for collecting relocation data. The amounts, types, and qualities of the various habitats an individual occupies will all influence its fitness. Furthermore, as remaining natural areas decrease in size and become increasingly fragmented and disturbed, an understanding of species' space requirements is critical for designing effective conservation strategies. The importance of quantifying space use was recognized early in the development of ecology and has led to the concepts of “home range” and “utilization distribution”. Space use, however, is a multifaceted aspect of animal behavior. Consequently, the home range concept has broadened substantially over time and a large and diverse literature on the subject now exists. This proliferation of concepts and methods has led to substantially different definitions of space use being conflated in the literature. To cut through this complexity, we show that many of these ideas cluster around two distinct notions of the utilization distribution. The range distribution describes the long-run behavior of a space-restricted movement process, and is consistent with the classical definition of home range. In contrast, the occurrence distribution quantifies uncertainty in the location of an individual during the observation period, can be used to link movement to environmental covariates, and is not directly related to the classical notion of home range. Using mathematical arguments, simulated data, and an empirical example with African buffalo, we demonstrate that the range and occurrence distributions quantify fundamentally different aspects of animal space use. We then show the linkages between different space use estimators in the literature and these two distributions. Finally, we describe how these contrasting notions of space use can be used to answer different ecological questions.

Session 3-O3 - How landscape diversity affects animals? Energy expenditure via movement

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Intensive agricultural land-use leads to the homogenization of structural landscape diversity, where a large matrix of fields surrounds small habitat remnants. In these agricultural landscapes with low structural diversity, animals often increase their home ranges to meet their nutritional and reproductive requirements. This response may result in higher energy expenditure for movement and less time for energy intake, which reduces individual fitness and may lead to a decline in animal abundance or even to the local extinction of a species. We selected the European hare (*Lepus europaeus*), often typical in agricultural landscapes, as our study species. Hare movements were recorded within two regions in Germany with pronounced differences in structural landscape diversity. In Bavaria, landscape diversity and hare abundances are high, whereas in Brandenburg, landscapes are homogenous and hare abundances are low. We were interested in understanding whether (1) hares in structurally diverse landscapes expend less energy than hares in homogenous landscapes, (2) larger home ranges result in higher energy expenditure, and (3) sudden resource changes (i.e. harvest) increase energy expenditure as hares search for alternative food sources. From 2011 to 2015 fifty hares were collared with GPS-tags including acceleration sensors. Acceleration data was used to calculate the overall dynamic body acceleration (ODBA) as a proxy for energy expenditure. Contrary to our predictions, energy expenditure decreased after sudden resource changes. However, energy expenditure increased significantly with home range size, but only for male hares. This effect was stronger for hares in diverse landscapes. Surprisingly, despite having significantly larger home ranges in homogenous landscapes, hares did not expend more energy than in diverse landscapes.

Session 3-O4 - Spatial ecology of urban squirrels and hedgehogs

James M. Turner[1], Lisa Warnecke[1], Stephanie Reher[1], Anju M. Abel[1], Sandra Fischer[1], Elisabeth Gajare[1], Peer Gregersen[1], Annalena Stuhlmann[1], Edna Teich[1], Lea S. Thomas[1], Kathrin H. Dausmann[1]

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Urbanisation is a continually expanding, anthropogenic process that fragments and damages native habitat. Consequently, it is generally associated with negative effects such as population decreases and the local extirpation of native wildlife. There are exceptions to this trend and although several species thrive in the urban environment we have little understanding of the underlying mechanisms contributing to their persistence. To quantify the effects of urbanisation on the spatial ecology of two species successfully inhabiting cities we examined the movement, foraging and activity patterns of the Eurasian red squirrel (*Sciurus vulgaris*) and European hedgehog (*Erinaceus europaeus*) in a large city in northern Germany using radio-telemetry. We found significant differences in home range size and core area use of squirrels among seasons and between urban and semi-natural habitat, which appeared to be largely influenced by food resource type and

availability. Additionally, urban individuals' home ranges overlapped more than those in semi-natural habitat and they spent less time active. During their active season (May to November) hedgehogs had smaller home ranges than rural conspecifics, routinely crossed roads and preferred private gardens over parks for nesting and activity in the first part of the night. Our novel data illustrate how two small mammal species opportunistically adjust their movement ecology in response to immediate environmental conditions. The observed flexibility likely helps individuals maintain a positive energy balance and contributes to their success in habitat altered by urbanisation.

Session 3-O5 - Animal communities under environmental change: The role of traits and individual space use

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Foraging movement and home range formation of individuals are key properties of animal communities since they determine their spatial structure and define the usage of resources within the environment. In face of environmental threats such as habitat loss, fragmentation or degradation animals alter their foraging movement and adapt their home ranges to the new conditions. These modifications in space use also affect community composition and structure. For a mechanistic understanding of community structures it is therefore crucial to identify key factors influencing individual space use and their effects on community composition and structure. In a previous modelling study which used an allometric model to simulate individual home range formation in animal communities, body mass was identified to determine the efficiency of different foraging strategies. We extend this modelling approach by introducing further traits such as different feeding types and habitat preferences that could act as key factors influencing foraging movement and affecting community structure. The model is then used to predict composition and structure of mammal communities in face of habitat loss, degradation and fragmentation for scenarios combining various foraging movement types and traits. Simulation results reveal how the different implemented traits influence community responses to environmental changes through modified foraging movement and habitat use. Thereby, this approach allows a mechanistic upscaling from individual organisms and traits to biodiversity pattern in heterogeneous landscapes.

Session 3-O6 - From step selection function to utilization distribution: How best to make a pretty map

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Ecologists have long been interested elucidating environmental drivers of animal movement and space-use patterns. Logistic regression models are often used to link environmental covariates to animal location data under the assumption that observations are statistically independent. Recent extensions allow joint modeling of animal movement and habitat selection via a conditional logistic regression modeling framework, thereby allowing researchers to take advantage of widespread availability of high resolution animal tracking data and hence dependent observations. These two analysis approaches are typically referred to as Resource Selection Analysis (RSA) and (integrated) Step Selection Analysis (SSA), respectively. The latter approach models conditional distributions – i.e., the likelihood is constructed for an observation at time *t*, conditional on the location at time $t-1$. This conditional formulation makes communicating results of SSA more challenging. In particular, managers often desire maps of expected utilization distributions (UD's), and it is not clear how these maps should be produced from fitted models. We explore two different approaches for generating maps from SSAs. First, we consider a naive approach that uses the coefficients from a fitted SSA model to estimate the UD, ignoring the conditional formulation of the model. Second, we consider a simulation-based approach, where space use is estimated by simulating movement via the fitted model. We compare the approaches using data generated by a stepping-stone process, where the underlying true UD is known. The simulation-based approach always provided better estimates of the true UD than the naive mapping approach. Differences between the approaches were greatest for complex landscapes and high sampling rates, suggesting that the simulation-based approach is likely to offer significant advantages when applying SSAs to real data.

Session 3-O7 - Migration strength of hoverflies (Syrphidae) in relation to meteorological conditions

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Hoverflies are known for their ecological services, such as aphid control and pollination, but little is known about their large-scale movements. Some species migrate south in large numbers during autumn, towards the Mediterranean. To

understand more about these movements, we captured individuals with 2 m-high flight interception traps on an alpine pass in Switzerland. One trap was directed towards the South and the other towards the North, the latter capturing the majority of the animals. The results showed a higher abundance of insects flying towards the South against the wind rather than with tailwinds. The rain and the cold seemed to deter the hoverflies from flying, while peak movement was usually between 12:00 and 15:00 hrs. Also, for most of the species, few males in comparison to the females seemed to be undertaking the journey. To our understanding, the insects have to adapt more to the weather conditions than bigger animals, due to their small size, and adopt different strategies to do so.

Session 3-O8 - Understanding life-history strategies of migratory birds to study indirect impacts of global change on biodiversity

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Migratory birds constitute an unneglectable part of avian biodiversity in seasonal environments. Due to their various interactions with other species, it is important to consider their temporal presence or absence, abundance and condition in biodiversity research. This requires a better understanding of their movement within an ecological and evolutionary context, especially since global change is increasingly affecting the behavioural patterns and population dynamics of migratory birds. Though recent advances in tracking technology helped in identifying current movement patterns of individuals, they lack the broader mechanistic perspective that is necessary for explaining migratory life-history strategies and for predicting anthropogenic impacts on the rhythmic movement pattern and population dynamics of migratory birds at the population level. Therefore, we implemented a flexible and soon freely available tool for modelling optimal animal life-history strategies in cyclic environments that is especially suited for theoretical studies of bird behaviour. In particular, we use stochastic dynamic programming to derive optimal state-based life-history strategies under cyclic food availability and wind conditions. Subsequently, we simulate population dynamics under the resulting strategy and potentially new environmental conditions. Here, we present the technique, the tool and exemplary results regarding potential impacts of global change on migratory birds, preparing the ground for further studies on how global change indirectly affects local biodiversity by changing movement patterns and population dynamics of migratory birds.

Session 3-O9 - High-throughput movement ecology and its potential contribution to biodiversity and ecosystem research

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The emerging field of movement ecology largely benefited from the recent development of new tracking technologies, enhanced computation abilities and powerful data analysis tools. Movement ecology studies have utilized those technological advances to better understand movement processes and predict movement patterns in general, and to examine how organismal movements affect biodiversity and ecosystem processes in particular. Despite these significant advances, some of the key questions in biodiversity and ecosystem research remain unresolved due to the lack of data about movements of organisms at the scale and resolution relevant to the interactions between animals and their environment. In this talk I will introduce a new powerful tracking system that provides new opportunities for linking movement and biodiversity research at a regional scale (10-20 km wide). This high-throughput system, called ATLAS (Advanced Tracking and Localization of Animals in real-life Systems), has been developed over the last 3 years by the Minerva Center for Movement Ecology. The system is based on "reverse GPS" technology and is capable to automatically and simultaneously track multiple small animals in an area of 15x25 km, at high sampling frequency and GPS-level accuracy. We implemented the first prototype of this system at the Hula Valley (Israel) and our preliminary work has yielded a dataset of over 20 species and more than 300 million data points thus far. Combined with fine-resolution data on key landscape and ecosystem features, ATLAS-derived high-resolution multi-species movement data can be used to examine intra- and inter-specific interactions, as well as interactions between animals and their environment in unprecedented detail. Consequently, the ATLAS system could play a key role in enhancing our understanding of movement-biodiversity relationships, marking the onset of a big data era in movement ecology. This will allow reexamination of previous dogmas, conceptions and assumptions that have long underlied biodiversity research, and will also bring new challenges in managing and analyzing big data.

Session 3-O10 - Linking animal movements with ecosystem functions

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Spatially explicit mapping of ecosystem functions remains a challenge and methodological hurdles have limited our understanding of dispersal pathways on the landscape scale. We demonstrate how movement data of frugivores can be used for spatially explicit mapping of seed dispersal networks in fragmented landscapes. We combined movement data of 30 Trumpeter Hornbills (Bycanistes bucinator) with gut-passage times and high-resolution habitat data in a fragmented forest landscape in South Africa. We identified potential seed dispersal paths and distinguished whether potential seed transport happened between forest patches, within the same patch, or into the habitat matrix. To quantify functional landscape connectivity we identified all possible between-patch connections and used graph networks to estimate landscape connectivity provided by hornbills. Although potential between-patch dispersal events were rare (on average 7% of all dispersal paths), hornbills could cover distances of up to 15 km. Hornbills visited over 100 forest patches and connected a habitat network with an extent of about 50 km which increased the potential functional connectivity of the landscape more than two-fold. We identified habitat patches that were critical stepping stones for seed dispersal pathways. Without these stepping-stones the network would likely disintegrate into separated components and lead to isolation of forest fragments. We showed that large frugivorous birds can greatly improve functional connectivity for fleshy-fruited plants across broad scales. Combining high-resolution movement and landscape data into graph networks allows the identification of seed dispersal pathways and critical stepping stones in fragmented landscapes, which could be widely incorporated in reserve design and landscape-level conservation planning.

Session 3-O12 - Individual movement decisions shape disease dynamics: Combining movement ecology and epidemiological models

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Host movement and thus individual movement decisions play an important role in driving on-going disease dynamics by transmitting pathogens to distant hosts, thereby connecting infected host patches with new areas that would otherwise be isolated. Thus, Riley et al. (2015) highlight the need to incorporate more flexible

and accurate movement algorithms as well as spatially heterogeneous landscapes in disease models to overcome population-based assumptions and integrate landscape structure between patches. Examples for such movement assumptions are rare long-distance dispersal events versus small-scale exploring trips, avoidance of open fields and/or urban areas, changes in movement behavior due to infection, seasonal aggregations on so-called transmission islands, or variation in the perceptual range of the individuals. The aim of this modeling study is to expand existing disease models by including more realistic movement algorithms than the assumptions used before, such as reaction-diffusion, displacement rules, neighborhood infection, or random walks. We investigate well-established spatially-explicit individual-based disease models: SwifCoIBM which simulates classical swine fever (CSF) in its social host, the wild boar (*Sus scrofa*; SIR epidemiological system) and a model on the spread of rabies in foxes (*Vulpes vulpes*; SI epidemiological system). Using a set of homogeneous and heterogeneous landscape scenarios, we will compare the effect of increasing complex movement assumptions on disease persistence while varying spatial and temporal landscape heterogeneity. With our modeling approach we aim to contribute to understanding complex disease dynamics and host-pathogen coexistence by unravelling the mechanisms behind heterogeneity in host behavior and contact processes acting at different spatial and temporal scale.

END OF SESSION 3

Session 4 – Habitat fragmentation: Demographic, genetic and environmental effects

Short title: Habitat fragmentation

Chair
Prof. Dr. Diethart Matthies

Session 4-O1 - Using circuit theory to estimate the effect of isolation on colonisation of forest fragments by plants

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It is difficult to assess colonisation rates of plants in fragmented habitats because dispersal of seeds is almost impossible to observe directly and significant numbers of colonisation events only occur on a time scale of decades. However, habitat patches that were newly established several decades ago allow to assess the number of colonisation events per unit time if the age of the patch is known. Further, it is possible to model the effect of landscape configuration on colonisation processes using the species richness of new habitat patches as proxy for colonisation. Temperate forests have been strongly fragmented in agricultural landscapes of Europe, but since the 19th century, numerous new forest "fragments" have been established and colonised by typical forest plant species. We modelled the effect of connectivity of hedges between forest patches on colonisation rates with a new approach using resistance distance based on circuit theory. Further, we also modelled the effect of Euclidean distance, assessed the importance of old forests as donor stands, and analysed the effects of patch age and area on species richness in new fragments. Regarding the calculation of resistance distance, we assumed that hedges were potential habitat corridors for forest plant species, whereas agricultural land was inhospitable and functioned as a barrier to colonisation. Resistance distance of hedges, but not Euclidean distance, had a significant negative effect on richness of typical plants in new forest fragments indicating that agricultural land was a barrier, while hedges were effective corridors for dispersal or multi-generational migration. Further, we found a threshold of resistance beyond which species numbers remained low even after more than 100 years. Connectivity to old forests through hedges increased species richness emphasising their importance as propagule donors.

Session 4-O2 - Environmental effects on inbreeding depression in plants

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Inbreeding usually has negative effects on fitness (inbreeding depression, ID) and can thus threaten the persistence of plants and animals in small populations. However, the magnitude of ID can vary among environments. It is usually assumed that ID is stronger under more stressful conditions, which would have important implications for the reintroduction of inbred plants and animals from captivity into potentially more stressful natural habitats. However, the available evidence is equivocal, and some studies also report stronger ID under more favorable conditions. To increase our understanding of the environmental influence on ID we performed controlled experiments with inbred and outcrossed offspring of two plant species, *Silene vulgaris* and *Rhinanthus alectorolophus*, under a range of environmental conditions and found that ID differed among environments, but was not generally increased under stress. Here, I want to present the results of these two case studies together with a meta-analysis of plant studies. The observed patterns differ depending on the type of stress and the chosen fitness measure. I conclude that the environmental influence on inbreeding depression in plants may be more complex than in animals, as it is not only determined by the stress intensity of an environment, but also by its effects on phenotypic variation and size-hierarchies among plants.

Session 4-O3 - Intensity of different types of stress does not increase inbreeding depression in the legume *Anthyllis vulneraria*

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Inbreeding can strongly reduce the fitness of plants, a phenomenon called inbreeding depression (ID), and thus contribute to the extinction of small populations. It is often assumed that ID is particularly strong under stressful conditions (Hypothesis 1). However, ID may be relatively mild under types of stress a plant population has experienced for a long time, because environment-specific deleterious alleles may already have been purged (H2). In addition, inbreeding depression may be higher in certain environments because of higher phenotypic variation among plants and thus more opportunities for selection (H3). To understand the interactions between inbreeding and environmental stresses, we examined the performance of open- and self-pollinated progeny of the legume *Anthyllis vulneraria* under three intensities of each of five stress types. Drought, nutrient deficiency and defoliation were chosen to be typical for the original

habitat, while shade and waterlogging were expected to be novel, uncommon stresses for *A. vulneraria*. All stress treatments reduced the biomass of the plants, and both morphological traits and the allocation of biomass were influenced by stress type and stress intensity. Inbreeding decreased fitness-related traits, but the magnitude of ID was independent of environmental conditions. There was no significant interaction of inbreeding and the intensity of any stress type. Furthermore, ID was not higher under novel than under known conditions, and ID was not higher in treatments which increased the phenotypic variation among plants. These findings do not support the common hypothesis of stronger ID under stressful conditions (H1), nor the other hypotheses tested (H2 - H3).

Session 4-O4 - Frog functional diversity in a fragmented landscape

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Madagascar's ecosystems are severely influenced by anthropogenic habitat fragmentation and conversion. Although in general these disturbances of natural ecosystems are thought to have negative effects on biodiversity, there is no consistent pattern on species' and communities' reactions. Ecosystem consequences remain poorly known. Differences in species' reactions may result in changes in community structures and food-web interactions, likely affecting ecosystem functioning. Hence, understanding fragmentation effects on functional diversity is crucial for future conservation efforts as it may reveal potential ecosystem consequences. We compared functional richness and functional β-diversity of frogs between three land use categories that represent an anthropogenic disturbance gradient in a mid-altitude rainforest ecosystem in Madagascar, ranging from continuous forest over forest fragments to matrix habitat including banana plantations and rice fields. Species occurrence data was collected on 56 line transects spread over stream and terrestrial habitats across the entire land use gradient. We calculated functional diversity using a set of twelve selected ecological, morphological and life history traits that are related to resource use. Stream habitats were functionally richer than terrestrial habitats. Our study revealed direct fragmentation effects on functional diversity in the matrix as well as indirect effects through reduced species richness in these habitats. Furthermore, functional clustering might be caused by natural and anthropogenic drivers. Patterns of functional β-diversity reflected the anthropogenic disturbance gradient and water availability. Although forest fragments as well as streams and banana plantations in the matrix can still be valuable habitats for frogs, changes in functional diversity indicate that ecosystem functions could be affected by anthropogenic habitat alterations.

Session 4-O5 - The distribution of brown bear in Northwestern Iran: mapping habitat suitability and potential connectivity

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Since the brown bear (*Ursus arctos*) is sensitive to loss of habitat and to the disruption of pathways all over its distribution range, we sought to elucidate the species' status and habitat requirements within an area encompassing the entire East Azerbaijan province, Iran. We used a consensus species distribution modeling approach using 12 uncorrelated environmental variables to explore the distribution of habitats suitable for the bears. Results indicated that normalized difference vegetation index, topographic exposure index, temperature seasonality, mean annual temperature and roughness index were expected to be important predictors of high quality habitat. Using these results, we identified 10 high quality patches across the study area, and applied concepts from electronic circuit theory to estimate regional patterns of connectivity among these patches. Modeled connectivity revealed that it is likely that the strong north-south subdivision in our study area is due to both natural habitat barriers that have existed for long time and recent anthropogenic barriers superimposed upon. Our outputs can be used to help target finer-scaled analyses in support of planning efforts concerned with the maintenance of bear meta-population structure, as well as the protection of landscape features that facilitate the dispersal process.

Poster presentations

Session 4-P1 - From in situ to ex situ and back - a case-study in conservation management of *Trollius europaeus*

Joscha Saxler[1], Tamina Wosch[1], Christina Mengel[1], David Behringer[1], Andreas Titze[1], Norbert Kowarsch[2], Birgit Ziegenhagen[1]

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The grassland species *Trollius europaeus* L. (European Globeflower) has become severely threatened in some of the mountainous areas of Northwest-Germany. This is due to habitat changes caused by an intensified grassland usage. One possible conservation strategy aims at pushing population sizes by collecting seeds in situ, raising the plants in an ex situ environment and bringing them back to the

place of origin. Such a procedure was started in the Botanical Garden of the University of Marburg. In 2013, seeds from individuals belonging to seven *T. europaeus* sites of the Rothaar-Mountains (North-Rhine Westphalia) were germinated and cultivated in the garden. The sites represented three different grassland scenarios (extensive meadow, mowing meadow and fallow land). Interestingly, when measuring performance variables in 2015 there was still an imprint of the former management. Those seedlings originating from extensive meadows generated the longest shoots. Instead, when measuring fitness related variables such as "thousand-seed weight" and "germination rate" there was no significant difference. We cannot exclude an overriding effect through open-pollination of the randomly set up plants in a small garden area. In ongoing studies of the season 2016 the plants, that had been brought back to nature in autumn 2015, will be studied for success of establishment as well as for performance and if possible for fitness variables. These data will be compared with the ex situ data as well as with data from co-habitating plants which had been continuously grown in situ. Thus, we will evaluate the ex situ – in situ management for performance and fitness related effects. In any case we will foster an additional genetic monitoring of the involved populations (see Poster by Bette et al.). This will widen our view and will contribute to a best possible management which in the long run may include the maintenance or increase of genetic diversity as well.

Session 4-P2 - Status and structure of populations of the endangered hemiparasitic herb *Pedicularis sylvatica* in Hesse (Germany) and neighbouring areas

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Pedicularis sylvatica is an endangered hemiparasitic plant species of wet and nutrient-poor grass- and heathlands. The populations of this species have strongly declined during the last decades due to land-use changes, eutrophication, drainage and other anthropogenic impacts. We studied small, medium and large populations of *Pedicularis sylvatica* in Hesse (Germany) and neighbouring areas in the summer of 2016. Environmental variables, vegetation characteristics as well as vegetative and reproductive traits of *P. sylvatica* were recorded in each population and related to each other. First results of the analyses will be presented.

Session 5 – Remote sensing in ecology - Fostering the spatial perspective

Short title: Remote sensing in ecology

Chairs
Prof. Dr. Jörg Bendix
Christine Wallis
Dr. Thomas Möckel
Dr. Lukas Lehnert

Session 5-O1 - Assessing ecological impacts of commercial land appropriation - An integrative approach developed for Latin America

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In Latin America, commercial actors realizing land-use changes are 1. far less regulated by governmental control, 2. far less monitored regarding the impacts of the impacts induced onto natural ecosystems. Both aspects create concern towards conservation of natural assets facing economic appropriation. This is true particularly for forestry by commercial tree farms (mainly Pinus spec.) for instance in Chile, but also elsewhere. Natural assets – like plant biodiversity – can be assessed and monitored by (repeated) ecological fieldwork. However, such assessments require a high amount of temporal and financial resources. Thus, they will remain limited to point wise assessments based on plot sampling. A particular support for such monitoring comes from remote sensing techniques. Despite the fact that they do not contain any ecological knowledge in the first place – unlike plot based sampling does – they provide their spatially and temporally extended characteristics. Remote sensing data are available at little or no cost for huge areas, ranging back into the 1970ies. Hence, combining field sampling and remote sensing techniques seems to provide especially useful when assessing the impacts of land-use changes in favour of economic activities onto biodiversity. Such an approach is presented herein. Several approaches have been published to interpolate local biodiversity assessments in remote sensing data. Herein, a new approach is proposed. Instead of inferring biodiversity, using environmental variables or the variability of spectral values, a hypothesis-based approach is applied. Empirical knowledge about biodiversity in relationship to land-use is formalized and applied as ascription rules for image data. The method is exemplified for a large study site (over 67.000km2) in central Chile, where forest industry heavily impacts plant diversity. The proposed approach yields a high correlation coefficient and allows for conclusive statements on biodiversity impacts due to forestry.

Session 5-O2 - A phenology-driven land-cover classification

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Most land-cover classification schemes like e.g. the MODIS land-cover product, use a variety of spectral bands (VIS, VNIR), a vegetation index (EVI) and land-surface temperature as input variables. Subsequently, machine learning algorithms are trained (supervised) and employed for classification. This multitude of input variables and different remote sensing products sometimes obscures the functional relationships responsible for discriminating land-cover classes. We consequently propose a more ecologically driven procedure which relies on phenological plant behaviour only. This work integrates and evaluates most commonly used methods to extract phenological metrics based on satellite imagery. MODIS Terra/Aqua daily NDVI observations (2001-2015), 250 m spatial resolution, for the area of Germany were used. The following metrics were extracted: greenup, senescence, length of vegetation period, max. and min. NDVI as well as the julian day of max NDVI. The metrics were used as input for an unsupervised classification using a clustering method which is based on gaussian mixture models and the expectation-maximisation algorithm. Despite using an unsupervised classification algorithm, results were in line with much more complex standard schemes. For vegetated land-surfaces the purely phenology driven method could discriminate land-cover classes a finer level. Urban areas were more difficult to identify and discriminate potentially because even heavily build-up areas exhibit some kind of phenological behaviour.

Session 5-O3 - Satellite-based monitoring of grassland – assessment of cutting dates and frequency using sentinel data

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Cutting date and frequency are important parameters determining grassland yields besides weather, soil condition, and plant composition. However, cost and time efficient methods to register cutting dates in grassland are missing. Therefore, we developed a highly automatised methodology for detecting cutting dates using SAR-amplitude data. Our approach is based on an amplitude change detection technique to derive grassland harvest events for given field boundaries provided via the European Integrated Administration and Control System (IACS). Therefore spatial statistics for identification of changes between pre- and post-harvest

acquisitions are used. The combination of this method with a grassland yield model will result in more reliable and regional-wide numbers of grassland yields. Both for optimisation of detection reliability as well as for an improved rendering of cutting dates a high temporal acquisition rate is required and generally met by using SAR-satellite constellations providing a revisit time of few days. During the initial phase of the study data of the X-Band SAR-Constellation COSMO-SkyMed were utilised for developing and prototyping of a monitoring system. Subsequently the approach was adapted to the use of the C-Band system Sentinel-1A. With the availability of Sentinal-1B data monitoring of grassland harvest and subsequent biomass modelling will become fully operational. In future, the methodology will profit from integrating also high resolution optical imagery data of Sentinel-2.

Session 5-O4 - Intra-annual dynamics of diversity drivers on grasslands communities using 3D images

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The positive relationship between plant species richness and plant productivity is supposed to be driven by complementarity effects. Based on annual measurements, long-term biodiversity experiments support complementary effects and reveal their strengthening with maturity of the plant communities. However, we still lack information on if and how the link of niche differences and increased productivity in more diverse communities is established within individual years over the vegetation period. High temporal resolution experiments will help to understand how and when diversity in plant stature and architecture allows communities to exploit resources over time. We used terrestrial laser scanning (TLS) and leaf area index to measure biweekly structural parameters of grassland communities over 2 years. These data were used to estimate biomass production and quantify temporal complementarity in the Jena Experiment. We investigated how functional diversity and functional identity perform over time to maintain higher productivity in more diverse plots. We expected that functional identity (FI) is positively correlated with the onset date of the growing season because of the potential dominance of the most productive species during this period. In contrast, functional dispersion (FDis) should be positively associated to later, more established plant communities due to increasing importance of relative trait dissimilarities. With non-linear mixed effect models we found that the importance of diversity drivers (FI vs FDis) varied along the growing season. While FI was important up to the first peak biomass production after winter dormancy, FI became important after the first harvest but only in the first weeks of recovery in both years. Interestingly, functional diversity indices, for both years, FI was very important along the growing season but not at the peak biomass during the recovery period. FDis was only important on the peak of community biomass after

winter dormancy. Moreover, species richness was more important at the onset dates of the growing season. Intra annual dynamics showed alternative importance of diversity drivers, especially after winter dormancy and recovery from harvest. After harvest, FDI suggested that greater temporal variability may increase opportunity to exploit more niches.

Session 5-O5 - Detection of an invasive shrub by combining hyperspectral vegetation indices at field and airborne level with LiDAR

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The Genus Acacia comprises some of the most invasive shrub and tree species worldwide. *Acacia longifolia* from Southeast Australia is invasive in coastal regions, for example in Southern Europe and South Africa. In southwest Portugal, protected dune ecosystems of the NATURA2000 network are severely affected by the invasive *Acacia longifolia* that has a negative impact on biodiversity, changes the vegetation structure, and alters the nitrogen and the water cycles. Understanding potential ecosystem changes at landscape scale as well as establishing management and control measures requires detailed distribution data of the invader and its impacts. In order to map the spread of *A. longifolia* and to understand the invasion process, we collected hyperspectral measurements of common native plant species and of the invader at leaf and canopy level in the field, together with high resolution hyperspectral airborne imagery and LiDAR data of the whole study area in southwest Portugal. We found that *Acacia longifolia* can be distinguished from common native dune species at both leaf and canopy level using hyperspectral narrowband vegetation indices. The most important indices were linked to chlorophyll, water, nitrogen, cellulose and vegetation cover, which is supported by recent field studies concerning biochemical and ecophysiological properties ofthe invaderand the native species. The indices identified at canopy level are used for detecting *A. longifolia* in the hyperspectral airborne images. Classification accuracy will be assessed using ground-truth information. In addition to the vegetation indices, LiDAR derived parameters of vegetation structure are used and their impact on classification accuracy will be quantified.

Poster presentations

Session 5-P1 - Interface of remote sensing & GIS; on tracking the status and resilience of biodiversity on the impact of climate change.

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The world's ecosystems are losing biodiversity fast due to impacts of climate change. A satellite mission designed to track changes in plant functional diversity around the globe could deepen our understanding of the pace and consequences of this change, and how to manage it (Jetz *et al*., 2016). Capturing and understanding this variation is vitally important for predicting how ecological life support systems will function in the future (Jetz *et al*., 2016). We used satellite and airborne remote sensing to provide us with potential tools to map and monitor Biodiversity at much larger spatial and rapid temporal scales. We combined high-resolution airborne imaging spectroscopy and a ground-based tree canopy census to investigate the change on the coverage caused by climate change. Currently there is a lack of consistent, repeated high-resolution global-scale data on the functional biodiversity. However, the technological tools, informatics infrastructure, theoretical basis and analytical capability now exist to produce this essential data (Jetz *et al*., 2016). The main of this study was to develop an innovative method to support research at the interface of remote sensing & GIS; on tracking the status and resilience of Biodiversity on the impact of climate change. These assessments and prediction are essential inputs to inform Policy makers for example: international initiatives and the Intergovernmental Science Policy on Biodiversity Services. To rise to these challenges posed by climate change, in particular access to standardised information on climate change impacts in the distribution of South African biodiversity is of high priority. Remote sensing has already proved to be a pivotal technology for addressing the global biodiversity data gap. Data on plant productivity, phenology, land cover and other environmental parameters from MODIS (moderate resolution imaging spectroradiometer) and Landsat satellites currently serve as reasonably effective covariates for spatiotemporal biodiversity models based on *in situ* data12,20,26.

Session 5-P2 - Higher predictability of beta diversity models by remote sensing considering multiple taxa in a mountain rainforest

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Information derived from various remote sensing (RS) sources provides surrogates for habitat structure and therefore information to model species diversities across space. Such information is of basic importance for conservation planning, particularly across hotspots of biodiversity. Nowadays, however, RS based monitoring systems often focus on alpha-diversity models which often do not exceed moderate predictive power. Because beta-diversity measures cover parts of species identity, we hypothesize that their predictability would be higher. Here, we investigated the predictability of four taxa (trees, ants, moths, birds) considering alpha and beta diversity measures in a mountain rainforest ecosystem. Diversity models are fitted by topography and optical texture metrics derived from very high resolution multi-spectral orthophotos using partial least-square regression. Predictability of species richness was taxon dependent with highest predictive power for ants (74 %) and lowest for trees (6 %). For all taxa, predictability of beta diversity measures was higher (>80 %). We explain this result by the fact that measures of beta-diversity incorporate also information of the response of individual species to changes in habitat structure in particular related to the elevational and thus climate gradient.

Session 5-P3 - Assessment of habitat quality and management of dry grasslands in Switzerland using multi-temporal satellite images

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Intensification, land-use change and management abandonment led to a massive decline of semi-natural, species-rich dry meadows and pastures in Switzerland. In 2010, a federal inventory was established to prevent further decline of the most important dry grassland habitats. A long-term monitoring project was started to evaluate protection success. Vegetation data are collected throughout Switzerland to produce reliable estimates of habitat quality measures. However, interpretation of the quality estimates is limited since the crucial information about management regimes is lacking. The goal of this study was to gain management information by using Normalized Differenced Vegetation Index (NDVI) time series. Seasonal NDVI phenology curves were fitted from multi-year Landsat satellite data for the locations of the nation-wide vegetation sample. A set of phenology metrics was derived and complemented by information on climate, management and topography. Linear regression analysis was conducted to (1) gain knowledge about management and productivity of protected dry grasslands, (2) predict habitat quality and (3) study change within the last 15 years. Seasonal phenology, characterised by a uni- or bi-modal NDVI curves, varied strongly between management types, biogeographical regions, and elevation. The NDVI peak value showed a non-distinctive pattern, whereas it's time of peak appeared to be much earlier (±20 days) in meadows than pastures and fallow. The number of peaks and the standard deviation of the raw NDVI values within the growing season were shown to be suitable proxies for management intensity. Predictions for habitat quality showed R-squared values of 37-57%. NDVI phenology metrics improved the explained variance of those models by 5-11%. Significant interactions of NDVI metrics with management were found, for example indicating that later mowing-dates are related to increased plant species richness. Furthermore, change of NDVI phenology (2000 to 2015) showed a significant relationship to recent change in temperature and precipitation. Our findings suggest the use of NDVI time series within an integral modelling approach, to increase explanatory power and ecological interpretability of dry grassland habitat quality models.

Session 5-P4 - A Sentinel based analysis of vegetation patterns of a semi-arid savanna in South Africa

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Senegalia mellifera var.*detinens* is an increaser woody species and serious bush encroacher of semi-arid Savannas in the North-West Province, South Africa. Large areas of the Molopo Bushveld have been transformed from a grassy tall open savanna of dominating *Vachellia erioloba* and *Boscia albitrunca* trees to a closed *S.*

mellifera thicket nearly devoid of key, perennial fodder grasses, used for the production of grazing livestock and/or game. The area is managed in three very distinctive land management regimes namely commercial, communal and conservation, which have diverse practices towards fire control and grazing/browsing management. A vegetation structure map was created using Sentinel-1 Ground Range Detected and Sentinel-2 multispectral imagery. Individual pixels were classified as predominantly bush, grass, bare ground or mixed, using machine learning algorithms. Vegetation patterns were characterized by various structural indices based on the vegetation classification and disturbances. The results of this study will be used to analyze whether bush encroachment is a stochastic process or driven by land management practices, fire events, climatic circumstances or a combination of factors. The data and results will be used in the development of a rangeland model as part of the IDESSA project (IDESSA: an integrative decision-support system for sustainable rangeland management in southern African savannas), which can help in the prediction of change and land users making scientifically sound management decisions in the long-term.

Session 5-P5 - Kilimanjaro forest landscapes assessed from LiDAR point clouds: is there bias in field studies of forest structure?

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Field inventory plots which usually have small sizes of around one hectare can only represent a fraction of the much larger surrounding forest landscape. The small size of such plots is the consequence of a trade-off between very detailed and still feasible quantities of data collection and often the chosen location of setting up a plot is affected by topographical constraints and local accessibility. These constraints may particularly affect the selection of inventory plots on tall mountains such as the Kilimanjaro in Tanzania because this ancient volcano has considerable slopes and also numerous steep gorges and valleys. Based on light detection and ranging (LiDAR) data it has been shown for tropical forests that the bias in the selection of small inventory plots may severely hamper extrapolation of structural forest attributes to landscape and regional scales. For example, mean biases in forest canopy structure (height, gaps, and layers) and aboveground biomass in both lowland Amazonian and montane Andean landscapes may reach as much as 9-98% (Marvin et al. 2014). Such biases may cause difficulties especially when the goal is to assess and simulate carbon stocks and fluxes with computer models for larger scales (Fischer et al. 2015). We therefore conduct here a LiDAR study on tropical montane forest in equatorial East Africa and evaluate the representativeness of chosen inventory plots with respect to key structural attributes such as top-of-canopy height, standard deviation and coefficient of variation of height, gap fraction, and standing biomass. We show that these

attributes may considerably differ between LiDAR measures derived from landscape grid plots and small inventory field plots. These results will be discussed with respect to topographical constraints and also potential anthropogenic influences.

Session 5-P6 - Coastal Objects: Mangrove area extraction using remote sensing and aerial LiDAR data in Bongabong, Oriental Mindoro

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The Phil-LiDAR 2 program aims to extract the natural resources of the country from the available two points per square meter LiDAR data. Mangroves, being coastal resources, were the focus of this study. About 30-40 species belonging to 15 families of true and associate mangroves can be located in some portions along rivers and shorelines of the Philippines. With a 1m x 1m resolution, existing LiDAR data presents good estimates of height information. And by implementing an object based image analysis (OBIA) approach and the support vector machine (SVM) classification algorithm an overall accuracy of around 90% was obtained. Using three classes namely, mangrove, non-vegetation, and other vegetation. Some of the LiDAR derived information that aided the mangrove area extraction were related to object texture, geometry, and relation to other known objects from the image. Moreover, conducted field data collection and validation provided key references in contextual editing of the extracted mangrove areas. With the final extracted mangrove coverage, management of the mangrove resources can now be proper and efficient. Furthermore, this kind of detail in spatial information can support programs like the Reducing Emissions from Deforestation and forest Degradation Plus (REDD+) and even biodiversity studies. With the results of this study, other areas of local government units covered by LiDAR data can also be extracted. And in terms of detailed carbon stock calculations, tree counting workflows and algorithm can expand the potential of remote sensing and LiDAR in the Philippines.

END OF SESSION 5

Session 6 – Conservation science for applied nature conservation

Short title: Science for nature conservation

Chairs
Prof. Dr. Martin Dieterich
Dr. Andreas Krüss
Prof. Klaus Werk
Prof. Dr. Nina Farwig

Session 6-O1 - All animals are equal, but some are more equal than others: the habitat directives and species conservation

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The birds and habitat directives of the European Union are cornerstones for conservation in Europe. One central aspect of the habitat directive is that one group of species has been singled out for particular attention as being of 'Community interest'. For these species, that include all breeding birds of Europe (Bird's directive) and a further about 400 species listed in Appendix IV of the habitat directive, a strict protection regime must be applied across their entire natural range within the EU, both within and outside Natura 2000 sites. While the habitat directive was ratified in 1992, it took many years until it was incorporated into national law, e.g. until 2009 in Germany. Only in the last few years has the directive been applied to roadworks and other building projects. The costs and benefits are only beginning to be assessed. I evaluated the success of the habitat directive by analyzing the application of the Habitats Directive in completed road construction projects in Bavaria. The first step of the assessment includes an evaluation of species presence in the area affected by the roadworks. Here, it was apparent that the majority of assessments relied on information of other sources rather than on mappings carried out for the particular project. Prominent among these were existing monitoring data which are often incomplete. In the second step, the impact of the roadworks on the protected species need to be assessed. In the majority of cases, it was unclear on what the assessment of impact and the recommendations for continuous ecological functioning of the habitat were based, leaving open the possibility that the species suffers from the roadworks. Finally, assessments focused on species listed in the directives, while other species were largely ignored. I speculate about the longer-term consequence of the habitat directive as implemented in current law.

Session 6-O2 - Nature conservation effects of different bio-energy cultures

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Using different indicator groups we assessed the biodiversity and nature conservation effects of different energy cultures including perennial (5-year) flower mixes (biogas), maize (biogas), crop for whole plant silage (biogas), sugar beet (ethanol), rape (diesel) and miscanthus (solid fuel). Indicator groups reflect different ecosystem functions and include segetal vegetation (primary production), leaf beetles (primary consumption), bees (pollination), spiders (predators in the vegetation), ground beetles (epigeic predators) and worms (detritivores). Maize (unfavorable for biodiversity) and perennial flower mixes (favorable for biodiversity) were used as references for the assessment of effects. Research was conducted in a well structured landscape in Baden-Württemberg and a less structured landscape largely dominated by agricultural fields in Northrhine-Westfalia. For ground-beetles more complex indicators considering rareness, distribution, sensitivity to disturbance and red listing were calculated to qualify nature conservation effects. Both study areas combined, 498 species were recorded and considered in the analysis. Flora and fauna in the energy cultures were dominated by generalists, species relevant for nature conservation were rarely recorded. Flower mixes provided best biodiversity results, maize was ambiguous depending on treatment with herbicides. There was little difference in species numbers or conservation value between rape, sugar beet, and whole plant crop silage. Miscanthus was particularly species poor when managed economically (dense stocking), but offered room for many species when management provided for low stocking densities and, thus, gaps. Calculating more complex indicators based on the ground beetle collection still yielded low overall conservation values and did not improve the resolution between cultures. Results indicate the need for the use of reference systems to assess the conservation value of agricultural fields.

Session 6-O3 - Conserving agrobiodiversity through important arable plant areas (IAPA) - Lessons learnt from the ‚100 Fields for Diversity' project

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The cultural landscapes of Central Europe, but also of most other regions on the continent, have been shaped by human land use over millennia. The most pronounced effects are seen in agricultural fields which were home to diverse communities of arable plants and their associated fauna. In the last century, land use has rapidly intensified, especially so since the advent of industrial arable farming in the 1950s. In consequence, declining agrobiodiversity is increasingly viewed as a major problem in nature conservation. Due to the lack of success of previous efforts to ensure the long-term conservation of the highly endangered arable flora, in 2009 the University of Goettingen started the project '100 fields for diversity' with funding from the German Federal Environmental Foundation (DBU). The aim of this project was to set up a nationwide network of important arable areas (IAPA). Based on a nationwide screening for the floristically most valuable sites of arable vegetation in Germany, 112 field complexes with a total area of ~470 ha were secured for at least 10 years (often up to 20-25 y) by contracts and appropriate low-intensity agricultural practices. The protected fields are spread over the whole area of Germany on either limestone, sandy or loamy soils with arable communities harboring many rare and endangered species. A key element is the commitment to extensive farming practices targeted at promoting endangered species. We discuss various instruments for achieving long-term financial support of the sanctuary management such as compensation payments and agri-environmental schemes (AES); the former are promising but require complex negotiations and considerable time for establishment. Selected case studies of protected fields are presented and the future development of the important arable plant area network is discussed. Finally, still required research questions and practical perspectives to stop the decline in agroecosystems will be discussed.

Session 6-O4 - Bryophyte diaspore bank in ‚Ecological Focus Areas' in arable farming in Swiss lowlands

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Ecological Focus Areas (EFAs) are an important tool of the Swiss agri-environmental schemes to support biodiversity in landscapes dominated by agriculture. EFAs are usually designed to promote bird and vascular plant richness or ecological functions such as pollination. An earlier study revealed also a beneficial effect of EFAs also on above-ground bryophyte species richness. Here, we focus on the bryophyte diaspore bank and of EFAs and adjacent conventionally managed fields.

We hypothesize that the diaspore banks of very young EFAs do hardly differ from those in conventionally manged fields, but that older EFAs show a different and richer diaspore bank, especially EFAs of intermediate age. We selected 18 study sitesin the Swiss lowlands, each consisting of either one flower strip for pollinators and other beneficials(sowed in the same season), one young (1-3 years old) or one old wildflower strip (4-6 years old) as well as the adjacent field. We sampled the diaspore bank at 3 and 15 cm at four randomly chosen points in each strip and the adjacent field (288 soil samples). The soil samples were cultivated in transparent, covered plastic boxes in the greenhouse during 4.5 months. To our surprise, the hornworts *Anthoceros laevis* and the threatenend *Phaeoceros carolinianus* emerged abundantly from the diaspore bank although they were not present above-ground. We currently analyse species composition and –diversity in the diaspore bank. First results show that EFAs are highly suitable to promote also non-target species such as arable bryophytes.

Session 6-O5 - Maintenance of species-rich grassland under agricultural use

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The proportion of species-rich grassland in Baden-Württemberg is around 20%. Diversity hotspots exist especially in the lower mountain ranges of Swabian Alb and Black Forest with their high structural diversity, rough climate and other conditions impeding intensive agricultural management. Farmers managing grassland under nature protection are confronted with the two opposite challenges of maintaining the species richness and at the other hand to gain agriculturally exploitable products and a sufficient income. Both goals often seem to be mutually exclusive: extensive management is related to low dry mass yields and - because of low forage quality - restricted use in the nutrition of grazing animals. Additionally, the presence of toxic plant species partially prohibits the use as animal fodder. The possibilities to repress such undesirable plant species or to increase the productivity or forage quality of the growth are limited. Farmers managing grassland under nature protection normally receive agri-environmental payments associated with management obligations, which impede flexibility in the use e. g. with respect to the yearly variable weather conditions. Latest informations hint to negative effects of these strict specifications on the maintenance of these habitats. In the presentation, these contradicting aims and interests are highlighted in the context of results of applied research with grassland experiments based on questions by concerned farmers. Different aspects of managing diverse grassland will be discussed: Management of *Colchicum autumnale*, possibilities for the utilization of extensive growths as roughage, effects of fertilization on botanical composition and moreover methods to restore formerly diverse grassland.

Session 6-O6 - Direct and productivity-mediated indirect irrigation and fertilization effects on plant and bryophyte diversity in meadows

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In Central Europe, agricultural grasslands have a long land-use history and they have harbored a high diversity of various taxa. However, over the last decades, the intensification of land use, with the aim to increase yield, has led to a drastic decline of grassland diversity. While the effect of land-use intensification on vascular plant diversity has well been studied in lowland regions, montane and subalpine grasslands received less attention, and taxa such as bryophytes were largely neglected. Therefore, we experimentally tested over a period of five years how land-use intensification, i.e. irrigation, slurry fertilization and the combination of both, affects the hay production as well as the diversity of vascular plants and bryophytes in low-intensity Swiss mountain grasslands (Valais, SW Switzerland). The hay production increased and the number of vascular plant and bryophyte species decreased with the amount of fertilizer and water applied. Structural equation modelling revealed direct negative fertilization effects on bryophyte richness to be stronger than the productivity-mediated indirect ones via competition for light. This finding is interesting because it questions the traditionally view of the mainly suggested indirect effects on bryophyte richness via increased aboveground biomass and competition for light. From a conservation point of view, we recommend maintaining extensive grassland management and avoid intensification of formerly extensively managed grasslands, which might be achieved with existing biodiversity promoting programs (i.e. subsidies) as a tool to compensate low hay production.

Session 6-O7 - Much more than bees - harnessing the conservation value of wildflower plantings

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One goal of wildflower plantings is to promote biodiversity in intensively managed agricultural landscapes. Most studies on flower-visitors of wildflower plantings have focussed on single or few prominent taxa (e.g., wild bees and hoverflies). In contrast, it remains largely unresolved how non-prominent flower-visitors of the community are affected by wildflower resources, landscape context and time of the flowering season. We studied flower-visitor communities on wildflower plantings varying in flower abundance and richness and their surrounding landscape context within a 500 m radius (percentage arable land, presence of additional wildflower plantings) in the early (May–June) and late (June–July) flowering season. Strikingly, only 81 of all 322 visiting species (< 50.0 % of individuals) were bees or hoverflies, and 241 non-prominent 'other' visitor taxa were sampled, encompassing many ecologically and economically important species such as parasitic wasps and non-syrphid Diptera. At the group-level, flower abundance and richness of plantings affected neither abundance nor richness of wild flower-visitors. Moreover, wild bees were the only visitor group to decrease in richness with higher amounts of surrounding arable land. At the species level, in the early flowering season, wildflower plantings that were accompanied by additional local plantings and embedded within complex landscapes supported the highest abundances of habitat specialists (e.g. *Bombus* spp.), whereas isolated plantings were predominantly visited by agricultural generalists (e.g. predatory hoverflies). These compositional differences diminished towards the end of the flowering season. Our study highlights the great conservation potential of wildflower plantings in agricultural landscapes. With the exception of wild bees, wildflower plantings support a high diversity of functionally complementary flower-visitor species from complex to structurally simple agricultural landscapes. These so-far overlooked flower-visitors may have the potential to provide complementary ecosystem services and to step-in in agricultural settings where prominent providers have been lost.

Session 6-O8 - Pollinator communities can be effectively supported by seed mixtures with only few attractive plant species

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Sown wild-flower fields are an established method of agri-environmental schemes (AES) for promoting pollinator diversity by increasing flower availability in agricultural landscapes. It remains unclear, however, how efficient commercial seed mixtures are with regard to number and composition of flower species.

We assessed the attractiveness of four different seed mixtures for a local flower-visitor community. Wild-flower plantings were established on 28 plots (4x4m) in 2013 in a random block design at the experimental farm Oberer Hardthof (Hesse, Germany). We sampled flower visitors in July and August in the years 2013 and 2014. A total of 1837 flower visiting specimens of the families Syrphidae (28 species with 702 individuals) and Apidae (46 species with 1135 individuals) were collected over the whole sampling period. These pollinators visited 43 out of 96 recorded plant species. Wild-flower plantings differed in the proportion of established plant species, the role of the seed bank, and abundance and richness of floral resources. Species richness of all pollinators and abundance of wild bees were not related to number of plant species. This was mainly caused by the occurrence of one highly attractive plant species (*Phacelia tanacetifolia*) in the least and the second most diverse mixtures. In fact, only four plant species were needed to achieve 70% of the observed pollinator species and another 10 to support the rest of our local pollinator community. In conclusion, the presence of some specific plant species was more important than plant species diversity *per se*. Thus, flowering fields can easily support common pollinator species with few suitable plant species. Rare and specialised pollinator species, however, may face increased competition by manmade restorations. Accordingly, flowering fields are a suitable tool for increasing common pollinator abundance and their pollination service, but cannot substitute extensive grasslands and their ecological functions.

Session 6-O9 - Landscape structure alters the response of wild bee communities to changes in weather conditions

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Wild bees are important providers of the pollination ecosystem service. Their abundance and richness are affected by changes in weather conditions and by alterations in landscape structure. Here, we assess the potential of semi-natural areas and landscape heterogeneity to maintain robust communities under changing weather conditions. We use data from an ongoing monitoring scheme and we perform two separate analyses. The data collection takes place six times per year in six sites in central Germany and 16 local communities per site. For our first analysis, we follow a multimodel inference approach to identify the most important weather and landscape variables that affect wild bee species richness and total abundance. We find a strong negative relationship of species richness and total abundance with temperature. However, high amounts of semi natural areas can considerably decrease the detrimental effect of warmer temperatures on bee species richness and abundance. In our second analysis, we assess the importance of landscape heterogeneity, weather variability and their interaction to the intra-annual spatiotemporal stability of wild bee abundance. We find that the stability

increases with higher landscape heterogeneity, but decreases with higher intra-annual variability in both temperature and precipitation. In heterogeneous landscapes a buffering mechanism enables the maintenance of high stability even under highly variable temperature conditions, but the same mechanism does not apply for highly variable precipitation. In total, our findings suggest that semi-natural areas and landscape heterogeneity are beneficial for wild bees and can be used as a countermeasure against changes in temperature patterns associated with climate change (warming, increased variability). Nevertheless, landscape heterogeneity should not be treated as a universal solution and alternative strategies need to be developed to tackle the effect of changes in precipitation patterns on wild bees.

Session 6-O10 - Global change in action - butterfly community shifts over time

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Recent global change and ongoing land-use modifications and agricultural intensifications are shaping recent biodiversity over major parts of the world. To understand potential trends of species community shifts, time series (observations performed at different points in time) are necessary. In various studies we analysed changes of butterfly communities over decades and centuries. Based on (i) butterfly occurrence data, (ii) the respective ecological behaviour of each butterfly, (iii) the ecological characteristics of each larval food plant used from the selected butterflies, and (iv) a considerable data set on the climatic conditions during this time period measured at our study site we got the following evidences: We found a significant decline in the community similarity over time. A decrease in the total number of species, but with an increase of the proportion of generalist species, and a decrease of the proportion of endangered (specialised) species. A declining Eveness – and subsequently some dominating species (generalists), which most probably might also be supported by nutrition loads. We discuss our findings against the background of global change, local land-use changes (and habitat effects like fragmentation and persistence), and close our contribution with the phenomenon of „shifting baselines“ – and the relevance of presenting large-temporal data-sets.

Session 6-O11 - Are semi-open corridors a tool to overcome landscape fragmentation for both endangered open and woodland arthropods?

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Habitat fragmentation is one of the main drivers of biodiversity loss. Corridors are a frequently used approach to overcome this conservation issue. However, in landscapes where both open and wooded habitats are endangered, corridors of one habitat type may further fragment the other habitat type. Some nature conservation authorities discuss semi-open corridors as a solution to this challenge. Semi-open corridors are defined as connecting landscape structures which consist of a mosaic of open habitat structure and woody vegetation. Due to low dispersal power and stringent habitat requirements, stenotopic arthropods are especially sensitive to habitat fragmentation. Preliminary results of a previous study on flightless ground beetles indicated that these corridors can harbor stenotopic species of both habitat types. In this consecutive study funded by the German Federal Agency for Nature Conservation (BfN) we dealt with the following questions: (1) Do semi-open corridors harbor a unique spider and ground beetle fauna not found in the adjacent wooded or open habitats? (2) How far from reproduction sites (open or woodland habitats) can stenotopic and flightless ground beetles move into semi-open corridors? (3) Does vegetation and habitat structure have an impact on the occurrence and movement of these stenotopic flightless species? Based on our results we present suggestions for the design of semi-open corridors.

Session 6-O12 - Using semi-open corridors to simultaneously connect open landscapes and woodlands - from a plant perspective

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Corridors, commonly used to counteract habitat fragmentation and enhance species dispersal, facilitate movement between isolated habitats and prevent loss of genetic variability. Typically, they are a linear strip of corresponding vegetation connecting two isolated habitats. However, when intersecting habitats, they may fragment these, forming barriers for species of the intersected habitats. Consequently, woodland corridors fragment grasslands and grassland corridors fragment woodlands, causing dispersal problems, especially for stenotopic species.

Semi-open habitats, such as pastures and heathlands, accommodate much of the European biodiversity and, due to existing shrubs and groves, can shelter both woodland and open landscape species. Thus, semi-open habitats may act as corridors for woodland and open landscape species simultaneously. Using a descriptive approach in landscapes of calcareous and acidic soils, we investigated whether open landscape and woodland plant species from adjacent habitats naturally occur in semi-open habitats. We quantified species composition using vegetation surveys respectively in woodlands, in (A) shaded/more densely vegetated and (B) brighter/less densely vegetated semi-open areas, and in open habitats, and recorded different environmental factors such as light availability and soil parameters. We used these factors as well as plant dispersal traits to identify the drivers which control species presence in semi-open habitats. Open landscape species utilised the semi-open areas more than woodland species on both soil types, possibly due to the low dispersal power of woodland species. Nevertheless, the high presence of species from adjacent areas indicates species dispersal and establishment through semi-open corridors might be possible. Thus, semi-open corridors form a promising tool in connecting isolated habitats by supporting the dispersal of species typical of those habitats.

Session 6-O13 - Evaluation of an integrative strategy for biodiversity protection in forests

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The ongoing loss of global biodiversity requires new nature conservation strategies, which are based on scientific evidence. Integrative conservation concepts that combine the production of commodities with biodiversity conservation are a potential way to stop further loss of biodiversity, but they need to be evaluated carefully. The forestry department Ebrach in Northern Bavaria has implemented an integrative nature conservation strategy. The key element of the conservation side of the strategy is the enrichment of deadwood during harvests. The strategy was implemented ten years ago. We investigated the success of the strategy, by addressing the following questions: (1) Does the implementation of the nature conservation strategy lead to an accumulation of deadwood in managed forests and which habitat features promote the accumulation and high amounts of deadwood? (2) Does the implementation of the nature conservation strategy have an impact on biodiversity? We used data of forest inventories carried out before and after the implementation of the strategy as well as biodiversity data. The inventories included a detailed record of deadwood amounts, habitat structures, and the living stand. Biodiversity data consisted of species lists and their abundances for birds, fungi, beetles and plants. These data reveal a strong increase

of deadwood amounts with a distinct enrichment of deadwood logs. Living stand features, such as the percentage of deciduous trees and the natural mortality of trees, affected deadwood amounts positively, both before and after the implementation of the strategy. Management intensity affected deadwoods amounts positively, but only beyond a certain management intensity. There was also a difference among management districts. Comparing the biodiversity of birds, fungi, plants and beetles showed that there were plots with increasing and those with decreasing species richness. Deadwood dependent species however, showed in general a positive relationship with deadwood enrichment. Multidiversity, calculated across all taxa, showed a positive relationship with increasing deadwood accumulation. Therefore, we consider the strategy as successfully implemented.

Session 6-O14 - Research for implementation: Restoring *Arnica montana* populations in Hesse

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Although protected by conservation laws, *Arnica montana*, a characteristic plant of nutrient-poor grasslands, has strongly declined in Central Europe during the last few decades. Several underlying factors related to habitat and population quality are discussed to be responsible for the decline, although large gaps in knowledge exist. Moreover, standard conservation management of such grasslands does not seem appropriate to halt the loss of *Arnica* stands. Hence, the development and application of specific ex- and in-situ conservation measures are needed in order to restore *Arnica montana* populations in the long term. This is the aim of the six-year research and implementation project "Arnica*Hessen*" which consists of closely linked research and implementation modules accompanied by a monitoring program. Intensive public relation activities serve to organize suitable land use management by local farmers and to integrate locals into efforts to preserve remaining *Arnica* stands. Research activities comprise studies on driving factors responsible for habitat degradation as well as population genetic studies for analyzing e.g. clonal and genetic diversity to finally assess the condition of all Hessian *Arnica* populations. Field experiments were set-up to identify suitable soil management techniques in combination with different land use types and intensities to promote reproduction in and re-establishment of *Arnica* populations. Crossing experiments serve to identify suitable donor populations to support seriously endangered populations and for re-establishment measures. The project structure, research results and their implementation in ex- and in-situ restoration strategies will be presented.

Session 6-O15 - Ex situ populations and their suitability for conservation purposes

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The importance of conservation action rises as many plant species are threatened in their natural environment (Corvalan et al. 2005). If the maintenance and recovery of viable populations of species in their natural habitats cannot be guaranteed, ex-situ actions can support in-situ efforts. Thus, Botanical Gardens have intensified their attempts to support in-situ activities by propagule storage and the cultivation of living conservation collections. However, several problems and risks associated with living ex-situ cultivation have been reported concerning the representation of the original species' genetic diversity and maintenance of it during cultivation. In a population genetic comparison between species cultivated in a small replica of a steppe ecosystem ex-situ in the Botanical Garden Mainz (established in 1986) and their respective in-situ source population of the NSG Mainzer Sand we assessed the ex-situ populations' suitability for conservation purposes ~30 years after establishment. Population genetic analyses (ISSR) of four different species (*Alyssum montanum, Gypsophila fastigiata, Helianthemum nummularium, Onosma arenaria)* with 15(16) individuals each confirmed that in 3 out of 4 investigated biennial/perennial species the genetic diversities could be preserved. Here, we could not detect genetic drift, inbreeding depression, and adaptation to the ex-situ environment, and the species featured negligible to moderate population divergence. However, the genetic diversity of *G. fastigiata* was ex-situ remarkably reduced and featured a strong genetic divergence from the source population, similar to findings in *Silene chlorantha* (Lauterbach et al. 2012). Thus, in the majority of the analyzed species diversity can be preserved in a small replica of a steppe ecosystem, proving the suitability for conservation purposes. However, in certain intervals (after ~20-30 generations of isolation) we recommend the reintroduction of the original in-situ genotype to prevent genetic drift.

Session 6-O16 - Predicting the colonization of reconstructed riparian areas - an example of an endangered shrub species

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Riparian areas of running waters have been altered for decades for e.g. flood protection and hydropower production in Switzerland. The resulting loss of habitat and increasing fragmentation of the riverscape have a major impact on specialized riparian species, especially sessile plants, which underwent a massive decrease in population size and distribution. Conservation efforts focus on restoring riparian areas, but little is known on target species' requirements in terms of habitat

characteristics as well as habitat connectivity and dispersal. Our study focuses on the German tamarisk, *Myricaria germanica*, a threatened riparian species which used to be a characteristic species along European rivers. The distribution of the German tamarisk decreased considerably in Switzerland over the last century, and the species survived only in few catchments. We combine classical techniques to estimate dispersal in the field and in the lab with a modelling approach on habitat suitability. A kernel of wind-mediated dispersal estimated in a field population is included in a species distribution model, where suitable habitats (estimated by environmental parameters) are identified, and dispersal of current source populations to suitable habitat can be modelled. This allows to make predictions about the colonization potential of this target species to newly restored riparian areas. Additionally, suitable areas for habitat restoration can be identified, and the vulnerability of local populations can be minimized by linking suitable habitats.

Session 6-O17 - Population genetics of the common barbel in Germany for conservation measures of genetic resources in the fisheries

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So far, information on the genetic diversity for the common barbel (*Barbus barbus*) in Germany has been insufficient. However, these data are essential for its future genetic management, stocking strategy and for the protection of its genetic diversity. Such a situation applies to most other fish species in German waters. Accordingly, the "National Programme for conservation and sustainable use of aquatic genetic resources" initiates research projects to establish the basis for the long-term conservation and use, research and development of genetic resources of fish species in Germany. The present study endeavoured to close the gap of knowledge in barbel genetic diversity by analysing 39 populations from 6 different river catchments in Germany. In total 809 individuals were successfully genotyped by the use of 12 microsatellite loci. In addition, the mitochondrial control region was analysed for 312 individuals from 37 populations. In summary, our analyses revealed that most of the detected genetic variation (mtDNA and microsatellite loci) was explained by differences between individuals within populations (66% and 84.6%, respectively). Only a small portion of the variation (23% and 9%, respectively) was explained due to spatially related differentiations between the river catchments. Especially individuals belonging to the river catchment Danube could never be clearly assigned to unambiguous groups, whereas within the river catchment Elbe and Rhine almost single, but differentiated genetic groups, could clearly be assigned to populations. The documented morphometric data, the results of the genetic analyses and the final report including stocking management recommendations will be implemented into the AGRDEU Database for the Aquatic Genetic Resources of the “Federal Office for Agriculture and Food”, which is open to the public and practitioners.

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Session 6-O18 - The effect of grazing exclosure on the conservation of plant community structure and diversity in arid Mediterranean steppe of Algeria.

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Desertification is a worldwide concern; in Algeria, land degradation threats more than 20 millions of steppe rangelands. Protection from grazing is a technique widely used as a management tool for the development of the steppes. The aim of this study is to investigate the effect of grazing on plant community structure, diversity and function (Pastoral value). We conducted a comparative study of the plant community structure and diversity in grazed and ungrazed areas. We assessed soil surface conditions; vegetation, litter, bare ground, biological soil crusts and *Stipa tenacissima* cover. In addition, we quantified plant species diversity using Hill numbers, and we evaluated plant community composition between grazed and ungrazed areas using analysis of similarity. Our results showed that grazing activities have largely reduced values of the vegetation cover and diversity in grazed areas. In addition, grazing activities affected plant community assemblages. The cover of the most dominant species (*Stipa tenacissima)*, was not affected by grazing. Nevertheless, the protection from grazing increased significantly the species diversity, vegetation cover and pastoral value. This study highlights the importance of protection and conservation as an effective management tool for maintaining the plant community structure and diversity in threatened ecosystems.
Keywords**:** degradation, diversity, grazing, protection, conservation, arid Mediterranean steppe.

Session 6-O19 - Do dynamics of foraging habitat explain high mobility of a desert-dwelling ungulate?

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Recent studies on movement ecology have revealed that in resource-poor environments, large mammalian herbivores tend to perform nomadic, long-range movements rather than seasonal migrations. Some studies have associated these nomadic movements with the temporal unpredictability and spatial variability of foraging resources at the landscape scale. Unlike in migration, however, our understanding of drivers resulting in nomadic movements is poor and so far very few case studies exist. The few studies that have examined drivers for within season long-range movements suggest that they are a response to spatiotemporal dynamics of ephemeral foraging habitats.We tested this hypothesis using the most mobile ungulate of the Mongolian Gobi – the Asiatic wild ass ("khulan") - to analyze whether spatiotemporal dynamics of the foraging habitat are indeed the most likely driver of their nomadic long range movements. We were especially interested in detectingdynamics of foraging habitat and thus focused on the summer vegetation period. We used six years of ground census data and built dynamic landscape-scale habitat models using remotely sensed imagery of vegetation productivity (NDVI) and examined khulan habitat dynamics over a 6-year period. Our analyses showed khulan habitat was highly predictable and most areas showed almost no spatiotemporal variability - making it unlikely that broad scale variability of foraging habitats can explain the high mobility of khulan. The few and small areas that did show habitat variability were related to locations of water sources. Additionally, we found that khulan avoided habitats relatively far way from a water source. Our findings have two important implications. First, foraging habitats may not be the key driver for long-range nomadic movements of this desert-dwelling ungulate. Second, water availability and switching among the sparsely located water bodies in the study region rather than dynamics of foraging habitats may be the key driver for the high mobility of khulan in the Dzungarian Gobi. Hence, large-scale conservation initiatives should consider water bodies, their spatiotemporal variability and functional connectivity to maintain long-ranging herbivores in resource-poor environments.

Poster presentations

Session 6-P1 - Bridging the gap: challenges in linking science and practice in ecology and conservation

Anne Rudolph[1], Birgit Ziegenhagen[1], Stefan Hotes[1], Nina Farwig[1]

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The process of globalization and humanity's growing demands have led to an apex of industrial success but have also caused lasting environmental changes. This makes nature conservation in science and practice a top priority today. However,

there still remains a gap between scientific research with relevance for conservation and practice. It has been a theoretical issue for 20 years at an international and national scale and still needs an effective bridging. The aim of this study is to evaluate the dimension of this gap by means of a scientific questionnaire. The survey targets members of the Ecological Society of Germany, Austria and Switzerland (GfÖ) who are currently carrying out research activities and are employed in one of these countries. The GfÖ is involved in many fields relevant to conservation and as such presents a suitable platform for this approach. The study intends to asses to what extend the implementation of science into practice is realized and to analyze the still existing gap. Thus it aims to find out whether scientists are accounting for the practicability of their results, in which ways they do it and which obstacles they face while trying to implement their results into conservation management. If an implementation, though it suggests itself, is not considered at the beginning the survey attempts to identify why not. Anticipating that the global phenomenon of the gap is also residing in the Ecological Society it is convincing to compile the state of the art and to re-consider alternative schemes. While analyzing dimension and reasons for the gap throughout the multifaceted ecological and conservational working groups of the GfÖ, the present study might contribute to concepts for an effective bridging. The GfÖ is among the biggest ecological societies worldwide. Thus, giving back the results and conclusions of the survey into its working groups could be a good starting point to improve conservation activities.

Session 6-P2 - A modelling approach to evaluating the effectiveness of Ecological Focus Areas: the case of the European brown hare

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With the current implementation of the Common Agricultural Policy (CAP) for 2014-2020, the European Commission wants to move towards “greener” farming practices in the European Union. Therefore, the EU funds both obligatory measures, such as Ecological Focus Areas (EFAs) through the Green Direct Payment program, and voluntary agri-environment measures. However, empirically evaluating the effectiveness of these measures is challenging. We therefore demonstrate here that mechanistic simulation models are a valuable tool for performing these evaluations. As an example, we use the Animal, Landscape and Man Simulation System (ALMaSS), an established simulation system that has been used to simulate a wide range of farmland species relevant to biodiversity. We analysed the benefits of seven greening scenarios, including several EFA types for the European brown hare (*Lepus europaeus*), which has been in widespread decline throughout Europe since the 1960s. We examined the short- and long-term effects of the following EFA types on hare population dynamics: the cultivation of legumes

such as (1) peas and (2) beans, (3) permanent and (4) rotational set-asides, (5) permanent extensive grasslands, and (6) herbaceous and (7) woody field margins. The cover of eachtype was increased separately up to 5% of the area in three Danish landscapes, which are characterised by low hare densities. The effects on female and yearling abundance, as well as on the abundance-occupancy relationship (AOR-index), were observed over a period of 30 years. All greening scenarios had significant positive effects on hare populations. The relative change in female abundance ranged from a factor of 0.4 in the peas scenario to 3.6 in the permanent set-aside scenario. However, only one EFA type, permanent set-asides, led to densities of more than 10 females per km² in all three landscapes, which we assumed to be the threshold for population viability. Herbaceous field margins were the second best EFA type, leading to population viability in two landscapes. Our results indicate that overall, 5% coverage with Ecological Focus Area is insufficient to improve the living conditions of the brown hare to a necessary degree. Permanent set-asides seem to be the most valuable type of EFA, but this needs to be confirmed for a wider range of species and landscapes. We demonstrate that the effectiveness of EFAs and other elements of the CAP reform can be quantitatively assessed with well-tested, mechanistic simulation models. Using such models for a suite of representative species, types of agricultural landscapes, and eco-regions could help in achieving the aim of the European Commission to promote biodiversity in the European community via greener farming practices.

Session 6-P3 - A concept for biodiversity monitoring in agricultural landscapes of Germany

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There is no comprehensive national database on the state and development of biodiversity in agricultural landscapes of Germany. Therefore, the prospects for an evidence based assessment of the biodiversity trends and the factors causing those trends are limited. Accordingly, our possibilities to inform policy about success or failure of agri-environmental measures with the aim to provide feedback for future improvement of agri-environmental policy are limited as well. A programme for biodiversity monitoring designed to meet the characteristics of agricultural landscapes of Germany is therefore urgently needed. Here we present a concept of a modular biodiversity-monitoring programme for agricultural landscapes in Germany. The programme enfolds a general trend monitoring on a national scale, which is based on existing stratified sampling units, and more question-based monitoring modules at the scale of particular “agricultural landscape units”. The idea behind those units is that agricultural landscapes are diverse with respect to productivity, intensity of management and trends of land-use change. Therefore, pressure factors on biodiversity vary among those units as well as quantitative,

qualitative and functional levels of biodiversity. An interdisciplinary approach is suggested to characterize and localize those units. Once they are established, unit specific biodiversity targets can be formulated and indicators for those targets can be developed. In contrast to the more conservative general trend monitoring, the question-based modules allow a higher adaptability of the monitoring to changing questions and challenges. The conceptual design of the monitoring programme is complementary to existing biodiversity monitoring schemes but adds modules which are essential for generating data of a spatio-temporal resolution necessary for generating feedback to agri-environmental policy.

Session 6-P4 - Long-term vegetation changes in *Nardus* grasslands in the UNESCO biosphere reserve Rhön

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Semi-natural *Nardus* grasslands (*Violion caninae*) are currently highly endangered by eutrophication, land-use intensification and abandonment in many mountain areas. Species-rich forms of these grassland communities are a target habitat of the EU Habitats Directive and therefore claim particular attention by nature conservation on national and EU level. We analysed the development of *Nardus* grassland sites in the biosphere reserve Rhön (both Hessian and Bavarian part) that were first documented in 1971 resp. 1986/87 by vegetation relevés and that were re-assessed in 2014/15. Our results show that only one third of the *Nardus* grasslands had maintained their former status. Other sites, however either developed into more productive mountain hay meadows (*Trisetion*) due to eutrophication and intensification, or into tall forb (*Poa chaixii-Deschampsia cespitosa*-community) and pioneer forest communities due to abandonment. Some sites were even afforested with spruce. Unexpected results are that even on sites that could still classified as *Nardus* grasslands, showed gradual and directed changes, i.e. the decline of nitrogen-sensitive species and the increase of nitrogen demanding species. Especially, the bryophytes diversity decreased and only some nitrophilous moss species became dominant. Soil analyses supported these findings by improved nutrient supply (esp. N), narrowed C/N coefficients and of the mineralisation of the organic matter. Our results suggest that the floristic changes have expired during the last decades, and are likely to continue, although the N deposition rates in the Rhön are lower than the maximum tolerated critical loads for this ecosystem type. Furthermore, the results show that the highly subsidised management of the *Nardus* grasslands in the Rhön (due to specific agro-environmental schemes) did not lead to the desired goal under the current environmental and socio-economic conditions and may not in the future. We conclude the need for an adapted landscape and conservation management in the

UNESCO biosphere reserve Rhön that aims to counteract the processes of vegetation change driven by eutrophication and land-use change processes.

Session 6-P5 - Genetic diversity of populations of a central European endemic species *Gentianella praecox* subsp. *bohemica* as a guide to its effective protection

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Gentianella praecox subsp. *bohemica* is biennial herb endemic to Bohemian Massif with most populations occurring in the Czech Republic, extending to Bavaria (Germany), Upper and Lower Austria and Poland. It occurs in semi-natural grasslands and is adapted to traditional land use. It has become rare during 20th century, probably due to land-use intensification or abandonment of traditional land use which lead to disintegration of large habitats and fragmentation of original populations. The aim of this study was to identify genetic composition of the remaining populations across the whole distribution range, identify gene flow between these populations, assess potential for inbreeding depression and identify the minimum set of populations to be protected to conserve all the populations within the species. To achieve the aims, we newly developed species specific microsatellites markers using NGS sequencing method. Afterwards by using multiplex PCR we were able to analyze each individual for 12 loci and together we genotyped 1400 individuals originating from 57 populations. We detected high frequency of tetraploid individuals across the area of distribution. Also we demonstrated massive gene flow among the populations. We also identified genetic composition of the studied populations. We did not detect inbreeding depression in investigated populations. The most genetically rich population is Hroby, containing 60% of the total genetic diversity. By protecting 15 populations across the distribution range, it is possible to preserve 100% of the genetic diversity. These results indicate high possibility for expansion of *Gentianella praecox* subsp. *bohemica* populations with proper protection management.

Session 6-P6 - Optimising a three-locus barcoding tool in species-rich Lauraceae in an Ecuadorian mountain rain forest

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Ecuadorian mountain rain forests are holding a top rank on the global list of biodiversity hotspots. This is particularly true for the involved tree species. While many of the taxa belong to the Lauraceae with 27 genera in the Neotropics, of which *Ocotea* with more than 300 and *Nectandra* with more than 100 species, are the largest ones. It poses a challenge to taxonomists and ecologists to identify the species. From previous own studies on a test sample set of Ecuadorian Lauraceae leaves from a herbarium (JH, University of Göttingen) it became clear that the three chloroplast barcoding loci (*rbc*L, *mat*K, *trn*H/*psb*A) can be used as an appropriate tool for taxa re-identification and phylogenetic reconstruction, in this family. The present study seeks to enlarge this set for more genera of the Ecuadorian Lauraceae while at the same time tries to optimize the system. So far, we have succeeded in improving PCR results and sequence quality for the *mat*K-locus. In ongoing studies we are currently barcoding specimen that have been selected from the same Ecuadorian Lauraceae herbarium. Once they are identifiable by sequence diversity this acquired information can directly be used for re-identification purposes in ecological field studies. Optimally in the long run the taxa diversity of the Lauraceae should be brought in line with sequence- and phylodiversity. More safety describing operational taxonomic units and deeper phylogenies in the Lauraceae, which make up a large proportion of the mountain rain forests, may support hypothesis testing on the impact of ecological factors on diversity at different evolutionary scales.

Session 6-P7 - DNA-maker assisted monitoring in dynamic gene conservation of a *Populus nigra* population on the Rhine River

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The Eurasian Black poplar (*Populus nigra* L.) is a key-stone species of Central European riparian softwood forests, but due to human impact one of the most threatened tree species there. Settlements, shipping and farming led to habitat losses but also to severe changes of the natural river dynamics the latter causing a lack of natural regeneration. Furthermore, the populations are prone to genetic introgression by hybrids between *P. nigra* and *P. deltoides*, the North-American close relative. While conservation measures often “just saved” plant material and genetic resources in ex situ clonal plantations, from an evolutionary point of view, dynamic in situ conservation measures would be a better option. For this purpose, large enough pure *P. nigra* populations with natural regeneration are a matter of first choice. We identified such a population on the Rhine River next to Dormagen,

called “Zonser Grind”, and propose a genetic monitoring scheme with consecutive steps. First, it should be ensured that the population represents pure *P. nigra* with an adequate genetic diversity and an appropriate sex ratio. Next, it is of uttermost importance to screen the germinated and established progeny for their parents from within the stand and from *P. nigra* or hybrids from outside. The overall targets are to analyze the spatio-temporal dynamics of genetic diversity and to check for undesirable introgressive events. This study will contribute to a full genetic inventory of the mature trees on the basis of nuclear microsatellite markers. Next, we will apply a straightforward survey of dispersed seeds on the river bank and their belonging or not to the donor trees using the same microsatellite markers on maternal tissue of the catkins. All next steps are dependent from the outcome of this simple first step as part of the scheme which we are illustrating. In the long run we may substantially guide a dynamic conservation management from the genetic point of view.

Session 6-P8 - Enrichment of floristic diversity along German Federal Waterways

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Waterways have been of high importance for humanity for hundreds of years, since they are serving e.g. as water source and transport medium for goods. Increasing global trade thus results not only in growing pressure for the waterways themselves, but also for the respective floodplains and their species diversity. Natural floodplains in particular provide a high habitat diversity and thereby a high species diversity. The small-scale habitat diversity is caused by dynamics in the water regime. Moreover, floodplains play a key role for the nutrient filtration and flood retention and thus provide relevant ecosystem functions. Through measures such as the installation of weirs and fixation of banks for an enhanced navigability along rivers, these habitats are changed fundamentally. However, the European Water Framework Directive purports the achievement of a good ecological state of the waterways and their respective floodplains. For that reason, restoration measures such as the removal of rip raps, the installation of shallow water zones and ecological bank protections are taken to grade up the respective areas for achieving the ecological requirements. The main aim of this project is to explore the ecological effects of the taken measures along federal waterways and to compare them to decide which is the most effective. For that reason, selected measures from different areas in Germany will be registered and analysed in their vegetation structure and composition. The results of this investigation should help the Federal Waterways Administration to decide which measures might be preferred and applied in the future. The research project should contribute to an improved ecological understanding of habitats along federal waterways to apply landscape management measures more efficiently.

Session 6-P9 - Brood interruption and brood removal as alternative summer treatments of honey bees (*Apis mellifera* L.) against *Varroa destructor*

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Varroa destructor is considered as one of the most dangerous threats to honey bee health and the control of those mites is a major challenge to modern apiculture around the world, especially under changing environmental conditions. Since resistances against some acaricides have occurred in *V. destructor*, while others cause residues in hive products or vary in efficiency, there is an urgent need for developing and establishing biotechnical treatment methods. We have therefore studied the effects of five summer treatment approaches for *Varroa* control in Hesse (central Germany), differing from each other in kind and/or time of treatment, on the development, fitness and overwintering ability of honey bee colonies (n=30). The study was set up near Kirchhain (central Germany) in July 2015 and lasted to April 2016. Each group consisted of six colonies and was balanced for colony strength at the beginning of the study. In three groups we caged the queens for 25 days to treat the broodless colonies with oxalic acid afterwards. This method of brood interruption was applied in July (CJ), August (CA) and September (CS). In another group, we performed a full brood removal incl. the usage of a trapping comb (BR) in July. The control group was treated with formic acid (FA) in July following the common local practice. Once per month we estimated bee and brood cell numbers following a modified “Liebefeld method” and took bee samples to detect *Varroa* infestation in each colony from July to October and in April (n=5). Additional samples were taken from each colony in July, October and April (n=3) to detect *Nosema sp*. and the four most common viruses. All colonies were treated with Perizin® in January 2016 to keep the *Varroa* infestation under the threshold level. We observed two queen losses (BR, CA) in November 2015, although these seems to be no effect of the methods. With few exceptions, we found no difference between the treatments in terms of overwintering ability or the other parameters in July, October and April. Before wintering (October) CA showed a sig. larger amount of brood than all other groups (p=0.001). The Group CS showed a sig. higher *Varroa* infestation in October (p=0.018) than FA and CA. Our results suggest that BR, CJ and CA could be useful alternatives for *Varroa* control in central Germany, without negative effects on the colonies so treated.

Session 6-P10 - Do dynamics of foraging habitat explain high mobility of a desert-dwelling ungulate?

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Recent studies on movement ecology have revealed that in resource-poor environments, large mammalian herbivores tend to perform nomadic, long-range movements rather than seasonal migrations. Some studies have associated these nomadic movements with the temporal unpredictability and spatial variability of foraging resources at the landscape scale. Unlike in migration, however, our understanding of drivers resulting in nomadic movements is poor and so far very few case studies exist. The few studies that have examined drivers for within season long-range movements suggest that they are a response to spatiotemporal dynamics of ephemeral foraging habitats. We tested this hypothesis using the most mobile ungulate of the Mongolian Gobi – the Asiatic wild ass ("khulan") - to analyze whether spatiotemporal dynamics of the foraging habitat are indeed the most likely driver of their nomadic long range movements. We were especially interested in detecting dynamics of foraging habitat and thus focused on the summer vegetation period. We used six years of ground census data and built dynamic landscape-scale habitat models using remotely sensed imagery of vegetation productivity (NDVI) and examined khulan habitat dynamics over a 6-year period. Our analyses showed khulan habitat was highly predictable and most areas showed almost no spatiotemporal variability - making it unlikely that broad scale variability of foraging habitats can explain the high mobility of khulan. The few and small areas that did show habitat variability were related to locations of water sources. Additionally, we found that khulan avoided habitats relatively far way from a water source. Our findings have two important implications. First, foraging habitats may not be the key driver for long-range nomadic movements of this desert-dwelling ungulate. Second, water availability and switching among the sparsely located water bodies in the study region rather than dynamics of foraging habitats may be the key driver for the high mobility of khulan in the Dzungarian Gobi. Hence, large-scale conservation initiatives should consider water bodies, their spatiotemporal variability and functional connectivity to maintain long-ranging herbivores in resource-poor environments.

END OF SESSION 6

Session 7 – IPBES - ecological knowledge exchange at the science-policy interface

Chairs
Prof. Dr. Aletta Bonn
Dr. Stefan Hotes

Session 7-O1 - IPBES: Activities emerging from completed and ongoing assessments & opportunities for involvement

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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. IPBES offers a unique opportunity for: (a) Identifying existing and credible scientific information needed by policymakers; (b) Performing assessments of knowledge on biodiversity and ecosystem services; (c) Supporting policy formulation and implementation by identifying policy-relevant tools and methodologies; (d) Prioritizing key capacity-building requirements needed to strengthen the implementation of its activities. The Federal Ministries for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) and of Education and Research (BMBF) have established the German IPBES Coordination Office to e.g. identify national experts and capacities that can support the IPBES activities, and to assist experts in getting involved in IPBES in order to ensure that their knowledge is included in the process and effectively communicated. The first IPBES assessments have been approved at the fourth IPBES plenary (IPBES-4) in Kuala Lumpur, Malaysia, in February 2016. Furthermore, a global assessment has just now started, following the approval of its scoping document at IPBES-4. The scoping documents of further thematic and methodological assessments have also been approved at IPBES-4 but the decision on starting these assessments have been postponed to IPBES-5 in 2017. Besides outlining the role of the German IPBES coordination office, this presentation will point out possibilities to get involved in the IPBES process, and will reflect on what is being done on the national level to process and distribute findings of the recently approved IPBES assessments.

Session 7-O2 - A complete assessment cycle within IPBES - Insights of the pollination assessment

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The IPBES (Intergovernmental science-policy Platform on Biodiversity and Ecosystem Services) is a process in which assessments play a crucial role. It has now started with thematic assessments - one on scenarios and one on pollination, which have been formally finished at the end of February 2016 during the plenary in Kuala Lumpur. Several regional assessments have started as well, e.g. for a) Europe and Central Asia, b) Asia - Pacific, c) Americas, and d) Africa. In the presentation experiences from the involvement in the pollination work will be presented.

Session 7-O3 - IPBES regional assessment for Europe and Central Asia

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The IPBES regional assessments started in 2015, after IPBES-3 accepting the scoping reports and requesting the Regional Assessments, and by 2018, all 4 regional assessments (for Africa, the Americas, Asia and Europe & Central Asia) should be finished. The IPBES regional assessment for Europe and Central Asia (ECA) is led by the co-chairs Mark Rounsevell (U Edinburg) and Markus Fischer (U Bern), who also hosts the technical support unit. A first authors meeting in Engelberg, Switzerland in September 2015, with more than 100 experts (co-chairs, coordinating lead authors and lead authors, experts of other task forces and the IPBES secretariat, MEP and Bureau) started the process. The First Order Draft of the ECA regional assessment will be reviewed by governments and experts in June/July 2016, and the second review will take place in 2017. All 4 regional assessments have the same structure following the IPBES conceptual framework. ECA specific questions look at options and opportunities with regard to biodiversity, ecosystem services and their role for human well-being, including promoting food security, economic development and equality, while avoiding ecosystem degradation and conserving cultural landscapes. The main challenges for the ECA assessment are the heterogeneity of the region itself and to get balances representation by experts. In general, all regional assessments have an enormous scope and ambitious timelines, and need to integrate with IPBES thematic assessments on invasive alien species, land degradation and sustainable use of biodiversity, harmonise with three other

regional assessments and global assessment and assess indigenous and local knowledge.

Session 7-O4 - Outputs of the 3rd Pan-European IPBES Stakeholder Consultation (PESC-3)

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The Pan-European IPBES Stakeholder Consultation (PESC) is a regional bottom-up initiative that seeks to support the effective implementation of the work programme of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES). It brings together European and Asian experts from science, policy and administration, as well as civil society organisations who may contribute to the IPBES process (e.g. through their expertise, knowledge, data), may use its outputs or may be affected by its outcomes (= "IPBES stakeholders" in the IPBES terminology). In 2016, the third PESC meeting (PESC-3) was organized by the German Network-Forum for Biodiversity Research (NeFo), in collaboration with partners from other European National Biodiversity Platforms. We present and analyse outputs of this third meeting (PESC-3) with regard to the following two agenda items: 1) Barriers for participation and ways to overcome them: According to its operating principles, IPBES is obliged to balance regional representation in its work and to take an interdisciplinary and multidisciplinary approach. In practice however, IPBES has fallen short on achieving this standard. We will present a synopsis of a session that addressed barriers for the engagement of experts from Eastern Europe and Central Asia as well as of social scientists and representatives of other forms of knowledge than generated by the academic endeavour. 2) Review of the IPBES Regional assessment for Europe and Central Asia (ECA assessment). PESC-3 participants scrutinised the first order draft of the ECA assessment and delivered comments on its individual chapters to IPBES as part of an external review procedure. Selected aspects of these comments will be presented and embedded in their context. With this presentation, we aim at showcasing a way to enhance engagement in IPBES across Europe and Central Asia and to share perspectives on IPBES procedures as well as on the ECA assessment as an early stage IPBES product.

Session 7-O5 - Japanese City Biodiversity Index (J-CBI) for large-scale assessments of urban ecosystems

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To assess the biodiversity of cities in Japan, the Japanese Ministry of Land, Infrastructure, Transport and Tourism (MLIT) launched the two-tiered (basic/advanced) Japanese City Biodiversity Index (J-CBI) in March 2015. By March 2016, MLIT had evaluated 665 municipalities using the basic index. We present the basic and the advanced index and discuss the challenges involved in assessing biodiversity using indices from the viewpoint of the expert committee that developed J-CBI. Adapting two previous indices ('Singapore Index on Cities' Biodiversity (SI)' and a modified CBI for Japanese cities proposed in 2010), we designed seven J-CBI indicators, namely 1) proportion of natural and vegetated area, 2) proportion of protected natural and vegetated area, 3) habitat connectivity measures or ecological networks, 4) number of native and alien species, 5) ecosystem services (carbon storage in vegetation, cooling effect by vegetation and flood mitigation), 6) rules, regulations and policies and 7) participation and partnerships. A method for integrating the seven indicators is under discussion. They were designed to be a self-assessment tool for cities. However, insufficient information about the occurrence of species as well as budget restrictions and a lack of trained staff prevented city administrations from deriving the indicator values. MLIT therefore decided to rely mostly on indicators involving land cover.
Limited availability of data would currently prevent meaningful assessments e.g. in most Asian cities. Because tools for comparative studies of biodiversity in cities are necessary for the work of the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES), efforts should be made to improve data availability and enhance indicator systems across countries.

END OF SESSION 7

Session 8 – Patterns and processes in wilderness development

Chairs
Dr. Alexander Peringer
Kiowa Alraune Schulze
Dr. Jochen Godt

Session 8-O1 - Wilderness areas in Germany - relevance for natural ecological processes and biodiversity

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One of the prominent aims of the National Biodiversity Strategy (NBS) is to establish wilderness areas on 2 % of the terrestrial area of Germany. The focus is on large areas (IUCN category Ib, > 1.000 ha) where natural ecological processes are allowed to occur without human intervention. We give an overview on both already existing wilderness areas in Germany and, beyond on the potential areas in different landscape types (mires, floodplains, forests, mountains, coasts). In each of these landscapes different processes and natural disturbances including grazer and browser impacts are relevant to initiate ecosystem dynamics and to generate a wilderness specific biodiversity. The unpredictability of these processes is the main contrast to conventional nature conservation measures and makes it a particularly challenging approach in our cultural landscapes.

Session 8-O2 - Approaches to identify

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Wilderness areas in the sense of the German national strategy for biodiversity are large-size, unfragmented areas free from human exploitation. Natural processes (such as succession, natural disturbances) shall be guaranteed in a long term perspective without human impact. The aim of our study is to identify substantial reasons for the establishment of wilderness areas from ecological points of view. The wilderness concept includes a wide range of approaches, reaching from preserving a certain status quo to the provision of processes leading to a mosaic of different stages of succession. The habitat qualities of undivided areas preserved for wilderness and natural processes in central Europe have become rare. In our study we focus on (i) biotic communities and species that depend on or are supported by the existence of wilderness, (ii) the specific qualities of wilderness

areas that allow the existence of these biotic communities and species (e.g. size, habitats, disturbances etc.), (iii) species and biotic communities that are endangered and for which Germany has a responsibility to preserve. The study focusses on qualities of large connected wilderness areas. As there are only few relevant existing areas in Germany, the study will also consider investigations from wilderness areas abroad. Also areas preserved for process dynamics will be included. The possibility to reestablish the conditions for wilderness in a realistic time frame will be discussed. All potentially capable wilderness landscape and ecosystem types in Germany, which have been identified in the former study "Implementing the 2% target for wilderness areas" will be included. In addition to the zonal forest ecosystems coasts, wetlands, mountains and moors will be considered in the survey. First results of the ongoing survey show that the size of wilderness areas, the natural disturbance as well as the continuity of habitats are important factors for the presence of species. For vascular plant species those factors seem to be less relevant than for mosses, fungi and different groups of mammals and insects.

Session 8-O3 - Effects of large-scale grazing on pioneer tree species in a northeastern German former military training area

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The study is implemented in a large-scale grazing project in the German natural heritage area “Oranienbaumer Heide”, where military use was abandoned in 1992. All year-round low-intensity grazing was implemented in order to restore and preserve the mosaics of open heathlands, basophile sandy grasslands and birch-pine-pioneer forest, all of high nature conservation value. We analysed the question whether the overgrowth of the open (mainly FFH relevant) habitats by tree encroachment will be hindered. A field experiment was conducted that aims to compare the effects of different grazing intensities of horses and cattle on germination and early establishment of sown pioneer trees, namely *Betula pendula* and *Pinus sylvestris*. Besides this, it was investigated whether horses and cattle significantly increase damage on young birches, pines and aspen and thereby hinder progressive succession towards pioneer forests. This is done by comparing grazing effects and growth parameters of the two species in permanent plots within the pasture with plots in exclosures keeping horses and cattle out but not game animals. The results suggest that there is no straightforward effect of grazing to hinder tree establishment, which is mainly due to the large number of factors influencing this succession process. However, some of the findings indicate that grazing can even foster tree establishment by creating suitable conditions for early establishment of light demanding pioneer trees. Furthermore, the browsing effect on *Betula pendula* and *Pinus sylvestris* was similar within the pasture and in the

exclosures, indicating that cattle and horses are hardly browsing these tree species, whereas for the basophile sandy grasslands *Populus tremula* was more strongly damaged in the pasture. So far it can be concluded that extensive grazing is not sufficient to slow down tree encroachment, which means that continuous mechanical removal of trees appears to be inevitable to maintain open heathland area.

Session 8-O4 - Simulation of natural succession in grassland areas and after windthrow

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The subject of natural processes in the landscape has come back into focus in the light of the establishment of wilderness areas and national parks on former military training sites, the restoration of rivers, and in the handling of windthrow areas in forests resulting from increasingly frequent extreme storm events. To integrate natural succession and reforestation processes into land use and the (non-)management of protected areas, it is vital to understand the underlying processes and interactions. Natural succession is strongly site-specific depending on abiotic environmental factors, ungulate browsing, the surrounding vegetation and the background of the site. In order to project the potential natural succession and reforestation on a specific site, we developed the process-based GraS (Grassland Succession)-Model. Data for model development was obtained using conventional monitoring and remote sensing techniques. A digital site classification procedure was developed in order to create a detailed raster map (from 1x1 m to 10x10 m cells, depending on the heterogeneity of the study area) with the site factors temperature (altitude), moisture, nutrient availability, pH, shading and the vegetation existing on and around the site. The model was then used to assess a) the succession of large grassland areas in the Eifel National Park and b) the natural regeneration potential of specific windthrow areas in North Rhine-Westphalia. Early succession was simulated over several decades and the resulting vegetation maps were visualized in 3D providing a clear image of the projected succession.

Session 8-O5 - Herbivore-vegetation-climate interactions in landscape dynamics of mountain pasture-woodlands

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Pasture-woodlands are semi-open landscapes with a century long land-use history that is still alive in remote mountain regions of Europe. Low-intensity grazing and progressive succession created dynamic mosaics of grassland, forest and interconnecting ecotones. The balance among these counteracting processes and thereby the structural properties of the mosaics is highly sensitive to land-use and climate change. Structural simplification and forest-grassland segregation were causal for the dramatic changes and the loss of habitats for threatened species in pasture-woodlands during the past century. Low-intensity grazed pasture-woodlands are one of the few ecosystems that provide insights to long-term interactions among large grazers and vegetation dynamics and therefore demonstrate central processes of the mega-herbivore theory. The upcoming "rewilding" approach in nature conservation relies on these processes for the preservation of open and semi-open habitats in potential wilderness areas that are important for threatened species endangered by habitat loss in the cultural landscape. We synthesize the results of several modelling studies of the mosaic dynamics in European mountain pasture-woodlands along gradients in climate and land-use practices that range from subcontinental Southern Carpathian (Romania) to Swiss suboceanic (Jura Mountains) up to Swiss high alpine sites (Central Alpine Valais). We highlight the dynamics of herbivore-vegetation interactions in response to herbivore densities and climate change that are prominent in each study area and relate the results to herbivore-driven vegetation dynamics in potential German wilderness areas. We aim on suggestions under which circumstances (forest community, traits of dominant tree species, topography and climate) mega-herbivores may positively contribute to the formation of structurally diverse forest-grassland mosaics in wilderness areas in order to increase their range of habitats and their nature conservation value.

Session 8-O6 - Model-based exploration of interactions among large grazers and natural disturbances in beech forest

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According to the German biodiversity strategy, nature shall develop freely towards wilderness ecosystems on 2 % of the national area until 2020. In the potential natural vegetation, beech-forests prevail. The question arises if interactions among large herbivores and natural disturbances may preserve semi-open habitats that would increase species diversity in wilderness areas. In order to explore such long-term developments of wilderness, we performed simulation studies with the spatially explicit model of wood-pasture ecosystem dynamics WoodPaM. We simulated a synthetic landscape of one kilometre square that consisted of 40x40 cells (each 25x25 meter size). The area reflected the characteristic soil conditions for mountain beech forest with shallow rocky ridges and deep colluvial plains. We used climate time series of the Swiss Jura Mountains that was at hand from

previous model applications. We considered the following experimental variables: natural densities of large grazers, extent and return intervals of windthrow and gap-dynamics. The model suggests that (i) high disturbance frequency (every 50 years) maintains sparse tree cover on sites with slow tree regeneration (ridge). The forage provision here allowed the development of closed forest on productive sites (plains). (ii) Low disturbance frequency (>125 years) shifted this pattern towards closed forest on the ridge and patchy glades on the plains. (iii) Small disturbance extent (<50% of the landscape) supported a fine-grained distribution of glades, whereas large extent led to few large grassland patches. We conclude that strong interdependencies among site conditions, vegetation dynamics and disturbance characteristics may lead to regime shifts in the spatial foraging behaviour of large grazers that in turn create semi-open landscape patterns of quite distinct structure. Both the allocation of open habitats on poor or rich soils and the size of glades implies constraints for the habitat quality for threatened species from e.g. dry grasslands and forest-grassland ecotones.

Session 8-O7 - Starting points for wilderness development in Germany and the potential role of natural disturbance and mega-herbivores

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Following the German National Strategy on Biodiversity, two percent of the German State area shall represent wilderness areas until 2020, for which potential areas were delineated by Rosenthal et al. (2015) based on their non-fragmented size (>1000 ha). The potential natural vegetation of these areas is dominated by various types of forest. Their current state strongly varies and comprises almost natural forests, as well as forestry with non-native species and agricultural use. Potential pathways of wilderness development are strongly determined by such distinct starting points, but a comprehensive overview at national level lacks. As part of our research about wilderness development in landscapes in Germany with its focus on the maintenance of semi-open and open habitats by natural disturbances and mega-herbivores, we analyzed information on landcover, terrain surface and climate within the potential German wilderness areas and compiled literature on the landscape-specific natural disturbance regimes such as fire, storm, or flood. We aim to evaluate the starting points and potential pathways of wilderness development in Germany in terms of scenarios that will be analyzed later in the project with a dynamic landscape model.

Session 8-O8 - Session synthesis

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The final talk of the session will provide a synthesis on the contributions and discussions and aims to provide some lessons learned.

Poster presentations

Session 8-P1 - Response and fitness of heathland plant species during progressive succession

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The German National Strategy of Biodiversity aims to dedicate 2% of the German state area to the development of wilderness. Many of the potential "wilderness areas" in Germany include grassland and heather habitats which develop into forest without management in most cases. Additionally, they fall under the protection of the FFH-directive with strict regulations to preserve the characteristics (e.g. low cover of shrubs) of these habitats. However, in the course of the reforestation process the habitat conditions (especially light and temperature) change and the question arises if habitats exist for rare grassland and heather species and how they are distributed in space and time in such potential wilderness landscapes. We analysed fitness parameters of such species under the influence of progressive succession, their phenotypic plasticity and the potential of regeneration from the soil seed bank. The study was conducted in the DBU Natural Heritage Site "Oranienbaumer Heide", an abandoned military training area with a high share of base-rich sandy grassland and heather ecosystems, partly overgrown by early and later successional stages of pine and birch. The results show which plant traits determine the persistence of heather and grassland species during forest development. Species with a persistent soil seed bank or a high adult longevity have a better chance to survive the conditions in later successional stages than species that have a short lifespan and rely on dispersal in space. Especially perennial species show a high phenotypic plasticity. Within these species a trade-off between vegetative and reproductive characteristics could be observed in response to even small changes in the surrounding vegetation structure. The decline of reproductive organs may lead to local extinction of the population and

caution is advised in the evaluation of the vitality of populations from its presence alone.

Session 8-P2 - Adaptability of Heathland-species through phenotypic plasticity

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Abandonment and inadequate maintenance are the main causes for forest development on Central European dry heathlands. During succession, habitat conditions change with vegetation structure. Heathland-species, especially those that require warmth and light, are known to disappear after the long-term development of forest canopies. It is unclear however, up to which threshold these species may persist. The threshold depends on the ability of the species to adapt to changing environmental factors. Species with a higher phenotypic plasticity are more likely to survive in later successional stages than those which lack adaptability. The master thesis includes two experiments that aim to analyse the phenotypic plasticity of five heathland species in response to different light and soil conditions. The experiments are led by the following hypothesis: (1) The phenotypic plasticity of a species mainly responds to the ground vegetation and less to the shading of trees. (2) The accumulation of nutrients during succession causes a higher growth potential in later successional stages that facilitates plasticity (e.g. bigger leaves, longer shoots). (3) Species that cannot cope with stress (especially annuals) lack phenotypic plasticity. The experiment is located at the garden at the University of Kassel. For the soil experiment, the species were planted into four different soil. For the light experiment, two different shadowing tunnels represent the light conditions of the birch and of the pine forest. One stadium has no shading cover and represents open landscape vegetation. Preliminary results show that soil conditions have a marginal influence on plant growth. To the contrary, the effects of light availability are significant: The shading from above as well as the shading from neighbouring vegetation affects the development of vegetative and generative plant traits. Contrary to hypothesis number three, the annual Teesdalia nudicaulis responded to poor light availability.

END OF SESSION 8

Session 9 – Genetic and phenotypic variation and local adaptation in plants

Short title: Local adaptation in plants

Chairs
Dr. J.F. Niek Scheepens
Dr. Johannes Metz
Dr. Christian Lampei

Session 9-O1 - Genetic and phenotypic variation and local adaptation in plants

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Investigations into local adaptation, ecotypes and other forms of intraspecific variation in plants have a long history. However, the uncertainties around the effects of rapid environmental change have given this field a renewed impetus, and important questions are waiting to be answered. In this introduction, we would like to give a short historical overview of developments in research on local adaptation in plants and highlight current themes.

Session 9-O2 - Relative importance of plasticity and local adaptation for species response to climate change: a multi-trait comparison

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Understanding mechanisms of species adaptation to changing climate is a key to properly predict the future changes in plant communities. Detailed studies on the mechanisms using wide-spread species along climatically well described gradients are still largely missing. We aimed to understand the ability of species to adapt to a

changing climate using data on range of morphological and physiological traits of individuals originating from natural populations of a widespread clonal plant *Festuca rubra* distributed along grid of independent temperature and precipitation gradients. The plants were grown in 4 growth chambers representing the four extreme climates (dry-wet combined with warm-cold). Most morphological and physiological traits of the species were significantly affected by both the environment of origin and of cultivation with frequent interactions between the origin and cultivation conditions with their relative importance differing between traits. In a range of traits, we also detected improved performance of plants grown in their local vs. foreign environment suggesting importance of local adaptation in the system. Among the traits, proportion of extravaginal ramets and stomata density turned out to be the traits with the highest genetic determination showing high degree of local adaptation. Overall the results suggest that the species is highly plastic with high ability to adapt to changing climate. In spite of this, the populations still show some degree of local adaptation with both temperature and precipitation at the localities of origin being important predictors of species performance and species response to new climate is thus determined by the climate of origin. In addition, species performance also strongly differed between genotypes. Species ability to cope with the future changes will thus be crucially dependent on the type of change and on the abundance of the specific genotypes able to cope with that specific change.

Session 9-O3 - Phenotypic plasticity of *Plantago lanceolata* in relation to land use

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Environments exposed to human land use change rapidly. Phenotypic plasticity, the ability of a genotype to produce different phenotypes, is one of the means by which plants can cope with this accelerated change. According to theory, phenotypic plasticity should be selected for in heterogeneous environments, allowing plants to better adjust to variable environmental conditions. The Biodiversity Exploratories cover a broad gradient of land use types and intensities, with varying heterogeneities in space and time (e.g. mowing vs. grazing; timing and frequency of these, etc.), and thus they are an excellent system to test for evolution of plasticity. Plantago lanceolata is a common grassland plant that occurs in 105 out of the 150 Exploratories grassland plots. We examined three features that may play a role in its success: i) competitive ability for resources (R*), ii) benefit from a nutrient pulse, and iii) tolerance against mowing. The latter two represent different kinds of phenotypic plasticity. We grew plants from 54 populations in a common greenhouse environment and measured the following variables: i) remaining soil nutrient content after 3 months of growth, ii) increase in leaf chlorophyll content in response to a nutrient pulse and iii) several phenotypic traits (aboveground biomass, height, SLA, phenology etc.), before and after cutting

the plants at 1 cm above ground level. Our first results show a regional differentiation in response to the nutrient pulse, and population-level differences in most of the measured phenotypes before and after cutting. As an example, maximum leaf length after clipping showed a positive relationship with land use intensity, suggesting that populations originating from more intensively mown sites are indeed more plastic compared to the ones with a history of less intense mowing. With further analyses we will explore the relationships and possible trade-offs between the three examined characteristics of this species, and possibly clarify whether they contribute to its persistence in these heterogeneous environments.

Session 9-O4 - Transgenerational effects of variable heat stress treatments in *Arabidopsis thaliana* ecotypes

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How plants respond to environmental stress such as heat, salt stress or nutrient depletion has been much studied. We also know that sometimes stress responses can extend to the next generations, a phenomenon called transgenerational effects (TEs). However, little is known about (1) how TEs are affected by different patterns of temporal variability of stress, (2) whether there is genetic variation in the responses to such stress variability, and (3) whether these TEs are adaptive. To answer these questions, we carried out a multi-generation experiment with *Arabidopsis thaliana* in which the plants were subjected to different temporal patterns of heat stress, with varying timing and frequency of heat stress but all with the same overall temperature mean. To test for intraspecific variation, our study included 12 different ecotypes of *A. thaliana*. We found that in the first generation changes in the timing of heat stress affected *A. thaliana* much more than changes in stress frequency. Moreover, the stress treatments significantly carried over to the offspring generation, again with timing having a stronger effect on plant phenotypes than stress frequency. Offspring stressed at the same time as their parents generally showed accelerated flowering, but there was no evidence of adaptive transgenerational effects. There were generally large differences between ecotypes in stress responses and TEs. In summary, changing the temporal patterns of heat stress not only directly affect plants, it even results in different transgenerational effects. The next question is now which mechanisms underlie these observed transgenerational effects.

Session 9-O5 - Non -adaptive transgenerational plasticity in *Silene vulgaris*

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Plants can respond to different environments by altering their phenotype. The plastic response to the environment may be influenced by the conditions the mother plant experienced. Several studies have shown that this transgenerational plasticity can be adaptive, because it can result in higher fitness of the offspring under conditions equal to those experienced by the mother plant. We grew clonal replicates of *Silene vulgaris* under control and three types of stress conditions (nutrient deficiency, copper addition, drought), which occur in natural populations of the species. We then subjected offspring from each type of mother plant to each of the different stress treatments to analyse the influence of maternal and offspring environment on performance and functional traits. Stress treatments strongly influenced biomass and other traits of the plants. The responses to the various stresses were mostly in line with those predicted by optimal partitioning theory. Plant performance was also influenced by maternal stress treatments, in particular during the early stages of development. However, the effects of the maternal and the offspring environment on plant performance did not interact. In particular, there was no evidence for adaptive transgenerational plasticity, as offspring from a mother plant that had grown in a specific environment did not grow better in that environment than other plants. Our results indicate that the maternal environment may affect offspring traits and performance, but also that this transgenerational plasticity is not necessarily adaptive.

Session 9-O6 - Differentiation in flowering traits due to elevation and temperature in *Campanula rotundifolia* and *C. scheuchzeri*

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Floral traits are considered as adaptation regulating the interactions between plants and pollinating insects. An increase of flower size in *Campanula* species with elevation has been confirmed repeatedly. It has been suggested that changing pollinators and visiting rates might be responsible for the increase. However, variability in floral size may also be driven by environmental factors, particularly by temperature. We studied floral trait variation along an elevational gradient among and within populations of the sister species *Campanula rotundifolia* and *C. scheuchzeri* from three regions in the Swiss Alps between 1000 and 2500m a.s.l. We used microsatellites to assess neutral genetic differentiation among populations and regions and to confirm the species delineation. Further, using a common garden approach, we grew plants from nine populations (three per region) under two different temperatures representing a difference of c. 1000 m in elevation in climate chambers. Populations differed in flower size, number of flowers per stem, ovule number, pollen-ovule ratio, seed set and seed weight

depending on their elevational origin, and on their species affiliation. However, the effect of temperature was even larger and, interestingly, corresponded for most traits in its direction with genetic effects. Flower size and number were not negatively correlated, giving no indication of a pronounced trade off. In a preliminary survey, we found no indication for a decline of pollinator service along elevation, and therefore strong differential selection caused by pollinators could not be confirmed. We conclude that a combination of genetic and temperature effects is causing the pronounced differentiation along elevation.

Session 9-O7 - The 1001 genomes of *Arabidopsis thaliana* reveal a deep climatic adaptation history driven by summer drought

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Could a plant native to the Arctic survive and reproduce if planted in the dry steppes of Spain, and vice versa? Some accessions of the model species Arabidopsis thaliana can. This striking potential for climatic adaptation has inspired numerous studies, but our understanding of the phenomenon remains incomplete. Recent resequencing data from the 1001 Genomes project allows us to investigate the environmental pliancy of A. thaliana with unprecedented precision. We observed a sharp genetic divergence between Central European and Mediterranean populations. Coalescent models indicated that these populations became isolated during the last glacial maximum and niche envelope models showed that Mediterranean populations inhabit ecosystems characterized by severe summer droughts. Genome wide associations (GWAs) with climatic variables put to ethylene response factors and cytochrome genes among the top correlated genetic variants, both known to mediate responses to abiotic stresses and candidates for local adaptation. To validate the hypothesis of local adaptation via specific genes, we performed common garden experiments with over 200 worldwide-distributed populations and characterized drought response using image analysis. Quantitative drought resistance was highly heritable and top hits in GWAs of drought resistance corroborated some genes identified from climatic GWAs results, although these were not significant under Bonferroni multiple test correction. The genetic architecture of drought adaptation is likely polygenic, so we used a multivariate framework to jointly test all top drought SNPs for non-neutral divergence and correlation to local climates and found a significant signal. This result strengthens the hypothesis that drought resistance has arisen through graded and orchestrated polygenic adaptation since the last ice age. Indeed, high drought resistance was associated with increasing genome proportion of Mediterranean and North-Eastern European ancestry. Why these populations from colder regions are relatively drought resistant remains an open question. In summary, by combining genomic data, empirical ecology and multivariate statistics, we quantified the adaptive

potential of alleles, groups of genes and population lineages. This advances our understanding of how and why broad climatic adaptation trends emerge in nature.

Session 9-O8 - Frost-tolerance in *Arabidopsis thaliana* is better explained by microenvironment than by altitude

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Strong vegetation changes with higher altitude are a result of many simultaneously changing environmental variables among which decreasing average temperatures play a prominent role. Therefore, high altitude populations often show enhanced frost tolerance compared to low altitude populations. However, changes in slope, soil depth and exposition are known to strongly affect microenvironmental conditions which may counteract average effects of altitude. We tested winter frost tolerance of *Arabidopsis thaliana* accessions originating from 12 sites along an altitude gradient in the South Tyrol and Trento provinces of Italy in a common garden experiment over 3 years and collected high resolution temperature data from 8 of these sites for two years. Our results show that frost-tolerance on average increased with altitude which is consistent with adaptation to higher frost frequency at higher altitudes. However, from about 900 m.a.s.l onwards strong deviations from a linear increase in frost-tolerance were observed. Indeed, the variance across populations for the number of cold days increased strongly with altitude. Including the temperature data in the model revealed a better association of winter-frost resistance with the number of days below 1 °C than with altitude. These results suggest that a strong microenvironment effect may partly overrule effects of altitude allowing a range of differently adapted populations to survive at high elevations. These results from intraspecific variation demonstrate how mountainous regions may act as refuge for plant species in times of changing climates.

Session 9-O9 - Phenology, root growth and reproductive allocation, but not the L-H-S model, shape ecotypes along an aridity gradient

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The degree to which plant species are segregated into locally and hence more narrowly adapted ecotypes will likely affect their vulnerability to ongoing climate change. Yet, at what spatial scale does ecotypic differentiation occur and which traits predominantly shape such diverging ecotypes? We assessed these questions for aridity gradients, using the widespread Mediterranean annual grass *Brachypodium hybridum.*We measured various phenotypic, growth and fitness

traits in a greenhouse experiment and tested for ecotypic differentiation at two spatial scales: we sampled 14 populations along a natural rainfall gradient in Israel (220 km; large-scale) and in addition compared plants originating from Northern vs. Southern hill slopes within single sites (<300 m; small-scale). Delayed phenology, increased root growth and lower reproductive allocation were the key traits shaping a clear ecotypic shift from arid to mesic-Mediterranean populations along the large-scale gradient. Intriguingly, none of the classic and often heralded L-H-S traits (Leaf SLA, plant Height and Seed size) changed with aridity. Plants from Northern vs. Southern hill slopes differed little and poorly reflected the large-scale trends. Our results suggest a clear large-scale segregation of populations into locally and more narrowly adapted ecotypes along the rainfall gradient. Sub-populations from South-facing slopes, however, are poor nearby outposts of more arid adapted ecotypes. Both aspects are likely to increase the species' vulnerability to climate change. We also highlight that phenology, reproductive allocation and the commonly overlooked root traits should gain key attention in future local adaptation studies, especially along aridity gradients.

Session 9-O10 - Local adaptation in the light of climate change: Phenotypic trait analysis *of Silene vulgaris* across a European latitudinal gradient

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Ecological impacts of ongoing climate change are intensively discussed, but detailed information about adaptation potential and its genetic basis in plants still remains scarce. We used the ecological model organism *Silene vulgaris* to compare phenological traits influenced by simulated climate change conditions. 25 Populations were sampled across a European-scale climatic gradient to analyze the underlying genetic base of phenotypic adaptation. Plants were grown in a randomized block design under two temperature (18°C, 23°C) and three precipitation (36mL, 40mL, 46mL) regimes under controlled glasshouse conditions. We detected ample variation among populations in phenological traits such as time until flowering, number of leaves and branches or individual height. However, the phenological traits revealed a significant latitudinal cline between the different European populations as well. Especially the latitude of origin of the different populations was significantly correlated to the individual height of plants and the time until flowering. The experimental regimes influenced phenological traits to a lesser extent but still had significant effects: The different temperature conditions

were significantly linked to plant height and days until flowering. Whereas the different water regimes only influenced the height of plants. Ongoing next generation sequencing (ddRAD) of the European populations and phenotypic trait analysis via QTLs will provide us with further functional genomic data to deepen our understanding of the genetic basis of plant adaptation to a rapidly changing environment.

Session 9-O11 - Local adaptation at different spatial scales in a long-lived perennial herb: the relative importance of climate versus soil composition

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Spatial variation in environmental variables can lead to local adaptation in plants. However, it remains unclear how influential different environmental variables are relative to each other, and at what spatial scales they may contribute to local adaptation. We conducted a fully reciprocal transplantation experiment over three growing seasons among five populations of the long-lived perennial herb, *Vincetoxicum hirundinaria*, from Finland and Switzerland. We investigated the role of spatial variation in climate characteristics and soil composition in explaining local adaptation at two spatial scales: within and between Finland and Switzerland (i.e. regions). We found adaptation of plants to their region of origin in number of shoots, number of inflorescences and resistance to local herbivores in at least one of the two consecutive years of measurement. This was mostly driven by Finnish plants having higher numbers of shoots and inflorescences and lower levels of leaf damage compared to Swiss plants when grown in Finland. Within regions, sympatric plant-site combinations had on average fewer shoots than allopatric combinations in one year, indicating maladaptation. Euclidean distance in climate variables between the two regions explained local adaptation whereas distance in soil composition had only minor or no effects. The observed adaptation of the plant to local herbivores at the regional scale may be due to differences in chemical defenses between the regions. Our findings highlight the importance of considering multiple environmental factors when investigating drivers of plant local adaptation at multiple spatial scales over multiple years and suggest that long-lived plants may adapt to their co-evolving antagonists.

Session 9-O12 - Does demography prevent species from adapting to new environments?

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Many individuals stay in their maternal environment, and many species conserve their ancestral environments (niche conservatism). Holt (1996 EvolEcolRes) hypothesized that the former results in the latter: (i) most offspring arrives proximate to mother individual or lineage, “at home”; (ii) “home” environments select for different phenotypes than “away” environments; (iii) overall, within a population most selected individuals represent “home” phenotypes; and (iv) demographic dominance of the “home” phenotype will maintain the species in its maternal “home” environment even though the species would have the potential to colonize ”away” environments. We test Holt’s hypothesis using monitor seeds and seedlings of oaks at different spatial distances from an adult, invoking different species (*Quercus robur* vs. *Q. petraea*) and different phylogenetic distances of neighbouring trees. Seeds and seedlings were phenotyped prior to plantation. Selective agents were excluded by application of insecticides and fungicides. Enemy pressure, mycorrhization, mortality, germination and budburst performance were observed. Tentative results suggest that indeed different phenotypes are selected “at home”, i.e. close to a conspecific or closely related neighbour, than “away”. This difference in selection “home” and “away” appears to reflect the respective enemy pressures and mutualist supports. Such differences in selection pressures between maternal and distantly related neighbourhoods might prevent the establishment of phenotypes adapted to the distantly related neighbourhood and conserve the ancestral niche.

Session 9-O13 - Local adaptations in plant populations: does arbuscular mycorrhiza matter?

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Local adaptations in plants are often explained by differences in abiotic in soil properties. They may be, however, also be related to the differences in soil biota, especially to arbuscular mycorrhizal fungi (AMF). AMF are obligate biotrophs. This led to formulation of co-adaptation model, which proposes that due to selection mutually beneficial associations are supported. If plant species will be adapted to their specific AMF, they should grow worse on sites, where such AMF is absent. This could be one of the reasons, why some plants are not able to colonize artificial sites. We tested if populations of model dry grassland species *Aster amellus* differ

in their dependence on mycorrhizal symbiosis and if such difference is a result of local adaptation to single AMF species or AMF community. Finally, we tested if preinoculation of species by native AMF could enhance their performance on other sites. We used 3 diploid and 3 hexaploid populations from nutrient poor sites (marl) and 3 diploid populations from nutrient rich site (limestone). The results showed that the percentage of mycorrhizal colonization is genetically determined since it is strongly determined by soil of mother plant origin, but it is independent of soil of progeny cultivation even when the progeny is cultivated in nature for 5 years. The pot experiment showed a positive response of plants to their native soil and AMF. In the field experiment, native plants grew better in their own soil and AMF community only when they originated from the nutrient poor region. Concerning local adaptation of 2x contra 6x, we observed more effective mycorrhizal symbiosis in native soil for both ploidy levels independently on origin of AMF. This suggests that mycorrhizal symbiosis is responsible for local adaptation of *A. amellus*, but it is not due to adaptation of the species to specific AMF. However, the preinoculation of plants did not enhance their performance on artificial sites.

Session 9-O14 - Evolutionary response to climate change? Regional adaptation of a range expanding species

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Due to climate change, some species are shifting their distribution ranges towards the poles. What happens with these species in their new range? Do they quickly evolve and adapted to the conditions in their new environments? How do novel biotic interactions affect species? We tested the (genetic) differentiation and regional adaptation of the range expanding plant Rorippa austriaca. This plant is native to central-east Europe and has expanded its range to West and Northern Europe. Genotypes were collected from across the distribution range. We investigated several plant traits such as clonal growth, chemical defenses, and herbivory in the field and in the lab. Regional adaptation was tested with a reciprocal transplant experiment with sites in the new as well as the native range. The genetic analyses using SNPs showed that the genotypes from the exotic range in Western Europe were mostly different from the native genotypes. Plants from higher latitudes in the new range showed faster clonal growth and subtle differences in chemical defenses and insect herbivory. At the different field sites, plants from the new range always grew bigger than the native genotypes. Thus, differentiation in growth was independent from environmental factors. Herbivory was higher and not lower at the sites in new range compared to the native range. At the most Northern field site, the native plants were more damaged by invertebrate herbivores than genotypes from the new range. Our results suggest that range expanding plants may evolve fast in their new environments. In

addition, processes that play a role in biological invasions could also play a role in the evolution and spread of range expanding plants.

Poster presentations

Session 9-P1 - Climate change, plasticity and genetic variation in *Anthyllis vulneraria*

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Climate is a key factor determining the distribution of plants. We are studying the possible impact of predicted climate change on the short-lived perennial plant *Anthyllis vulneraria* along environmental gradients. We are analysing 40 natural populations and their habitats along altitudinal and latitudinal gradients throughout Europe to investigate relationships between population characteristics and environmental conditions. We are also investigating molecular genetic diversity in relation to the same gradients. Furthermore, the variation in a number of quantitative traits and its distribution among spatial scales will be studied in a lowland common garden and compared with that of the variation in neutral genetic markers. Thus, we will also be testing whether plants from mountain and high latitude populations perform less well under lowland conditions than plants from lowland and central European populations, and whether genotypes exist in the mountain and high latitude populations that are preadapted to the predicted warmer future conditions. Plants will be genotyped to detect loci correlated with ecological gradients in *A. vulneraria* and to relate the identified alleles to the performance of the plants in the common garden experiment and in stress experiments.

Session 9-P2 - Role of phenotypic plasticity and genetic differentiations in ecophysiological traits in adaptation to climate change in the species *Festuca rubra*

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Understanding the ability of species to respond to climate change is essential for prediction of their future distribution. When migration is not adequate, reaction via phenotypic plasticity and/or genetic adaptation is necessary. The aim of this study is to determine mechanisms of responding to climate change in dominant grass species *Festuca rubra* by separating microevolutionary effect from plastic responses to answer following question: is the response of *F. rubra* driven primarily via phenotypic plasticity or genetic adaptation? The study used reciprocal transplant experiment with growth chambers simulating different climatic conditions. Original localities in western Norway represent factorial crossed gradients of annual temperatures and annual precipitations, thus it was possible to study the effect of temperature and moisture separately as well as combined. Plants with different genotypes from original localities were transplanted to growth chambers set to simulating temperature course in the four extreme localities (wettest and driest combined with warmest and coldest). After five months, ecophysiological photosynthetic-related traits were measured. They are key adaptive and fitness-related, and thus essential for plants function. Specifically, it was net photosynthetic rate (PN), fluorescence of chlorophyll (parameter ϕP0), water potential, stomatal density, stomatal size and specific leaf area (SLA). The study demonstrated that relative effect of phenotypic plasticity and genetic differentiations strongly differs between traits and these effects are influenced by temperature, moisture and their interactions depending on each trait. Overall, it was suggested that the response of the species *F. rubra* to climate change is driven by phenotypic plasticity as well as by genetic differentiation.

Session 9-P3 - Parental effect of mild heat on flowering time in *Arabidopsis thaliana* is explained by climate: Potential for climate change adaptation?

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Transgenerational plasticity is increasingly recognized as an important source of phenotypic variation, affecting potentially the response to selection. It was postulated to play a role in adaptation to environmental change. Yet experimental evidence is scarce. It is also an open question how environmental cues from different generations (e.g. parental, grandparental) interact to influence the offspring phenotype. Here we present effects of grandparental and parental mild heat, and their combination, on the third generation phenotype in 14 *Arabidopsis thaliana* genotypes and test implications with a conceptual model. We reveal strong evidence for genotype by environment interaction in transgenerational plasticity. Furthermore, a complex pattern of interdependence among phenotypes

of different generations supports a stronger influence of the parental environment, but also acclimation to mild heat across several generations. Most intriguingly, genotypes from climates with hot and dry summers responded through earlier flowering. According to the conceptual model this is adaptive under the assumptions of environmental autocorrelations and hot and dry summers, which are met by climate change predictions for the greater Mediterranean region. Our findings corroborate the hypothesis that transgenerational plasticity may support adaptation to climate change in plants and provide evidence of environment acclimation across generations.

Session 9-P4 - Effects of climate and extreme weather events on growth of European beech (*Fagus sylvatica* L.) towards the cold and dry distribution margins

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European Beech (*Fagus sylvatica* L.) is the dominant natural forest tree in Central Europe and thrives under a wide range of environmental conditions. Yet, beech is expected to suffer from climate change due to a high drought sensitivity and a low seed dispersal capacity. Phenotypic plasticity, however, is high within and between populations and can be expected to buffer against climate change in situ. As the limits of phenotypic plasticity are still unclear, we study the importance of phenotypic variability in tree-ring width at 8 sites across Europe. These sites display strong climatic gradients of decreasing summer precipitation towards the south (Spain) and decreasing temperatures towards the north (Sweden) and east (Poland). The tree-ring data is used to analyse site-specific climate-growth relationships and to quantify the frequency of extreme growth depressions (negative pointer years) per site. Further, covariance in linear mixed models of tree-ring width among trees is used as indicator for site specific plasticity. We hypothesise that i) climate–growth relationships differ between study sites, ii) the number of negative pointer years increases towards the margins due to extreme weather events in winter (i.e. Golub-Dobrzyń in Poland) or summer (i.e. Montseny Mountains in Spain), and iii) growth variability within populations decreases, but temporal variability in growth increases towards the distribution margins. Overall, our study will make an important contribution to increase the understanding on distributional range limits for European beech.

Session 9-P5 - Detecting potential micro-geographic adaptation at a species' range edge

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As species approach their ecological limits their populations typically become smaller and more fragmented. These range-edge populations are more likely to maintain specialized genotypes that are particularly well-adapted to their harsh or extreme climates (e.g. Bridle and Vines 2007, Rehm et al. 2015). We found evidence of this by investigating the genetic pattern (AFLP) of 12 fragmented *Geropogon hybridus* (L.) Sch. Bip. (Asteraceae) populations at their range-edge in Israel along a very strong precipitation gradient. In the investigation area within a distance of 45 km the annual rainfall changes rapidly from 450 to 300 mm per year without significant temperature changes. Our AFLP data (3 different primer combinations, 91 individuals, 123 polymorphic loci) revealed strongly structured populations (AMOVA Φ_{ST}= 0.35; P<0.001), however, differentiation did not change gradually towards range edge. Significant isolation-by-distance (IBD; Mantel test r: 0.81; P: 0.001) suggests differentiation as result of drift and dispersal limitation. Next to IBD we also found very significant isolation by environment (IBE), which could be correlated to precipitation here. Applying the spatial analysis method (SAM) to correlate annual precipitation with AFLP data, we detected 11 outlier loci to be potentially under selection, which was also detected by other software (BAYESCAN, MCHEZA). Populations distributed across climatic gradients commonly show high levels of local adaptation but rarely on this micro-geographic scale. Furthermore, IBD-IBE-associations by means of climatic variables on larger geographic scales commonly comprise temperature and precipitation changes without the possibility to detangle one cause from another. In contrast, on this micro-geographic scale precipitation was the only change along the gradient, implying that the detected outlier loci are most probably linked solely to reduced water availability.

Session 9-P6 - Tropical tree species responses to temperature and precipitation changes: A transplant experiment at Mount Kilimanjaro

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Climate and land cover changes are heavily impacting the world's ecosystems. Tropical forests provide crucial ecosystem functions and services, but how tropical trees will respond to the main components of climate change, i.e. temperature and precipitation, is poorly known. For trees, early stages in the live cycle, e.g. germination and seedling establishment are most sensitive to environmental changes and crucial for recruitment and population dynamics. To study how tropical trees respond to temperature and precipitation changes, we germinated and grew 48 tree species from different vegetation zones between 800 and 3000 m.a.s.l., under standard conditions in two experimental gardens at Kilimanjaro. One garden was located in the savanna zone at 880 m.a.s.l. and the other in the montane vegetation zone at 1450. Under these different temperature regimes we supplied to half of the individuals additional water on top of the normal rainfall. We measured germination success and the performance of the emerging seedling after 3 and 6 months. Initial results suggest, that germination success was in general significantly higher in the hotter savanna than in montane garden. Although savanna temperature caused a higher rate of mortality, the surviving ones showed a higher performance in terms of plant height, diameter and leaf number. Furthermore the response depended on water availability. Trees grown in the montane garden could more benefit from additional water in terms of height growth than in savanna garden. However, the opposite was found for leaf number, which was strongly increased in savanna garden under water supply. Our results indicate that increased temperature may act as a strong survival filter and thus may change species composition, whereas temperature effects on growths appear much smaller. Moreover, we show that the effect of warming on tree saplings changes with water availability, underlining the need to study the combined effects of climate change components.

Session 9-P7 - Phenotypic Plasticity: Transfer of one morphotype into another by manipulation of growth conditions

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Individuals within wild populations differ substantially in their fitness. Within Charophyta algae two phenotypes of species *Chara baltica*: *C. baltica* var. *baltica* und *C. baltica* var. *liljebladii* can be found in different water depths, probably due to different adaptation to light regime. Both phenotypes are mainly distinguished by their size. In detail they are separated by lenght of the internode and bract cells, as well as cortication type. Our genetic analyses revealed that individuals of both morphotypes are genetically identical, and hence belong to the same species. Here we test whether a given *C. baltica* var. *baltica* phenotype can be transferred into a

C. baltica var. *liljebladii* (and vice versa) by manipulation of the environmental conditions. We observed significant changes in the morphology of the *C. baltica* var. *baltica*: decreasing light intensity significantly increased growth of the internode cells and branchlets, and the plants grew larger, thus changing their morphology into the direction of the *C. baltica* var. *liljebladii* morphotype. In the reverse experiment, subjecting *C. baltica* var. *liljebladii* to decreasing light intensity, the individuals had slightly reduced growth, but none of the analysed morphological characters changed. Both varieties have thus shown different adaptations to light limitation. They had differnet morphologies that cannot be changed due to environmental factors. Thus, presence of the differnet morphologies reflect the ecological characteristics of their habitats - such as light availability or turbidity.

Session 9-P8 - Testing early fitness traits in seedlings of *Abies alba* and *Picea abies* for signatures of local adaptation

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Under on-going climate change, many plant populations might no longer be optimally adapted to the climatic conditions at their sites. In this context, we need a better understanding of the role of local adaptation and plasticity, as they are critical for the response of plants to changing climatic conditions. This is of particular interest in trees where long generation time might impede fast evolutionary responses. In our study, we focus on detecting signatures of local adaptation in the phenotype of populations of *Abies alba* and *Picea abies* in the Bavarian Forest National Park. Previous studies investigated phenology and growth at sampling sites at low and high elevations, and found differences in the date of bud burst and several growth related parameters between sites. To dissect whether phenotypic differences between sampling sites are due to local adaption or due to a plastic response to different climatic conditions, we grew seedlings under controlled climatic conditions and investigated early fitness traits. If trees are locally adapted, we expect significant differences between seedlings from the two elevations in these traits. For this experimental set-up, cones were collected from ten trees per species from high and low elevations in our sampling sites in the national park. We germinated seeds under controlled conditions to determine the germination rate. Afterwards we grew ~ 400 seedlings per species in greenhouse under two different light conditions. After a growing period of ten weeks, we collected data on survival, number of needles, height growth, above and

belowground biomass and leaf mass per area. Data is currently being analyzed and first results will be presented during the conference.

Session 9-P9 - Adaptive potential of a clonal plant in an environmental gradient - the link between genetic and phenotypic diversity

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Understanding the relationship between plant phenotypic variation and plant genotypes is a key to understand mechanisms responsible for species adaptations to novel environments. We studied the adaptive potential of *Festuca rubra*, a clonal plant, in a unique setting of natural populations chosen in an elevation gradient in which only temperature and moisture vary. We use data on a range of physiological and morphological traits of 275 genotypes sampled from 11 populations and grown in 4 growth chambers simulating the four extreme natural climates, and we link those traits to genetic characteristics of each genotype. These data are currently being explored. Specifically, we are looking at the corelations between genetic similarity of the plants and their phenotype or phenotype plasticty using multiple matrix correlation tests and analysis of coinertia, Fst-Qst comparisons and multivariate regressions of phenotypic traits on fitness estimators (biomass) and of individual genetic diversity on phenotypic plasticity. Our goals are to i) describe the link between genotypic diversity and the phenotypic response for phenotypic traits and also their plasticity, ii) test whether the most diverse genotypes are also those that yiel the highest plasticity, iiia) detect signature patterns of evolutionary processes such as selection and genetic drift and iiib) in the case of significant selection on phenotypic traits, identify the selection types operating in the studied system. Altogether, these results will help to assess the adaptive potential and mechanisms of *F. rubra* in the context of climate change.

Session 9-P10 - Phenotypic plasticity to growth-limiting factors at tree-line in Alaska

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Compared to 1986-2005, climate change scenarios project an increase in June-August air temperature in Alaska of up to 4°C by the end of this century. As precipitation most likely will not keep up with this warming, droughts might become more frequent and (or) severe. Several dendrochronological studies in Alaska found, that growth of white spruce (*Picea glauca* (Moench) Voss) lost its positive correlation with summer temperatures. A switch from temperature to

water limitation due to climate change is one likely explanation. To enhance our understanding on the climate sensitivity of white spruce and their local adaptation, we compared growth responses and wood anatomy of two tree-line sites, where we assumed tree growth to be either water or temperature limited. We assessed individual-tree and population-level responses to climate. While annual radial growth is taken as an integrator for tree health and vitality, wood anatomical properties (cell number, lumen area, cell-wall thickness) are plastic growth traits, which trees can use to regulate their water conducting system to counteract local drought. Smaller lumen diameter and increased cell-wall thickness seems to have become more frequent in recent years. This suggests that drought stress increasingly affects white spruce growth. Wood anatomical adaptation does not seem to fully compensate for increased drought stress, even at the tree-line, that was formerly temperature limited.

Session 9-P11 - Disturbance and adaptive potential - How fast can long-lived plants react to environmental change? A study on *Picea glauca*

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Within the life span of long-living trees the local climate may change to a degree that would not allow the very same individuals to establish again today. Therefore, the individuals performing best today may not necessarily be those that will perform best tomorrow, but once established, they should, because of their size and age, produce most of the offspring. To look for possible differences in the number of offspring between trees of different generations we performed a parentage analysis based on eleven microsatellites at two different field sites in Alaska (Brooks Range and Alaska Range). Surprisingly, our results suggest that younger trees produce more offspring than older ones, and we assume these trees to be better adapted to recent climate conditions. If this holds true, we have a case where individual performance (tree age and/or size) and fitness (number of offspring) differ significantly. This would speed up change in genotypes, thus increasing the adaptive potential of the species. Since Alaska is severely affected by global warming, this might be important to predict species turnover in Alaskan forests.

Furthermore we discovered that especially stands at the treeline have a significant proportion of clonal trees. Virtually all clones form clusters (<10 m in size), which hints to layering as the major mechanism for cloning. However, not all clusters of trees are clones, which indicates as well a role of facilitation effects for seedling recruitment, enabled by pronounced masting effects in white spruce. Both effects

may accelerate the reaction of the species to global warming, which is reflected by quickly advancing treelines in many regions of Alaska,

END OF SESSION 9

Session 10 – The relevance of intra- versus interspecific variation of plant functional traits

Short title: Intra- versus interspecific variation of plant traits

Chairs
Dr. Susanne Tautenhahn
Dr. Kirsten Thonicke

Session 10-O1 - The role of plant adaptive responses for ecosystem functioning in a changing climate: what we know and what we don't

Kirsten Thonicke[1], Alice Boit[1], Susanne Tautenhahn[2], Florian Fahr[3], Thomas Hickler[4], Jasmin Joshi[3], Jens Kattge[5], Miguel Mahecha[5], Talie Musavi[5], Christine Römermann[2], Simon Scheiter[4], Werner von Bloh[1], Ülo Niinemets[6]

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Climate change is becoming an increasingly powerful selective force in natural plant populations. Recent advances in functional biogeography have quantified the role of functional plant traits and their variability in ecosystem functioning and resilience, and characterized the bioclimatic envelopes of plant traits. A related line of research in functional ecology has highlighted the importance of specific functional traits with high intraspecific trait variability for plant adaptive plasticity. High intraspecific trait variability could therefore serve as a proxy for the adaptive capacity of species to climate change. However, quantitative evidence supporting this hypothesis is still scarce and limited to local sites, and we even lack the conceptual basis for mechanistically including both intraspecific trait variability and plant adaptive responses in vegetation models for projecting ecosystem functioning under future climates. Here, we review how climate change influences plant functional traits and how resulting, climate-induced adaptive responses could contribute to maintain ecosystem functioning. We then argue which experiments, observational strategies, database-design schemes and modelling concepts could help to better project the adaptive capacity of vegetation systems in a changing climate. Our synthesis makes a major leap towards advancing functional biogeography to a predictive science by suggesting a mechanistic framework on

how to upscale local relationships between trait variation, adaptive responses, and ecosystem functioning to larger-scale ecosystem resilience under climate change.

Session 10-O2 - Effects of plant functional traits on soil stability: intraspecific variability matters

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Background and Aims: Soil stability is a key ecosystem function provided by agricultural landscapes. A multitude of influential factors such as soil texture and plant community structure have been suggested, but few studies compare the relative importance of these factors for soil stability in the field. In addition, studies on effects of plant traits on soil stability have ignored intraspecific trait variability despite growing evidence of its importance for ecosystem functioning. *Methods*: Using path model analysis, we quantified the effect of plant functional traits (PFTs), abiotic soil characteristics and vegetation characteristics on three soil stability measures in 30 field margins of an agriculture landscape of Korea. We compare models with and without intraspecific trait variability. *Results*: Variance in soil stability was relatively well explained by our conceptual path model (81% explained variance for soil aggregate stability, 50% for penetration resistance and 35% for soil shear vane strength). The overall most influential variable was root density while vegetation cover and species richness was much less important. Accounting for intraspecific trait variability improved the goodness-of-fit of all path models but not the overall explained variance. However, intraspecific trait variability allowed identifying important direct and indirect effects of PFTs on soil stability that would have remained unrecognized otherwise. *Conclusion*: We have demonstrated that the consideration of intraspecific trait variability – even though strongly limiting achievable sample sizes – is essential for uncovering the substantial effect of plant functional community composition on a key ecosystem function, soil stability.

Session 10-O3 - Inter- and intraspecific variation in floral and vegetative traits as response to altitude: implications for community assembly

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Communities are composed of species that are able to survive and reproduce under local conditions. The establishment of species is either controlled by the environment (habitat filtering) or by interspecific competition for resources or mutualistic partners such as pollinators leading to a limited similarity of functional traits. Therefore, the functional diversity of vegetative and floral traits in plant communities may respond to different selection regimes enabling plants to cope with abiotic factors (resulting in low functional diversity in a community), or to successfully compete for pollinators (high functional diversity). Likewise, plant species phenotypically respond to variation in environmental factors and interaction partners. Within that framework, we quantitatively measured the inter- and intraspecific variability of several floral and vegetative traits of plant species in eight communities along an altitudinal gradient in the Austrian Alps. This dataset allowed us to evaluate whether the phenotypic plasticity in plant species as a response to altitude is reflected by whole plant communities consisting of multiple species. Both plant species and plant communities strongly responded to altitude. For some traits, we found that the responses of plant species were reflected by responses of the community. In other traits, species and communities showed different responses. In general, the importance of habitat filtering increased with increasing altitude suggesting that the environmental conditions in higher altitudes exert stronger selection on plant species and communities. The study suggests that vegetative traits are rather controlled by the habitat, whereas the diversity of floral traits within a community reflects the need of plant species to compete for pollinators by displaying unique and salient floral signals. Our results provide insights into assembly processes of plant communities, which partly are reflected by plastic responses of plant species to altitude. Additionally, our data are suited to pinpoint functional traits that help plant species and communities to establish and sexually reproduce under given conditions.

Session 10-O4 - More constant rather than more plastic plant species are the winners of ongoing anthropogenic environmental changes

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Increasing attention is being paid to the importance of intraspecific trait variation. It has been shown, for example, that mammalian species with more variable adult

body masses are less vulnerable to extinction in native areas and more likely to establish in exotic ranges. Similarly, invasive plant species were characterized by larger phenotypic plasticity compared with native species. However, other studies found that more variable and more plastic plants were less common and had narrower niches. We explored whether differences among species in mean and plasticity of five plant functional traits (SLA, LDMC, plant height, leaf thickness, greenness) can explain their response to several anthropogenic drivers (increasing land-use intensity, exotic plant invasion, atmospheric nitrogen deposition and experimental addition of nutrients). We also asked whether a non-random loss of more sensitive species translates into community effects on ecosystem functions such as productivity. By using vegetation data from nine European grassland systems exposed to these drivers we showed that plant species with a smaller SLA and those with larger plasticity were more prone to extinction. Less diverse (i.e. more altered) communities were thus characterized by a larger community mean SLA, but by a smaller community mean plasticity. We then found that the covariance between richness and community mean plasticity modifies diversity effects on biomass production, as based on resampling data from eight biodiversity - ecosystem function studies. Compared with random species assemblages, presence of more plastic species in more diverse communities both pronounced or, on the contrary, weakened positive effect of species diversity on biomass production, depending on the particular study. Our findings suggest that species plasticity is an important characteristic that jointly predicts plant responses to human disturbances as well as ecosystem functioning of altered communities.

Session 10-O5 - Plant responses to climatic extremes: within-species variation equals among-species variation

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Within-species and among-species differences in growth responses to a changing climate have been well documented, yet the relative magnitude of within-species vs. among-species variation has remained largely unexplored. This missing comparison impedes our ability to make general predictions of biodiversity change and to project future species distributions using models. We present a direct comparison of among- versus within-species variation in response to three of the main stresses anticipated with climate change: drought, warming, and frost. Two earlier experiments had experimentally induced (i) summer drought and (ii) spring frost for four common European grass species and their ecotypes from across Europe. To supplement existing data, a third experiment was carried out, to compare variation among species from different functional groups to within-species variation. Here, we simulated (iii) winter warming plus frost for four grasses, two nonleguminous, and two leguminous forbs, in addition to eleven European ecotypes of the widespread grass Arrhenatherum elatius. For each

experiment, we measured: (i) C/N ratio and biomass, (ii) chlorophyll content and biomass, and (iii) plant greenness, root 15N uptake, and live and dead tissue mass. Using coefficients of variation (CVs) for each experiment and response parameter, a total of 156 within- vs. among-species comparisons were conducted, comparing within-species variation in each of four species with among-species variation for each seed origin (five countries). Out of only six significant differences, within-species CVs were higher than among-species CVs in four cases. A formal comparison of phenotypic plasticity indices further emphasized the ecological importance of within-species variation. Our observation that within-species variation was generally as high as among-species variation emphasizes the importance of including both within- and among-species variability in ecological theory (e.g., the insurance hypothesis) and for practical applications (e.g., biodiversity conservation).

Session 10-O6 - A root is a root is a root? - The importance to know your root type

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Knowledge on root traits, and their plasticity to spatial or temporal environmental conditions, will increase our understanding of plant and ecosystem functioning. However, even within root systems a distinct heterogeneity of traits exists. Thus, detailed knowledge of the traits of individual root types and segments, especially those related to resource uptake as well as carbon invested, is key to understand overall root system functioning. Classification schemes have to match functional root types as closely as possible to utilize them for sampling and modelling. The presentation will summarize classification systems frequently used in (woody) plants, illustrating differences among root types. Examples will cover water uptake rates by different root types with and without salt stress, species-specific differences in root respiration, and the diverging activity of key enzymes on different root types. Finally, the consequences of using root type-specific traits for parameterizing terrestrial biosphere models will be discussed on the example of fine-root productivity and turnover.

Session 10-O7 - How do functional traits of dominant and broad-range species compare to overall trait space in trees, other terrestrial plants, and epiphytes?

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Co-occurring species within ecosystems often show a wide range of trait expressions. These trait expressions allow for survival in specific habitats, but

species differ in both their abundances and the range of environmental conditions they tolerate. This may be a result of particular trait values or large intraspecific variability compared to the respective communities. Leaf and stem samples were collected for all vascular species accounting for 80 % of the terrestrial plant biomass in 60 plots of 50 x 50 m along an elevation gradient of 3500 m at Mount Kilimanjaro, Tanzania. Low-level vascular epiphytes were sampled from the ground on the same plots. One major tree per plot was climbed and all epiphyte species collected. Another tree was selected and one outer branch retrieved to record outer-canopy epiphytes. Abundance was estimated for both terrestrial and epiphytic vascular plants. Plant functional traits including leaf C_{mass}, N_{mass}, and P_{mass} were measured for all samples obtained. Broad-range species were characterized by low specific leaf area, low leaf P content in terrestrial plants, and large intraspecific variability in most traits investigated. Dominant species also had low specific leaf area and trait values relatively centered in the overall trait ranges. While dominant epiphytes overlapped strongly in the traits investigated, this was not the case for terrestrial plants, both trees and others. Our findings indicate that the size of species distributions is mainly determined by the plasticity of functional traits within species, rather than by absolute trait values. In contrast, dominant species are characterized by trait values close to the community mean. These trait values may offer highest revenue for growth investment and other species may clump around those being constrained by limiting similarity. In addition, both dominant and broad-range species responded to a probable P-limitation of their habitats: Low leaf P_{mass} may be an adaptation to the scarcity of this resource at Mount Kilimanjaro. In general, competition appeared to be stronger among terrestrial plants than among epiphytes, as the dominant epiphytes showed significant trait overlap, while terrestrial plants separated clearly in terms of most traits.

Session 10-O8 - Inter- and intraspecific root trait variability in grassland species

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Trait based approaches are becoming more and more important in plant ecology. Characterizing species, populations and communities by traits rather than by taxonomy holds the advantage of a direct link to the potential ecosystem function. Traits are mainly considered as species specific and obtained by calculating mean values either per species or per community. This approach offers the opportunity

of evaluating interspecific trait variation within and across communities. Knowledge of interspecific variation is pivotal when asking questions about individual life strategies, community structure, plant economic spectra or niche partitioning. Another source of variation, which is strongly underrepresented in current studies, is the intraspecific trait variation. It consists of both variability between genotypes and plasticity along environmental gradients. Especially for root traits, on which knowledge is scarce anyway, little is known about interspecific variation within and among communities nor the soil environmental factors that could affect trait expression and lead to intraspecific plasticity. To asses interspecific root trait variation we grew 150 grassland plants that occur within the three Biodiversity Exploratories in Germany on a common soil in a greenhouse experiment. We calculated species specific mean values for root morphological traits characterized by using the WinRhizo® scanner-based system. We found coefficients of variation ranging from 30% to more than 100%. Furthermore we conducted a highly mechanistic experiment manipulating environmental conditions in water agar growing seedlings of the Poaceae *Corynephorus canescens* in large Petri dishes in a climate chamber to explore intraspecific root trait plasticity. We evaluate inter- and intraspecific root trait variation within grassland communities and discuss the importance of implementing root traits as well as their variability and plasticity in trait based approaches.

Session 10-O9 - A trade-off between primary and secondary seed dispersal by wind

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Understanding how plant and seed traits determine seed dispersal distance is challenging for plant ecologists because seeds of most plant species are dispersed by multiple mechanisms. Whether traits cause positive correlations or negative correlations (trade-offs) between dispersal by different mechanisms has important consequences for ecological and evolutionary dynamics. However, few studies quantify the effects of seed morphology on wind-driven seed dispersal through the air and over ground (primary and secondary wind dispersal, respectively). To quantify the relationship between primary and secondary dispersal, we released 10 seed morphologies (5 types of the heterocarpous *Zygophyllum xanthoxylon* and seeds of five *Calligonum* species) at varying wind speeds and release heights and on four ground surfaces in a wind tunnel. The seeds' primary dispersal distance and lift-off velocity (the threshold wind speed at seed height for seed movement over ground) were measured. Primary dispersal distance was mostly explained by positive effects of wind speed and release height. Secondary dispersal was mostly

explained by additive effects of seed type and ground surface. Importantly, we found a trade-off between primary and secondary wind dispersal. This trade-off results from a positive relationship between seed height and wing loading (the ratio of mass to projected area): An increasing seed height not only promotes secondary dispersal by increasing the wind interception of seeds lying on the ground – it also decreases primary dispersal distance by increasing wing loading and the terminal falling velocity of seeds. The trade-off contradicts the tacit assumption of several ecological theories that assume a positive correlation between dispersal by different mechanisms. These findings deepen our insights into seed dispersal by wind and will improve our understanding of plant dispersal mechanisms.

Session 10-O10 - The role of abiotic versus biotic effects for the intraspecific variability of plant functional traits

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Plant functional traits are widely used in ecology. Often so called species mean trait values are applied relying on the assumption that in macroecological contexts the intraspecific trait variability (ITV) is much smaller than the interspecific trait variability. Therefore it is important to uncover the degree of intraspecific trait variability alon environmental and biotic gradients. Environmental filtering is selecting for individuals matching the „trait-range“ providing a certain environment. Further, individuals can modify their traits in response to their nearest neighbors via competition or facilitation effects. We provide a field study on ITV aiming to disentangle the effect of environmental filtering and species interactions (neighborhood effects). We measured individual based trait distributions for five species based on 62 populations and 1082 individuals across Europe. We have further measurements on site conditions and the traits of the four most important neighbors respectively. We can show that biotic interactions as well as environmental filtering influence ITV. Using variation partitioning we show that there is a great proportion of variation in the traits that can be explained either by biotic interactions or by environmental filtering. This points to an combined effect where the environment shapes the biotic interactions which shape the intraspecific trait variability.

Session 10-O11 - Phenology of herbaceous species along elevational gradients is associated with plant functional traits

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Changes in the timing of phenological phases are a good and easily observable indicator for climate change. Previous studies on tree species along altitudinal gradients have shown that shifts in phenology occur along altitudinal, i.e., temperature gradients, yet they are highly species specific. The ability of species to track changes in abiotic conditions is essential for their vulnerability to climate change and may change the competitive balance within a community. We studied eleven herbaceous species along two altitudinal gradients ranging from 700 to 1800 m a.s.l. in the Bavarian Alps, covering a difference of 6.6K in mean annual temperature. We monitored flowering phenology at weekly intervals in 2012 and 2013. We also recorded plant functional traits related to plant performance such as SLA, leaf nutrient status as well as stomatal characteristics at peak flowering. We found that all species delayed their phenology with increasing altitude tracking interannual differences in climate, but their reaction differed between the flowering types (i.e. early flowering or late flowering). Likewise the influence of traits on flowering phenology differed between flowering types. In general, high SLA, leaf N and leaf P content advanced phenology whereas leaf K and stomatal characteristics delayed the onset of flowering in most cases. We concluded that not only climate leads to changes in phenology but that functional traits modulate this response.

Session 10-O12 - Plant trait changes along a precipitation gradient in Mongolian rangelands

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Predicting the response of vegetation to environmental and land-use change has become an important factor in recent theoretical and applied ecological research. One essential step is to determine the individual species' reactions, because individual plant species often show intraspecific variation. To find out how traits of pairs of congeneric species with usually different but partly overlapping distribution areas change with changing environmental conditions, we established 15 sites along a precipitation gradient in Mongolian rangelands Each site was separated into five plots with changing grazing intensity, from highly grazed plots to almost ungrazed plots. We focused on the three species pairs *Stipa krylovii* and *S. glareosa*, *Artemisia frigida* and *A. adamsii*, *Caragana microphylla* and *C. leucophloea*, which are common species in the Mongolian rangelands. All measurements were carried

out on eight healthy adult individuals per grazing level plot to cover the intraspecific variability within this plot.

We hypothesize that the trait values of the respective species gradually change and alternate according to their alternating distribution ranges along the gradients. To test this, we measured leaf economic and hydraulic traits as well as traits characterizing species performances. Traits used for the characterization of individual performance were canopy height, plant width, individual plant coverage and aboveground biomass. These performance traits were chosen due to their high influence by water availability which is the limiting source in arid and semi-arid rangelands for the biomass development. Results of univariate as well as multivariate analyses will be presented and discussed in the talk.

Session 10-O13 - Growth scaling irregularities explained by local adaptation in *Arabidopsis thaliana*

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Seed plants vary tremendously in size: five orders of magnitude in height, and over twelve orders of magnitude in mass. However, plant functional diversity is remarkably constrained to two major phenotypic dimensions: size-related (*i.e.* allometric) variation, and the leaf economics spectrum (*i.e.* the universal trade-off between leaf longevity and growth potential). The metabolic scaling theory (MST) predicts that allometric variations are determined by a set of mathematical functions with invariant parameters, such as the scaling exponent. Nonetheless, recent observations within and across plant species challenge the universality of these parameters, suggesting that allometric variation exists and might be adaptive. Here we show that scaling exponents diversify across ecotypes of *Arabidopsis thaliana* as the result of adaptation to local climatic conditions. In contrast with interspecific observations, allometric variations in this small herbaceous species are directly connected to changes in leaf economics; and adaptive differences in extreme environments are associated with extreme values for the scaling exponents. These variations are genetically correlated with local climate through genes related to abiotic stress response. These genes showed signatures of heterogeneous selection in space, which maintains high allelic

diversity between populations, such as mediterranean versus central- and north-european populations. Our findings illustrate that selection for an efficient use of resources in *A. thaliana* results in the genetic diversification of allometric relationships, notably at the extreme range of a species' niche breadth. This provides an evolutionary explanation for the observed discrepancies to MST predictions, settling a long-standing debate. In addition, it questions whether variation of scaling exponents could also predict the distribution of species and taxa across geoclimatic conditions.

Session 10-O14 - Intraspecific trait variation increases biodiversity by fostering the persistence of rare species: insights from an individual-based grassland model

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There is an increasingly large consensus that intraspecific trait variation (ITV) is an important contributor to both functional and bio- diversity. Though recent literature has called for a mechanistic investigation of ITV, difficulty in experimental design has left empirical explorations so far lacking. With this in mind, we retrofit an established, trait-based and individual-based community assembly model with ITV. By varying the levels of trait variation within the system, we were able to observe the population and community level consequences of ITV. We found that ITV greatly enhances the survivability of rare plant species while only marginally affecting that of common species. ITV is able to facilitate this coexistence by reducing the average individual's resource stress and increasing its net seed production. Even relatively low levels of trait-variation were able to enhance biodiversity over the long term. We furthermore describe the presence of "keystone individuals," that sometimes sustain small populations during bad years, especially in high ITV scenarios. Taken together, we corroborate the growing body of research confirming ITV's importance and establish a mechanistic understanding of how ITV influences functional and bio-diversity.

Session 10-O15 - Plant traits as indicators of environmental change - simulating trait heterogeneity in a semi-arid savanna

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Climatic conditions and land use largely affect the composition of plant communities in semi-arid savannas. This will likely also affect the composition of plant traits that are present in the community and the functioning of the ecosystem. Therefore, to fully understand the impact of environmental conditions on ecosystem functioning, it might be very helpful to determine, how traits shift under different environmental settings and how different traits might interact. Typical vegetation models of savanna systems aggregate plant species to very broad plant functional types (PFTs), such as woody vs. herbaceous vegetation. These PFTs are generally characterized by a mean value for each trait. Therefore, shifts in trait composition below the broad PFT-level cannot be adequately be detected. In this study we extended the ecohydrological savanna model EcoHyD – originally including three PFTs (perennial grasses, annuals and woody plants) by various sub-PFTs to assess the trait composition along environmental gradients. These sub-PFTs were represented in a realistic way by considering diverse trade-offs among plant traits. We simulated changes in grazing intensity and mean annual precipitation and assessed the resulting community composition. The simulation results show that dominant traits evolve differently for perennial grasses, annuals and woody plants: On the other hand, trade-offs between traits in a lower level play an essential role in the dominance of perennial plants while single trait more determines the performance of dominant annuals. Most plant traits respond more strongly to changes in precipitation than to changes in grazing intensity, suggesting different filtering effects of environmental variables on the selected traits. Our approach clearly demonstrates that it is important to allow for plant heterogeneity below the PFT level to assess how savanna vegetation may respond to environmental conditions. This will also allow to better project the impact of altered climatic conditions or land use on ecosystem functions and services.

Poster presentations

Session 10-P1 - Effects of inter- and intraindividual differences in plant quality on population dynamics of two aphid species

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The Asteracae *Tanacetum vulgare* (common tansy) is an aromatic plant that shows a high interindividual variation in its leaf terpenoid profiles, thus forming distinct chemotypes. In nature, these chemotypes seem to influence the abundance of the specialised aphids *Uroleucon tanaceti* and *Macrosiphoniella tanacetaria*. We studied how population dynamics of both aphid species are affected by interindividual variation using two distinct chemotypes (thujone and trans-carvyl-acetate), as well as by intraindividual variation by fixing aphids either on the upper stems close to the bud, young leaves or old leaves. Aphids of *M. tanacetaria* showed an overall higher survival than *U. tanaceti* and were neither affected by the chemotype nor the plant part. In contrast, *U. tanaceti* responded very sensitive to both variables, surviving best on old leaves of the thujone chemotype. Regarding the reproduction, *M. tanacetaria* feeding on older leaves initially produced less offspring than aphids feeding on stems, but numbers of offspring were comparable on both plant parts after about two weeks, indicating that they may be able to compensate over time for poorer conditions. Aphids of *U. tanaceti* fixed on old leaves of both chemotypes produced more offspring than conspecifics on the other plant parts. Thus, the niche of *U. tanaceti* seems to be restricted to older leaves, whereas *M. tanacetaria* has a broader niche. To test whether the differences in population dynamics are caused by differences in the food quality, we collected phloem exudates and analysed the composition of primary metabolites. Our study highlights the importance to consider both inter- and intraindividual variation in plant quality when studying factors that determine aphid population dynamics.

Session 10-P2 - Phenotypic plasticity of red clover (*Trifolium pratense* L.) in response to cutting

Denise Herbert[1], Klemens Eckschmitt[2], Volker Wissemann[1], Birgit Gemeinholzer[1], Stephanie Eschenbrenner[1], Stephanie Jung[1], Annette Becker[1]

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One of the most important impacts on existing structures of biodiversity and ecosystem processes arecaused by changes in land use. However, our knowledge on how organisms cope with environmental perturbations and changes in land use on the molecular level is scarce. Red clover (*Trifolium pratense L.*) is an important forage cropworldwide and thus of great agricultureinterest. The perennial plant offers several advantages like a high nutritional value and soil improving characteristics, improving protein intake in livestock farming and reducing the need of fertilizer. Unfortunately, its persistence to environmental perturbation is low such that red clover shows drastic phenotypic plasticity, affecting the whole plant

morphology and architecture in response to grazing and mowing. The knowledge about red clover architecture under land use scenarios is scare but could provide a basis forfuture breeding programs and to optimize timing of mowing and fertilization. So far no fundamental research was conducted to evaluate the “mowing effect”.We present the results of our phenotypic monitoring, including the measurement of a large spectrum of morphologically important traits in many individuals, to describe the temporal changes in plant architecture in response to cutting/mowing. Our results reveal morphogenetic adaptations of red clover leaves and show the fast regeneration of total number of leaves and main branches, as well as the increasing number of inflorescences in response to the cutting and thus provide an insight into the amazing regeneration capacity of this plant.

END OF SESSION 10

Session 11 – Spatial patterns and ecological processes

Chair
Dr. Katrin M. Meyer
Daniel Esser

Session 11-O1 - Spatial scale moderates the imprint of demographic rates on species' coexistence in a diverse tropical forest

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Coexistence between competing species depends on the balance between their stabilizing (niche) differences and equalizing (fitness) differences. However, by its very definition, coexistence between species is a matter of scale, and as such, the balance between stabilization and equalization among species should change predictably with spatial grain. Here, we used signatures of stabilizing and equalizing differences derived from species-specific models of light dependence of demographic rates for the entire community of > 200 tree species in a 50-ha tropical forest plot in Panama. By varying the spatial grain in which species co-occurrences were considered, we showed that the relative importance of stabilizing and equalizing differences shifted with spatial scale – at smaller scales co-occurrence was primarily influenced by equalizing differences (consistent with competitive exclusion), whereas stabilizing differences became increasingly important at larger scales (consistent with a species-sorting view). Predictions from coexistence theory that species coexist when stabilizing and equalizing factors are balanced were only corroborated at intermediate scales. At the smallest scale, species co-occurred without signatures of stabilizing differences (consistent with neutral theory), whereas at the largest scales, species co-occurrence was consistent with effects due almost entirely to stabilizing, but not equalizing factors. Overall, our study illustrates the inextricable role of spatial scale when examining the patterns and processes of species coexistence.

Session 11-O2 - Multiple stable fixpoints of the n-species Lotka-Volterra competition model: method and relevance for spatial diversity patterns

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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 competition model. For a few species its equilibrium behavior, resulting in the community structure, has been studied since decades, for example demonstrating that multiple stable fixpoints (SFP) may arise, depending on the parameter values. For higher species numbers, an analysis which SFP, i.e. community compositions, result from a given parameter set up to now was restricted to numerically solving the model from numerous initial vectors. This did not guarantee to find all SFP. We present a novel method based on theoretical stability criteria and linear programming that allows to determine all SFP for the n-species Lotka-Volterra competition model. An analysis with this method demonstrates that the number of potential communities, and the number of species cooccurring within each community, depend on the level and on the spread of the inter- relative to the intra-specific competition. We discuss these results and their relevance for describing and projecting biodiversity in space.

Session 11-O3 - Moving in focus: Within-island pattern of species-specific dispersal

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A strong, globally consistent empirical relationship between elevation and endemism on islands indicates an effect of topography-driven isolation on speciation whose generality has hitherto been unrecognized. Isolation is locally more important than temperature, biotic interactions and area in influencing speciation rate on mountainous islands and strongly determines the spatial patterns of evolutionary dynamics within islands. This finding is further refined analysing species-specific dispersal characteristics. Environmental pre-adaptation, dispersal traits as well as directional dispersal vectors (wind current systems, bird migration routs etc.) cause colonisation rates to differ between species resulting in distinct, observable spatial patterns of isolation within islands that may vary with time. Again, differences in isolation are directly reflected in evolutionary dynamics. These findings, together with mounting evidence for species-specific evolutionary

pathways gained from phylogenetic studies, urge us to acknowledge species characteristics and interactions in the environmental context within islands. The findings thus suggest the quantitative implementation of probabilistic species pool models that acknowledge both, species-specific characteristics as well as within-island environmental and topographic heterogeneity.

Session 11-O4 - Does seed disperser territoriality restrict gene movement in a Neotropical understory tree (*Leonia cymosa*)?

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Animal behavior, particularly feeding, foraging and locomotion within habitat, influences spatial patterns of zoochorous seed dispersal. Territoriality imposes limits to animal movement and therefore may affect such patterns. In this study we analyze whether territoriality of two Neotropical primate species, *Saguinus fuscicollis* and *Saguinus mystax*, can create an ecological barrier strong enough to create genetic differentiation between subpopulations of the understory tree *Leonia cymosa* (Violaceae). The two primates are the only known dispersers of *L. cymosa* at our study site in the Peruvian Amazonia. We combined primate movement data from the last 12 years with microsatellite information of *L. cymosa* and analyzed whether genetic differentiation exists between subpopulations in different primate territories. We compared measures for genetic diversity and spatial genetic structure (SGS) among *L. cymosa* subpopulations and tested for genetic differentiation between them. We found presence of SGS at different levels on both subpopulations and no genetic differentiation between subpopulations of *L. cymosa* in different primate territories. This indicated that either gene flow by insect pollination or minor shifts in the location of territories suffice to mitigate effects of spatially restricted seed dispersal.

Session 11-O5 - Effect of terrestrial cover types on occurrence of odonates along lowland creeks

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Landscape structure and habitat fragmentation have a considerable impact on the ecology of insects we study, regardless of our entomological interests. Our focus

group are the odonates (dragonflies and damselflies) which were usually considered for a long time as only aquatic insects. The effects of terrestrial habitat structure on odonate communities is relatively understudied, despite of the fact that their life history is linked strongly to the terrestrial environment. Our study focus on the role of local and landscape variables on the occurrence of odonate species. We studied the species diversity and richness in 2015, along 11 lowland creeks in North-East Hungary and North-West Romania. We aimed to demonstrate that both local (water coverage, bankside coverage, pattern of the bankside vegetation etc.) and landscape (composition and configuration) variables have a significant effect on the community's structure. Between May and September we sampled monthly a 500 meter long section of each creek. During the five month we counted a total number of 5211 specimens belonging to 13 Zygoptera and 17 Anisoptera species. The highest abundances of individuals (cca 500 specimens per site) occurred on sites surrounded by forest patches. Considering local variables the ratio of tree cover of bankside, while considering the landscape variables the fragmentation on a circle with 500 meter radius affected significantly the species richness. These findings support the hypothesis that terrestrial circumstances are relevant for odonates.

Session 11-O6 - Predicting susceptibility and collision patterns of the Common Buzzard at wind turbine structures in the federal state of Brandenburg, Germany.

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The federal state of Brandenburg is of particular interest in the context of Germany's ambitious aims of 80-95% CO2 reduction by 2050, with an initial 40% by 2020, coupled with 35% from renewables. Brandenburg already has the highest capacity of wind energy amongst other installed renewables, but with increasing turbines bird collisions have developed as a potential hazard, especially for the populations of Red-Kites and Buzzards. Unlike Red-Kites the Buzzards occur almost everywhere in the state making the future of wind power expansion in Brandenburg more challenging. From the spatial information of bird collisions at windfarms in parts of the federal state, we used the subset of Buzzard detections to investigate their collision profile and strike patterns in relation to their general distribution in the state. The study utilizes the ensemble method of boosted regression trees (BRT) to determine functional responses of collision distribution relative to distances from the edges of different land use types. From the generated collision potential map, we identify areas with increased susceptibility of strike by integrating it with the distribution based frequency map of breeding Buzzard populations in the state. Our study examined the Buzzard collisions to be

primarily concentrated at turbines situated in the vicinity of settlements and structures, particularly the green and open areas around settlements, and also to the ones situated in close proximity to the edges of bushlands and shrub lands, together explaining a larger proportion of variance in their collision distribution. By means of BRT we also highlighted the sensitive distances to these different land use types in the landscape. Validation tests showed higher predictive capacity of the detected collision potentials at these distances and together with density distributions identified areas with increased strike susceptibility on deployment of wind turbines in future. Our study demonstrates the benefits of comprehending long-term spatial information of bird strikes at wind turbines into species distribution modeling algorithms to direct appropriate mitigation strategies by careful positioning of wind turbines in the landscape.

Session 11-O7 - Female biased sex-ratios of a *Wolbachia* infected parasitoid community: local and landscape effects

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The sex ratio of a species is important for the survival and dynamics of its populations. Skewed sex ratios are adaptations to the environment on different scales, resulted by inbreeding due to small population sizes, mating behaviour, resource limitations, reproductive parasitic microbes such as *Wolbachia*, and changes in density or spatial distribution. Parasitoid sex ratios are known to be strongly female biased. Host size, density, population sizes of parasitoids and reproductive parasites are known to affect their sex ratios. But less information is available on the effects of community level characteristics as phenology at a small scale. Large scale effects on parasitoid sex ratios as landscape composition and configuration are of great interest since generalisations for applicability in conservation efforts is high and studies are scarce. We examined effects of local and landscape scale environmental and also community characteristics on parasitoid sex ratios of the same tritrophic community. On community scale phenology, on local scale resource amount and density, while on landscape scale land use, fragmentation and landscape history were studied as explanatory variables. We controlled with the incidence and prevalence of *Wolbachia* infections in the studied populations. We found that sex ratio is best explained on the species level with the presence of *Wolbachia*, but on a community level by community, local and also landscape scale characteristics. Where *Wolbachia* was present its prevalence explained the sex ratio. On community level phenology, size of galls, and interaction of gall abundance with habitat size, fragmentation and with landscape history explained significantly the sex ratio. Our results support the hypothesis that large scale environmental characteristics do also effect sex ratios.

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Session 11-O8 - Spatial turnover in multitrophic ecosystem functioning across tropical and temperate ecosystems

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Predicting ecosystem functioning at large spatial scales rests on our ability to scale up from local plots to landscapes, but this is highly contingent on our understanding of how functioning varies through space. Such an understanding has been hampered by a strong experimental focus of biodiversity-ecosystem functioning research restricted to small spatial scales. To address this limitation, we investigate the drivers of spatial variation in multitrophic energy flux—a measure of ecosystem functioning in complex communities of interacting functional groups—at the landscape scale. We use a structural equation modelling framework based on distance matrices to test how spatial and environmental distances drive variation in community energy flux via four mechanisms: species composition, species richness, niche complementarity, and biomass. We found that in both a tropical and temperate study region, geographic and environmental distance indirectly influence species richness and biomass, with clear evidence that these are the dominant mechanisms explaining variability in community energy flux over spatial and environmental gradients. Our results reveal that species composition and trait variability may become redundant in predicting ecosystem functioning at the landscape scale. Instead, we demonstrate that species richness and total biomass may best predict rates of ecosystem functioning at larger spatial scales.

Session 11-O9 - The future of herbaceous community productivity and CO_2 fluxes due to changes in rainfall pattern and grazing in Lambwe Valley, Kenya

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Uncontrolled grazing and related land uses in Lambwe Valley have reduced biomass and plant species composition through vegetation loss, reduced CO2 uptake (photosynthesis) and gross primary productivity (GPP), increased bulk density and reduced soil moisture, thereby limiting the ability of the this ecosystem from carrying out its functions. We set out to investigate how land use and rainfall induce changes in herbaceous species composition and vary habitat productivity, through changes in soil moisture. SWC (soil water content) was critical in determining net ecosystem exchange (NEE), ecosystem respiration (Reco) and GPP. Maximum SWC value of 42.32 ± 1.4 % was recorded during a wet months as the lowest SWC value of 9.99 ± 0.6 % was recorded in a dry month. Similarly, NEE, Reco, GPP, biomass and bulk density were strongly influenced by SWC. SWC had significant effects in the treatment plots especially with the reduction of ambient rainfall by 50% as compared to increased rainfall by 150% of ambient. NEE, SWC, GPP, respiration and percentage ground cover of plants reduced in grazed areas, whereas bulk density increased with grazing as the highest mean value of 1.203 ±0.138 was recorded in the grazed area receiving 50% of ambient rainfall. Similarly, a maximum monthly value of 1.611 was recorded in the same area. The highest percentage deviation from ambient in the parameters tested was in biomass as the lowest deviation was in Reco. Although, these results are specific to Lambwe Valley, they are of great value in predicting the future trends of other moist tropical savanna with similar traits.

Session 11-O10 - Ecosystem processes and spatial patterns along a climate- and land-use gradient in Mongolia

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Rangelands in dry areas of the world are facing severe challenges through global land use and climate change. Understanding the dynamics of ecosystem processes and services is crucial to provide and maintain the livelihood for the 2 billion inhabitants of these ecosystems. Two important variables shape dryland ecosystems: Lack of water and land-use. The scarcity of water and its variability in time and space determines the different vegetation types and control biomass and thus ultimately forage production. This links directly to animal husbandry as the main form of land use. Although numerous studies have investigated the influence of grazing on plant communities, little is known on how the effects of grazing intensity on ecosystem processes interact with changing moisture availability over time and space. This is crucial for the fate of ecosystem processes and services under global land use and climate change. Large-scale gradient studies on these issues are, however, mostly missing, and we designed a study across scales to unravel the climate - land use interactions: Sampling was conducted along local gradients of grazing intensity, nested in a large scale precipitation gradient in Mongolia. Our goal was to find differences in the effects of grazing under different climate conditions with respect to a broad range of indicators on both plant community and individual level scale. We found strong evidence that grazing effects differed along our climate gradient. Degradation threat was most severe in the transition zone between dry and moist steppe types, and we also found evidence for complex spatial relationships along land-use gradients. In this session, we will discuss the relevant models on rangeland dynamics across scales and present results against the background of spatial patterns in Mongolia‘s steppe ecosystems.

Session 11-O11 - Topographic influence on the structure of a shrub steppe-temperate forest boundary

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The location and structure of ecological boundaries have important consequences for ecosystem processes. Climate change and altered disturbance regimes, however, may combine to alter the location of forests worldwide, especially boundaries at the warm and dry forest distribution limit. Recent mortality rates across semiarid forests in the western USA are exceptionally high. Meanwhile, shrub steppe is predicted to expand its range upslope into currently forested areas. To understand how disturbances and climate change will impact such dry biome boundaries, we applied theoretical ecotones models across the entire sub-

continental-scale distribution of sagebrush steppe. Specifically, we located ecotones and quantified features including abruptness of vegetation transition, edge length and width, and indicators of ecotone movements; and we tested the influence of topographic variables on these ecotone measures. We developed a new software tool (published as R package 'ecotoner') and included several improvements to theoretical models such as using spatially-explicit methods. Our sampling approach using 30-m gridded data located 643 transects across the entire longitudinal and latitudinal distribution of sagebrush steppe across the western USA. Transects were located unevenly with high densities in Nevada and southwestern and central Utah. While our results demonstrated abrupt vegetation transitions, published scaling laws between slope and ecotone features could not be confirmed for sagebrush ecotones (they were 60-80% shallower than expected), and few transects showed indications of boundary movements. Our results suggest that current theoretical ecotone models may not be adequate for large-scale field applications because of limiting assumptions, e.g., homogeneity. Our analysis demonstrates the need for expanded methods to model the complexity of ecological boundaries in topographically rich areas and to evaluate the future conditions of shrub-forest boundaries.

Session 11-O12 - Agricultural heterogeneity as an essential tool to protect a rich and diverse community within agricultural systems

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For six years, we investigated how reptile community structure in the agroecosystem of Southern Judea Lowland, Israel, was affected by several agricultural cultivations: wheat, pea, olive and vineyard. We chose six sites for each one, including a natural patch, an adjacent field and the patch-field edge (24 total). We set 40 traps, distributed in two arrays at each site, and erected a 100 m-long fence on the patch-field edge to channel reptile movement between the natural patch and the cultivated field through five passageways. Additionally, we sampled reptile population density, using an active search method, in 5 natural patches and adjacent olive plantations, and 5 natural patches and adjacent vineyards. We found a rich and diverse community in the natural patches, while wheat, pea and vineyards were found to be hostile and sparsely inhabited. Unlike other cultivations, olive plantations support an abundant reptile community. We also found that various crops differently affect reptiles' mobility between adjacent patches. Wheat fields present an ecological trap for the most common reptile species (*Trachylepis vittata*) in our research area, with no post-harvest movement. Conversely, pea fields, subject to different agriculture practices, allow movement later in the season. Overall, our results support the 'land sharing' approach: natural patches in agricultural fields conserve biodiversity within agroecosystems. However, mobility of individuals between patches is vital to maintaining stable

populations in natural areas, and this ability depends, among others factors, on agricultural cultivation. Since some cultivations promote animal movement better than others, annual changes (e.g. seed rotation) facilitate mobility between different natural patches. Consequently, mixed agricultural crops form seasonal corridors between natural habitats and enhance persistence of natural populations, which could otherwise become extinct due to isolation and declining numbers.

Session 11-O13 - Scale-dependency and species distribution dynamics of snails at Southern Judea Lowlands

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One of the major goals of ecology is understating the processes that shape biodiversity. In particular, understanding the dynamic interactions of populations and communities, enables us to explain their distribution and persistence, with implications for basic and applied ecology. Here, we examine the community dynamics of land snails in Southern Judea Lowland, Israel, occupying a heterogeneous, highly fragmented agroecological landscape. We hypothesized that community dynamics is determined by scale-dependent and multi-scale processes and therefor can be assorted to one of four metacommunity dynamics types differing in the extant of processes in different scales. We also hypothesized that fragmentation per-se, after cleaning the habitat loss effect, would reveal one of four possible effects on species richness: negative, positive, threshold-sensitive and unimodal. We found that species diversity, richness and abundance were largely influenced by patch attributes and fragmentation. Likewise, geographical location and proximity to various crops had a considerable effect on the community composition and dynamics. Consequently, our findings suggest that scale-dependent processes influence metacommunity structure at our heterogeneous, fragmented landscape, with no particular dominating determinant. Our results emphasize the importance and influence of the spatial aspects of ecological studies, and demonstrate the advantage of low-dispersal organisms, such as snails, in population and community dynamics researches.

Session 11-O14 - Arthropod diversity at the agroecosystem of Southern Judea Lowlands

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Modern agricultural systems have intensified in an attempt to meet the global rise in food demand by increasing, among others, the use of pesticides and fertilizers. This agricultural intensification comes at the expense of conserving natural

ecosystems and biodiversity. Although the effect of agriculture on natural habitats and vice versa has been explored previously, the effect of different crop types on arthropod community in their adjacent natural habitats was merely studied. Our research hypothesis is that different crop types affect differently on arthropod community within the field and in the adjacent natural habitat due to dissimilarities in crop density and productivity. We tested this hypothesis by sampling ground-dwelling arthropods, using wet pitfall traps, in two crop types – wheat and pea -- and their adjacent natural habitats at the agroecosystem of Southern Judea Lowlands. Our results show that during the spring (April, before harvest takes place), no difference was observed in species abundance in both crop types and their adjacent natural habitats. However, species richness and diversity were higher in the semi-natural habitats adjacent to pea fields. Additionally, we have found that in summer (August) arthropod abundance was higher in pea fields compared to other plots. Hereby, we suggest that although agricultural fields have negative effect on arthropod community, pea has a lower effect compared to wheat on arthropod community in the adjacent natural patches. Such lower negative effect may allow higher species diversity. These results confirm the idea that agricultural heterogeneity, through crop diversity, may mitigate some of the negative effects of a particular crop, e.g., wheat, to enhance biodiversity.

Session 11-O15 - A general relationship between landscape structure and farmland bird diversity? - A comparative study between Germany and Japan

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Agricultural landscapes are characterized by a huge variety of measurements related to landscape composition and configuration. While it is acknowledged that heterogeneity is ecologically important in general, specific characteristics of landscape structure enhancing biodiversity beyond regional scales are not fully identified. Therefore, using common landscape indices, our study explored the relationship between landscape structure and farmland bird diversity in Germany and Japan, i.e. regions that have developed and very different climatic, biogeographical, and socioeconomic conditions. We acquired detailed distribution data of 31 (Germany) and 29 (Japan) farmland speciesand assessed how species richness distribution was associated with the selected landscape indices. Although the agricultural landscapes differed substantially between the countries regarding e.g. proportion of farmland and woodlandandirrigated and non-irrigated systems, habitat uses of farmland birds were surprisingly similar. Further analysis revealed that the extent of farmland - whether cropland, pasture, or paddy field – had a positive and most significant influence on farmland bird diversity in both countries. Abundance of woodland surrounding farmland played a secondary role in

enhancing bird diversity, but woodland-related indices relevant to farmland birds differed between the countries. For example, in Germany the proportion of woodland was selected as an important explanatory variable over edge density whereas vice versa was true for Japan. We discuss underlying mechanisms of the differences and similarities based on ecological traits of farmland birds and landscape structures and identify reasonably comparable landscape characteristics important for farmland bird conservation across countries.

Session 11-O16 - Determining Scots pine (*Pinus sylvestris* L.) natural regeneration patterns by spatial distribution of overstorey seed trees

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The establishment of near-natural regeneration strategies in formerly mono-cultured pine stands requires a profound ecological understanding of the regeneration processes in general and between the interacting individuals. Particularly the management of seed-trees as well as shelter tree systems are considered as near-natural silvicultural treatments for light demanding tree species. Those silvicultural systems use natural seed dispersal processes and thereby enable the opportunity to initiate admixtures of other tree species. To integrate spatial aspects of natural regeneration processes successfully into a broader silvicultural context and further professional forest management, it is necessary to define the link between spatial patterns of seed trees and the resulting spatial patterns of pine seedlings. Therefore we measure and test different spatial overstorey pine tree constellations and analyze the outcome of natural tree regeneration patterns. Besides spatial distribution functions we use allometric relations to quantify the strength of individual seed tree influences to the amount of seedlings. The overall aim of the study is to gather spatial information of full inventory data of the natural regeneration deriving recommendation to manage these forests ecologically as well as economically. Based on our recorded field data we parameterized the individual-based forest model MesoFON for *Pinus sylvestris* trees to test different management settings on the success of the natural regeneration. We implemented saplings growth within the model for the first time. All trees and saplings are described by their stem position within the simulated area as well as their growth features and competition strength. The results of the simulation experiments are relevant in practice to assess the different scenarios regarding the outcome of the spatial and temporal natural regeneration.

Session 11-O17 - Spatial patterns of forest humus forms and decomposition processes in two Italian Alpine valleys

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In the context of the D.A.CH. project “Effect of climate on coarse woody debris decay dynamics and incorporation into the soils of forested Alpine areas” (DecAlp) soil ecological relationships and processes are investigated in an area in the Northern Italian Alps (Val di Sole / Val di Rabbi, Trentino). Data on humus forms serve as valuable information about the decomposition of organic matter. The aim was to investigate spatial patterns of decomposition processes inside the forested parts of the study area by implementing models from the local to the landscape scale. Spatial modelling is realised applying a GIS-based approach and using environmental covariates including topography and vegetation. Sample data on humus forms from the local to the landscape scale are analysed by statistical approaches such as decision tree analysis. Different sets of environmental covariates are used depending on the model scale: On the local scale, they comprise a digital terrain model (DTM) with a grid width of 1 m as well as quantitative field estimates of the forest ground cover (e.g. no vegetation, moss, grass). On the landscape scale, they comprise a DTM with a grid width of 10 m as well as a forest vegetation map. The results from modelling reveal a high spatial variability of forest humus forms. On the local scale, variations of humus forms depend on small-scale variations of the forest ground cover (e.g. no vegetation, moss, grass). On the landscape scale, forest humus forms show a trend according to environmental factors such as elevation and slope exposition. At high elevations and north-exposed slopes, environmental conditions for the decomposition of dead organic matter are generally less favourable in comparison to low elevations and south-exposed slopes.

Session 11-O18 - The Edaphobase Nationwide Field Monitoring - an approach to find reference values of soil organism communities for different habitat types

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Since 1998, the Federal Soil Protection Act (Bundesbodenschutzgesetz, BBodSchG) requires the protection of the soil and its natural functions (e. g. organic matter decomposition or its function as a habitat). These natural soil functions are provided mainly by the complex interactions of numerous organisms belonging to

different taxa and trophic levels. Government agencies frequently have to assess the ecological value of different sites but possible effects of anthropogenic activities on soil functions cannot be evaluated yet, mainly because of a lack of comparable data on the detailed occurrence of soil animals in combination with site-specific information (e. g. habitat types or soil properties such as pH or texture). In a first phase of the Edaphobase project, the German Federal Ministry of Education and Research (BMBF) supported the collection of data for different groups of soil animals (e. g. Oribatida, Collembola, Oligochaeta). In the Nationwide Field Monitoring - subproject of the actual second Edaphobase phase, different habitat types in four German regions are systematically surveyed, i. e. vegetation and soil properties are determined and soil animals are sampled and identified using standard methods. This synecological approach is a way to provide an improved basis for the assessment of soil functions by identifying reference values (e.g. species composition and consistency) for different habitat types.

Poster presentations

Session 11-P1 - Does nature play the rock-paper-scissors game? Investigating the role of intransitive competition for species coexistence

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Most ecological theory assumes that there is a strong hierarchy in competition in natural communities, where the best competitor displaces all others and so forth (A > B > C). Thus, the coexistence of many species depends on the dominant species limiting itself more than others (niche segregation) or on third parties (such as herbivores) reducing its competitive strength. A complementary mechanism that could explain why many species can coexist when competing for very few different resources is, nevertheless, the lack of this strong competition hierarchy. This is known as rock-paper-scissors dynamics (as analogy to the famous game) or intransitive competition. Under intransitive competition, there is no clear competitor winner, as one species can displace some others, but it is at the time limited by third species (A > B > C > A). Intransitive competition has attracted ecologists during 40 years, yet its empirical support is scarce and limited mostly to mathematical models and three species experiments. We first developed a method to measure competition intransitivity with field observations, then applied it to observational datasets of plant and moss communities and lastly evaluated

coexistence in experimental communities of plants, mosses and saprophytic fungi differing in their degree of intransitivity. We found a high level of intransitivity in both plant and moss communities, which largely matched the findings in experimental communities. These intransitive competition networks are nested, with dominant plants competing among each other in a non-hierarchical system, but generally outcompeting rare and subdominant species. Intransitive competition is jeopardized by decreases in environmental heterogeneity or the productivity of the target plant and moss species, both caused by land-use intensification, particularly N fertilization. Most importantly, higher levels of intransitivity were related to an increase (~10%) in species richness and diversity, and these results were consistent both, in the observational, and the manipulative approaches.

Session 11-P2 - Biotic and abiotic drivers of co-occurrence patterns across shrub communities in the South African Fynbos

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Understanding processes that determine the geographic distributions of species forms a basic challenge of ecological research. Across spatial scales, the occurrence of species is influenced by demographic responses to environmental variation, biotic interactions and dispersal. Commonly applied species distribution models (SDMs) focus on abiotic factors but lack an explicit consideration of biotic interactions − a limitation that motivated the recent development of joint species distribution models (JSDMs). Such multivariate models estimate environment-occurrence-relationships simultaneously for multiple species and include a covariance structure that describes residual patterns of co-occurrence. However, covariance in species' occurrence may result from various factors including biotic interactions (competition, facilitation), migration history or correlated responses to additional (and unknown) abiotic drivers. Thus attributing co-occurrence patterns to specific processes remains a challenge. In this study we investigate geographic distributions and co-occurrence patterns of shrubs (Proteaceae) in the Cape Floristic Region, South Africa. Using an extensive dataset of species records in >50.000 plant communities across the Fynbos biome we estimate joint species distribution models and quantify covariance in species' occurrence. The found patterns of co-occurrence are then combined with species-level demographic data and functional traits that could mediate inter-specific interactions (e.g. flower phenology) to better disentangle potential drivers of co-occurrence in local communities across the species' geographic ranges.

Session 11-P3 - Environmental filtering structures the functional and phylogenetic diversity of local dragonfly communities across Europe

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Functional traits of species and their phylogenetic relationship are inevitably associated with one another. Understanding the ecological and evolutionary causes that lead to variation of these two aspects of diversity has become a central theme in evolutionary biology and community ecology. However in the absence of an integrative framework, most studies have so far studied functional distances (FD) and phylogenetic distances (PD) of communities separately. Here we aim to test the prediction that the functional traits, which are associated with thermal tolerances and dispersal, are phylogenetically conserved in European dragonflies and that climate drives the composition of dragonfly communities across Europe. We hypothesize that this signal will be especially strong under extreme temperatures but moreover in communities north of the isotherm at the last glacial maximum (LGM, 21kya).We combined information on the colour, size and hind wing-length as well as the phylogenetic relationship of 124 European dragonfly species with absence/presence data for 116 species and 360 local communities across Europe, respectively. Variation of the functional traits was simplified to form a single principle component. The composition of communities was compared to a null-model of species-neutral assembly based on random pairwise functional and phylogenetic distances of the regional species pool. Varying the importance between FD and PD of communities allowed distinguishing between processes that either led to significant underdisperal, overdispersal or random assembly. FD and PD was significantly under-dispersed in 34 communities in northern European communities and significantly over-dispersed in 13 communities in southern Europe. Similarly, FD and PD decreased from warm regions in the South to cold regions in the North. These results highlight that temperature and its association with the phylogenetically conserved traits colour and body-size is the most important factor structuring the composition of local communities across Europe.

Session 11-P4 - Colour lightness of assemblages of geometrid moth along an elevational gradient

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Colouration of animals is driven by a complex array of selection pressures. Especially the thermal environment seems to be highly correlated to insect colour

lightness, obviously a thermoregulatory function as dark- coloured individuals absorb more solar radiation. However, a recent study on geometrids showed, that also the colour lightness of non- basking moths forms a latitudinal cline as known from butterflies and odonates, with light coloured assemblages in the south and dark coloured assemblages in the north, and is correlated to the thermal environment. As latitudinal gradients can be shaped by several processes, recurrent observations in space and time of species- specific colour lightness in different thermal environments are needed to further elucidate these mechanisms. If the colour lightness of geometrids is correlated to the thermal environment, than it should a) form elevational clines and b) show shifts corresponding to climate warming. The BIOKLIM project launched in the Bavarian Forest National Park provides ideal possibilities to test these predictions. From May to August 2006, 36 light traps were set up along an elevational gradient. Colour lightness data of the wings were compiled for the recorded species from published images using the method described in Zeuss et al (2014; DOI: 10.1038/ncomms4874) and averaged per assemblage. First results indicate that geometrid assemblages are darker coloured at high elevations compared to assemblages at low elevations, supporting the thermal environment as a driver of colour lightness. However, it could also be induced by the deposition of melanin as a way to guard against harmful UV radiation. In 2016, the sampling will be repeated. If colour lightness depends on the thermal environment, we expect an increase in the colour lightness of assemblages of geometrids from 2006 to 2016, because temperature during the growing season increased by 0.2 °C in the last decade (Bässler 2008, DOI: 10.14279/depositonce-1951).

Session 11-P5 - The Edaphobase Nationwide Field Monitoring - A survey of oribatid mite assemblages in different habitat types in Germany

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In a Nationwide Field Monitoring – a subproject of the second project phase of Edaphobase funded by the German Federal Ministry of Education and Research (BMBF), oribatid mite assemblages in soils of different habitat types in four German regions were systematically surveyed, including use of standardised methods for sampling (ISO 23611-2:2006) and data collection. Investigated habitat types cover different land-use types of forest, grassland, and arable land on acidic and calcareous soils. For each habitat type three sites were sampled with 10 replicates each in spring and autumn. This design was used to examine an expected wide range of ecological amplitudes. The first results for oribatid mite species diversity

and abundance for the different habitat types are presented, patterns and differences between the oribatid species assemblages are demonstrated.

Session 11-P6 - Tools to study microbial communities inside Bromeliad tanks

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Bromeliad tanks contain structured communities of microorganisms. The structure of these community is a function of mainly two things: environmental conditions such as the size of the bromeliad tanks or food availability, and predatory pressures. Mosquito larvae are the primary predator of these microbes. Furthermore the bromeliad tanks constitute well-bounded "islands" that are spatially separated. These microbial communities provide an ideal setting to study the processes influencing the structure of a community and from there, help us infer how a metacommunity may be structured. In this poster, I present the various tools I use to study the microbial community living inside Bromeliad tanks: petri dish experiments, video analysis, phone application and modeling.

Session 11-P7 - In field distribution of phytopathogenic fungi of wheat; an analysis

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Filamentous fungi colonise the phyllosphere of wheat (*Triticum spp.*) They are often responsible for plant diseases causing severe yield losses and potential health problems for the consumers. We focus on phytopathogenic fungi belonging to two distinct genera, *Fusarium spp.* and *Alternaria spp*., found on the ear, the grain-bearing tip of the plant. Fusarium fungi are considered the responsible for the appearance of the “Fusarium head blight”, one of the most devastating diseases in wheat, while Alternaria is responsible for a disease called “black dots”. Both genera produce mycotoxins that are toxic for consumers, once ingested. In this work, we determine the in-field distribution of these filamentous fungi, with the aim of explaining possible spatial patterns using in-field microclimatic conditions and biotic variables as proxies. Two wheat fields situated in the north part of Brandenburg are analysed. These fields have a hilly heterogeneous topography, which produces different microclimatic conditions, leading to a potential different microhabitat differentiation that could result in different species compositions. Among the biotic variables, a focus is given to the presence of bacteria belonging to the phylum of *Pseudomonas fluorescens*. Members of this phylum were, in the

past, often found on the ears and showed a strong antagonism to phytopathogenic fungi. With our results, combined with in-vitro observations, we want to reach a better understanding of the dynamics of the microbial communities in the phyllosphere of wheat while setting the basis for the study of the dispersal processes that generate these patterns. The final aim is to provide useful information for the development of more sustainable plant-disease control methods.

Session 11-P8 - Does seed disperser territoriality restrict gene movement in a Neotropical understory tree (*Leonia cymosa*)?

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Animal behavior, particularly feeding, foraging and locomotion within the habitat, influences spatial patterns of zoochorous seed dispersal. Territoriality imposes limits to animal movement and therefore may affect such patterns. In this study we analyze whether territoriality of two Neotropical primate species, *Saguinus fuscicollis* and *Saguinus mystax,* can create an ecological barrier strong enough to create genetic differentiation between subpopulations of the understory tree *Leonia cymosa* (Violaceae). The two primates are the only known dispersers of *L. cymosa* at our study site in the Peruvian Amazonia. We combined primate movement data from the last 12 years with microsatellite information of *L. cymosa* and analyzed whether genetic differentiation exists between subpopulations in different primate territories. We compared measures for genetic diversity and spatial genetic structure (SGS) among *L. cymosa* subpopulations and tested for genetic differentiation between them. We found presence of SGS at different levels on both subpopulations and no genetic differentiation between subpopulations of *L. cymosa* in different primate territories. This indicated that either gene flow by insect pollination or minor shifts in the location of territories suffice to mitigate effects of spatially restricted seed dispersal.

Session 11-P9 - The distribution pattern and evolutionary history of Gymnosperms

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The evolutionary history of gymnosperms has long been a controversial issue in evolutionary biology. Although this group was thought to be ancient to angiosperms, increasing studies in the recent years have revealed that gymnosperms may be much younger. Despite several studies, the evolutionary

history of this group and how it shaped the contemporary global distribution pattern still remains unknown to us. Since imprints of evolutionary history are recorded in genetic materials, the patterns of nucleotide variations can reflect the evolutionary rate of a species or a taxon. Here, by constructing an age-calibrated phylogenetic tree consisting of all 1,118 extant gymnosperms, we have attempted to reveal the divergence history of gymnosperms and evaluate its effects on the present day diversity patterns. We found that most extant gymnosperm species diverged in Neogene, which is much younger than that was thought before. A strong increase in net diversification rate was observed from 10 Ma to present, which may be the results of rapid diversifications of Cycads and *Pinus*. Geographically, gymnosperm species diversity and evolutionary rates were found to vary between continents, which imply distinct evolutionary patterns across continents. Our study depicts the evolutionary history of gymnosperms and reveals important events during the evolution of this group.

Session 11-P10 - Elevation and distance to river are key environmental factors for floodplain habitat changes along the Upper Danube River

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Large river floodplains in Europe have experienced severe changes in recent years. In this study, we analyzed landscape pattern changes along the Upper Danube Floodplain from 1963 to 2010, with a focus on the special floodplain habitats: floodplain grasslands and riparian forests. Landscape metrics and transformation matrix were used to explore the change of landscape structure and composition. Landscape structure in active floodplains experienced increasing fragmentation during the study periods. The decline of agricultural land including arable land and grassland in floodplains with an increasing patch size are the consequences of agricultural intensification, land consolidation as well as agricultural policy. Despite of the more aggregated structure, riparian forest suffered from a loss from 1995 to 2010 due to the management measures. A CART analysis showed that elevation and distance to river are the most important environmental factors to the land-use changes in floodplains. The comprehensive understanding of land-use changes is helpful for the enhancement of landscape functions and sustainable development in floodplains.

Session 11-P11 - Emergence of piospheres around waterholes in savannas: A modelling approach

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From the beginning up to the middle of the twenties century, people in drylands world-wide started to introduce artificial waterholes to provide drinking water to their livestock. These additional boreholes allowed to keep livestock at higher densities. However, the high grazing and trampling pressure especially of cattle strongly impacts the vegetation around the waterhole often leading to a typical spatial pattern formation with distance to the water point. This spatial pattern of the vegetation is referred to as 'piosphere'. In this study, we aim at better understanding the emergence of such spatial pattern formation and especially the impact of grazing intensity under varying rainfall conditions. For this purpose, we developed a grid-based modelling approach of coupled differential equations to assess the spatial heterogeneous impact of grazing and trampling on water and vegetation dynamics around waterholes especially in African savannas. Our model results are then compared with remote sensed data of piospheres.

Session 11-P12 - Effects of vineyards and olive plantations on reptiles in the agroecosystem of Southern Judea Lowlands

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The current intensification and expansion of agriculture cause damage to wildlife in various ways worldwide. Agriculture poses a severe threat upon reptiles, an important group with key position in the trophic web and the ability to serve as bioindicators of ecosystem integrity. Maintaining biodiversity within the agroecosystems requires knowledge about the effects of different agricultural crops on biodiversity, yet the effects of many crop types on diversity remain unknown. In this field study, we have examined the effects of two common crop types in Mediterranean regions, vineyards and olive plantations, on reptile diversity patterns. While vineyards are intensively cultivated and highly homogenized, olive plantations are more traditionally cultivated and structurally heterogeneous. Reptile richness and abundance were significantly and drastically lower at the vineyards in comparison to adjacent natural patches. At the olive plantations, species richness was also significantly lower in comparison to the natural patches, though the difference was more moderate. In contrast, reptile abundance in the olive plantations did not differ significantly from the natural patches. Moreover, olive plantations (as the natural patches) maintained large populations of some species which are associated with their prominent structural features, including species at high risk of extinction. Moreover, the composition of species was significantly different among olive plantations and natural patches, with different

dominant species and higher proportion of generalist species at the olive plantations. Therefore, we believe that for reptiles, vineyards are extensive hostile areas which might cause severe habitat fragmentation for many species at the long term. In contrast, integrating traditional olive plantation in such landscapes might increase diversity at a large scale.

END OF SESSION 11

Session 12 – Spatial ecology and evolution

Chairs
Dr. Emanuel A. Fronhofer
Dr. Alexander Kubisch

Session 12-O1 - Stable partial migration? Bridging theory and practice

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Partially migratory populations are populations that consist of both migratory and resident individuals. The stability of partial migration has been hotly debated in both theoretical and empirical studies. Here we present an individual-based, spatially explicit metapopulation model investigating the evolution of partial migration, and trying to reconcile theoretical and empirical views on its stability. The model features a grid of populations with a cline of winter survival for non-migrants. Each individual has an inherited threshold value that determines the migration decision: it migrates when the expected winter survival is lower than the threshold. We observe a spatial gradient from fully migratory to fully resident populations with a substantial, temporally stable zone of partial migration, which is critically dependent of dispersal. This is in line with the evolutionary stable state paradigm in theoretical studies. Diversifying selection on the migration threshold value occurs at the borders of the partial migration zone, explaining its stability. The inclusion of variation in the actual winter survival, simulating good and bad years, results in yearly changes in the size and position of the partial migration zone. This would explain the differences between theoretical and empirical views on its stability, and shows that a threshold model underlying migration decisions allows for realistic patterns.

Session 12-O2 - Population genetics and individual-based modelling - Siberian treeline dynamics in a warming climate.

Stefan Kruse[1], Alexander Gerdes[4], Laura S. Epp[1], Kathleen Stoof-Leichsenring[1], Ludmila Pestryakova[2], Mareike Wieczorek[1], Florian Jeltsch[3], Ulrike Herzschuh[1]

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It is unclear how fast arctic treeline will advance north in the next decades. One of the most determining factors of tree migration is the ability to disperse seeds (and pollen). Hence, to realistically forecast the migration of tree species in a dynamic vegetation model, it is crucial to incorporate reliable estimates of dispersal. Classical methods, for example counting seeds in seed traps, have been used to describe local dispersal abilities but are not applicable to give precise estimates on rare long-distance dispersal events. In this study we try to overcome this gap with the help of modern molecular techniques to assess an estimator for gene flow. The cryptic signal of heritage among larch (*Larix*) individuals is inferred with the help of nuclear microsatellites. This approach helps to study the migration history between established tree stands and for different time-cohorts. We analyse the genetic structure of larch populations for several latitudinal transects, spanning north-to-south from tundra to open taiga forests in Siberia. Furthermore, genetic structure of several age cohorts, which established throughout the last century in prevailing cold and warm periods, was examined. This information about past and actual connectivity of tree stands in a changing climate will then be used to calibrate the dispersal processes of our individual-based and spatially explicit vegetation model for larches in Siberia (LAVESI). Together with downscaled global climate models and 'representative carbon pathway' (RCP) scenarios it is then possible to project the future treeline in Siberia. We show results of simulations with an enhanced version of the model originally developed to study local population dynamics of larch forest stands in changing climates. Finally, we present challenges for inferring a good estimator for dispersal and connectivity among sub-populations in a continuous population and about the incorporation of these estimators in the model.

Session 12-O3 - Impact of gene-flow and hybridization in the evolution of *Micromeria* (Lamiacea) from the Canary Islands.

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Adaptive radiation events are common in oceanic islands which together with their well-known geological history make them and ideal system to test evolutionary genetic questions. Caujape-Castels (2011) proposed that an island colonization can be made through multiple colonization events that through hybridization create highly admixed populations. These have a high genetic diversity and theoretically have a high adaptive ability which can promote speciation events. The resulting species would still be connected through gene-flow. We expect this process to have an impact in species genetic diversity and morphological patterns. In the present study we test if the evolutionary patterns from the *Micromeria* species endemic to

the Canary Islands are congruent with this hypothesis. *Micromeria* occupies all islands and habitats in the Canary Islands being an ideal system to test these questions. It presents morphological forms that seem to have appeared several times during its divergence through what seems convergent evolution. One of these, are the species previously classified as *M. varia* that occupy most of the islands. We evaluate if the genetic diversity, structure and gene-flow patterns of *Micromeria* are congruent with Caujape-Castels (2011) hypothesis using microsatellites markers. Additionally, we access the phylogenomic patterns of *M. varia* using RAD-seq. We found evidences of interspecific gene-flow through hybridization both between and within islands. Genetic diversity was higher in younger islands than in older indicating that founder effect does not have an impact in *Micromeria* colonization process. RAD loci supported a common origin for *M. varia* species from the eastern islands but several independent origins for the western species. Incongruences to the major phylogenetic pattern supported introgression between species of the same island. Genetic diversity and hybridization results are congruent with Caujape-Castels (2011) where multiple colonization and hybridization prevent the loss of genetic diversity. High within island introgression may be masking a common origin of *M. varia* and this phenotype may be kept through selection.

Session 12-O4 - Biotic interactions and dispersal ability determine recruitment of Swiss stone pine at both, upper and lower elevational range edges

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Three basic components determine the spatial distribution of species: abiotic factors, biotic interactions and the ability of species to disperse. Abiotic constraints determine range limits under harsh environmental conditions (e.g., at high elevations), and biotic constraints determine range limits under benign conditions (e.g., at low elevations), whereas dispersal limitation affects both ends of species distribution. However, empirical studies exploring how abiotic factors, biotic interactions and species' dispersal ability interact across environmental gradients are scarce. We here investigate which factors constrain the recruitment of Swiss stone pine (*Pinus cembra*) across and beyond the entire elevational range of the species in the Swiss Alps. We investigated natural occurrences of juvenile pines and additionally conducted seed transplant experiments to test whether abiotic factors (mean summer temperature, mean winter temperature, soil moisture), biotic interactions (understory vegetation cover, seed predation) and / or the seed deposition by the Spotted nutcracker (*Nucifraga caryocatactes*) determine pine establishment. We found significant effects of biotic interactions and dispersal ability on the recruitment of Swiss stone pine at both elevational range edges, but

could not detect significant abiotic effects. Our results highlight that species interactions are the main determinants of the recruitment of Swiss stone pine across and beyond its elevational range. We show that dispersal limitation rather than abiotic constraints restrict the recruitment at the upper elevational edge of juvenile pines. Potential upwards movements of the Swiss stone pine under climate warming may therefore strongly depend on its main seed disperser, the Spotted nutcracker. Our findings stress that understanding biotic interactions and dispersal ability of plants is essential to project species' range shifts under changing climate.

Poster presentations

Session 12-P1 - The Edaphobase Nationwide Field Monitoring - A survey of soil oligochaete assemblages in different habitat types in Germany

Stephan Jänsch[1], Jörg Römbke[1], Adam Scheffczyk[1], Rüdiger M. Schmelz[1], Ulrich Burkhardt[3], Andreas Toschki[2]

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In the Nationwide Field Monitoring, subproject of the currently ongoing second phase of the Edaphobase project, sponsored by the German Federal Ministry of Education and Research (BMBF), the oligochaete (Lumbricidae, Enchytraeidae) assemblages in soils of different habitat types in four regions of Germany were systematically surveyed using standard methods. The habitat types are covering the land-use types forest, grassland and arable land, on both acidic and calcareous soils. Three sites for each habitat type were sampled with 5 (Lumbricidae) or 10 (Enchytraeidae) replicate samples each with sampling in spring and autumn. This design was used to examine a presumably wide range of ecological amplitudes. In total, 13 earthworm species (including the first record of *Bimastos parvus* for Germany) and 45 enchytraeid species (eight of them new to science) were found. Results on oligochaete species occurrence and abundance for the different habitat types are presented. In addition, typical patterns and differences between the different habitat types are demonstrated.

Session 12-P2 - Genetic diversity and variation of the European endemic *Poa badensis* (Poaceae) - a transect study in Central Europe

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To study patterns of genetic variation, diversity and plant fitness at the absolute distribution periphery of rare and endangered Central European steppe plants, a study transect across their (north)westernmost range limit was used. All of our study species basically show a similar, disjunct distribution pattern with more widespread continuous occurrences in the Pannonian Basin (Hungary) compared to the western range edge of their continuous distribution range (i.e. the Pannonian area in Eastern Austria) and the (north)westernmost isolated exclave in Western Germany (mainly Rhineland-Palatinate). Theories like the 'Central-Marginal-Model' or the 'Abundant Centre' hypothesis discuss several characteristics of peripheral populations and assume increasing population differentiation, decreasing genetic diversity and reduced fitness towards the species' range limit. Here, we report results on phylogeographic patterns obtained for our study species *Poa badensis*, a perennial and xerophilous grass occurring on dry and rocky grasslands. The total distribution range of this endemic steppe plant is restricted to central and southern parts of Europe. The three study regions in our peripheral transect represent the north-westernmost exclave in Rhineland-Palatinate (Western Germany) and the western and eastern range edge (Eastern Austria and the Pannonian Basin in Hungary) of the continuous occurrences in Central Europe. With two molecular marker systems, Amplified Fragment Length Polymorphisms (AFLPs) and chloroplast DNA sequence analyses, four representative populations per study region were analysed. Our results show a clear differentiation of the German exclave from the Pannonian region (i.e. Austrian and Hungarian populations). Moreover, the AFLP data indicate a further split of the German populations into two groups, giving evidence for increasing population differentiation towards the absolute distribution limit.

Session 12-P3 - Very small scale spatial dynamics in experimental grassland communities

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Recent ecosystem function and biodiversity research focuses on community or larger scale effects, and how these might change with biodiversity decline. Unfortunately, these studies provide only little insight to very small scale dynamics, which are the basis for the community wide observations. Specifically in grasslands, studies should consider the small plant individual size and their resulting small horizon for experiencing environment. In this study we exploit a gradient of

functional diversity and species richness established in experimental grasslands of the Jena Biodiversity Experiment in 2010. We mapped the spatial grid patterns of plant species in 80x80cm areas with a resolution of 1x4cm. 138 communities differing in species number and composition have been sampled both in fall of 2014 and 2015. First explorative results indicate an increased stability of species specific spatial patterns with increasing species richness, whereas monocultures exhibit a higher non-directional fluctuation in area. By analyzing these patterns and their shift between years we expect to gain more insights into the association of plant species, their spatial organization, the stability of resulting patterns, and how these are affected by diversity.

END OF SESSION 12

Session 13 – The ecological dimension of genetic diversity

Short title: Ecological genetic diversity

Chairs
Dr. Lars Opgenoorth
Dr. Katrin Heer

Session 13-O1 - Scale dependent spatial genetic patterns of *Frangula alnus* as a basis for the identification of provenance regions

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The role of genetic diversity to safeguard the adaptability of populations especially in the face of climate change has long been recognized and gene flow as the driving factor thereby emphasized. Concurrently, gene flow can also have negative effects by counteracting local adaptation. For both of these reasons, population genetic aspects play an important role in conservation, restoration, and reforestation projects. In recent years, this has led to statutory seed sourcing, particularly to prevent the potentially negative effects of outbreeding depressions. However, the delineation of provenance regions is mostly not based on actual population genetic information. In Germany for example, for 38 tree and shrub species every planting measure beyond those in an urban context will be legally bound to 6 very broadly defined eco-geographic regions from 2020 onwards. Aim of our study was to investigate the population genetic patterns of one of those species, the insect-pollinated and bird-dispersed shrub species, *Frangula alnus* (alder buckthorn), to compare actual structures with the predefined regions. We investigated on the basis of two different marker types, nuclear SSR and cp DNA sequences, 30 populations throughout Germany. Results revealed a large scale structure of populations following a longitudinal gradient that was present in both marker types, pointing to the role of postglacial recolonisation processes for more recent genetic patterns. On a regional scale, differences in gene flow were attributable to relations of dispersal processes and the structure of the landscape. Finally, multivariate analyses of the SSR data and environmental variables, geographic coordinates, and cp DNA data supported the results of the large scale analyses while no significant relation of the environmental variables with the genetic population structure was found. On the basis of the results, management advice is

given for the reorganisation of provenance regions as well as the selection of planting material for reforestations.

Session 13-O2 - How does the historical land use influence on population dynamics of *Spondias tuberosa* Arr. Câm. in Caatinga?

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Spondias tuberosa Arr. Cam. is an endemic fruit-bearing tree of the Brazilian semiarid region with great socioeconomic and environmental importance. However, there is a lack of seedling recruitment in their natural environment, which has been attributed to seed predation, the low seed germination and establishment, and the irregularity of rainfall in the region. Furthermore, land use change and overexploitation have been hypothesized to cause a risk of extinction of this species. We aimed to analyze the genetic variability of adults and offspring of *S. tuberosa* under different land use options (agricultural area, degraded caatinga, severely degraded caatinga and preserved caatinga) using AFLP and microsatellites markers to test two hypotheses: 1) individuals adults and offspring of *S. tuberosa* collected in less disturbed areas show a higher genetic diversity, and 2) the offspring of all study areas have a lower genetic diversity and a stronger genetic differentiation than the adults, since the current environmental disturbance may result in the reduction of gene flow. Both molecular analyses showed that the samples are connected in one genepool. The genetic diversity was higher in adults trees compared to the offspring, and higher in protected áreas than in other land use classes. The highest reduction of genetic diversity from the adult generation to the offspring generation was recorded in protected areas while in severely degraded areas this index even increased. Although loss of genetic diversity, the changes in population density and structure the gene flow within offspring increased compared to the adult generations. Our analysis supports findings in other species that the probable reduction in population size does not necessarily lead to separation of subpopulations but can be compensated by long distance pollination. However, the loss of genetic differentiation in the preserved Caatinga may indicate loss of the adaptative potential in this species and detailed knowledge of local gene pools of the valuable tree species will be a prerequisite for conservation programs and the development of sustainable management strategies in the view of anthropogenic disturbance.

Session 13-O3 - Eco-evolutionary dynamics in rapidly evolving antagonistic algae-virus populations

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In recent time there is an increasing recognition that evolutionary dynamics can occur at timescales that are rapid enough to impact ecological responses to environmental changes and to influence ecological dynamics. Such so called eco-evolutionary dynamics have been shown to be important for understanding population and community stability as well as their adaptive potential and therefore can have driving effects on natural communities and ecosystems. We study eco-evolutionary dynamics of the algae *Chlorella variabilis* and its antagonistic lytic *Chlorovirus* PBCV1. In previous work we demonstrated that the interaction between the antagonists initially resulted in population density cycles due to arms race dynamics with selective sweeps of increasingly more resistant and infective phenotypes. However, at a certain time point, populations stabilized when a general resistant host evolved. Importantly the general resistant host did not go to fixation in the populations, as a trade-off between host resistance and growth enabled the maintenance of host diversity over time. We are now in the process to disentangle the influence of selection from the one of demography and also intensively study the underlying genetic changes and mechanisms using a combination of chemostat experiments and sequencing analysis. Specifically we quantify the temporal changes in effective population size of the host and the virus and in strength of selection changes, identify mutations arising and their changes in frequencies in the host as well as the pathogen, and analyze the order of appearance of those mutations, and their functions. Hence, our experiment will provide significant insight and a mechanistic understanding of ecological and evolutionary dynamics within antagonistic co-evolving populations in aquatic environments.

Session 13-O4 - Genetic basis of priority effect exhibited by dominant nectar yeast, *Metschnikowia reukaufii*

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Floral nectar is a harsh environment that hosts a complex community of microbes. Floricolous yeast, *Metschnikowia reukaufii*, is a dominant species in this community, competing with other fungi and bacteria. Specifically, this species exerts a strong priority effect, excluding other microbes and deterministically

influencing community structure. We sequenced the genome of *M. reukaufii* and identified the genetic mechanisms by which it specialises in nectar. We found a high rate of tandem gene duplication in the genome, with majority of duplicated genes involved in nitrogen metabolism and transport. The two high-capacity amino acid transport genes, *GAP1* and *PUT4,* involved in amino acid scavenging when nitrogen is scarce, were present in tandem gene arrays. We confirmed that all four copies of *GAP1* were expressed in nectar conditions and in fact regulated via the nitrogen catabolite repression pathway, establishing their role in nitrogen scavenging. *M. reukaufii* is able to efficiently deplete up to 90% of amino acids present in nectar soon after colonisation, limiting potential competition from late-arriving species. These genes, expressed only in nitrogen-limited environment provide an example of adaptation to high carbon, low nitrogen nectar resource, and explain the strong priority effects exhibited by *M. reukaufii.*

Session 13-O5 - Does irrigation facilitate or hinder dispersal for soil mites and collembola

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Lowland meadow irrigation used to be widespread in Central Europe, but has largely been abandoned during the 20th century due to land use intensification. This old management practice has been shown to represent a crucial driver to maintain biodiversity in some groups, but e.g. not in orthopterans and carabids (Schirmel et al. 2016). If surface-dwelling invertebrates do not profit from the intermediate disturbance, how do subsurface organisms respond? Will soil fauna communities' composition reflect the frequent disturbance, or, alternatively, might soil fauna use the irrigation as a dispersal vehicle, - with some semi-aquatic organisms maybe "surfing the flood wave"? In a field observational study we examined the long-term impact of traditional irrigation on OTU and haplotpype distribution patterns of Acari and Collembola in hay meadows. The main hypothesis was that communities would be distinctly different between irrigated and non-irrigated meadows. If they were, then the next hypothesis was that within the irrigating cultivation, communities experiencing the same floodwave would be genetically more homogeneous than the unflooded communities. Finally, the question arises whether gene flow is unidirectional with irrigation flow from the river.

Session 13-O6 - Genetic structure of the rufous-throated antbird (*Gymnopithys rufigula*), an Amazonian obligate army ant follower

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The rufous-throated antbird (Thamnophilidae: *Gymnopithys rufigula*) is a common nonmigratory passerine found in the Guiana Shield, northern Amazon. The species is an obligate army ant-follower that inhabits the understory of lowland *terra firme* forests. Army-ant following is a specialization mostly developed in the typical antbirds that has evolved to effectively exploit army-ant swarms as a food resource and includes morphological and behavioral changes, such as loss of feeding territoriality. Nonetheless, little is known about dispersal patterns of the rufous-throated antbird and the consequences of such specialization on population connectivity. In this study, we used nuclear microsatellites and mitochondrial control region sequences to reveal patterns of genetic structure within and between spatially structured populations of *G. rufigula*. We found that geographically distant populations are weakly, but significantly differentiated. There was evidence for isolation by distanc. Within populations, however, we found a lack of genetic spatial autocorrelation, suggesting that genotypes are randomly distributed. There was no signal of sex-biased dispersal either within populations or among populations. Our results suggest that random spatial distribution of genetic diversity in army-ant following birds may be due to the lack of feeding territoriality. As ecological traits and behavioral characteristics play an important role on the patterns of gene flow, comparative studies to other understory birds with different behavior and ecological requirements will be necessary to better understand patterns of Amazonian genetic diversity.

Session 13-O7 - The diversity of ageing within species

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A recent study by Jones et al. (2013) has shown that age-trajectories of mortality and fertility vary greatly across the tree of life. Only some organisms show increasing mortality and declining fertility after maturity, as predicted by the standard evolutionary theories of aging. Most organisms show other patterns such as increasing, constant, decreasing trajectories, and other shapes. Here, we ask the question how flexible the trajectories of mortality are within species, and focus on variation across populations. It is generally understood that the trajectories of mortality and fertility are moulded by a genotype to maximize fitness in a given environment. Consequently, we expect that mortality trajectories within a species should show at least some variation across environmental gradients. Here, we

utilize Keyfitz' entropy, a measure developed to measure inequality of deaths in human demography, to compare the variability of mortality trajectories across environments. Utilizing a unique dataset on more that 1000 mortality trajectories across a variety of organisms (DATLife, soon to be online, open access), we test the prediction that "fast" organisms (sensu Stearns 1983) show greater variability in Keyfitz' entropy than "slow" organisms.

Poster presentations

Session 13-P1 - Effects of recent habitat fragmentation on molecular and quantitative genetic variation of the grassland plant *Saxifraga granulata*

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Formerly common species are expected to be particularly susceptible to the recent fragmentation of their habitats but the effects of fragmentation on their population genetics are not well studied. We used the formerly common grassland plant *Saxifraga granulata* as a model species to study the relative importance of drift and selection in shaping the genetic variation among and within populations and the relation between plant fitness, quantitative genetic variation, molecular genetic variation and population size. We studied the molecular genetic structure of 19 *S. granulata* populations in a restricted geographic area in Luxembourg and neighbouring Germany using RAPD markers and grew plants from several families per population in a common garden to determine the variation of quantitative traits. Differentiation was slightly lower for quantitative traits (QST) than for molecular markers (FST) suggesting that homogenising selection for optimal trait values has contributed to the variation among populations. Contrary to our expectation, the level of differentiation among fragmented *S. granulata* populations was low and did not increase with the geographical distance among populations. Moreover, molecular genetic diversity of populations was high and not correlated with their size or with plant performance. Gene flow by long distance dispersal as well as longevity, clonality and polyploidy of *S. granulata* may have prevented genetic erosion within and strong genetic differentiation among populations. The spatial genetic structure within populations suggests reduced gene flow by localised seed dispersal, geitonogamous pollination and biparental inbreeding. In the studied populations of *S. granulata* the effects of genetic drift due to recent habitat fragmentation are not yet perceptible. However, it is important to preserve extant populations and increase the size of small populations to avoid genetic erosion in the future. Management measures should maintain gene flow among populations.

Session 13-P2 - Discovering biodiversity: Pollen metabarcoding

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The biological and economic importance of pollen is widely acknowledged in the pharmaceutical industry (allergy trigger), agriculture, the food processing industry (e.g. honey or food allergies), and for basic research.

Currently, only manual microscopic pollen grain analyses which demand special training and expert knowledge allow for accurate pollen identification. However the numbers of experts who can reliably determine organisms to species level are diminishing. Homoplastic species specific characters impede correct pollen identification and can contribute to misleading assessments due to misidentifications, which renders these assessments inherently operator dependent and often only allows identification to the genus, subfamily or family level. DNA Barcoding uses specific molecular regions for organism identification by comparison with a reference database. 'Next Generation Sequencing' (NGS) technologies allow for bulk-sample processing and mixed-sample organismal identification of pollen, which is especially useful for the analysis of environmental samples. The technology has the potential for fast, standardized species-level identification useful for a wide variety of applications such as allergologists in relation to food and cross reactions, plant breeding in agriculture, pollen identification in honey, or basic research. We are currently developing standard protocols suitable for pollen metabarcoding purposes (airborn pollen, insect pollen and pollen from honey) to be routinely applied for pollen monitoring purposes. The development demands standardization of collection techniques in the field, purification recommendations (e.g. air pollution), the establishment of standardized laboratory routines for DNA-based, automated high-throughput species identification of environmental samples for multi-species and multi-locus identification and enhancing the analysis pipeline.

Session 13-P3 - *Phalaris arundinacea* experiences isolation by distance in Baltic archipelagos

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Genetic diversity and population structure of a species are important aspects of biodiversity. Genetic variation is affected by several mechanisms, including landscape structure and environmental factors. Understanding how these mechanisms affect the existing diversity could help taking measures to preserve the currently endangered biodiversity. Following the latest glaciation, several uplift archipelagos emerged in the Baltic Sea along the Scandinavian coasts. These archipelagos represent a remarkable system to study the impact of landscape structure (e.g. geographic distance, size of the islands) on the genetic structure of species. We collected samples of the grass *Phalaris arundinacea* in three of these archipelagos along the Swedish Baltic coast. In total, 262 samples were collected on 39 islands and 9 mainland sites. We used genotyping by sequencing (GbS) to genotype our samples, thus providing us with a dataset consisting of 23534 single nucleotide polymorphism markers (SNPs). As GbS data typically contain large proportion of missing data, we compare datasets of varying numbers of missing data. Preliminary results indicate the existence of a strong genetic differentiation between the three archipelagos. Isolation by distance (IBD) was found between the three regions and also on a local scale within two archipelagos.

END OF SESSION 13

Session 14 – Physiological plant ecology: current and upcoming topics

Short title: Physiological plant ecology

Chairs
PD Dr. Günter Hoch
Prof. Dr. Maaike Bader
PD Dr. Arthur Gessler

Session 14-O1 - Forcing requirements and cold tolerance are independent for tree buds in winter and spring.

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In temperate regions warmer winter and spring temperatures are causing species-specific changes in tree budburst dates in the spring. Species attaining high bud dormancy in winter may not advance their spring budburst dates as much as less dormant species. Bud cold tolerance is also important as random frost events may still happen after winter warm spells and spring budburst. Since the breaking of bud eco-dormancy and cold deacclimation are both known to happen with increasing temperatures and photoperiod, we therefore hypothesized that species-specific bud eco-dormancy and cold tolerance levels would be correlated. We determined budburst forcing requirements (proxy for bud dormancy level) and relative cold tolerance for 18 tree species from an Arboretum in Greifswald, Germany in winter and spring. Forcing requirements were determined by placing the cuttings in cups of water under forcing conditions in a greenhouse (18°C; 12h day length) and recording days to budburst. Cold tolerance was quantified by excising buds from the cut twigs and freezing them to -30°C in late January and to -10°C in early March. The spring freeze was administered as buds were bursting in the greenhouse. A separate set of twigs was allowed to develop leaves before being frozen to -5 °C. Control buds were kept at 4°C. Relative electrolyte leakage was measured and correlated against bud forcing requirements for the winter and spring samples. Actual spring budburst dates were also recorded in the arboretum. Surprisingly, forcing requirements and cold tolerance values were completely independent both in winter and spring. Species rankings in forcing requirements and cold tolerance were maintained from winter to spring, with both winter and spring forcing requirements being positively correlated with later budburst dates. Bud cold tolerance was not correlated with leaf cold tolerance. Bud dormancy and cold tolerance therefore likely respond to similar environmental ques but are

biochemically and/or genetically independent. Species with low bud dormancy and high cold tolerance could be favored with climate change.

Session 14-O2 - Future tree phenology - chilling requirements and photo-period limit budburst advancement

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This study investigates whether the assumed increase of winter and spring temperatures is depicted by phenological models in correspondingly earlier bud burst (BB) dates. Some studies assume that rising temperatures lead to an earlier BB, but even later BB has been detected. The phenological model PIM (promoter-inhibitor-model) fitted to the extensive phenological database of the German Weather Service was driven by several climate scenarios. This model accounts for the complicated mechanistic interactions between chilling requirements, temperature and photo-period. It predicts BB with a r2 between 0.41 and 0.62 and a RMSE of around 1 week, depending on species. Parameter sensitivities depict species dependent interactions between growth and chilling requirements as well as photo-period. A mean trend to earlier BB was revealed for the period 2002–2100, varying between −0.05 and −0.11 days per year, depending on species. These trends are lower than for the period 1951–2009. Within climate scenario period, trends are decreasing for beech and chestnut, stagnating for birch and increasing for oak. Results suggest that not fulfilled chilling requirements accompanied by an increasing dependency on photo-period potentially limit future BB advancement. The combination of a powerful phenological model, a large scale phenological database and several climate scenarios, offers new insights into the mechanistic comprehension of spring phenology.

Session 14-O3 - Dwarf, subalpine coniferous forests on permafrost lenses below the treeline in the Swiss Alps.

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In several parts of the Alps on small patches with permafrost lenses below the treeline there is alpine dwarf vegetation occurring. In the Alpine region, these stand of extremely bad growing trees combined with alpine plant species are known as cold-holes. Such permafrost lenses can be detected below the treeline at

north facing scree slopes at positive annual temperatures in the Swiss Alps. They are formed by a thermal effect, which is called "chimney effect". Evidence of this permafrost lenses under cold holes was provided recently for the Engadin from *Schwindt* (2013) and for the Swiss Jura of *Delaloye and Lambiel* (2005). Up to now the vegetation on these permafrost lenses had not be studied in detail. For the first time we present a phytosociological description of this vegetation type comparing different stands in Switzerland. The three study areas Brüeltobel (Appenzell), Val Susauna und Val Bever (Engadin) with different geological bedrock material are compared and interpreted in terms of their species inventory. Additionally, physiognomic-structural comparisons, soil analysis and soil temperature measurements help to describe the environmental conditions of these vegetation stands as well as the consequences of the unusual micro-climate conditions in the mountain belt. The species composition on such permafrost lenses is physiognomically and regarding species composition strongly influenced by the very special micro-climate, nevertheless also the bedrock is strongly influencing the species composition. According to the phytosociological analysis two communities can be differentiated according to the bedrock: one community on calcareous, one on acidic bedrock.

Session 14-O4 - Plant water relations revisited

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Plant water relations, particularly those of trees, have received increasing attention in the last ca. 5-10 years, while over the 25-30 years before, only a small group of researchers worked in this field. For that reason, most university curricula lack courses on classical plant water relations, although this is perhaps the most central issue for plants since they established on land during the Devonian. In this presentation I will revisit some basic paradigms of plant water relations and will recall common pitfalls and misconceptions. Among the most widespread misunderstandings are the function and interpretation of plant water potential, the term water use efficiency and its relation to carbon isotope signals, the role of stomatal density, the interaction between stomatal responses and plant carbon relations under drought (dying from thurst or hunger?), and various aspects related to the hydraulic system of plants. In essence, I will try to familiarize young researchers with this field of research, with unresolved (largely below ground) questions, and I will discuss implications for functional plant ecology in the context of an increasing risk of drought in a warmer world.

Session 14-O5 - Productivity and water use of *Populus euphratica* trees and stands along groundwater gradients in riparian forests of Central Asia

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Along Central-Asian rivers in arid regions, lowering of the groundwater level constitutes a major threat to the riparian forests, whose tree layers are dominated by Euphrates poplar *(Populus euphratica).*At the Tarim River (Xinjiang, NW China), changes from traditional land use to industrialized cotton farming combined with a dramatic increase of the population within the past 60 years were accompanied by an uncontrolled overuse of the river water. This resulted in a drastic decrease of the groundwater level and in the frequency of natural floods. As a consequence, the *P. euphratica* forests declined and are now being declared as a highly threatened ecosystem. Some of these fragile ecosystems are supplied with additional ("ecological") water for protection and conservation. Within the framework of the joint German-Chinese project SuMaRiO, we determined the stand structure, tree morphology, above-ground wood production and water use of *P. euphratica* trees and stands along groundwater distances of 2.0—12.0 m at the upper, middle and lower reaches of the Tarim River at the fringes of the Taklamakan Desert. The distribution of age classes differed significantly among the plots: stands growing at a larger distance to the groundwater harboured a larger fraction of old trees (> 80 years) and a smaller fraction of young trees (≤ 20 years). The annual above-ground wood production per ha was highest on a plot with a short groundwater distance and lowest, at a plot with a large distance to the water table. At the largest groundwater distances, however, wood production and transpiration of mature trees were not lower than in stands growing close to the water table or in stands supplied with "ecological water". The wood production of plots with a short groundwater distance or supply with ecological water responded sensitively to interannual variations in the river discharge. Overall, the productivity at the stand level was most closely correlated with the stand density. Productivity was negatively related to tree age, whereas groundwater distance alone is not a good predictor of above-ground wood production. In conclusion, growth of *P. euphratica* is possible at sites with groundwater distances of up to 12 m. Supply with "ecological water" may be beneficial to trees growing at groundwater distances of up to ~ 6 m. Allocation of water should focus on stands with a short distance to the groundwater because only under these conditions, natural generative reproduction of the poplars is possible.

Session 14-O6 - Trees and grasses in savannas: modelling the functional mechanisms

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Savanna ecology research has long been dedicated to develop a general theory on the mechanisms that lead to a coexistence of woody and herbaceous plants. One of the earliest, but still widely used concepts providing a mechanistic explanation for tree-grass coexistence in arid and semiarid topographically flat savannas founds on the so called Walter's two-layer hypothesis. It assumes a vertical differentiation of soil water uptake by woody – mainly using subsoil water – and herbaceous plants – mainly using topsoil water. The observed differences in water uptake and ultimately in the abundance of the two different life forms thereby are assumed to be an emerging result of differences in whole plant carbon and water economies. Although the vertical differentiation in water uptake has been proven in numerous studies the principles of plant functioning behind the differentiation are still to be found. Here, we aim at identifying possible plant traits and physiological processes that allow for the differential water and carbon economies of trees and grasses. In so doing, we intend to find key elements of savanna functioning. We use the spatially explicit ecohydrological process model EcoHyD based on the two-layer concept combined with a model of plant growth based on simple physiological principles and plant functional strategies. The model further includes a grazing module to simulate effects of land use. It is parameterized for several Namibian sites along a rainfall gradient from 200-600 mm/year using remote sensing and field data and simulates the fate of several herbaceous and woody species commonly found in Namibia. Results of this study will help better understanding the mechanisms behind the coexistence of contrasting growth forms such as trees and grasses in arid and semiarid savannas. They moreover will give insights into the sensitivity of those ecosystems to changes in climatic conditions and the role of plant physiological functioning in stabilising them.

Session 14-O7 - Functional trait relationships of bryophyte

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Exploring the relationships among nutrient concentrations, metabolic rates, morphological traits and leaf longevity has become a hot topic in recent years, which manifests the fundamental trade-off between structural tissues and biochemical liquid phase processes, and further reveals the growth strategies, resource allocation and eco-physiological adaptions of plant species. However, related studies on bryophyte are scarce, despite its great contribution to the ecosystem and distinct morphological and physiological characteristics. Our research firstly confirmed that the functional trait trade-offs of vascular plant leaves are also exist in bryophyte, but the relationship regression parameters are differ between the two groups. Higher nutrients vs. metabolic rates regression slopes of bryophyte suggest it allocates a greater proportion of nutrients to metabolic components rather than to the non-photosynthetic tissues. Furthermore, we compared the trait levels and relationships between erect and prostrate bryophyte, found that the erect bryophyte possess higher photosynthetic capacities. It also invests more nitrogen in chloroplast pigments to improve its light-harvesting ability, while the structure of prostrate species permits more efficient light capture. And now, our current study is to expand the existing trait spectrum of bryophyte to its water retention properties, thus link the carbon gain to its special poikilohydric capacities.

Session 14-O8 - Mechanisms behind the estimation of photosynthesis traits from leaf reflectance observations

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Many studies have investigated the reflectance-based estimation of leaf chlorophyll, water and dry matter contents of plants. Only few studies focused on photosynthesis traits, however. The maximum potential uptake of carbon dioxide under given environmental conditions is determined mainly by RuBisCO activity, limiting carboxylation, or the speed of photosynthetic electron transport. These two main limitations are represented by the maximum carboxylation capacity, $V_{cmax,25}$, and the maximum electron transport rate, $J_{max,25}$. These traits were estimated from leaf reflectance before but the mechanisms underlying the estimation remain rather speculative. The aim of this study was therefore to reveal the mechanisms behind reflectance-based estimation of $V_{cmax,25}$ and $J_{max,25}$. Leaf reflectance, photosynthetic response curves as well as nitrogen content per area, N_a , and leaf mass per area, LMA, were measured on 37 deciduous tree species. $V_{cmax,25}$ and $J_{max,25}$ were determined from the response curves. Partial Least Squares (PLS) regression models for the estimation of photosynthesis traits from leaf

reflectance were studied. We found that $V_{cmax,25}$ and $J_{max,25}$ can be estimated from leaf reflectance with good to moderate accuracy for a large number of species and different light conditions. The dominant mechanism behind the estimations was the strong relationship between photosynthesis traits and leaf nitrogen content. This was concluded from very strong relationships between PLS regression coefficients, the model residuals as well as the prediction performance of N_a - based linear regression models compared to PLS regression models. While the PLS regression model for $V_{cmax,25}$ was fully based on the correlation to N_a , the PLS regression model for $J_{max,25}$ was not entirely based on it. Analyses of the contributions of different parts of the reflectance spectrum revealed that the information contributing to the $J_{max,25}$ PLS regression model in addition to the main source of information, N_a , was mainly located in the visible part of the spectrum (500-900 nm). In summary, we found that the main mechanism behind the estimation of $V_{cmax,25}$ and $J_{max,25}$ from leaf reflectance observations is the correlation to N_a but that there is additional information related to $J_{max,25}$ mainly in the visible part of the spectrum.

Session 14-O9 - Non-structural carbohydrates in tree ecophysiological research - from what we can measure to what we want to know

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Carbohydrates are the building blocks for plant structures and the currency of plant metabolism and, as such, the basis of ecophysiological processes. The non-structural carbohydrates (NSC), mainly sugars and starch, fulfil distinct functional roles, including transport, energy metabolism and osmoregulation, and provide substrates for the synthesis of defence compounds or exchange with symbionts involved in nutrient acquisition or defence. At the whole-plant level, NSC storage buffers the asynchrony of supply and demand on diel, seasonal or decadal temporal scales and across plant organs. Despite its central role in plant function and in stand-level carbon cycling, our understanding of storage dynamics, its controls, and response to environmental stresses is very limited even after a century of research. This reflects the fact that often storage is defined by what we can measure, i.e. NSC concentrations, and the interpretation of these as a proxy for a single function, storage, rather than the outcome of a range of NSC source and sink functions. New isotopic tools allow direct quantification of timescales involved in NSC dynamics, and show that NSC-C fixed years to decades previously is used to support tree functions. Here we review recent advances, with emphasis on the context of the interactions between NSC, drought and tree mortality.

Session 14-O10 - Facilitation consequences for the benefactor cushion plant *Laretia acaulis* in the high Central Andes of Chile: costs or benefits?

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Facilitation is an interaction that occurs when a species benefits in any aspect of its fitness from the presence of its neighbors. For the facilitator (the benefactor), the presence of other plants may imply benefits or costs; for example, due to sharing space, nutrients and water, N fixation (by leguminous species), and/or microclimatic or edaphic changes that have an influence on reproduction and survival in the long term. At the same time, possible costs and benefits may also depend on the degree of beneficiary cover on cushions. We studied the effect of beneficiary biomass and cover on the reproduction and accumulation of non-structural carbohydrates (NSC) of the benefactor cushion plant *Laretia acaulis (*Apiaceae) in the Central Andes of Chile. Study sites were situated along an elevational gradient at 2600, 2800, 3000 and 3150 m a.s.l. This distributional gradient include a cold upper end and a dry lower end. At the extremes of the elevational distribution of a plant species, for example at the upper cold end, establishment success and/or growth vigor may decline. Beneficiary cover had a negative effect on flower density, but not on inflorescence and fruit densities. Beneficiary cover had a positive effect on the fraction of flowers converted into fruits, but only in hermaphroditic cushions. The beneficiary effect was independent of elevation or cushion sex. The results suggest a negative effect of beneficiaries on flowering, but this is neutralized with respect to fructification. NSC concentration in leaves and stems of *L. acaulis* did not change with beneficiary cover at any of the elevations. NSC concentration in stems was lowest at the highest elevation (3150 m), while NSC concentration in leaves was highest at 3000 m. However, at 3150 m, cushions were significantly smaller in size and less abundant. The same pattern holds along the entire environmental gradient. To conclude, the interaction between the beneficiaries and their benefactor *L. acaulis*, at the level of reproduction and NSC concentration, is probably not parasitic, but neutral (+/0). Moreover, the interaction is stable along the elevational gradient and time. This suggests that this system of facilitation is evolutionarily stable and not very sensitive to environmental change.

Session 14-O11 - Examining the impact of phloem translocation on C-13 signatures of broadleaved and conifer trees using compound-specific isotope analyses

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Carbon isotopes in plants are a valuable tool for ecological and paleoclimate studies. Leaf and phloem water-soluble organic matter (WSOM) and tree rings can serve as short- and long-term integrals of ecophysiological conditions. While photosynthetic isotope discrimination is well understood, the post-photosynthetic and transport related fractionation mechanisms that influence phloem and subsequently tree ring $\delta^{13}C$ are less investigated and vary among species. The aims of our study were (1) to distinguish between the impact of phloem export and translocation on $\delta^{13}C$, (2) to quantify the isotope fractionation related to carbohydrate export from the leaves and (3) to assess the need for WSOM purification prior to isotope analyses. We investigated seasonal and diurnal courses of leaf-to-phloem differences in $\delta^{13}C$ of WSOM in vertical crown gradients and followed the phloem translocation via branches to the stem phloem in mature European beech and Douglas fir. A subsample was purified from ionic and phenolic compounds, and $\delta^{13}C$ of sugars and cyclitols was determined by HPLC-IRMS. In beech WSOM, a significant leaf-to-phloem enrichment in the sunlit twigs increased during the growing season but showed no diurnal variation. The height-specific differences were partly caused by ionic compounds. Beech phloem sugar enrichment against leaf sucrose occurred in all crown heights. In Douglas fir, we found no enrichment from leaf to phloem WSOM. Intra-height variations of needle sugars were not transferred to the phloem, which contained large amounts of pinitol. In beech, the phloem pathway from twigs via branches to the stem phloem reflected mixing processes and all crown heights contributed to the stem phloem signature at breast height. Contrastingly in Douglas fir, stem phloem did not reflect a canopy mean value. We hypothesise for European beech that, besides fractionation between leaf compounds, additional mechanisms related to sucrose export contribute to a continuous enrichment of phloem against leaf sugars. Contrarily in Douglas fir, slow phloem loading and transport partly uncoupled phloem from needle sugars and the stem phloem from the crown. WSOM purification is favourable for beech leaf samples. For Douglas fir, we recommend compound-specific analyses to eliminate the isotopically invariable pinitol signal.

Session 14-O12 - Luxury consumption in epiphytic bromeliads

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Luxury consumption, i.e. the uptake of nutrients in excess of current metabolic needs is typical for plants fromnutrient-poor habitats. Vascular epiphytes, which

lack direct access to the soil, live in such a nutrient-poor environment. Previous studies with epiphytes have given strong support for a dominant role of P rather than N limitation, but the metabolism of phosphorus in epiphytes is still little understood. Remarkably, one study had found a strong increase of phytic acid in leaves under high P supply. This was a surprising finding because larger concentrations of this organic molecule are typically only found in seeds and fruit. However, lack of data on other P compounds did not allow a more unambiguous interpretation of a possibly unusual role of phytic acid for P-storage in epiphytes. This motivated the present study, which focuses on the changes in phytic acid and other foliar P fractions as a function of P supply. In a number of experiments with three different bromeliad species we studied the changes in P fractions (anorganic P, phytic acid P, nucleic acid P, phospholipids and residual P) both during nutrient starvation and fertilization treatments over several months in the greenhouse. In the fertilization treatments we manipulated both P and N supply in a full factorial design with 3 x 3 concentration levels. At the end of the experiment, total foliar N levels varied about 2-fold depending on treatment conditions, while P-levels varied more than 6-fold. Although phytic acid levels increased most strongly during the first month of fertilization (making up almost 20% of total P), foliar concentrations reached saturation after two months. Inorganic P, however, continued to increase for the entire 4-months duration of the experiment and accounted in the end for c. 60% of total foliar P. Although rather high compared to most plants, there are reports with a similarly dominant role of inorganic P as storage compound. Phospholipids varied relatively little with c. 20% of total P, nucleic acid P typically made up about 10% of total P. We conclude that phytic acid acts as an important initial storage compound in these epiphytes when nutrient-deprived individuals are supplied with a source of P, but by far the most important compound for bulk storage is inorganic P.

Session 14-O13 - High food quality of prey lowers its risk of extinction

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The biochemical quality of prey may limit predator production. This well-studied direct bottom-up effect, which is especially prominent at the plant-herbivore level, can interact with phenotypic variation among prey. Thus, low-quality prey species, particularly when defended, are generally considered to be less prone to predator-driven extinction. Undefended high-quality prey sustains high predator production thereby potentially increasing its extinction risk. However, in communities of competing prey species, unselective predators supplement their diets of low-quality prey with high-quality prey, leading to indirect horizontal interactions between prey species of different food quality. We explore how these predator-mediated indirect interactions affect species coexistence. In contrast to the

intuitive notion, our simulations demonstrate that being of high food quality promotes persistence of prey. The high-quality prey enables a high conversion efficiency and control of the low-quality prey by the predator allowing for re-allocation of nutrients to the high-quality competitor. Thus, high food quality can protect against extinction and promote species richness and functional biodiversity.

Session 14-O14 - An orchid's exquisite taste for truffles - partial mycoheterotrophy in the genus *Epipactis*

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The orchid genus *Epipactis* contains 49 species distributed throughout the Northern hemisphere occurring in habitats from closed forests to open wetlands. Roots of *Epipactis* species form orchid mycorrhiza (OM) either with rhizoctonias or ectomycorrhizal (ECM) fungi. Yet information about fungal partners and trophic strategies (autotrophy, partial or full mycoheterotrophy) remains scarce. We sampled leaves and roots of eight *Epipactis* species and accompanying autotrophic plant species as reference for site conditions at 11 locations in NE Bavaria and on the coastline of the Netherlands. Fruiting bodies of ECM fungi were collected at some sites consecutively. We measured C and N stable isotope natural abundances of dried leaf and sporocarp material and identified mycorrhizal fungi from the orchid roots using ITS-sequencing.Stable isotope abundances showed that all *Epipactis* species in this survey were significantly enriched in ^{13}C and ^{15}N towards autotrophic references, while the *Epipactis* species lie on a gradient in ^{15}N enrichment between 3 and 25 ‰. The *Epipactis* species exhibiting the highest enrichment in ^{15}N were found to form OM exclusively with ECM ascomycetes. The stable isotope profiles in ^{15}N of sporocarps of ECM ascomycetes and ECM basidiomycetes correspond to the ^{15}N enrichment of the *Epipactis* species mycorrhizal with ECM ascomycetes and ECM basidiomycetes, respectively. Thus, the type of fungal partner seems to drive $e^{15}N$. This allows drawing conclusions to food-web interactions: ectomycorrhizal *Epipactis* species obviously obtain carbon simultaneously from photosynthesis and their mycorrhizal fungi (partial mycoheterotrophy) while the complete nitrogen gain seems to be from the fungal source.

Session 14-O15 - The battle for nitrogen in the rhizosphere

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Global change, such as climate change and plant invasions, will affect plant growth and development, and thus, fitness and competitiveness, especially in highly vulnerable seedlings. Facing these challenges in the view of the daily competition for limiting resources, particularly plant growth limiting nitrogen (N), plants have developed different mechanisms to optimise the utilisation of limited N resources in the rhizosphere, for example by avoiding competition for N, preferring different N sources, exuding inhibitors, and/or by supporting facilitating microorganisms. However, the consequences of global change on the complex interactions between different competitors in forest ecosystems are still only little understood. The research presented here provides new insights into the understanding of the processes involved in the regulation of belowground competition for N in plant-plant interactions in a temperate native forest community. ^{15}N uptake experiments were conducted to study the N acquisition patterns of seven tree species growing in competition. For the overall effect, all species were grown together using a multi-species approach. To disentangle the specific positive or negative influence of one species on another a second experiment was performed in which only 2 species where competing for the same N sources. The results show that competition for N is regulated by N source (organic *vs.* inorganic) and shifts depending on environmental factors. Furthermore, different species favour different N forms (i.e. organic, inorganic) when growing in competition.

Session 14-O16 - Linking root exudates to functional plant traits of ten grassland species in natural grassland communities

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Root exudates are primary and secondary metabolites which can be involved in nutrient acquisition, plant defence or stimulation of growth of mycorrhizal fungi. So far, root exudate patterns are only known from model plants, such as *Arabidopsis thaliana*. Our aim was to asses root exudate patterns for common Central European grassland plant species and relating root exudates to plant functional traits. We conducted an experiment in the three regions of the German Biodiversity Exploratories where we planted 10 common grassland species (5 grasses and 5 forbs) as phytometers into 54 natural grassland community plots. The plant species composition of the local neighbourhood was recorded in 15 cm radius around each phytometer. Three month after planting we dug out the phytometers in order to

extract root exudates and measure root, shoot and leaf functional traits. Our results show that root exudation patterns of primary metabolites as well as plant traits were species-specific and strongly differed between grass and forb species. Using variance partitioning, we found that 61% of the total variance of plant trait composition could be explained by species identity of the phytometer, plot characteristics, such as soil variables and land use intensity, and local neighbourhood composition. Compared to traits, the same predictor variables explained only 18% of the primary metabolite composition of exudates.Using plant traits in addition to species identity and plot characteristics as predictors for primary metabolites, we were able to account for 29% of the variation in exuded compounds. Our study is the first to demonstrate this species-specificity of root exudates for a large range of plant species, which gives a completely new perspective on community assembly in grasslands and complementarity of root traits. Moreover, we also could show to which degree root exudate patters are regulated by the abiotic environment and by the local neighbourhood.

Session 14-O17 - The relationship of leaf and wood decomposability: from global to local patterns

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Decomposition of dead wood and leaf litter has an important impact on local and global nutrient and carbon cycling. When climatic variation is accounted for, wood and leaf litter decay are controlled by functional traits. In a recent global meta-analysis we showed that wood and leaf litter decay are uncoupled across organs due to a lacking relationship between wood and leaf traits that drive decay rates (Pietsch *et al*., 2014). However, the species for the respective study were sampled from a global pool spanning all forested climate zones. That raises the question whether these results are transferable to the local scale, where species are more equal to each other due to adaptations to climatic, geographic and historical conditions. Here, we studied wood and leaf litter decay rates of 22 tree species in a subtropical evergreen forest in Southeast China. We used plant functional traits which were measured in the study area to explain variation of decay rates from both organs. Finally we analyzed the relationships between wood and leaf traits as well as between wood and leaf litter decay rates. Our analysis reflects the results from the global scale. We did not find a correlation of leaf and dead wood decay, which is explained by decoupled allocation strategies to leaves and wood, locally as well as globally. This may be interpretetd as an afterlife effect of the different plant organs. While regularly shed leaves serve as a short term nutrient source for the originating tree, dead wood is a long term carbon and nutrient storage pool for the

forest. Our results help to improve understanding the investment strategy of plants across organs and its influence on local and global carbon and nutrient turnover.

Poster presentations

Session 14-P1 - Phytosociology and ecology of treeline ecotone vegetation in Rolwaling Himal, Nepal

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This study presents the phytosociology and ecology of a treeline ecotone in the Rolwaling Valley in the central Himalaya (Nepal). We analysed 91 phytosociological relevés along three elevational transects, rangingfrom 3745 to 4300 m above sea level. Plant communities and vegetation-environment relationships were differentiated using cluster analysis and ordination. For each community, we detected diagnostic species according to their fidelity index (phi coefficient). Ecological preferences of each community were examined using one-way analysis of variance (ANOVA). We detected five communities, belonging to two different classes: the *Clintonia udensis – Abies spectabilis* and *Saxifraga pallida – Abies spectabilis* communities occupy the upper part of the subalpine forest zone, representing the uppermost forest stands below the treeline. These communities are primarily composed of*Abies spectabilis* and *Betula utilis* in the tree layer, with varying cover of several tree species and distinct differences within the herb layer. Above the treeline, the *Abies spectabilis*-forest is replaced by the species-poor *Boschniakia himalaica – Rhododendron campanulatum* community, forming a dense krummholz belt. We assigned the forest and krummholz communities to the class *Abietea himalayae*prov. In the alpine zone two communities were classified and assigned to the class*Rhododendretea anthopogonis*prov. which we propose as a new tentative class of Himalayan *Rhododendron* dwarf thickets. The species-poor *Rhododendron lepidotum – Rhododendron anthopogon* community has a less developed herbaceous layer, whereas the *Codonopsis thalictrifolia – Rhododendron anthopogon* community is characterized by higher cover and higher species richness of herbs and grasses. Species composition of identified communities is mainly differentiated by soil temperature, nitrogen supply and availability, and soil moisture content. Since the crucial site factors for vegetation differentiation are directly or indirectly affected by climatic conditions, substantial changes in future

community structure and species composition are to be expected, given the above-average climate warming in the central Himalaya.

Session 14-P2 - Diversity, assemblage and functionality of mycorrhizal fungi in treeline *Nothofagus pumilio* forest in the Andes of Southern Chile

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Temperate rainforests of southern Chile have been floristically stable over the Holocene and are considered as a pre-industrial blueprint for the biogeochemical functioning of forests, because inputs by air pollution are still low. A large contribution of mycorrhizal symbiosis to forest nutrition under such conditions seems likely, especially on nutrient limited volcanic soils in the high Andes. Therefore, we aimed to establishing vegetational patterns and mycorrhizal status of a *Nothofagus pumilio* forest, to compare the arbuscular mycorrhiza assemblages in contrasting plots, and to measuring the growth effects imposed by inoculating *N. pumilio* with ectomycorrhizal fungi. We found that, i. from 46 described vascular plant species, 41 form arbuscular mycorrhiza, two are associated with ectomycorrhizal fungi (*N. pumulio* and *N. dombeyi*) and only three are non-mycorrhizal; ii. 26 ectomycorrhizal fungal species were described, of which 14 belong to the genus *Cortinarius*; and iii. 18 arbuscular mycorrhiza fungal species were described, being *Acaulospora* the genus with the highest relative abundance. The highest species richness was found in the *N. pumilio* forest plot, compared to herbaceous and intervened plots. Plant available P, pH and aluminum saturation in soils had a similar effect in differentiating the arbuscular mycorrhizal fungi communities; finally, iv. we found that the inoculation of *N. pumilio* with the ectomycorrhizal fungus *Lacaria laccata* showed clear growth advantages in seedling and growth traits. We suggest that mycorrhizal fungi play an important role for the colonization of plants in extreme climatic and edaphic conditions.

Session 14-P3 - Modelling plant hydraulic strategies in drylands

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Vegetation in arid and semiarid areas is confronted with the particular challenge of minimizing water loss through transpiration whilst maximizing concurrent carbon gains through CO_2 uptake. This interplay is further complicated by the fact that increasing drought stress resulting from low soil water potentials can lead to a loss of hydraulic functioning induced by xylem cavitation, which ultimately leads to whole-plant mortality. In this context, a key role for plant survival plays the strategy by which a plant regulates its water status: While isohydric plants tend to maintain relatively constant leave water potentials despite declining soil water potentials, anisohydric species draw down leaf water potentials with declining soil water potential in a linear manner with slopes close to unity. Therefore, isohydric plants prevent xylem cavitation with the costs of low carbon gains under drought. In constrast, anisohydric species trade carbon gains over a wide range of drought conditions against a lower hydraulic safety. Here, we ask how contrasting hydraulic strategies and their interaction with other plant functional traits affect the growth and survival of dryland vegetation under different environmental settings. To approach this question, we use a physiological model of single plant growth for two species commonly found in drylands following opposing hydraulic strategies. The model describes plant growth on the basis of carbon assimilation including stomatal conductance, respiration, mortality and biomass allocation. It uses a novel framework to describe plant hydraulic strategies based on an observed relationship between predawn and midday leaf water potentials, which are used as surrogates for soil and leaf water potential, respectively. The model is applied to a wide range of climatic conditions and soil textures. The performance of the modelled species on the basis of net primary productivity is then compared along an environmental gradient to reported distributions. Results of this modelling exercise will help to identify possible successful hydraulic strategies under changing environmental conditions, such as climate change. Moreover, it will further our understanding of the role that different hydraulic strategies play within the complex interactions of whole plant functioning.

Session 14-P4 - Predominance of immune profile of photosynthetic metabolism in plants exposed to CeO2 Nano-powder

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Cerium oxide (CeO_2) has become ecologically relevant as an air pollutant, as forming prominent nanoparticles (CeO_2-NP) upon use in diesel fuel. However,

CeO_2-NP has been studied mostly for its belowground effects on plants, after being washed out into soil. In the atmosphere, CeO_2-NP can have toxic effects when in contact with biological structures such as plant leaves. Its phytotoxicity is associated with the inductionof reactive oxygen species (ROS), either by direct physical impact or immunity-triggered, defence-related metabolism (IT). Both pathways can alter the photosynthetic metabolism specifically each. CeO_2-NP-induced ROS-mediated injury results in lowered maximum photosynthetic efficiency ($max\phi_{PSII}$) and/or Quinone A oxidation rates (qL), but increased energy loss through non-photosynthetic quenching (NPQ). In contrast, IT tends to enhance $max\phi_{PSII}$ or qL. Here we hypothesize that CeO_2-NP injury is mostly caused by direct impact on tissue structures, with extents being species-dependent. For evaluation, CeO_2-NP was applied with a brush on leaves of *Zea mays*, *Ocimum basilicum*, *Brassica oleracea, Rudbeckia hirta, Salvia officinalis, Quercus robur and Helianthus annuus*.Plants were assessed weekly for chlorophyll fluorescence as an early indicator of photosynthetic alteration.CeO_2-NP effects varied by time and species. *Ocimum sp.* and*Zea sp.* reflected characteristic patterns of pathogenic IT response, corroborated by reduced NPQ and increased $max\phi_{PSII.}$ Similar were responses of *Rudbeckia sp.* and *Helianthus sp.*, although $max\phi_{PSII}$ was distinctly reduced, but Quinone A oxidation rates (qL) increased. Conversely, enhancement of NPQ and reduction in $max\phi_{PSII}$ was found in *Quercus sp.* as immediate responses. Such effects could not explicitly interpreted as direct tissue injury, but as a delay involving the relaxation kinects of phosphorylation in light-harvesting complex II (LHCII).In conclusion, CeO2-NP mainly acted through IT responses, although modified by species and through leaf ontogeny.

Session 14-P5 - Faster turnover or extended longevity? Effects of plant diversity on plant longevity in experimental grasslands

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Life span is an important demographic trait for the persistence and stability of plant populations and plant species` responses to the environment. Plant diversity modifies the biotic and abiotic environment experienced by plant individuals. However, it is not known how increasing plant diversity influences the turnover of populations and the age of individuals. Therefore we studied the 12-year old sown experimental grassland communities of the Jena-Experiment. The species number of the experimental plant communities is controlled and ranges from 1, 2, 4, 8, 16 to 60 species per plot. We harvested five individuals of each available dicotyledonous forb species on each of the 82 experimental plots. Age was determined by growth ring analysis at the root crown. Mean age of the species was

not affected; however, maximum age was influenced by plant species richness. The species responded differently to increasing plant diversity of the communities. In 24 out of 38 studied species the age declined with increasing species richness; in contrast, for 12 species it increased. Our results prove that plant diversity alters the age structure of plant communities, through species specific age effects. Faster turnover as well as extended longevity is found within communities. Understanding the relationship of plant species richness and age is an important step to unravel the mechanisms of species coexistence.

Session 14-P6 - Functional trait relationships of bryophyte

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Exploring the relationships among nutrient concentrations, metabolic rates, morphological traits and leaf longevity has become a hot topic in recent years, which manifests the fundamental trade-off between structural tissues and biochemical liquid phase processes, and further reveals the growth strategies, resource allocation and eco-physiological adaptions of plant species. However, related studies on bryophyte are scarce, despite its great contribution to the ecosystem and distinct morphological and physiological characteristics. Our research firstly confirmed that the functional trait trade-offs of vascular plant leaves are also exist in bryophyte, but the relationship regression parameters are differ between the two groups. Higher nutrients vs. metabolic rates regression slopes of bryophyte suggest it allocates a greater proportion of nutrients to metabolic components rather than to the non-photosynthetic tissues. Furthermore, we compared the trait levels and relationships between erect and prostrate bryophyte, found that the erect bryophyte possess higher photosynthetic capacities. It also invests more nitrogen in chloroplast pigments to improve its light-harvesting ability, while the structure of prostrate species permits more efficient light capture. And now, our current study is to expand the existing trait spectrum of bryophyte to its water retention properties, thus link the carbon gain to its special poikilohydric capacities.

Session 14-P7 - Competition for N between native trees and an introduced grass in the subtropics

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Plant-plant interactions are a key factor shaping plant community structure. A main plant-plant interaction such as competition for soil resources is particularly relevant in the context of the restoration of disturbed plant communities. Specifically, competitive interactions between planted tree seedlings and introduced plant species frequently hinder ecological restoration efforts that aim at the reestablishment of native woody vegetation. We conducted a greenhouse study to quantify the combined effects of soil N availability and competition with the introduced grass *Pennisetum clandestinum* on the biomass and organic and inorganic N uptake capacity of seedlings of *Acacia melanoxylon* and *Podocarpus elatus*, two native tree species commonly used in rainforest reforestation programs in subtropical Australia. Total biomass of the tree seedlings did not change with competition or N availability, but the root:shoot ratio of *P. elatus* decreased in response to competition with the grass. Furthermore, tree seedlings showed plastic responses in their inorganic and organic N uptake capacity, which increased in response to competition with the grass, as well as in response to increased N availability. For the grass, total biomass increased strongly in response to higher N availability, while N uptake capacity increased with N availability, but showed no response to the competition with neither tree species. The strong growth response of the grass to higher N availability suggests that it has the potential to outcompete seedlings of the two tree species, in sites with fertile soils. Moreover, the nitrate uptake capacity was higher for the grass than for *P. elatus*, indicating a potential further advantage over this species in sites with expected higher soil nitrate availability, such as disturbed areas. Differences among species in their N uptake capacities suggest a potential for niche differentiation and competition avoidance between the native tree species and the grass, via the use of the different N forms available in the soil.

Session 14-P8 - Growth trends of *Spondias tuberosa* Arr. under different concentrations of organic waste

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In tropical dry forests, plant growth is often limited by unfavorable environmental conditions such as drought, lack of nutrients and environmental changes. The nutrient supply can be optimized by organic wastes derived from residues of livestock rearing or plant production. In this study, we tested the use of organic residues from fish tanks as a source of nutrients to seedling growth of the tropical dry forest (Caatinga) tree *Spondias tuberosa* (umbu) in a green-house experiment. The study area was the municipality of Itacuruba-PE, in which soil of Caatinga, the organic waste of the fish tank and seeds of *Spondias tuberosa* were collected. The experiment consisted of six treatments: one only with soil of dry forest (control) and five proportions of fish tank sediment mixed with the soil used in control treatment. The seeds were germinated in plastic trays containing washed sand. After the development of primary leaves, the plants were transferred to glasses rhizotrons with the substrate of each treatment described above. Once the plants were transplanted to rhizotrons biometric measurement were carried out every 7 days with a total duration of 42 days. We measured plant height, stem diameter, root length and the number of leaves and analyzed the data using ANOVA followed by Newman Kell's post-hoc test. The plants of treatments containing 20% and 30% of organic waste showed a significant increase of 12% and 45% for height compared to control. For the diameter and number of leaves, all treatments, except 10% organic waste, showed significant increases compared to the control. Accordingly, root length was significantly larger than the control in all treatments. Based on the results, we can infer that the treatment of 30% for *S. tuberosa* is optimal treatment as it presented an increase in both growth rates (shoots and roots) compared with the other treatments. Overall, sediments of fish tanks proved to be a valuable fertilizer for Caatinga plants which may be used in restoration schemes for degraded areas in tropical dry forest. The results may contribute to optimized techniques for planting schemes of Caatinga plants - which may be important within restoration approaches for degraded areas.

END OF SESSION 14

Session 15 – Land use, climate change and the biotic homogenization of animal communities

Short title: Biotic homogenization of animal communities

Chairs
PD Dr. Catrin Westphal
PD Dr. Klaus Birkhofer

Session 15-O1 - How to see the species behind the community: detecting responses to environmental gradients

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Responses of animal or plant communities to land use, habitat disturbance or other environmental gradients are commonly analysed at an aggregate community level, e.g. by describing changes in total diversity, multivariate community composition or community-weighted means of traits. Such community-wide indices are statistically adequate and meaningful, but may not represent the responses of individual species, particularly if species respond differently. Most importantly, in weighted indices, rare species are underrepresented, although these may be particularly affected by land use or disturbance. Here we show how a simple approach, based on the abundance-weighted distribution of each species along an environmental gradient, can help to identify individual species responses. The "environmental niche" of each species is described by its weighted mean and standard deviation, and tested against a null model of a random distribution. Results based on this approach are unbiased by rarity and the proportion of plots on which the species occurs. In contrast, regression analyses of the abundance of a species against the gradient are not as statistically powerful as the "niche" approach and are biased. For several datasets of insect communities along a land-use gradient in grasslands, we show how the niche approach detects numerous strong species-specific responses, although the aggregate diversity indices suggest relatively weak overall effects. It seems likely that community-wide biodiversity analyses often greatly underestimate the underlying impacts on many of the species involved.

Session 15-O2 - Diversity guarantees quantity: social bees in the tropics benefit from plant species richness through increased food quantity and quality

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Bees are highly important pollinators in most ecosystems. Because they entirely depend on (flowering) plants for acquiring resources essential for nutrition and nesting (i.e. pollen, nectar and resin), they are seriously threatened by anthropogenic activities that directly or indirectly affect the availability and diversity of flowering plants. Despite the obvious link between diversity loss and bee decline, we still have not fully understood the relationship between resource availability, diversity, quality and bee fitness. To disentangle the factors underlying this relationship, We have experimentally investigated whether and how both colony and individual fitness as well as the intake and quality of resources collected by the Australian stingless bee Tetragonula carbonaria (Apidae: Meliponini) depend on landscape-related plant species richness and resource diversity and abundance. Field observations were further complemented by laboratory experiments on the functional efficiency of resource diversity. Our results show that colony fitness (i.e. colony reproductive rate and production of queens and workers) strongly increase with increasing plant species richness, because bees can collect both a higher diversity and a larger quantity and thus store more resources in landscapes with high plant diversity. While resource quality did not directly depend on plant species richness or resource diversity in the field and only marginally affected colony fitness, laboratory experiments revealed that bees can benefit from resource diversity through complementary effects (i.e. fulfillment of different functions). Functionality itself largely depends on resource composition, demonstrating that both resource diversity and composition determine bee (colony) fitness.

Session 15-O3 - Influence of land use on the decomposition rate of dead mammals in conjunction with the diversity of carrion insects

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Animal carrion is the most nutrient-rich form of dead organic matter and is considered to be an important component of recycling energy and nutrients in ecosystems. We hypothesize that land use intensity has an influence on the carrion

insect community and consequently on the removal rate of animal biomass. We simultaneously exposed 75 piglet cadavers on 75 forest experimental plots in three regions of Germany (DFG-supported Biodiversity Exploratories: Swabian Alb, Hainich-Dün and Schorfheide-Chorin) and collected and determined individuals of coleopteran and dipteran taxa to species level. Furthermore, we took soil samples for isotopic analysis and reared fly maggots on minced meat for later species determination. We found that not only temperature but also other structural habitat parameters like soil texture, forest stand density and forest understory have a significant influence on carcass associated carrion beetle abundance. For the forensically important calliphorid fly *Lucilia sericata* we detected that their maggots can be retrieved almost exclusively in the Hainich-Dün Exploratory what is linked to a higher humidity in the forests of this region. In the scarabaeoid copronecrophages, we were able to show that a higher proportion of forest understory raises the abundance of these important ecosystem service providers. It also became obvious that temperature and species richness of cadaver beetles (silphids and scarabaeoids) significantly lower decomposition time whereas forest management intensity significantly raises the persistence rate of an aboveground exposed cadaver. Concerning the input of organic carbon from decomposing mammal tissue, we were able to show for the first time that higher forest management intensity lowers its ratio in the soil beneath the carcass. Consequently, land use, with its impact on biotic and abiotic habitat parameters, influences the course of decomposition and the return of dead animal biomass in forest ecosystems.

Session 15-O4 - Tiny engineers face modern land use: dung beetle communities, their ecosystem services and responses to management

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Dung beetles (Scarabaeidae) are important detritivores, and particularly the tunnelling genera *Geotrupes*, *Anoplotrupes* and *Onthophagus* enhance soil quality and support nutrient cycles within a very short time after dung deposition. Whereas dung beetles are known to provide important ecosystem services in forests and grasslands, little is known in which way land use affects dung beetles. We thus conducted quantitative surveys of the abundance and diversity of dung beetles and their dung removal rates on 150 forest and 150 grassland sites with varying land-use intensity, located in north-east, central and south-west Germany. We show distinct habitat preference of dung beetles, with 9 species that mainly occur in forests, 8 in grasslands, and 3 in both habitats, including differences in abundance and diversity. Although known for generalised foraging behavior, baiting with six different dung types revealed significant preferences of dung beetles in the field, with cow, wildboar and sheep as the most attractive dung types and deer and horse dung as the least attractive ones. Overall, heavy disturbances

such as timber harvest, fertilization or mowing in grasslands were associated with a much lower removal rate of dung, whereas coniferous forests and grazing tend to have positive effects on dung beetles and their ecosystem services.

Session 15-O5 - Land use intensity and edge effects determine abundance and species composition of macro-detritivores in European small forest fragments

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Soil arthropods play a crucial role in the decomposition of organic matter. Litter fragmentation by soil macro-fauna, such as wood lice and millipedes, represents the first step in the process of decomposition on forest floors. They reduce large particles to smaller sizes and are therefore functionally important for nutrient cycling. In this study we focus on the distribution of woodlice and millipedes in the forest interior and edges of small forest fragments in agricultural landscapes. Arthropods were sampled using pitfalls in 224 deciduous forest fragments in 7 regions across Europe from south France to central Sweden. Land use intensity and edge effect were the most important factors explaining variation in the dataset. Both woodlice and millipede numbers were higher in forest patches embedded in intensively used agricultural areas as well as in forest edges. Besides abundance, also species composition was highly affected by both factors. We analysed community weighted means of different woodlice traits to investigate the underlying patterns. From our analysis we conclude that traits related to drought resistance could explain distribution patterns in these small forest patches. Clearly, the functioning of forest ecosystems (here litter decomposition) can be heavily influenced by their fragmentation and the land use of the surrounding landscape, via the impact on the abundance and functional composition of macro-fauna communities.

Session 15-O6 - Ant community changes under increasing land-use intensity in temperate grassland

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Ants are an important functional group of temperate grassland ecosystems. Land-use intensification has been shown to have a negative influence on ant diversity. However the mechanisms leading to these effects are not well understood and may affect different ant species differently, as ant species may differ in trophic niche. Predatory ant species or those with a broader nutritional niche are less affected as prey items are still available in intensively used plots while trophobionts strongly decrease, potentially limiting the availability of carbohydrates. To investigate the changes in ant communities, we sampled ants in 140 temperate grassland plots (50x50m) in three regions in Germany within the Biodiversity Exploratories using pitfall traps (12 pitfall traps per plot) and hand-sampling. The grasslands are used as meadows or pastures at different intensities. We found that ant species richness decreased significantly with increasing land-use. This was not only the result of losing particular ant species, but also resulted from a turnover in occurring species. As a consequence, functional diversity of ant communities decreased significantly with larger and subterranean species being absent at higher land-use intensity. Apart from the decreasing number of species we also found a reduced colony density and smaller nest-mound sizes with higher land-use intensity. This indicates that some grassland ant species seem to be less affected by land-use intensification, which might relate to the trophic niche of the ant species in question. To determine the niche we are conducting stable isotope analysis for the ant species present over the land-use intensity gradient.

Session 15-O7 - Landuse determines phylogenetic diversity - a multi-taxa approach

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Most nature conservation concepts nowadays are developed and evaluated on measures of taxonomic diversity. However, phylogenetic diversity has become increasingly relevant in determining the conservation value of local species communities. Yet, little is known on what factors determine phylogenetic diversity on a landscape scale but such knowledge would be important to prioritize conservation efforts. Here, we analysed an extensive dataset coveringbirds, bats,

dragonflies and grasshoppers in the federal state of Bavaria, Germany on a 5 x 5 km grid scale. We used generalized additive models to test the influence of landuse and climate variables on observed species numbers, observed phylogenetic diversity and phylogenetic diversity corrected by species numbers. We identify areas that inhabit high phylogenetic diversity among all study groups.

Session 15-O8 - Landscape moderated effects of land use intensity on biotic homogenization in arthropod communities

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Increased land use intensity has been shown to select for generalist species at the expense of specialists – the so called 'winners' and 'losers' of agricultural intensification. However, landscape complexity can strongly moderate this trait-filtering, which may represent opportunities for sustainable intensification. Based on evidence from arthropod communities in the Biodiversity Exploratories we will discuss how landscape complexity moderates the effects of different local management practices (fertilizer inputs, grazing intensity and mowing frequency) in the filtering of winners and losers in grasslands, and the implications for ecosystem function and the species conservation.

Session 15-O9 - Agri-environmental schemes affect numeric and trophic responses of generalist predators along a landscape gradient

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Agri-environmental schemes (AES) are among the most common management strategies for biodiversity conservation in Europe. While AES such as organic farming still allow for agricultural production, others such as sown flowering fields exclusively focus on biodiversity conservation and environmental benefits. Here we compare effects of these two fundamentally different types of AES located within a gradient of landscape complexity on the individual densities and trophic niches of selected species of generalist predators (two web-building spiders and four carabids). In total, 11184 predators and 4800 prey items from spider webs were sampled and 138 individuals of carabids were analyzed using naturally C and N stable isotope ratios. All predator species, except *Phylloneta impressa* (Araneae),

showed a numerical response to the AES type, landscape complexity or the interaction term between these factors. In general, predators were more frequently found in cereal fields compared to flowering fields. Moreover, the activity densities of the carabid species *Anchomenus dorsalis*, *Poecilus cupreus* and *Pseudoophonus rufipes* increased from complex to simple landscapes. In contrast to the widespread numeric responses, only *P. impressa* showed a trophic response that was characterized by an interaction between AES type and landscape complexity. Nematoceran prey was more frequently captured in spider webs in flowering fields compared to cereal fields. Potential pests (aphids, thrips and cicadas) dominated prey composition of *P. impressa* in cereal fields in complex landscapes.The difference between numeric and trophic responses in generalist predator species emphasizes the need for future studies that address both aspects. Only this will provide appropriate estimates of the consequences of AES strategies and large scale land-use changes for biological control services.

Session 15-O10 - Farmland heterogeneity effects on trait filtering of predatory and flower-visiting arthropod communities across Europe

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Biodiversity conservation research has mainly focused on the role of semi-natural habitats showing that landscape simplification decreases the functional diversity of arthropods. The heterogeneity of the crop mosaic has received much less attention, as cropland is often considered only as a hostile matrix. In our study we aimed to disentangle the effects of configurational and compositional crop heterogeneity on community trait filtering of biological control agents and flower-visiting insects at European scale. In seven regions situated in France, Germany, Spain and the UK, we sampled 605 cereal fields in 324 landscapes selected along two independent gradients of configurational heterogeneity (total border length of fields) and compositional heterogeneity (Shannon diversity index of crop types). Carabids, spiders, hoverflies and butterflies were sampled during the crop growing season in two 50m transects at the field border and in the field interior. We gathered information on three arthropod traits expected to be influenced by crop heterogeneity: body size, dispersal ability and diet specialization. We hypothesized that high configurational heterogeneity is associated with smaller body sizes and lower dispersal ability due to a higher connectivity of habitats. We also hypothesized that low compositional heterogeneity favors feeding generalists, and causes a shift to more predatory communities, because more pests will be available

in landscapes dominated by monocultures. The final analyses will show whether the loss of crop heterogeneity in agricultural landscapes leads to a general homogenization of arthropod communities across European regions, and whether small-scale farming and crop diversification can promote functional diversity of arthropods providing important ecosystem services such as biological control and pollination.

Session 15-O11 - Artificial light at night disturbs nocturnal pollination service

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Artificial light is worldwide rapidly increasing with an estimated rate of 6% per year. Although we know that organisms do respond to artificial light with changes in behavior and physiology, there is very little known about the impact on biological diversity and ecosystem functioning. In 2015, we thus investigated how artificial light influences nocturnal flower visitations to a model plant species, *Cirsium oleraceum,* and we assessed the impact on the seed set of the plant. To do so, we conducted an experimental field study on seven artificially illuminated and seven dark control sites in the Bernese Mountains (Switzerland). We assessed nocturnal visitors to *C. oleraceum* and analyzed its seed mass. We show that the number of nocturnal flower visitors, and consequently the seed mass of *C. oleraceum,* is significantly reduced under the light treatment. To our knowledge, this is the first time that the impact of night-time illumination on the ecosystem service pollination has been investigated. We conclude that nocturnal flower visitors are important for providing pollination, but are disrupted in their composition and functional role by the presence of artificial light.

Session 15-O12 - Effects of habitat loss and isolation on specialization in pollinator networks

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Habitat conversion and agricultural intensification at the landscape scale result in decreasing size and increasing isolation of (semi-) natural habitat islands. Within pollinators, wild bees are assumed more susceptible to such land use change than hoverflies, and within taxonomic groups, small specialists have been shown to be

more affected than large generalists. Thus, we have a fairly good idea of homogenization processes regarding specific traits within communities, but very little understanding of the functional consequences regarding e.g. interaction networks. We used a dataset of wild bees (85 species with 2544 bees) and hoverflies (53 species with 3009 syrphids) recorded in 32 calcareous grasslands that showed detrimental effects of habitat loss and isolation on species numbers and/or abundances, mainly related to traits reflecting dispersal ability (wild bees) and resource specialization (hoverflies). From this, we constructed bipartite flower visitation networks for each site and calculated the degree of specialization at the community level (Blüthgen's H2') and at the species level (d') for the two most abundant and frequent wild bee and hoverfly species, respectively). Total network structure showed significantly decreasing specialization with decreasing habitat area, also when standardized by comparison with null models. The most dominant flower visitors showed contrasting responses of individual specialization to habitat isolation expressed by decreasing availability of suitable habitat in the surrounding (500 m). The homogenization of flower visitor communities following agricultural land-use change clearly reduced specialization in the interaction structure among species. Additional resource availability in the agricultural matrix, however, seems to moderate flower visitor behavior at the species level. Thus, complex interaction networks are simplified by both removing specialist species and decreasing specialization within species, but the latter showed a degree of plasticity in specialization that has rarely been acknowledged yet.

Session 15-O13 - Diversity and trait composition of moths respond to land-use intensity in grasslands

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Grasslands belong to the most relevant habitats in cultural landscapes both economically and ecologically, particularly when used as meadows or pastures. However, land-use intensification in grasslands negatively affects plant diversity as well as arthropod communities depending on plants as resource and habitat, with important consequences for the quantity and resilience of ecosystem functioning. We investigated whether species composition, diversity and life-history trait characteristics of the nocturnal moth community respond to the type and intensity of land use, comparing 26 sites in three different regions of Germany. Consistent across the three regions we found that grasslands under livestock grazing harbour fundamentally different moth communities as compared to the more intensively used sites, were mowing and fertilization were applied. Land-use intensification significantly reduced species richness and diversity as well as abundance of moths, and prompted a shift towards generalist life-history traits: under frequent mowing, rare specialist species were replaced by ubiquitous, highly reproductive generalists. These results show how the biodiversity of moths, an important group of arthropod

herbivores and potential pollinators, is sensitive to the impacts of intensified land use on grassland ecosystems. The functional homogenization of life-history traits in plants along land-use gradients is mirrored by their herbivore consumers, leaving high-intensity grasslands less diverse and potentially less resilient to environmental disturbances.

Session 15-O14 - Soil food web structure in heavily disturbed forest and agroecosystems

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Soils are bound to continuously experience external disturbances which also affect structure and functioning of belowground animal communities. Consequently detrital food webs may dramatically change their performance after disturbance events. We reviewed shifts in the structure of soil food webs associated with severe disturbances on the example of several forest and open managed ecosystems. Single strong disturbances like forest fires result in the drastic, however reversible die-back of soil fauna. Bacterial-feeding animals prevailed among early colonizers at the early stages of post-pyrogenic succession. However, this effect was strongly modulated by macrogeographic conditions and initial taxonomic composition of soil food webs. In case of multiple severe disturbances like in the rice paddies, decline in the amount of soil animals after each land preparation event resulted in an almost complete degradation of soil foodwebs. In case of incorporating upland crops into field management cycles terrestrial food webs recovered relatively fast and were taking over the primarily aquatic communities with the high proportion of non-specialists. Lack of predators in the system probably accelerated the process of soil food web complexity restoration. This ascending trend remained visible despite regular disruptions due to tillage. We may conclude that mechanisms of soil food web resilience in disturbed soils will be (1) specific in relation to the nature and severity of disturbances as well as background macroenvironmental conditions, and (2) mainly associated with the presence of trophically non-specialized taxa which incorporate a wider range of resources into a food web. This analysis is based on the compilation of results accumulated within the Russian Science Foundation projects 14-14-00894, 16-14-00096 and DFG-Research Unit FOR 1701 (ICON).

Poster presentations

Session 15-P1 - Ant abundance as indicator for climate change and predation in megadiverse mountain rainforests in Ecuador

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Biodiversity provides the basis for the functioning of ecological processes within ecosystems. But anthropogenic climate and land use change lead to a rapid and dramatic loss of biodiversity. Therefore, a continuous monitoring is urgently needed, which should focus not only on changes of certain single species but also on functional changes of species assemblages and the functioning of ecological processes. Predators play an important role within ecosystems as they modify the abundance, composition and traits of species assemblages. One of the most important generalist predators of arthropods and a key taxonomic group for numerous ecosystem processes within terrestrial ecosystems are ants. Their quick reactions to environmental changes suggest them as indicator group for abiotic, biotic and functional changes within ecosystems. In this study we tested the suitability of abundances of ant colonies and their functional richness as indicators for climate change, forest degradation and the ecosystem process predation during the wet and dry season within a montane rainforest in southern Ecuador. The abundance of ant colonies and their functional richness strongly declined with increasing elevation and was higher during the dry season, whereas forest degradation did not affect the ant assemblages. Predation of artificial caterpillars by ants also decreased with decreasing temperature and was mainly influenced by the abundance of ant colonies and season. Our results suggest that projected climate change might favor more abundant and functionally rich ant assemblages and an increased predation on herbivorous arthropods at higher elevations. Furthermore, our study showed that degraded forests can provide suitable habitat for abundant and functionally rich ant assemblages. Most importantly our results highlight the suitability of abundances of ant colonies as effective indicator for both climate change and the ecosystem process predation within megadiverse forest ecosystems.

Session 15-P2 - Wild bees in cereal field margins: benefits of small-scale agriculture and organic management

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In contrast to the effects of landscape composition and management, the direct influence of landscape configuration on pollinators has rarely been tested in European cropland. The impact of organic vs. conventional farming on wild bee and wasp communities was compared between small-scale agricultural landscapes in West Germany and large-scale agricultural landscapes in East Germany. Within each region, species richness and abundance of wild bees were surveyed, comparing nine pairs of organically and conventionally managed winter wheat fields. Bees and wasps were sampled using pan traps and trap nests. Overall plant diversity and flower cover were assessed at the field margin and within the field. Statistical analyses were conducted fitting generalised linear mixed effect models and using redundancy analysis (RDA). Both abundance and species richness of bumblebees were higher in small- compared to large-scale agricultural landscapes, with no effect of management (organic vs. conventional). Species richness of solitary wild bees tended to be higher in margins of organic fields. The RDA revealed an effect of landscape scale but not management on bee community composition. Species richness and flower cover of insect pollinated forbs were higher in margins of organic fields with an additional positive influence of small-scale agriculture on plant species richness. Extensive management practices at the local and the landscape scale may enhance resource availability for pollinators with mixed responses of solitary and social bees. Both small-scale agriculture and organic management seem to be powerful conservation tools to face adverse consequences of land use change while targeting different groups of wild pollinators.

Session 15-P3 - Birds as indicators for biodiversity in agricultural landscapes - an assessment across four trophic levels

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In the last decades, agricultural intensification led to severe declines in species diversity but also in functional diversity. Breeding birds are often used to assess changes in biodiversity and the effectiveness of agri-environmental schemes. Generally, it is assumed that high bird diversities and positive population trends indicate high overall diversity and improved habitat conditions for other taxa. However, recent studies provided contrasting results regarding correlations between diversity patterns across taxa. The respective habitat type, trophic relationships and species traits such as habitat and food specialization are expected to influence the strength of these correlations. So far, only few studies considered these aspects when evaluating correlations of diversity patterns across taxa. In our research project, we will compare diversity at four trophical levels (plants, leafhoppers and butterflies, spiders, birds) in agricultural landscapes. We selected 22 sites in Central Hesse, which are part of the monitoring program of common breeding birds in Germany realized by the DDA (Dachverband Deutscher Avifaunisten). Data of bird diversities in the monitoring sites will be provided by the DDA. Arthropod sampling and vegetation surveys will be conducted in three habitats per site (crop fields, meadows, and semi-natural habitats) in May and July 2016. We will compare the strength of correlations between diversity patterns with respect to habitat types and trophic relationships. Furthermore, we will calculate functional diversity, to test whether the incorporation of species traits improves the predictive power of our models. Our results will shed some light on the reliability of birds as indicators for biodiversity at various trophic levels and might further improve the application of indicator taxa for biodiversity monitoring.

Session 15-P4 - Losers, winners and opportunists: how grassland land-use intensity affects communities of plant-, leaf- and grasshoppers

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Land use and habitat loss are important drivers of local and global species extinctions. Orthoptera and Auchenorrhyncha as important grassland herbivores showed inconsistent responses to land-use intensity in past studies. We sampled 150 temperate grassland sites (meadows and pastures) across three regions of Germany (Biodiversity Exploratories), for which land-use gradients were quantified as mowing, grazing and fertilization intensity. We analyzed the effects of land-use intensity on diversity and community abundance. To quantify species-specific responses to environmental gradients beyond common diversity indices, we employed a new approach termed ‘niche model’. Coupling this model with a randomization procedure, we identified potential losers, winners and opportunists of high land-use intensity. Negative effects of high land-use intensity prevailed: the niche model detected a high proportion of ‘losers’, showing significantly higher abundance in grasslands with low-intensity land use. Mowing had the strongest impact on both groups, while grazing intensity was the least detrimental

management type. Our highly replicated, long-term and large-scale survey suggests that further land-use intensification threatens many grassland herbivores and causes a consistent diversity decline and species loss in Orthoptera and Auchenorrhyncha.

END OF SESSION 15

Session 16 – Linking stress ecology and resilience research: you'll never walk alone

Short title: Stress ecology meets resilience research

Chairs
Prof. Dr. Volker Grimm
Dr. Mechthild Schmitt-Jansen

Session 16-O1 - Quantifying the mechanisms underpinning resilience of ecosystem functions

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Accelerating rates of environmental change and the continued loss of global biodiversity threaten functions and services delivered by ecosystems. Much ecosystem monitoring and management is focused on the provision of ecosystem functions and services under current environmental conditions, yet this could lead to inappropriate management guidance and undervaluation of the importance of biodiversity. The maintenance of ecosystem functions and services under substantial predicted future environmental change (i.e., their 'resilience') is crucial. I will discuss attempts to quantify the mechanism underpinning the resilience of ecosystem functions across three ecological scales- from species to communities and landscapes. I will integrate these findings with stress ecology, biodiversity ecosystem functioning (BEF) and ecological resilience literature.

Session 16-O2 - Soil microbial ecology, resilience, and novel ecosystemssystems

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The term "resilience" is widely used, and widely abused. We are, however, starting to see how the concepts that have been used in the scientific literature for the past half a century may be explored and applied at a number of scales. We have been investigating how the concepts of critical slowing-down, auto-correlation and changes in variance may be diagnostic of resilience phenomena. We have specifically studied soil systems under varying degrees of stress and disturbance

and established how they respond in relation to such parameters following controlled perturbation under laboratory conditions. We shall present our findings relating to a wide range of soil samples drawn from across England and Wales. These results will be discussed in the wider context of resilience as applied to ecosystems, and what might be the underlying factors and constraints to resilience dynamics. We then frame the debate going forward to determine potential management actions to conserve and enhance the condition and function of the natural capital and ecosystem flows that we depend on. We shall draw examples from ecological restoration, urban ecology and soil science.

Session 16-O3 - Multiple stress and resilience: matters of body size and population demography

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Populations are frequently exposed to multiple stressors such as natural stressors or chemicals released into the environment. Body size is thereby an important demographic attribute influencing the impact each stressor might pose on populations. As regards natural stressors, body size might influence population dynamics e.g. via intra-specific competition or selective predation. Under chemical stress, differences in the initially exposed size were shown to generate differences in apparent sensitivity to chemicals among population members. In this presentation, I address mechanisms behind size dependency in individual stressors, predation and chemical exposure. Both stressors can individually lead to shifts in population structure, while compensating mechanisms may buffer the effects to a certain extent. Buffering capacity can however be exhausted by too strong or too long-lasting a stress. Using the water flea *Daphnia magna* and the insect predator *Notonecta maculata* as a case study, I will provide an example where a combination of stressors, predation and chemical exposure, lead to population extinction although single stressors hardly caused any effects on population size. For multiple stressors, synergistic effects are usually claimed whenever a combination of effects is amplified beyond additivity as observed at the level of individual organisms. In the *D. magna* example, the combination of a natural and chemical stressor did not increase the effects on the organismal level but led to a nonlinear combination of effects at the population level. The population response to single stressors inevitably caused changes in structure and internal organization. These responses had different profiles, each changing the susceptibility to other stressors in a particular way. The effect of the second stressor finally led to the exceedance of buffering capacity, thus to the loss of resilience.

Session 16-O4 - How much compensation is possible? Effects of disturbance by grazing on regrowth of palatable perennial grasses in a semiarid Namibian savanna

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Semiarid savannas in southern Africa have been used for cattle grazing for decades. In many areas unsustainable high stocking rates have led to severe changes in vegetation cover and composition i.e. shrub encroachment. The increase of woody shrubs at the cost of palatable herbaceous vegetation causes a significant reduction in the economic value and decrease in human livelihoods. Since shortage of water is the key factor of semiarid systems, an understanding of the relationships between disturbance by herbivores, drought stress and desired perennial grass vegetation is highly requested. We studied the effect of disturbance on morphological and physiological traits and assessed regrowth and recovery potential from two different viewpoints. First, in a field study, we established grazing gradients where we use shrub cover as proxy for long term grazing impacts and recorded the magnitude of disturbance for several grass properties. Second, in drought controlled experiments (greenhouse and field), we applied different clipping intensities to analysed grazing impacts on recovery of grasses that varied in age and size. While we found evidence that water limitation negatively alters the relationship between disturbance and regrowth potential of older grass tussocks, we revealed that moderate grazing disturbance of young grass individuals may be beneficial under drought stress conditions. We propose a simple modified intermediate disturbance model, in which perennial grass performance in natural savanna communities is determined by disturbance in terms of grazing intensity and the rate of recovery from disturbance, which is mainly influenced by water availability. The model may have important implications for future savanna management.

Session 16-O5 - Ecological niches and local adaptation of two closely related *Saxifraga rosacea* subspecies with different ploidy levels

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Polyploids have been found to occupy a wider range of environments than their relatives with a lower ploidy level. As they are often more heterozygous, their higher genetic diversity may confer them the ability to exist in a wider range of habitats. To evaluate the ecological differentiation between the two closely related taxa *Saxifraga rosacea* subsp. *sponhemica* (2n = 48) and *S. rosacea* subsp. *rosacea*

(2n = 64), we investigated environmental characteristics of 22 populations of the two subspecies. *S. rosacea* and *S. sponhemica* showed different ecological niches as the composition of the vegetation of their habitats differed significantly. Analyses of local climatic conditions in the 22 populations confirmed this differentiation. While *S. sponhemica* is restricted to Central Europe, *S. rosacea* also occurs in Central Europe, but has a much wider distribution including the arctic. To investigate a possible adaptation to local climatic conditions in the two subspecies, we planted rosettes of both subspecies originating from different populations into field gardens in two different climatic regions: Luxembourg (Central Europe) and Iceland (arctic). The two subspecies responded differently to climatic conditions at the two sites. In Iceland, survival of *S. rosacea* was twice as high as that of *S. sponhemica*, while in Luxembourg *S. sponhemica* survived much better the more continental climatic conditions. The plasticity of the two subspecies to different stresses was studied in a common garden experiment at the MnhnL by applying drought, shade, competition and frost to the plants. Results indicate no differentiation between the two plant taxa but a genetic differentiation among populations.

Session 16-O6 - Stress ecology of beech trees in dry forests: role of multiple stressors on crown dieback & growth sensitivity under recurrent drought

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Owing to the growing sensitivity of forests to drought under warming climate; role of soil water storage capacity, tree species diversity, plant-plant interactions, and other abiotic stressors on crown dieback of trees should get more attention. How recurrent droughts are linked to growth response in trees with contrasting water availability in forests, and when increasing crown dieback swerve to death had not been studied yet. We researched how permanent soil water stress together with climatic drought impacted crown dieback and annual growth of European beech trees in near-natural temperate forests of Germany and Switzerland. We quantified soil water storage capacity and combined with other biotic (e.g. plant-plant interactions, tree species diversity) and abiotic (e.g. light availability, pH and bulk density of soil) stressors to find their combined influence on crown dieback; additionally, examined whether any threshold in respect to crown dieback exist. We used 65 years of tree annual growth and climate data for relating growth sensitivity to drought under contrasting soil water stress. Increase in soil water storage capacity, tree species diversity, light, and neighbourhood interactions decreased crown dieback; more prominently in the upper part of the crown. Permanent death occurred when the amount of dead above-ground biomass crossed the threshold of 58%. Drought stress on annual growth had been becoming

severe in trees growing on drier plots than less dry plots, since 1980s. Resistance, recovery and resilience of annual growth to climatic drought were higher in less-dry than in dry plots within a stand under same magnitude of submitted drought stress, and were negatively influenced by recurrent severe drought events. This field observational study supplemented by dendroclimatological analysis would help us to understand the role of growing environment and climate on crown dieback and growth of beech trees in drought stressed forest ecosystems.

Session 16-O7 - Linking research on resilience and multiple stressors

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Research on multiple stressors focusses on the responses of ecological systems to disturbances and stress. In particular, the combined effects of multiple stressors are explored regarding the question of how much stress ecological systems can cope with and how to prioritize stressors in ecosystems. However, a mechanistic understanding on stressor interactions is still lacking. Resilience research focusses on stability properties of ecological systems, in particular recovery, resistance, and persistence. A central question is how much stress a system can absorb before its internal organization collapses and the system changes abruptly to a different kind of organization. Although both research fields address stress and the ability of ecological systems to cope with stress, they are more or less disjoint as can be shown in bibliometric analyses. In a systematic literature review, we identified the mutual strengths and weaknesses of the two fields: stress ecology identifies limits to stress, beyond which functioning breaks down, and quantifies stressor interactions in terms of synergistic or antagonistic combined effects. Resilience research fosters a certain way of framing questions about the functioning and persistence of ecological systems, but is rather based on heuristics than on mechanistic understanding. We provide an overview of system response mechanisms which were identified in stress ecology and discuss how they could be integrated into resilience theory. We discuss specific examples and demonstrate the links between stress ecology and resilience research with conceptual and simulation models. Finally, we present a set of questions that can be addressed in both fields and thus have the potential for unification.

Poster presentations

Session 16-P1 - Flooding tolerance of seedlings of 4 floodplain meadow species of the Central European lowland at different age

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In Central Europe, species rich grasslands have decreased in area and habitat quality since the middle of the 20th century. Especially lowland flood meadows harbour several of the most threatened plant communities in EU countries. Typical plants in these habitats are well adapted to the specific site conditions, which are characterised by a combination of periodic flooding and drought. In terms of Ellenberg indicator values they serve as indicator species for fluctuating moisture conditions. Typically, the study meadows are on average flooded for up to 26 days per year. While the effect of flooding on adult plant individuals has been studied before, knowledge about flooding effects on seedling establishment is still scarce. Therefore, we tested the response of differently aged seedlings towards a 2-weeks flooding period. To this end we flooded 400 seedlings of 4 plant species (2 from wet flood meadow habitats: *Veronica maritima*, *Sanguisorba officinalis*, and 2 from dryer flood meadow habitats: *Veronica teucrium*, *Sanguisorba minor*) 2, 4, 6, and 8 weeks after germination. Our results show that flooding causes more severe damage on seedlings of species from dryer habitats compared to those of wet habitats and that damage on seedlings decreases with age.

END OF SESSION 16

Session 17 – Forest ecology

Chair
Prof. Dr. Christian Ammer

Session 17-O1 - Deadwood amount and diversity determine functional and phylogenetic diversity of saproxylic organisms along an elevational gradient

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Ecologists and conservationists have increasingly begun to quantify functional and phylogenetic diversity of species assemblages. Among the most important determinants of functional and phylogenetic diversity are ressource amount, ressource diversity but likewise environmental gradients, such as elevation. We quantified functional and phylogenetic diversity of assemblages of wood-inhabiting fungi and saproxylic beetles along a 1000m elevational gradient. Our results reveal, that high levels of deadwood amount and deadwood diversity support functional and phylogenetic diversity, particularly in higher elevations. Hence, conservation strategies that aim on maintaining functional and phylogenetic diversity of wood-inhabiting fungi and saproxylic beetles should foster enrichment of deadwood diversity and amount in higher elevations.

Session 17-O2 - Dead wood enrichment in European forests - which tree species should be used to promote saproxylic beetle diversity?

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Modification of natural ecosystems has threatened biodiversity worldwide with forests suffering especially. Strategies aiming at mitigating such loss in forests often

include enrichment of dead wood, a critical resource for many decomposer species. It remains unclear how dead wood can best be enriched to most effectively promote the diversity of saproxylic species. In this study, we investigated saproxylic beetle diversity in experimentally exposed deadwood logs of 13 different tree species across 30 forests in three regions of Germany. We tested whether gamma-diversity differs between treespecies,and whether the alpha-diversity within an individual log depends more on management intensity or on the dominanttree species of the forest. We found significant differences in gamma- and alpha-diversity of saproxylic beetles among tree species, but the ranking of tree species differed between regions, suggesting differences in local beetle species pools. The overall diversity of saproxylic beetles increased with the number of tree species exposed, due to the strong turnover of beetle species between tree species. Some species (e.g. *Carpinus*) and species combinations (e.g. *Carpinus-Picea*) reached exceptionally high beetle diversity compared with others in randomization tests. Alpha-diversity was additionally determined by dominant tree species, but not by management intensity. Canopy cover above logs and average stand temperature strongly influenced alpha-diversity, suggesting that environmental conditions, rather than management itself, act as habitat filters for species assemblages. We conclude that dead wood enrichment strategies would be most effective when combining particular tree species that support highest diversity.

Session 17-O3 - Influence of tree hollow characteristics on saproxylic beetle diversity and diversity patterns in a managed forest

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Tree hollows are key structures in forest ecosystems, as they provide shelter and nutritional resources for many saproxylic arthropod species. Due to the complex microhabitat structures and conditions inside a tree hollow, they can support generalist as well as specialist species. However, trees with hollows decreased strongly within forests due to management practices, resulting in a decrease and endangerment of saproxylic species. Therefore we investigated 40 beech trees with hollows in a managed forest in the northern Steigerwald (Germany) over two years with emergence traps to collect the emerging saproxylic beetles. We collected 89 species of which 33% were threatened. We characterized the tree hollows themselves by their physical characteristics and their surrounding environment. Important hollow parameters correlated with high species richness for both years

were the degree of decomposition of the wood mould and the size of the tree hollow entrance. Wood mould is one important habitat in tree hollows and therefore the early stages of decay support a broad range of species, whereas later decay stages support fewer but maybe specialized species. The area of hollow entrance is important for the regulation of the microclimate in the tree hollow. In our study a large entrance was connected with higher saproxylic beetle richness. Due to the large entrance the conditions in the tree hollow might be drier and thus preferred by the beetle assemblages we found. The importance of the tree girth, the height above ground and the tree hollow volume varied between 2014 and 2015. Furthermore, we found a high spatial and as well high temporal species turnover of saproxylic beetles. Our result suggest that a network of tree hollows with different parameters can support species richness in a managed forest.

Session 17-O4 - Support for the habitat-amount hypothesis in a study of saproxylic beetles in forested landscapes

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The recently proposed *habitat-amount hypothesis* challenges traditional concepts of species–habitat relationships. It posits that effects of patch size and patch isolation are driven by effects of sample area, and thus that the number of species at a site is basically a function of the total habitat amount surrounding this site. We experimentally tested this hypothesis for saproxylic beetles and their habitat of dead wood by manipulating local habitat amounts across landscapes with a high variation in habitat amount, i.e., dead tree density, as identified using airborne laser scanning (LiDAR). Both local and surrounding habitat amounts independently affected species numbers in the local patches without a significant interaction effect, hence supporting the prediction of the hypothesis, i.e.,total habitat amount is of importance and not habitat spatial arrangement. The results indicate that to protect saproxylic beetle biodiversity in forested landscapes, restoration of habitat should generally focus on increasing the overall amount of dead wood rather than on its spatial arrangement.

Session 17-O5 - Forest stand structure little, but specifically affects biodiversity in European beech forests.

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Forest stand structure is suggested to influence biodiversity through changes in resource availability (diversity-productivity relationship) or resource heterogeneity (habitat-heterogeneity hypothesis). However, it is unclear which components of stand structure drive the biodiversity of organismic groups. In this study we tested which forest structural components are most important for biodiversity in European beech forests. More specifically we were interested which taxa rely on which stands structures. We used data on biodiversity and forest stand structure observed in the Hainich-Dün region of the German biodiversity Exploratories project. We quantified 32 metrics of forest stand structure which *a priori* were selected to characterise stand maturity, tree size heterogeneity, compositional heterogeneity, horizontal heterogeneity, and combinations of tree size, compositional and horizontal heterogeneity for even-aged (N = 13), uneven-aged (N = 13) and unmanaged (N = 15) beech forests. Within the sample of beech forests we could identify four principal components of forest structure which explained 86.4 % of the variance: stand maturity, combined species and tree size diversity, stocking degree, and local diameter differentiation. Relating biodiversity of animals, plants, fungi and bacteriato PCA axis and single metrics of forest stand structure we found significant correlations only for some organismic groups. The greatest effect strength was observed for birds and spiders, which contrarily responded to changes in stand structure. The finding suggests that the species communities of European beech forests in general are not adapted to specific forest stand structures. However, specific organismic groups benefit from changes in habitat heterogeneity or resource availability.

Session 17-O6 - Functional trait diversity of ant communities between land-use types

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Ants are an important functional group of temperate forest and grassland ecosystems. Land-use intensification has been shown to negatively influence species diversity. As species with particular traits, i.e. larger species, are lost from communities functional diversity decreases. While these patterns are well studied for some taxa, the effects of land-use intensification on functional diversity of ant communities are quite unknown. To investigate the changes in ant communities,

we sampled ants in 150 forest plots (100mx100m) using pitfall traps (3 traps / plot) in all three regions within the Biodiversity Exploratories (BE) project. Plots comprise different land use types such as unmanaged forests and uneven-aged and even-aged managed forest. At each site, we identified the ant species and measured morphological traits to characterize functional trait diversity. Ant species richness in a subset of plots (VIP plots) was quite low in the Exloratory Schwäbische Alb with a mean ± SD = 2.1 ± 1.0 ant species per plot only likewise in the Exploratory Hainich with 2.3 ± 1.9 ant species. Species richness was significantly higher in the Exploratory Schorfheide with 9.4 ± 4.2 ant species per plot. This is in contrast to the ant species richness found in grasslands of the BE where ant species richness was highest in the Exploratory Schwäbische Alb and lowest in the Exploratory Schorfheide. Thereby, we found a strong turnover of species richness between the forests and grasslands within regions. While ants of *Formica* spp. were abundant in the Exploratory Schorfheide both other Exploratories were dominated by *Myrmica* spp.. Thus functional diversity differs strongly among the regions and an increase of land-use intensity results in increased species homogenization. We will compare functional trait diversity between ant communities in forest plots as well as with those from the grassland plots of the BE as well as along a gradient of land use intensity.

Session 17-O7 - Canopy gap dynamics drive structural complexity in a beech virgin forest in Slovakia

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For the understanding of forest ecosystems the natural disturbance regime and the ecosystems response are of high importance. Temporal changes in canopy gap area, the released within-gap structures and the regeneration development following disturbance are key components in this context. We mapped canopy gaps using line intersect sampling in a beech (Fagus sylvatica L.) virgin forest in 2003 and 2013. For all gaps mapped in 2003 we examined the process that caused the size development. Regeneration cover in all gaps was estimated and in a subset plant density and yield of regeneration was studied in dependence on its position within the gap. Total gap area decreased from 13.6 % of the forest area in 2003 to 8.2 % in 2013. With increasing gap size the frequency of gaps decreased exponentially in both years. Large gaps (> 1000 m²) made up for 50 % of the gap area in 2003. In 2013 no large gaps were encountered and the share in small (< 100 m²) and medium (< 1000 m²) sized strongly increased. 95 % of the gaps encountered in

2003 decreased in size and 1/3 of them were closed in 2013. Crown expansion of bordering canopy trees was the main closure process in most small gaps, while in larger gaps there was a remarkable recruitment to the canopy layer from lower strata. Most gaps showed several regeneration periods resulting in different regeneration layers. The area in old and new gaps had a similar regeneration cover of about 60 %, however there was a shift in percentage cover from the lowest (< 2 m) to the next upper stratum (< 10 m) regarding new vs. old gaps. The availability or absence of direct sun light significantly influenced the regenerations plant density and yield. Increasing gap size and gap age also showed significantly positive effects. The results show that stand structure is the outcome of complex interactions on spatial and temporal scales. Ordered processes and random events create a heterogeneous structure of high resilience to disturbances.

Session 17-O8 - Are canopy gaps important to maintain woody species diversity in subtropical forests?

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Forest canopy gaps are expected to have a different species assemblage and higher species richness of plants compared to areas under intact canopy. However, the generalization on differences in composition and richness between gaps and intact canopy are not always supported by empirical studies. We compared tree and woody species composition, richness and regeneration between gaps and closed-canopy to examine whether (i) species composition differs between the two habitat types, (ii) gaps are richer than corresponding closed-canopy, (iii) gap diversity is a function of the density of individuals, and (iv) gaps promote regeneration of tree species. Vegetation data were collected from two subtropical Shorea robusta forests stands in central Nepal across 128 plots of 100m2 equally spread out in two habitat types. We recorded the total number of woody species, number of individuals of tree species as seedling, sapling or mature trees, and measured the girth of saplings in each plot. Ordination is used to analyze species composition, and a species accumulation curve to illustrate the effect of density on species richness. Regeneration of tree species between the habitats was also compared. The species composition of all woody species and of seedlings was similar between habitats but the species composition of saplings differed between the habitats. Overall woody species and seedling richness were similar between habitats at one site while they were richer under closed-canopy at the other site. Sapling richness was higher in gaps at both sites. Sapling richness was a function of stem density at one site, but not at the other site. Tree species were disproportionately favored for regeneration in the gaps. We conclude that gaps are not always areas of higher species richness and may be less important than expected for the overall species diversity of woody plants; instead they are

potentially important for enhancing local tree diversity by favoring their regeneration. Therefore, we suggest incorporating disturbance regimes that add structural heterogeneity and diversity into forest management plans to derive synergy between conservation and production.

Session 17-O9 - Traits, trade-offs and functional groups among Central European tree species

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A large amount of research has been conducted on plant functional traits and the identification of functional groups of plants. Functional classifications are necessary tools in plant and ecosystem ecology, when the response of biotic systems to environmental variation is to be explained, because they simplify the floristic complexity of real-world systems to a level which can be handled in models. However, some of the more recent classification systems (e.g., Turner 2001) which reflect the diversity of functional types that are present in most tree floras have not yet been tested for their applicability to temperate tree floras. We identify three main fields of research needed to improve our capability of predicting trees' responses to environmental change: (1) shift to more sophisticated measurements, (2) focus on adult trees, and (3) exploration of complete floras. We conducted a comprehensive literature survey on the ecology of the Central European temperate tree flora and achieved a high information quality level by (i) exploring a large number of morphological and physiological traits, (ii) considering mostly measured data instead of estimated parameters or species rankings, (iii) including only traits of adult trees and not of seedlings or saplings, and (iv) covering the entire tree flora of the study region rather than selected species. In our presentation, trait variation across the tree flora, the change in species traits with succession, and negative correlations between species' stress tolerances will be discussed. Finally, we will identify five (more or less distinct) functional groups in the Central European temperate tree flora which differentiate mainly by the (1) minimum light demand, (2) leaf longevity, and (3) tree height.

Session 17-O10 - Different formulations of tree mortality lead to vastly different forest dynamics: an assessment across 15 models from the stand to the global scale

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Models of forest dynamics are pivotal for assessing future forest dynamics under the impacts of changes in climate and management practices. Such models must necessarily include a representation of tree growth, mortality, and regeneration. The empirical foundations for formulating tree growth are quite solid, but quantitative knowledge for developing robust models of tree mortality is scarce. In the context of the COST Action PROFOUND ("Towards robust projections of European forests under climate change"), 15 Dynamic Vegetation Models (DVMs) were evaluated in terms of their sensitivity to different, equally plausible formulations of tree mortality. The study included both „chronic" („background") mortality as well as mortality events induced by extreme conditions such as droughts. The set of models included 8 DVMs at the stand scale, 4 at the landscape scale, and 3 at the global scale. While some models include empircally derived mortality models (e.g., based on inventory or tree-ring data), others are based on experimental data (e.g., drought experiments), whereas still others are based on theoretical reasoning alone (e.g., consideration of the simulated whole-plant carbon balance). Each DVM was run with at least two alternative mortality algorithms. In a first step, model behavior was evaluated against past time series data. In a second step, the models were subjected to different scenarios of climate change for the 21st century. Most DVMs matched empirical data quite well, irrespective of the mortality formulation that was used. Based on the simulation results, the sensitivity of the models was classified, and the reasons for the different sensitivities were investigated. It became obvious that it is generally very difficult to assess the suitability of a mortality formulation based on past model behavior only. However, mortality algorithms that performed in a very similar manner when evaluated against past data were often found to lead to sharply different trajectories of future forest dynamics. We conclude that it is indispensable to employ several alternative mortality formulations in DVMs when assessing future forest dynamics. Although this will increase the uncertainty of the simulation results because there are hardly any a priori reasons for favoring one alternative over the other, it precludes that decision makers draw erroneous conclusions based on seemingly clear simulated future trajectories.

Session 17-O11 - Different facets of diversity are driving browsing intensity of tree saplings on plot and individual level

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Browsing of tree saplings by deer hampers forest regeneration in mixed forests across Europe and North America. It is well known that tree species are differentially affected by deer browsing, but little is known about how different facets of diversity, such as species richness, identity and abundance, affect

browsing intensity on the plot and individual sapling level. Based on forest inventory data from the Hainich National Park, a mixed deciduous forest in central Germany, we examined drivers of browsing intensity of saplings. In a hierarchical approach, we first modelled between-plot selectivity, i.e. the probability of a plot being browsed by roe deer. In a second step, we modelled within-plot selectivity, i.e. the species specific proportion of saplings being browsed within a plot. We found that species-rich plots were more likely to be browsed, however, within species-rich plots, a lower proportion of saplings per species was browsed, presumably because browsing pressure on single individuals of each species is diluted by the presence of co-occurring species. Between plots, the abundance of *Fagus sylvatica*, as well as forest stand parameters and disturbance, further influenced the browsing probability of a plot. Within plots, species identity was the most important factor for predicting the proportion of saplings browsed per species, providing a "palatability ranking" of the 11 tree species under study. By showing the effects that various facets of diversity, as well as environmental parameters, exert on browsing selectivity at the plot and individual level, our study advances the understanding of mammalian herbivore – plant interactions across scales.

Session 17-O12 - Modelling browsing of deer on beech and birch in northern Germany

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Food selection by cervids is of high interest for forest management as they tend to browse on trees, causing severe damage and shifts in the regeneration capacity of certain preferred tree species. This behaviour could contradict forestry management strategies as deer may browse on target species, e.g. beech or oak, which are of high economic value for forestry and nature conservation. The choice of feeding habitat is influenced by a variety of different parameters, ranging from forest characteristics to human impacts. Therefore, we focused on factors influencing browsing of roe deer (*Capreolus capreolus*) and red deer (*Cervus elaphus*) on two different plant species: beech (*Fagus sylvatica*), which is an important species for forestry, and birch (*Betula* spec.), which may be an alternative food resource to beech. We measured browsing damage in relation to, variables such as tree density, tree height, ground cover vegetation, possible human impacts and landscape features in the Lüneburger Heide, Germany, for our modelling approach. Our results revealed that browsing on beech is positively influenced by the availability of young beech and birch trees, whereas browsing on birch was influenced by the availability of birch trees only. Furthermore, the occurrence of blueberry (*Vaccinium myrtillus*) was positively and significantly related to browsing damage on both plant species, but a negative relationship was found for old Norway spruce stands (*Picea abies*). Surprisingly, other tree species,

landscape features and human impacts had no significant influence on the feeding damage of either tree species. Our results indicate that the availability of young birches might decrease the proportion of browsed beech, or even favour the selection of birch over beech for food, which would consequently lead to increased future beech regeneration. Our modelling approach is applicable to forest management, providing an overview of interactions between browsing by cervids and young tree regeneration processes.
Keywords: Large ungulates, browsing damage, feeding habitat selection, vegetation composition, *Fagus sylvatica*, *Betula* spec.

Session 17-O13 - Resource attributes, not time, determine fructification of *Fomitopsis pinicola* following bark-beetle outbreaks

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To understand biological forces driving trade-offs linked to fungal sexual reproduction such as basidiome size and available resources, we surveyed basidiomes of *Fomitopsis pinicola* on 1,280 standing snags and lying logs. Surface, decay stage, position and time since death of each dead-wood object was characterized to test their influence on the presence of *F. pinicola* basidiomes, total basidiome biomass, and biomass of dead basidiomes. Presence of basidiomesincreased with decay stage and was higher within snags. Basidiome biomass increased with increasing dead-wood surface and was higher on snags too. Thus, *F. pinicola* trades off reproductive investments against the total amount of resources available. Biomass of dead basidiomes was higher on logs, increased with increasing wood surface, but decreased with increasing decay stage. Time since death of the tree had no effect on studied parameters. Our results demonstrated that *F. pinicola* fructification is affected more by substrate quantity than quality.

Session 17-O14 - Identity rather than richness drives neighbourhood species composition effects on sapling growth in a young forest

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In light of ongoing global biodiversity loss, the influence of species composition on ecosystem functioning has increasingly attracted more attention. However, questions remain whether neighbourhood species richness or identity is more

important and particularly what mechanisms drives these composition effects. In this study, we investigated the role of local species richness and identity on growth of oak saplings in young forest stands and attempted to establish a link with two commonly expected mechanisms: oak powdery mildew (PM), a host-specific leaf pathogen, and the degree of shading. Furthermore, we attempted to determine how such effects might interact with a stress gradient. We established a rainfall reduction gradient on potted oak (*Quercus*) saplings planted within two sites of a young tree diversity experiment (FORBIO, Belgium). We found no effect of species richness on growth, whereas the presence of particular species had significant impact. In one site, an identity effect on growth was found through negative effects of oak (*Q. robur*) presence, which was linked to increased PM infection severity, which in turn had a strong negative effect on growth. Such a link was less clear in the other site, where the impact of PM and oak (*Q. petraea*) presence was lower and there was no relation between the two. Other identity effects were related to levels of shading, which were themselves influenced by fast early growth rates or high mortality rates of the neighbouring trees. We found no consistent effects of the rainfall reduction gradient on growth and soil moisture measurements showed minor differences, only consistently between the control and most severe treatments. We conclude that host-mediated effects through oak PM and functional size-mediated effects through shading were the most important composition effects in our young forest experiment, with no support for species richness effects through local environmental conditions or natural enemies.

Session 17-O15 - Limited tree richness effects on herb layer composition, richness and productivity in experimental forest stands

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In forests, the understory vegetation plays an important role for ecosystem functioning as it represents a significant component of total aboveground productivity. In addition, the herb layer contributes to overall forest species richness and controls tree species regeneration. Vice versa, trees in the overstory control understory plant growth through competition for resources. Compared to natural forests, where effects of tree species richness and identity cannot be separated, experimental forest plantations with manipulated tree richness allow to quantify there separate effects. We asked to which degree tree species richness and identity affect herb layer composition, richness and productivity and how these relationships across strata change with abiotic environmental conditions and competition intensity. In the context of the Biodiversity-Ecosystem Functioning

project in subtropical China (BEF-China), we made use of the integrated BEFmod experiment that modifies environmental conditions along a tree species richness gradient at two sites, with additional subplot treatments of phosphorus addition, herb layer weeding and no weeding. We recorded the understory vegetation and determined herb layer biomass production on a total of 201 subplots. We applied multivariate analyses and mixed effects models separately for the two sites. While tree layer richness influenced herb layer species composition, there was only a weak effect on herb layer richness and no effect on productivity. There were strong tree layer identity effects on all response variables, which were partly explained by differences in leaf area index and by a high share of woody species in total herb layer species richness and biomass. There were strong “no weeding” treatment effects, but we did not find any treatment × tree layer richness interaction in herb layer responses. Thus, most effects can be explained by increased competition intensity within the herb layer in the absence of weeding. Despite the young age of the experiment, the interactions between tree species identity, tree richness and the herb layer have already emerged which can be explained partly by light and soil conditions that were already modified by the closing tree canopy and partly by woody recruits that contribute both to total herb layer species richness and biomass.

Session 17-O16 - Estimation of epiphytic biodiversity and biomass in a tropical montane forest, western Panama

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A forest is more than trees, especially in tropicalmontane forestswere epiphytes represent a substantial portion of biodiversity and green biomass, peculiarly where fog occurs almost daily. Epiphytes play important ecological roles in these systems regulation.g. in forest hydrology and as a multiplier of arthropod biodiversity, but quantitative data on epiphytic biomass and species composition are rare. Such data are important, however, for assessing ecological roles and as a baseline for detecting ecological change due to climate or land-use changes. To estimate epiphytic biomass (dry weight) in a lower montane cloud forest (1200 m a.s.l.) in Panama, we collected epiphytic material, including vascular plants, bryophytes, and dead organic material (DOM), from 22 tree trunks (180° of each trunk) and 28 canopy branches. Additionally, we collected understory epiphytes in 22 plots of 2x2 m. Plants were identified to species and subsamples of all collections dried to obtain biomass estimates.

A total of 155species of vascular epiphytes and hemi-epiphytes were found. Orchidaceae were by far the most species-rich family, followed by Araceae and

Bromeliaceae. The vertical distribution of these species in the forest showed species-specific vertical preferences, but species numbers were relatively invariant from undergrowth, trunks to tree crowns. A total of 94 kg of epiphytic material was collected, 57 kg was collected from the trunks, nearly half of which (42 %) was DOM, while epiphytes represented 23 %, hemi-epiphytes 26 % and bryophytes only 9 %. From the tree crowns, 25 kg of epiphytic material was composed of 50 % of epiphytes and 45 % of DOM, 4 % of bryophytes and the remaining 1 % of hemi-epiphytes. The lasting 12 kg of epiphytic material was collected from the understory.We found that epiphytic material was positively related to tree size, so that we could use tree-size data from a nearby 1-ha plot to extrapolate our data to the plot level. Estimations of epiphytic biomass in tropical montane cloud forests range widely from 2,100 kg ha^{-1} in Jamaica to 33,100 kg ha^{-1} in Costa Rica.The resulting estimate of total epiphytic biomass was within the range of lower montane cloud forests.

Session 17-O17 - Vegetation as bioindicator of decomposition in a high mountain forest, Italian Alps

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In high mountain forests, environmental conditions are very heterogeneous. Thus, decomposition processes show a high spatial variability, manifested in patterns of humus forms. Information on these patterns is often scarce, because field data on humus forms is difficult to obtain in high mountains. Our aim is to identify robust and time-efficient methods to use vegetation parameters as indicators of humus forms. In the project “DecAlp” (“Effect of climate on coarse woody debris decay dynamics and incorporation into the soils of forested Alpine areas”), forests were studied in the Province of Trentino on siliceous parent material between ca. 900 and 2200 m a.s.l. They are dominated by Norway spruce and European larch. Vegetation relevés and humus forms were recorded at 153 plots. The vegetation parameters tested for their suitability as indicators of humus forms comprise mean Landolt indicator values of the various vegetation layers as well as structural parameters. Mean Landolt indicator values for reaction as well as for humus, in both cases based on all herb layer species, show closest correlations with humus forms. Also, aggregated cover values of certain plant species groups within the herb layer (e.g. herbs excluding grasses and ferns; Ericaceae) display a close relationship with humus forms. Partly, these parameters can quickly be determined in the field without the need for detailed species identification. Hence, the use of

vegetation data has the potential to increase our knowledge on spatial patterns of decomposition.

Session 17-O18 - Life on the edge: Stand structure, growth performance and reproductive success at treelines in Alaska - a genetic fingerprint?

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Alaskas treelines offer an exciting opportunity to study the natural dynamics of forest ecosystems “on the edge”. Treelines in central and northern Alaska are mainly formed by white spruce (*Picea glauca*) and have been subjected to rapidly warming (and drying) conditions, resulting in treeline advances in some and structural changes in other locations. Here we briefly summarize the current knowledge on Alaskan treeline dynamics, with a special focus on shifting drivers for growth and reproduction. We then use a massive sampling effort (tree survey, tree cores, genetics) of well over thousand individuals at two treeline locations in Alaska to exemplify the effect of shifting climatic drivers, clonal versus non-clonal growth form, and micro-environment on spatial structure, growth performance and reproductive success.

Session 17-O19 - The importance of disturbed and converted forests landscapes in the assessment of the biodiversity of land snails on Mt. Kilimanjaro

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Human-modified habitats are more and more dominating large areas of the tropical landscapes. Sampling only natural habitats, could easily lead to insufficient biodiversity data. We studied the richness and abundances of land snails on the slopes of Mt. Kilimanjaro, which harbours a range of disturbed habitat types and their natural counterparts. For two years we sampled snails in a total of 60 plots of 50m x 50m^2 in natural habitats, logged and burned forests, traditional village home gardens, maize fields, coffee plantations and grasslands, over a broad elevation gradient of 866-4550m asl. Nearly 43.1% of all living snails were collected from secondary habitats. About 88.3% of all species and 81.5% of endemics were found in both natural and secondary habitats. Snail species richness and abundance was significantly different between and within habitats types.Low montane forests had

the highest number of species, followed byvillage home gardens and logged forests. The lowest species count was observed insubalpine vegetation and in maize fields. Mean species richness per plot, however, was significantly higher in upper montane forests than in other habitat types. The abundance of species did not follow the same pattern as species richness. Snails were most abundant in low montane forest, followed by subalpine vegetation and burnt forest. Snails were least abundant in grassland, followed by savanna and maize fields. Subalpine vegetation had significantly larger mean abundances than all other habitat types. Habitat type explained significant variation in species richness and abundance independent of the effects of elevation.Each habitat type had a unique molluscan species community. We propose that a considerable number of common and habitat specialist land snail species can survive indisturbed and converted forest landscapes**.**

Session 17-O20 - Forests of Lake Baikal Eastern coast

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A study of flora and vegetation diversity – the most important components of the biosphere is one of the priorities in the modern biology. Lake Baikal, UNESCO World Heritage Site is a unique ecosystem which locates in the south-eastern Siberia. Our research aims to investigate the terrestrial vegetation on the eastern coast of lake Baikal. Results of field studies contribute the first data about species and soil diversity, plant communities structure and spatial patterns of lake Baikal forestland. Thestudying territory represents predominantly the low and medium mountain taiga landscapes in combination with psammophytes groups and lowland bogged meadow-bushes plant communities on the territory 500 km^2. The vegetation was collected and classified according to Braun-Blanquet methods. JUICE package was crucial for management and analysis of relevés. The mapping was developed by means of ArcGIS software. The routing and detailed routing methods of geobotanical research contribute the fullest identification of phytocenotic diversity and spatial distribution of Baikal forestland. For the tracking a route we used the informational content of satellite image SPOT 6 with resolution 1,5 m for optimizing the field work. The vegetation is presented by dominant forest communities, which were united into one classical boreal class *Vaccinio-Piceetea* Br.-Bl. In Br.-Bl. et al. 1939. Azonal vegetation were classified into class of typical boreal mires *Oxyccoco-Sphagnetea* Br.-Bl. &Tx. The close presence of Lake Baikal and its wave activity forms unique coastal communities, which were identified as class *Brometea korotkyi* Hilbig et Korolyuk 2000. Despite the relatively small territory under study, the central zone of Lake Baikal eastern coast is characterized by diverse habitat types. Lake Baikal plays the crucial role in the conservation of macrothermophyte plant species on the coastal line. The close presence of the seasonal frost soil layer forms suitable habitat conditions, which contribute

flowering of tundra and peatland species. The location of the study area within the zonal light coniferous taiga belt shows the obvious dominance of the forest type habitat. Thus, we assume that this territory can be considered as the model forestland of Lake Baikal which contiguous to it from the east.

Session 17-O21 - Edaphic factors structuring soil fungal assemblages in old-growth temperate rainforests of Chile

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Chilean old-growth temperate rainforests are subjected to extreme environmental and edaphic conditions, as high precipitation, soil-nutrient limitation and regular natural disturbances. These forests at southern Chile are located within two mountain systems (Andes and Coast mountains), which differ in geological history, edaphic characteristics and atmospheric inputs. There are three major Chilean temperate rainforest types: *Nothofagus* spp. forest (dominated by ectomycorrhizal trees, ECM), Valdivian and coniferous forests (dominated by arbuscular mycorrhizal trees, AM). There is little information about soil fungal communities in these forests. We described diversity patterns of soil fungal communities in Chilean Coastal and Andean temperate ECM dominated (*Nothofagus*) and AM dominated forests (Valdivian and coniferous forests), using Illumina sequencing of fungal ITS2 region to determine the effects of mountain system, mycorrhizal dominance and edaphic factors on soil fungal communities. We found higher soil fungal richness in ECM *Nothofagus* forests in Andean Mountains, but lower richness in Coastal Mountains when compared to AM coniferous and valdivian forests. In general, Agaricomycetes was the most abundant and diverse class. ECM fungi were the dominant guild in ECM *Nothofagus* forests, and saprotrophic fungi dominated in AM coniferous and valdivian forests. The most abundant ECM fungal genus was *Cortinarius*. Among edaphic parameters, soil Al content, electrical conductivity, and contents of Na, N, plant available P, Mg and K were most important variables structuring soil fungal assemblages. This study provides the first step towards understanding diversity of soil fungal assemblages in southern temperate rainforests, their diversity, structure and their ecosystem functions.

Poster presentations

Session 17-P1 - Forest management intensity leads to a shift in functional groups of epigeic spider communities

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For centuries, silvicultural management has been widely applied in Central Europe, particularly in Germany, where every forest is anthropogenically influenced to some degree nowadays. However, knowledge about the influence of forest management on ecosystem functioning is still limited. With regard to global species decline, it is essential to understand how anthropogenic activities such as silvicultural management affect biocoenoses. Therefore we studied the impact of different forest management approaches applied in the Eifel region (administrative districts Ahrweiler and Euskirchen, Germany) on epigeic spider communities. As highly abundant and mostly polyphagous predators, spiders (Arachnida: Araneae) play a key role in the food web of forest ecosystems. Due to their differentiated ecological demands they represent a worthwhile object of investigation for biocoenological questions. The following forest types were investigated: near-natural beech forests (Bn) with single tree selection, shelter-wood managed beech (Bk), spruce (F) and Douglas fir (D) forests. In Addition to that, beech forest reserves (Bt), that have been without management for 20 years, served as reference sites. Epigeic spiders were pitfall-trapped in 2014. In spider community composition we found clear differences between Bk, F, D and the reference site Bt. Near-natural beech forests could not be distinguished from the beech reserves, indicating a certain similarity. Furthermore, our study showed a clear influence on the functional spider community composition. Higher management intensity resulted in a significant increase of generalist species. Above all, coniferous forests showed clear differences in most analyses compared to beech forests. Particularly a significant shift in the body size was spotted.

Session 17-P2 - How does forest management affect food web structures?

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Forests are crucial ecosystems, as they are not only highly productive 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 functioning and account for an important proportion of Germany's biodiversity. Protecting diversity and structure of native forests is one key objective of nature conservation. It is essential to harmonise silvicultural practices with conservation goals, since nowadays only a minor part of German forests remains unmanaged. However, ecological impacts of silviculture are in many cases not yet 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 different trophic food web levels, we investigated ground beetles (Coleoptera: Carabidae), spiders (Araneae), weevils (Coleoptera: Curculionoidea), woodlice (Isopoda), and higher plants as bioindicators. Subsequently, we compared the different forest types particularly with regard to forest structures of different spatial scales (single tree, micro habitat and stand) as well as to structural and functional community composition. We found effects of forest management on habitat relevant tree structures, deadwood amount, development of the ground vegetation, micro-habitat distribution, horizontal and vertical stand structure, and age structure of the stand. The study clearly showed several management related shifts in structural and functional community composition, which are correlated to the studied forest structures.

Session 17-P3 - Disentangling the effects of forest-stand type and dead-wood origin on the diversity of wood-inhabiting fungi

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Multifunctional forestry increasingly aims at both optimizing timber production and the maintenance of species diversity. Wood-inhabiting fungi, crucial for the functioning of forest ecosystems (carbon and nutrient cycle), are among those taxa most threatened by commercial forestry. Therefore, effective forest conservation concepts should consider the enrichment of dead wood. However, there are

various open questions and convincing concepts are still lacking. Therefore, species depending on dead wood in commercial forests continue to decline. Especially which type of dead wood should be enriched in which forest stand context, is still debated. In this study we exposed more than 1,000 logs of 9 broad-leaved and 4 coniferous tree species in 19 broad-leaved and 9 coniferous forest stands in 2009 and surveyed the logs in 2012 and 2014 for wood-inhabiting fungi. Our study aimed at disentangling the effect of forest-stand type, dead-wood origin and time since death on the diversity of wood-inhabiting fungi. Moreover, based on this setting we were able to address the question whether there is a home-field advantage for wood-inhabiting fungal diversity or not. Our results demonstrate that the origin of the dead-wood substrate is the main driver of fungal diversity. We found no support for a home-field advantage which makes dead-wood enrichment effective irrespective of the tree species composition of the forest stand. Please note that forest managers changed the tree species composition during the last 100 years in most areas throughout Europe.

Session 17-P4 - How many species can be expected in a protected area? A case study in the Black Forest National Park

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How many species may occur in a given area is one of the first questions in recently established nature reserves. The Black Forest National Park has been established in 2014 to represent montane and high-montane forest ecosystems and to protect natural forest development and all related processes. So far the core area (34%) ist strictly protected but within the next 30 years 75% of the 10,067 ha will be released to natural development. Some habitat specialists are known to occur wihtin the national park such as the high-montane ground beetles Leistus montanus and Oreonebria boschi, the latter being an endemic species to Germany. A systematic monitoring of species is planned to start in 2017. However, the park administration and the public are already interested to know the potential number of species that occur in the national park. The species-area relationship and the regional species pool are exemplarily used to estimate the number of ground beetle species (Coleoptera: Carabidae) for the area of the national park. The regional species pool in the federal state of Baden-Württemberg is represented by 417 carabid species of which 136 species likely may occur in the national park due to their preference for forests or for montane environments. The species-area relationship calculated for carabids living in in differently sized forest areas in southern Germany predicted 123 species that can be expected in the 10,000 ha large Black Forest National Park. At the moment only 51 species are known to have populations in the park, but systematic monitoring starting in 2017 will certainly increase the number of of species. We provide an overview of current species richness in other taxa known to occur in the Black Forest National Park. And finally,

ground beetles were used as a reference group to estimate the potential species richness of other groups such as vascular plants, lichens and fungi.

Session 17-P5 - Low contribution of arthropods to decomposition along a major elevation gradient

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The decomposition of organic material is an important component of nutrient cycling and carbon fluxes and therefore a major ecosystem service. The progress of litter decomposition depends on temperature and moisture, characteristics of the litter and the diversity and composition of decomposer assemblages. Decomposer arthropods and other invertebrates can facilitate decomposition. However, the effect of arthropods on decomposition rates depends again on climatic variables. In this study, we aimed to quantify the relative contribution of decomposer arthropods on decomposition rates along a major elevation and therefore climate gradient of 3685m. Furthermore, we were able to compare disturbed and undisturbed habitats along an elevation gradient of 2200m. We used maize husks as a standard litter in litter bags with two different mesh sizes (4mm x 4mm and 20µm x 20µm), excluding arthropods from the small-mesh bags, and naphthalene in both large- and small-mesh bags to exclude arthropods chemically, and for control purposes, respectively. Overall decomposition rates were most influenced by humidity and temperature, with a peak at mid-elevations (ca. 2000 m a.s.l.) in undisturbed habitats, and a linear decrease in disturbed habitats. Decomposer arthropods contributed only little to litter removal in undisturbed habitats. The effects of arthropods were higher in disturbed habitats, but these effects decreased linearly with increasing elevation to reach zero at the highest disturbed sites. Naphthalene had a negative effect on decomposition rates. Overall, decomposition was controlled by climate, not arthropods. Decomposer arthropods facilitated decomposition only when both temperature and humidity were high. The negative effect of naphthalene on decomposition was too large to be ignored, and even comparable to the contribution of arthropods.

Session 17-P6 - Dynamics of soil carbon processes following forest disturbance by clear cut harvest and stem girdling

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Decomposition of soil organic matter (SOM) is an important ecosystem function and depends *inter alia* on the availability of above- and belowground C inputs, soil microbial biomass, and soil microclimate. Trees therefore heavily influence soil C processes both indirectly by regulating soil moisture and temperature (e.g. water uptake, shading), and directly through C inputs into the soil via leaf litter, root exudates and root turnover. However, abrupt and substantial changes occur during forest disturbance events, and subsequently a range of important driving factors are quickly reconfigured. In order to study how forest disturbance affects the respective biotic and abiotic factors driving soil C processes, and to investigate their respective influences, we established a forest disturbance experiment in a mature beech forest located in the Austrian Alps. The experiment includes stem-girdling, clear-cutting and woody debris addition treatments and started in spring 2015. Immediately after clear-cutting soil temperature significantly increased compared to control and girdling treatments, whereas changes in soil moisture were of minor importance. However, woody debris addition at the clear cuts attenuated extreme temperatures via shading. Neither soil microbial biomass, dissolved organic C and dissolved nitrogen (N), C and N content, pH, and root bio- and necromass, nor the decomposition of SOM (measured as microbial C mineralization at 10°C; R_{10}) and its temperature sensitivity (Q_{10}) changed in the first weeks post-disturbance. Since total soil CO_2 efflux was non-responsive to the treatments, we assume a mainly temperature-related increase in microbial respiration and/or root respiration from stored carbohydrates to maintain total CO_2 efflux at pre-disturbance levels.

Session 17-P7 - The effect of tree and herb diversity on epigeic arthropods in a highly diverse forest ecosystem: a multi-taxon approach

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Arthropods are the most diverse group of animals and play a prominent role in the functioning of terrestrial ecosystems. Despite extensive research, our knowledge about relationships between plant, decomposer, herbivore and predator diversity for species-rich, real world ecosystems is limited. We assessed key arthropod taxa (isopods, diplopods, chilopods, diverse beetle groups, especially staphylinids, carabids, scarabaeids s.l., weevils, spiders, ants) to determine how the diversity and abundance of macrofaunal decomposers, herbivores and predators is related to tree and shrub diversity in a subtropical species-rich forest ecosystem. We performed our research in south-east China, embedded in the framework of the BEF China project. Comparative Study Plots (CSPs) are located in subtropical forests in the Gutianshan National Nature Reserve (Zheijang Province). The 27 CSPs differ in woody plant species richness (25 – 69 trees and shrubs per plot). In total, 108 pitfall traps (4 per CSP) were set up to assess the macrofauna during one growing

season (March to September 2009). While decomposer species richness showed a positive relationship with tree species richness, it was negatively correlated with herb species richness. A negative relationship was also observed between the abundance of herbivores and herb species richness. Predator species richness increased with increasing tree species richness, whereas predator abundance decreased. Within the decomposer, herbivore, and predator groups, individual taxa showed pronounced differences in their response to tree and herb species richness, emphasizing the importance of taxon-specific patterns. Our results clearly indicate that tree and shrub diversity impacts diversity and abundance of arthropods. However, idiosyncratic and taxon-specific patters highlight the need for a broader taxonomic perspective when trying to understand the overall effects of plant diversity on arthropod assemblages.

Session 17-P8 - Vegetation structure and diversity in strict forest nature reserves - Impact of browsing intensity and former management

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Strict forest nature reserves (SFNR) were established to allow natural forest development and to protect natural forest communities and its biodiversity. Regular monitoring of stand structure and vegetation is an inherent part of natural forest research as it documents the ongoing processes without forest management. A comparison across several SFNR is thereby important to detect general trends in forest dynamics in Central Europe and to draw conclusions for future management and conservation strategies. Here we present vegetation data sampled in 19 SFNR in Rhineland-Palatinate (south-west Germany) between 2000 and 2015 that were unmanaged for up to 76 years. These reserves were compared regarding vegetation structure and diversity of vascular plants. In ten SFNR fenced and unfenced plots were available that allowed an assessment of deer browsing intensity. In eight SFNR, a comparison to adjacent still managed forests was possible. While 5 SFNR represent azonal vegetation types of eutrophic floodplain forests (3 SFNR) and bog woodlands (2 SFNR), 14 SFNR are characterized by zonal beech forests on mesic (2 SFNR) but mainly oligotrophic soils (12 SFNR). Former management, though, largely changed tree species composition as proportions of oaks or conifers in the tree layer are often high up until today. This has positive effects on herb and shrub layer species diversity, as our results show a negative relationship between beech proportions in the tree layer and species numbers in the understorey of zonal beech forests. In addition, species diversity in the tree layer promoted shrub layer diversity. This is, however, largely limited by deer browsing as fencing increased species diversity and abundance of the shrub layer.

Management decreased tree layer cover significantly compared to unmanaged stands. With increasing time of management abandonment, though, tree layer cover also decreased in the SFNR with positive effects for understorey plant species diversity.

Session 17-P9 - Effects of different sheep grazing treatments on herbaceous biomass and species diversity in a semi-arid Eucalyptus forest

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In Israel, livestock grazing is often used as a management tool to help remove herbaceous biomass and prevent wildfires, as well as to promote higher species diversity for conservation purposes. We investigated the influence of sheep grazing on herbaceous biomass and diversity in a planted Eucalyptus forest. We hypothesized, based on ecological principles, that intermediate grazing pressure can both reduce biomass and increase species diversity due to a change in vegetation composition. Our experiment consisted of manipulation of grazing intensities by gradual grazing treatments. We found that exclusion of grazing resulted with biomass increase with no change in species diversity.However, intermediate grazing intensities resulted in a small decrease in biomass with a large increase in species diversity. Furthermore, freely-grazed plots revealed no change in biomass, while species diversity mildly increased. Hence, the change in species diversity with grazing intensity presented a unimodal response, as the intermediate intensity resulted with the highest species diversity. Among all treatments, relative cover of forbs, legumes and tall grasses decreased through time, while short grasses and thistles increased, implying seasonal processes.In addition, grazed plots showed higher proportions of short grasses compared to ungrazed plots. This implies that short grasses benefit from a grazed environment due to their resistance to disturbance. Our results suggest that intermediate grazing intensities can result in high herbaceous species diversity and low biomass levels, as desired by forest and land managers.

Session 17-P9 - Forecasting pest outbreaks in forest

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Insect outbreaks can result in serious economic losses in forestry. Different systems have been developed to forecast pest outbreaks. Evaluations based on pest

abundances are commonly used methods, while determining long-term forest susceptibility is rather complicated. We conducted a global review of studies focusing on drivers of forest pest outbreaks to summarize current knowledge and identify major knowledge gaps. We found that previous studies combined diverse structural variables, amount of parasitism/predation and assessments of single tri-tropic interactions to forecast pest outbreaks. In general the applicability of structure effects and pest antagonists to forecast forest susceptibility for pest outbreaks were contradictory or narrowed in landscape scale or on single interactions possibly resulting in restricted applicability of risk assessment systems. Our main conclusion is that the impediments to forecast forest susceptibility are determined by the high number of biotic, abiotic and multi-trophic factors affecting forest systems. As occurring systems reached a complexity of variables that complicates the applicability for forest managers new systems have to be developed, but the focus have to be orientated to other aspects like interaction networks instead of creating more complex systems. Structure and climate factors affect the whole community and spatiotemporal plasticity of tri-tropic networks and therefore the suppression of pest outbreaks. The reasons for pest outbreaks might be determined due to the lack of redundancy of antagonist or indirect effects of community composition on the choice of antagonists for their prey. However systems to forecast insect outbreaks are lacking the inclusion of interaction networks. Assessing the redundancy and complexity of tri-trophic-networks might help to determine the susceptibility of forest for pest outbreaks.

Session 17-P10 - Modelling potential distribution of *Betula utilis* in the Himalayan region: evaluation of different modelling approaches

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At local and global scales, high-altitude treelines can be considered as sensitive indicators of past and recent climate change and variability, due to the fact that treelines are controlled by heat deficiency. Thus, climate warming is expected to induce treelines to advance to higher elevations. *Betula utilis* is a major constituent of north-facing alpine treeline ecotones in the western and central Himalayan region. The objective of this study is to provide, for the first time, an analysis of the potential distribution of *B. utilis* in the subalpine and alpine belts of the Himalayan mountains applying environmental niche modelling. The Himalayan mountain range is located between the Indian Subcontinent in the south and the Tibetan Highland in the north. The study region extends from Himal Pradesh (India) in the west, over Nepal and Bhutan to Arunachal Pradesh (India) in the east. Using three different modelling approaches (Boosted Regression Trees, Maxent and Random Forest), we aim at examining climatic factors controlling the species distribution

under current climate conditions. We found two temperature-related (Temperature Annual Range, Mean Temperature of the Wettest Quarter) and three precipitation- related variables (Precipitation of the Driest Month, Precipitation Seasonality and Precipitation of May) to be useful for predicting the potential distribution of *B. utilis*. Model accuracy was measured by a multi-faceted evaluation approach, using threshold-independent and threshold-dependent measures. We found all modelling algorithms having a high predictive power (Area Under the Curve ≥ 0.96 and True Skill Statistics ≥ 0.86). Finally we compiled an intersected map, displaying the area predicted by all modelling algorithms. We conclude accuracies of the current environmental niche models to have a significant impact on models under climate change scenarios, the significance of which should not be underestimated. With this study we constitute a new starting point for further analyses on range shifts of treeline species in the Himalayan mountains under climate change scenarios.
Keywords: climatic space, environmental niche modelling, habitat, range shift, treeline dynamics, treeline ecotone

Session 17-P11 - Metagenomic analyses of seasonal dynamics of phyllosphere fungi in *Fagus sylvatica*

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Phyllosphere fungi colonize the surface (epiphytic) or the interior tissues (endophytic) of leaves. They appear symbiotically as part of the leaf microbiome on nearly all terrestrial plants. At least the fungal part of this microbiome consists of a diverse and abundant community and is highly influenced by biotic and abiotic factors. Recent studies on phyllosphere fungi revealed seasonal variation as an important factor structuring these communities. To test the seasonal dynamics of phyllosphere fungi in *Fagus sylvatica*, we benefited from the design of the Exploratories for functional biodiversity research (DFG Priority Programme 1374) and investigated the plot HEW11 (unmanaged forest) as exemplar plot. Samples of fresh beech leaves were collected biweekly within the vegetation period in Hainich-Dün (Thuringia, Germany) from five unvaried trees in 2015. We inferred the seasonal dynamics of phyllospphere fungi based on a metabarcoding approach using high-throughput sequencing (Illumina MiSeq) of the ITS-rDNA-region. To address *Fagus sylvatica* leaves as an ecological filter for the fungal community, we analyzed surface-sterilized (only endophytic fungi) and non-surface-sterilized (phyllosphere fungi) leaves in comparison. Our results indicate that the composition of the fungal phyllosphere OTUs at each time point is highly variable during the vegetation period. In direct comparison endophytic fungi revealed a lower variation, but both communities seem to expand during the vegetation

period. Additionally, our data suggest that the fungal community becomes more consistent towards the end of the season.

Session 17-P12 - Treeline responsiveness to climate warming: Insights from a Himalayan krummholz treeline ecotone

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Climate warming is expected to induce treelines to advance to higher elevations. Empirical studies in diverse mountain ranges, however, give evidence of both advancing alpine treelines as well as rather insignificant responses, pointing to an evident research deficit. We aim at investigating the sensitivity and response of the near-natural treeline ecotone in Rolwaling Himal, Nepal, to climate warming. Treeline response is analyzed focusing on the modulation of climate change effects by spatially differentiated patterns and processes. We implement an integrated landscape approach focusing on topography, climate, soils and vegetation on randomly selected forest stands along elevational transects (3700-4200 m) across the ecotone. Objectives of this poster are to identify environmental variables which influence the complex species specific stand density of the krummholz treeline ecotone and assess the parameter's relevance in particular with regard to climate change effects on stand structures. Our methods comprise extensive field sampling and modelling of vegetation, soil and climate data. Results indicate that tree species populations of the treeline ecotone show species-specific responses to the influence of environmental parameters, and that juvenile and adult stand responses are modulated by different variables.
Keywords: *Abies spectabilis*; *Betula utilis*; Climate change; Multivariate analyses; Regeneration; *Rhododendron campanulatum*; Rolwaling Himal; *Sorbus microphylla*; Species composition; Treeline dynamics

END OF SESSION 17

Session 18 – Plants and water - mechanisms, fluxes and experiments from the leaf to the ecosystem

Short title: Water - from the leaf to the ecosystem

Chairs
Dr. Henrik Hartmann
Prof. Dr. Thorsten Grams,
Dr. Ansgar Kamen

Session 18-O1 - Water transport in plants: why does it work, and when does it fail?

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Long distance water transport in plants relies on a system that typically operates under tension as commonly accepted by the cohesion tension theory. However, this system is prone to hydraulic failure due to gas bubble formation, resulting in trapped gas emboli that disable the hydraulic pathway. Two main, controversial questions addressed in this presentation include: (1) Why are plants able to transport water transport under tension?, and (2) How common is embolism formation and refilling in conduits? One primary mechanism of gas bubble formation takes place at intervessel pit membranes, which are composed of cellulose fibrils with geometrically highly variable pores. Traditionally, the high surface tension of pure water is assumed to prevent bubble entry. However, amphiphilic, choline containing phospholipids and proteins are found in uncontaminated xylem sap. These substances function as surfactants, appear to be secreted by vessel associated parenchyma cells, accumulate in intervessel pit membranes, and line the inner conduit walls. Postfixation of fresh wood samples with osmium tetroxide shows dark, electron dense intervessel pit membranes under the transmission electron microscope due to the binding of osmium with unsaturated, fatty acid chains of phospholipids. Moreover, surfactants lower the surface tension substantially, resulting in rapid, snap-off events by the movement of an air-water meniscus through the tortuous pathway of many pores in intervessel pit membranes. Area-dependent surface activity of the coating will affect nanobubble behaviour under pressure fluctuations and possibly favour dissolution over expansion, thereby avoiding embolism, which also makes xylem sap gas-saturated or supersaturated.The finding that safe and stable nanobubbles occur in plants complements the cohesion-tension theory and suggests that embolism formation is less common than previously thought. In addition, microCT

observations of xylem tissue in intact plants confirm that embolism resistance is typically higher than some indirect measurements on stem segments suggest.

Session 18-O2 - Bordered pits in xylem tracheids of vesselless angiosperms and their misinterpretation as ‚cryptic' vessels

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Vesselless wood represents a rare phenomenon within the angiosperms, characterizing Amborellaceae, Trochodendraceae, and Winteraceae. Due to the lack of perforation plates, it could be suggested that vesselless taxa show special anatomical characteristics associated with tracheids to overcome potential disadvantages in their water transport capacity. Yet, anatomical details of intertracheid pits, which represent openings in the secondary cell wall between adjacent tracheids, are poorly studied in vesselless angiosperms. Based on light and electron microscopy, the intertracheid pits were investigated in 11 vesselless species to better understand their ultrastructure. Intertracheid pit membranes were electron transparent, showing black dots after fixation with OsO_4 due to the binding of osmium particles with double carbon bonds in unsaturated fatty acid chains of phospholipids that accumulate in the meshwork of cellulose microfibrils. The intertracheid pit membranes showed a homogeneous thickness, ranging from 143 to 292 nm. The pit membrane thickness and OsO_4 staining reaction was similar to intervessel pit membranes in vessel-bearing species, providing evidence for the occurrence of xylem sap surfactants. However, shrunken, damaged, and aspirated pit membranes, up to 60 nm in thickness, occurred in dried wood samples of all species and in latewood tracheids of *Tetracentron* and *Trochodendron*. Scanning electron microscopy demonstrated that shrunken pit membranes showed artificially enlarged (> 100 nm) pores, which were lacking in fresh material of *Drimys winteri* based on perfusion experiments with 20 nm colloidal gold particles. The association between shrunken, dried pit membranes and large pores provides an explanation for the misinterpretation of "cryptic vessels" in vesselless angiosperms. Finally, unusual tracheids, which were characterized by alternate bordered pits on their tangential walls, were limited to *Tetracentron sinense*.

Session 18-O3 - Water status measures on mature individuals of five European forest tree species indicate species-specific differences in drought performance

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Estimating the performance of mature tree species during dry periods is key to forecasting future forest species compositions and changing forest management to adapt for the predicted increase in drought frequency. Yet, the assessment of water status parameters in tall trees is generally difficult due to limited canopy access. We therefore used the Swiss Canopy Crane (SCC) facility in a mixed forest in North-Western Switzerland to measure water potential in the crowns of mature forest trees and assessed sap flow and stem diameter variations (SDV) at the stem base. We calibrated the SDV measurements with water potential values and were, thus, able to model the seasonal course of branch water potentials in the five species during one moist (2014) and one exceptionally hot and dry (2015) growing season on a day to day resolution. We compared both intra-species differences between the two years and inter-species differences in drought performance. We hypothesized that the ring-porous *Q. petraea* would show the highest performance during drought followed by diffuse-porous species and conifers. While most species showed a reduced sap flow in the dry compared to the moist season, *Q. petraea* was even able to increase its sap flow in the dry season. The strongest decrease in sap flow over the course of the dry period in 2015 was observed in *P. sylvestris* and *P. abies* followed by *F. sylvatica* and *C. betulus*. *Q. petraea* showed almost no decrease in sap flow. Modeled and measured water potential values indicate a strictly isohydric behavior in *P. sylvestris* as opposed to a pronounced anisohydric behavior in *Q. petraea*. *P. abies*, *C. betulus* and *F. sylvatica* gradually fell in between these two types. We conclude that of all the investigated species *Q. petraea* has the highest performance during drought followed by *F. sylvatica*, *C. betulus* and the coniferous species. In the long run, however, a strict isohydric strategy as exhibited by *P. sylvestris* might outcompete an anisohydric strategy under prolonged and high-frequent drought periods. This should be subject to further long-term studies.

Session 18-O4 - Heat and drought: Stress and recovery responses of Aleppo pine seedlings

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Aleppo pine trees growing at the arid timberline (Yatir forest, Israel) are facing extreme seasonal drought combined with hot temperatures during summer and short heat wave periods in spring. These heat waves have large effects on the forest carbon and water exchange, and might likely increase in severity with predicted climate change scenarios. To better understand the trees' physiology during stress and subsequent ability to recover from heat and drought, we performed a greenhouse experiment on one-year-old *Pinus halepensis*. Soil moisture was kept close to the winter optimum in the control and heat treatment and close to summer values in the drought and heat-drought treatment. The trees

of the heat treatment were exposed to two short heat waves (4-days each) with temperature maxima of 43°C, about 15°C above the control and drought trees. Aboveground carbon exchange, transpiration and emissions of selected volatile organic compounds (VOC) were measured continuously using automated tree chambers (n=4 per treatment). To detect changes in biomass allocation and carbohydrate pools, additional trees were sampled before, during and at the end of the stress periods. We will present first results of stress and recovery responses of carbon and water exchange including VOC emissions. In combination with changes in biomass allocation and carbohydrate pool analysis, this can give us a better view on pine seedling performance during periodic combined environmental stress.

Session 18-O5 - Finders keepers, losers weepers - drought as a modifier of competition between European beech and Norway spruce -

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Mixed stands of European beech and Norway spruce frequently reflect over-yielding, when compared to respective monocultures. Under climate change, however, water limitation may become crucial in modifying the competitive interaction between neighboring beech and spruce trees. To this end, we investigate species-specific drought response including underlying mechanisms of species interaction in a maturing group-wise mixed beech-spruce forest. Experimental drought is being induced over several years through a stand-scale approach of rain throughfall exclusion (Kranzberg Forest Roof Experiment). The experimental design comprises 6 roofed (closing only during rain) and 6 control plots. Drought stressed spruce showed a distinct decrease in both stomatal conductance (g_s) and net assimilation rate (A_{net}) by more than 80%, suggesting isohydric response. Beech rather displayed anisohydry indicated by less pronounced reduction of g_s and A_{net} by more than 50%. In the control, a negative species interaction effect on g_s was found in beech, contrasting with a positive effect in spruce. Drought reversed the effect of species interaction on g_s, suggesting competition release in beech and by contrast, a shift from facilitation to competition in spruce. Based on fine root distribution and soil moisture assessments, we interpret this reversed interaction effect as a consequence of different spatio-temporal patterns of soil water use in combination with enhanced root stratification in the beech-spruce mixture. Under humid climate conditions the strategy of spruce (isohydric, shallow rooting) appears to be advantageous. During extended periods of drought, however, shallow rooting and early stomatal closure limits the accessibility to deep soil water and photosynthetic carbon assimilation,

eventually constraining competitiveness of spruce. Regarding g_s, positive effects of beech-spruce interaction are overridden under extended periods of drought.

Session 18-O6 - Drought impact on reactivity of ectomycorrhizal communities of spruce and beech

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We analyzed ectomycorrhizal community composition, enzyme activities and morphological traits to identify mechanisms of drought adaptation in the two tree species *Fagus sylvatica* and *Picea abies*. The two trees belong to the anisohydric respectively isohydric spectrum of stomatal closure upon dry spells. The main research question of the joint experiment is whether mixture of different tree species enhances stress resistance and resilience against drought compared to trees neighboring the same species. Fine root samples were collected at the Kranzberg Roof Experimental Site next to the Campus of Technische Universität München, Germany. 6 of 12 plots were equipped with retractable roofs to exclude precipitation during the vegetation periods of 2014-2015. Soil samples were always taken at the end of the vegetation period in late autumn. 2013 samples were analysed to account for inter-plot variability before the drought experiment started. In the year 2013, community composition was not different between the control and future drought plots. This changed in beech already in 2014 and also was visible in 2015, while changes in spruce were only visible in 2015. Community composition changed also between horizons and according to the neighbor (same or other tree species). Enzyme activities revealed complex patterns but overall indicated high functional redundancy and relative little changes could be attributed to the drought treatment. It appears that beech in the first two years of severe drought is able to maintain a flexible root system that allows to maintain structures to forage for resources (water and nutrients) while spruce roots do not seem to profit from mixture with beech at the level of fine roots and their mycorrhizae. This points towards limits of the isohydric strategy when maintenance of the root system prevents to invest in mycorrhizae at the expense of potential space exploitation.

Session 18-O7 - Effect of drought and nutrients on the distribution of recently assimilated carbohydrates to ectomycorrhizae of poplar

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Ectomycorrhizae (ECM) are considered to play a significant role in resistance and resilience mechanisms of trees during and after drought. Concomitantly, the nutritional status of the plant influences their fitness. So far most experiments on nutrient stoichiometry have been conducted with arbuscular mycorrhizal fungi. In a greenhouse experiment, poplars were grown under low and high N (nitrogen) and P (phosphorus) fertilization regimes (↑N & ↓P; ↓N & ↑P; both↑and both↓) and subject to drought followed by rewatering and continuous irrigation (control), respectively. Our main focus was on the recovery phase following the drought period. We studied carbon allocation to poplar ECM using ^{13}C and the dynamics of extracellular enzyme activities involved in carbon and nutrient release. According to the stress gradient hypothesis we assumed that the benefit of ECM for trees would be highest under low nutrient availability (N, P) in soil. A reduction of carbon supply to the ECM was hypothesized to increase degrading enzyme activities due to altered C:N:P stoichiometry. During the drought period, photosynthesis was reduced due to stomatal closure compared to controls. After rewatering, photosynthesis of drought treated plants recovered, achieving the rates of continuously irrigated control plants. ECM received considerably more photosynthates in the recovery phase after rewatering than the ECM of the continuously irrigated control plants in the same time period. In agreement with our hypothesis, carbon allocation to ECM was highest where neither N nor P was added and lowest where both nutrients were added. Exoenzyme activities were highest in drought treatments but did not differ significantly due to either fertilisation. This indicates promotion of mycorrhizal growth and mobilization of C, N and P by mycorrhizae during recovery after drought stress.

Session 18-O8 - Land use impact on diversity and water related traits of three African savanna grass species

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In African drylands, land degradation is a major problem largely been attributed to climate change and changing land use. Thus, an understanding of the relationships between degradation processes, land use, climate and vegetation is necessary. Multiple factors are involved regarding drylands under grazing. Within these areas, land use gradients exist which are thought to be built out of multiple ecological gradients like disturbance by grazing, shrub cover or water availability. That raises the question which properties of the vegetation are best related to these gradients and what are the underlying processes. Plants have developed a variety of possibilities to avoid drought. Thus, traits can be used to predict water related

properties of these gradients. Different processes in plants are affected by drought, but relations between soil moisture and water extraction of the different functional types, growing in Namibian semiarid savanna, and eventually determining their occurrence, are widely unknown. In our study, we focused on the diversity of the herbaceous community and on water related traits of perennial and annual grass species across a land use gradient. We showed that areas with high shrub cover include higher species number than areas with lower shrub cover. It can be suggested that disturbance through land use positively affected diversity. Moreover, cover of perennial grasses decreased, cover of annual grasses increased with an increasing shrub cover gradient, providing evidence of the importance of disturbance. Regarding ecohydrological relationships, 'turgor loss point' (TLP) was, however, found to be more negative in perennial grass species than in the annual grass species. This indicates a better adaption of the perennial species to withstand drought periods. It may point out to a superimposed positive ecohydrological feedback loop of land use. Additionally, the annual species seems to extract water out of deeper soil layers than the perennial grass species. It is suggested to proceed from hydraulic uplift, because individuals of the annual species grew mainly under acacias. In contrast with such trait data across functional types, at the group level of perennial grasses there is no evidence of land use induced ecohydrological feedbacks. Grazing seems to have a major effect on plant communities here.

Session 18-O9 - Effects of nitrogen availability and drought on interactions of a hemiparasite with its host species

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Climate change and nitrogen deposition are major drivers of global change. Both drivers may differently affect biotic interactions among plants and hemiparasites. Hemiparasites, such as *Rhinanthus alectorolophus,* are photosynthetically active plants which attach to the roots of host plants to obtain water and solutes. Apart from being a source of solutes for the hemiparasite, the hosts are competitors for light. Therefore, effects of nitrogen and drought may not only act directly on the hemiparasite or host performance, but indirectly via changes of competitive interactions. To test how nitrogen availability (low, medium and high) and drought (no drought, periodic drought) influence the host and hemiparasite performance and change interactions among the latter, we performed a full-factorial experiment in a climate chamber. We used *Rhinanthus alectorolophus* as hemiparasite and *Dactylis glomerata*, *Medicago sativa* and *Sanguisorba minor* as host species. First results indicate that nitrogen availability increases, while drought decreases the stem length and flower number of the hemiparasite. However, further analyses on

the host performance may deliver insights into changes of the interactions between the hemiparasite and its host species.

Session 18-O10 - How do changes in CO_2 concentration affect cellulose δ18O?

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Cellulose oxygen isotope ($\delta^{18}O_{cell}$) is often used as a proxy in retrospective environmental and ecological research including paleoclimatic study. However, $\delta^{18}O_{cell}$ is influenced not only by climatic factors (such as precipitation and temperature) but also by physiological processes. For example, $\delta^{18}O_{cell}$ can be influenced by carbohydrate turnover rates (τ) because the degree to which organic molecules exchange oxygen with local water during cellulose synthesis (p_{ex}) varies under different τ. Therefore, factors that can affect τ, such as atmospheric CO_2 concentration or water availability, might also influence the interpretation of $\delta^{18}O_{cell}$ in paleo-climatic studies. To partition the contribution of these factors, we grew winter wheat (*Triticum aestivum*) under different [CO_2] spanning from glacial to present (170, 280, and 400 ppm) and under different water availability (well-water and drought). We addressed the following questions: 1) how do [CO_2] and water availability influence $\delta^{18}O$ of leaf water and cellulose and 2) can changes in $\delta^{18}O_{cell}$ be explained by carbohydrate turnover rates (τ)? Although our analyses have not been completed yet, results from this experiment will have important implications for the interpretation of $\delta^{18}O_{cell}$ data in environmental/ecological studies.

Session 18-O11 - Encroachment of *Elymus athericus* in salt marshes - The role of waterlogging and physiological integration

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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* even into low marsh areas. 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 an experiment we tested how N-availability, sedimentation rate or elevation, as a proxy for flooding frequencyaffects the growth of single *Elymus* plants. In a salt marsh in Schleswig-Holstein we planted *Elymus* in four experimental blocks with different sedimentation rates and applied three levels of N-fertilization treatment to subplots within blocks. Elevation was measured in each sub-plot as a proxy for flooding frequency. We found elevation to have a positive effect on *Elymus* growth in the experiment. Our results suggest that *Elymus* is not able to grow in low elevations, most likely because these are flooded more often which causes hypoxia. In a second experiment, we therefore tested in the greenhouse how Elymus is able to spread into unsuitable wet habitat. We determined whether *Elymus* mother ramets are able to support daughter ramets under stress (waterlogging) via the rhizome, a process called physiological integration. We tested for this physiological integration in plant pairs of mother and daughter ramets by using a ^{15}N-marker on mother ramets. First results suggest that this process is indeed likely to lead to successful establishment of Elymus in low salt marshes.

Poster presentations

Session 18-P1 - Water transfer between bamboo culms indicated by deuterium tracing

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Bamboos are long-lived woody monocots. Their culm walls have abundant parenchyma and culms are often connected by rhizomes. The aims of our study were to analyze water residence times as related to culm water storage, culm water use and water transfer between culms. In a common garden in Bogor, Indonesia, deuterium (D) was injected once to culms (> 10 m high) situated at edges of big clumps of *Bambusa vulgaris*, *Dendrocalamus asper* and *Gigantochloa apus*. In these culms, D was traced over time in water transpired from leaves and finally analyzed in different organs. In addition, water extracted from freshly sprouted and established culms in the neighborhood of the labelled culms was analyzed frequently. Sap flux densities were also measured with thermal dissipation probes (TDP) at two culm heights and species-specific calibration parameters were applied. The D-derived water residence time in labelled culms was 5 to 6 days. Residence time was not much influenced by the estimated contribution of the culm water storage to transpiration, probably because of its limited importance. Classically calculated, the daily water use of labelled culms by

the D tracing method and the calibrated TDP method were highly and linearly correlated (R^2=0.9) but by 70% higher from D tracing results. This difference can only partly be explained by D retention or incomplete mixing. It was most likely related to D transfer, as increased D concentrations were observed in both freshly sprouted and established culms neighboring the labelled culms. An isotope mixing model suggests considerable contributions of transferred water to daily transpiration of a culm; on average 10% of water use of a freshly sprouted culm came from a labelled, connected culm. One may consider that bamboo culms are usually connected to more than one other culm. We conclude that bamboos exchange water, likely via rhizomes, and the contribution of transferred water to transpiration can be considerable in culms situated at clump edges.

Session 18-P2 - Does long-term drought affect phloem functionality in mature European beech?

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Study objects are c. 60 year-old beech trees, readily accessible via scaffoldings and canopy crane at the study site Kranzberg Forest (30 km north-east of Munich, Germany). Effects of severe and long-term summer drought are assessed in an ongoing throughfall-exclusion experiment with roughly 100 trees assigned to a total of 12 plots (**K**ranzberg forest **ROOF** experiment, kroof.wzw.tum.de). The drought treatment started in 2014 with precipitation throughfall being completely excluded from early spring (March) to late fall (end of November). In a similar way, throughfall exclusion was repeated during 2015/2016. On average, lowest pre-dawn leaf water potential of beech trees reached -2.2 MPa during late summer. The hypothesis was tested that long-term drought negatively affects phloem functionality, e.g. speed of sugar transport. Allocation of recently fixed photoassimilates was assessed by branch-bag labelling with 99 atom% $^{13}CO_2$, employed for few hours. Dynamics of C allocation were mostly pursued assessing carbon isotopic composition of CO_2 efflux from branches. Mean residence time of ^{13}C label in the leaves was increased from 34.5 h under control conditions to 52.6 h under drought. The speed of phloem transport, however, appears unaffected with an average velocity of 0.15 m/h.

Session 18-P3 - Stem diameter variations of six temperate European forest tree species reflect the species' water status

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Assessing a trees' stem water potential is essential to evaluate the tree's performance during drought. Particularly for mature trees, it is, however, extremely hard to monitor water potential throughout the growing season because of the difficulty of canopy access. Daily variations of stem diameter (SDV) could provide a powerful alternative. SDV have been shown to incorporate both radial growth and the diurnal shrinkage and swelling of bark tissue, which is caused by daytime transpiration and nighttime refilling, respectively. During dry periods, bark tissue that is depleted in water cannot entirely refill at night, leading to a progressive overall shrinkage of the tree's stem diameter and allows calculating values for tree water deficit (TWD). Comprehensive tests, if SDV-based values for TWD reflect values for a tree's stem water potential are yet missing for mature trees. As such, TWD has not yet been fully established as a simple and continuous proxy for a trees' water status. Using a canopy crane we calculated an SDV-derived TWD for six Central European forest tree species during one moist (2014) and one exceptionally dry (2015) growing season and compared these values to the trees' stem water potential. We found a tight overall relationship between stem water potential and TWD in all six species. Most of the six approaches that we used to calculate TWD yielded TWD values that resulted in significant relationships with stem water potential ($p < 0.001$) for the different species. However, only one TWD variable had the highest explanatory power (R^2) across the six species and both years (up to 86 % explained variation). Intriguingly, this variable does not account for radial growth during periods of shrinkage in its calculation indicating that plastic growth is impeded in such times. The relationship between TWD and stem water potential can best be explained by a logistic function. We propose that this function in combination with SDV measurements can be employed to estimate stem water potential of trees for an entire growing season. We conclude from our data that TWD is tightly correlated to the stem water potential of mature tree species and can, thus, be used to describe continuous seasonal variations in a tree's water status. Because of its relatively easy application and deployment, there is high potential for this method to play a major role in future investigations of tree water relations.

Session 18-P4 - Wilting point and water sources of savanna plant species along a precipitation gradient in Namibia

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Water is the crucial element in semi-arid ecosystems like savannas, since its availability determines plant occurrence and plant survival. Where precipitation is not evenly distributed, different plant species occur to use different water sources from the soil at different times of the year. Their ability to extract water from the ground is limited – the lowest soil water potential at which plants are able to absorb water from the soil is the so called Wilting Point. Every further loss in turgor below that point affects the growth, foraging and therefore the survival of the plant negatively. To gain knowledge about this ecohydrological feedback trait is important for a better understanding of how and why certain woody species displace grass species in the event of shrub encroachment in semi-arid ecosystems and to optimize process based simulation models which are based on that phenomenon. Therefore we measured Wilting Points of different encroachment species and a grass species on four sites along a precipitation gradient in Namibia and compared them. Furthermore Xylem water samples and rain water samples were collected and analyzed for isotopic composition to determine which water sources the plants use preferably. First results will be presented.

Session 18-P5 - Change in aboveground biomass and biodiversity along a precipitation and grazing gradient in Mongolia

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We concentrated on the steppes of Mongolia to show changes in above ground biomass and species biodiversity along a precipitation and grazing gradient. Both gradients represent environments with a long history of natural grazing. Over the last few decades, increasing population sizes and socio- economic changes have subjected the Mongolian steppes to increasing pressure and associated degradation. We expect a widespread trend of decreasing biomass with the decreasing precipitation gradient and the increasing grazing pressure. In the process, the decrease of precipitation will thereby show a change in community composition and biodiversity parameter. At the grazing gradient we expect a change in species composition and a decreasing species biodiversity with increasing grazing. We hypothesize, that Herbs tend to populate with increasing grazing, although this might be through the increase of annual herbs. Furthermore, with

medium grazing pressure the shrub population seem to rise. Most of the shrubs are *Artemisia* spec. or *Ajania* spec., which are species producing essential oils for avoidance of herbivory. It could be that grazing does have more influence in the relatively moist grass steppes whereas in the semi- arid deserts, precipitation controls community composition and productivity. In addition, soil samples were collected to see if the nutrient availability could be restricting productivity. Current results will need to be confirmed over the next few months.

Session 18-P6 - Quantification of sediment and nutrient retention by floodplain vegetation

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Floodplains along lowland rivers filter water via retention of sediments and nutrients. This ecosystem service of purification plays a crucial role in river restoration projects. Caused by the community structure and specific functional traits the floodplain vegetation reduces flow velocity while floods and cause sedimentation. However, it is still unclear, which functional traits cause the retention capacity of various plants and plant communities. Nevertheless, the functional traits, such as roughness,rigidity via shape, size, mass and emergences are expected to be key factors. This study aims to identify the key traits that are responsible for sediment and nutrient retention in floodplain vegetation from the level of single leaves to the level of whole plant communities. We hypothesise that the species with rougher leaf surface, i.e. denser emergence cover, retains more sediment than plain and smooth leaves. Therefore, a flume experiment with simulated inundation will be conducted. The sedimentation on the leaves of several typical floodplain species will be analysed. Further, we address the question, how various plant communities influence flow velocity differently caused by their structure, i.e. height, density, rigidity and biomass. Therefore, we plan to measure these structural parameters in floodplain communities along the Mulde River, Germany, in situ. To be able to predict nutrient retention, nitrogen and phosphorus will be analysed in the vegetation and the soil. Additionally, in situ sedimentation will be measured with sediment traps, while a flood event. Finally, the project will upscale the findings to be able to make predictions of the role of different plant communities on sediment and nutrient retention capacity. The revitalisation along the Mulde River is expected to change the plant composition. How will that change the purification capacity?

END OF SESSION 18

Session 19 – Biological invasions: novel interactions, communities, and modified ecosystem processes

Short title: Interactions and processes in novel communities

Chairs
Dr. Lotte Korell
Dr. Kristin Ludewig
Dr. Madalin Parepa

Session 19-O1 - Rapid evolution during plant invasion influences competition with native species

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Biological invasions have provided classic examples of how evolution can influence contemporary ecological dynamics. Invasive species often evolve clines in traits such as size and phenology as they spread along environmental gradients in their new range, leading to the concern that evolution could influence the outcome of interactions, such as competition, with native species. This could happen by increasing the fitness of locally adapted non-native genotypes relative to natives, and by altering the degree of niche overlap between the invader and native species. The net effect of these changes could affect the outcome of competition by changing the way in which species compete for resources, either making coexistence more or less likely. *Lactuca serriola* is an annual plant native to Eurasia, which has a global distribution and has evolved its flowering phenology as it spread along climate gradients in the new range. We conducted field experiments to parameterize mathematical models to ask how the evolution of phenology in *Lactuca* has affected its potential for coexistence with a native plant community in California. Knowledge of the introduction history of this species makes it possible to demonstrate the impact of evolution on competitive outcomes by comparing ancestral and descendent populations. *Lactuca* populations from the regions with the warmest climate, including the local non-native population from California, bolted and flowered earlier than those from cooler climates from the native range – except for a few individuals, plants from the population originating from the coolest climate (from Switzerland) failed to bolt at all. Variation in phenology affected the ability of *Lactuca* to suppress native competitors, with early flowering plants exerting a stronger competitive effect on native species than late phenology plants from the native range. This suggests that evolution of phenology during

invasion has reduced the potential for the native and introduced species to coexist. This demonstrates the contribution of evolution to invasion dynamics, and more generally that evolution can affect contemporary community dynamics.

Session 19-O2 - Post-introduction evolution of invasive Chromolaena odorata in response to water deficit

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Clines of ecologically important traits along environmental gradients have been considered as adaptation to local environments and could contribute to the success of some invasive species. Phenotypic plasticity and post-introduction evolution are two mechanisms might cause cline variations during plant invasions. However, clines variations may also arise due to multi-introduction of pre-adapted genotypes from different native populations. Although colonizing history is important in interpreting the mechanisms under clines, few studies tried to include colonizing history when analyzing the mechanisms underlined clines in success invasions. *Chromolaena odorata* (Asteraceae), a perennial native to Central American regions, was first introduced into India in 1840s and from there it spread into many habitats in (sub-) tropical Asian regions. The species occupies habitats varied in water deficit and habitats with a dry season are particularly vulnerable to *C. odorata* invasions. To study the roles of phenotypic plasticity and post-introduction evolution on *C. odorata* in response to water deficit, we grew *C. odorata* plants from 13 native and 15 invasive populations under ambient conditions or a 50% rainfall reduction treatment. We found clear clines in biomass allocation pattern to climatological water deficit in native and invasive *C. odorata* populations when grown in ambient or 50% rainfall treatment. However, cline trends differed between native and invasive *C. odorata* populations. Based on the species colonizing history in Asia, we inferred that post-introduction evolution might have occurred in invasive *C. odorata* populations in response to water deficit. The species might be able to invade temporally dry habitats through shifts in biomass allocation from leaf development to stem growth and reproduction.

Session 19-O3 - Selfing ability as a driver of alien plant naturalization on islands

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Baker's Law poses that plant species with selfing ability are more likely to colonize oceanic islands after long distance dispersal compared to ones that require mates and pollinators. On the other hand, there is a high frequency of self-incompatible and dioecious species in the floras of some islands. This contradiction might be the result of subsequent evolution of species traits, as the colonization has happened long ago. The potential for evolution of self-incompatibility or dioecy post-arrival on an island should still be small for naturalized alien species. When plant species are introduced on islands by humans, the ones with high selfing ability should be more likely to naturalize there, because suitable mates and pollinators are likely to be more limited than on the mainland. To test whether the benefit of selfing ability for naturalized alien plants is larger on islands than on the mainland, we used a global breeding-system database of angiosperm species, and combined it with the Global Naturalized Alien Flora (GloNAF) database. Of the 1,752 species in our database, 498 have become naturalized outside their native ranges, among which 285 are naturalized on islands. Phylogenetic logistic regressions showed that alien species naturalization on islands was positively associated with selfing ability (at least so with autofertility). Path analysis showed that species with high selfing ability (both self-compatibility and autofertility) are more likely to naturalize on islands, as such species are also more likely to be annuals or biennials, and occupy large native ranges, both of which in turn increase their ability to naturalize on islands to which they were introduced. By showing a positive association between alien plant species naturalization on islands and selfing ability, which is mediated by indirect effects of annual or biennial life form and a large native range, we provide support to the validity of Baker's Law.

Session 19-O4 - Genetic diversity, fluctuating resources, and the resistance of native plant communities to *Solidago* invasion

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It has been frequently shown that species-rich plant communities are more resistant to invasion than species-poor communities. In contrast, the influence of genetic diversity has been much less studied. Besides genetic and species diversity,

another key driver of community invasibility are resource conditions. Specifically, communities should be more vulnerable to invasion under fluctuating resource conditions. The aim of our study was to gain insight into the interplay between genetic diversity and nutrient availability in determining plant community invasibility. We established mesocosms with artificial communities of native plants, either with low or with high intraspecific genetic diversity of the native plants, that were confronted with an invading species (*Solidago canadensis*). In addition, a high or low amount of nutrients was either applied in a constant or a variable manner in ten applications over the experimental period of 100 days. As a measure of invader success, the portion of aboveground biomass represented by *Solidago canadensis* was determined for each community at the end of the experiment. Here we present our results for the relationship between intraspecific genetic diversity and nutrient availability, respectively, on the invasibility of a native plant community.

Session 19-O5 - A global legume invader shows high resistance towards extreme weather events and competition

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Climate and competition by other species are the primary filters affecting the invasiveness of alien plants. Changes in the invasiveness of single species under climate change, especially under extreme weather events, are thus of major conservation concern, but little studied. The effects of extreme weather events and competition on the invasibility of the non-native *Lupinus polyphyllus* were investigated. We used three experimental approaches: (A) effects of severe drought, fluctuating precipitation, and late frost events (-3°C, -7°C, -10°C) were assessed for three life cycle stages (seedling, juvenile, adult) for potted *L. polyphyllus*; (B) competition of native grassland species with *L. polyphyllus* was tested in a pot experiment; (C) the combined effects of drought and competition were tested within native temperate grassland vegetation in an experimental field site. Drought reduced the survival of juvenile *L. polyphyllus*, and juveniles and seedlings showed growth reductions and increased senescence. Fluctuating precipitation and late frost, but not drought reduced the length of inflorescences. Juveniles were most frost sensitive, already dying at temperatures below -7°C. Interspecific competition altered metabolism, reduced photosynthetic activity and negatively affected aboveground growth of *L. polyphyllus*. Under competition and drought, *L. polyphyllus* saved water while simultaneously increasing photosynthesis. First slight stress effects occurred after 6 weeks in competition and

drought. *L. polyphyllus* seemed resistant towards many extreme weather events. Neither drought nor late frost completely impeded its growth. The further spread across most of Europe seems likely, as drought performance of the legume invader was superior compared to native vegetation.

Session 19-O6 - Colonization of New Marginal Habitats, Effects for Life History for the Long-lived Ocean Quahog Arctica islandica

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Marginal populations of species are often characterized by the reduction of genetic diversity and thus reducing population viability and evolutionary potential as compared to their habitat of origin. Limits of the colonization potential can be influenced by the individual's demographic response to variation in environment. Since marginal populations are often geographically isolated from their original habitats, their persistence mainly depends on the balance of reproduction rates and mortality. Therefore the question arises whether or not individuals of both marginal and original populations exhibit similar trends in key life history attributes such as growth, reproduction and mortality. Therefore, the geographically isolated, brackish Baltic Sea with a strong gradient in salinity and temperature provides a unique model system to study the consequences of invasion of marine species from e.g. the North Sea. The ocean quahog *Arctica islandica* (Bivalves) is the longest-lived complex animal reported so far with a maximum life span of > 500 years, which makes it a unique model to understand life-history patterns in long-lived organisms. One aim of our project is to investigate the demographics of three populations of *Arctica islandica*: (1) the population at the northern limit of its geographic range of distribution (ICELAND), (2) the population at what is believed to be its southern limit (IRISH SEA), and (3) a marginal population (the brackish water of the BALTIC SEA). The specific intention is to identify the type of senescence observed in each population. Random samples of 592, 1025, and 770 individuals of the Iceland, Irish Sea (Belfast), and Baltic Sea populations respectively were analyzed. The second aim of our project is to investigate the molecular aging process and cellular damage parameters of the shortest- (BALTIC SEA) and longest-lived (ICELAND) populations of *A. islandica* to understand the drivers of long life span.

Session 19-O7 - Impact of the invasive Impatiens glandulifera on the growth of co-occurring native plant seedlings

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Biological invasions are a major threat to biodiversity. One possible reason for the success of alien plant species is that they can outcompete native plant species by allelopathy (novel weapon hypothesis). It is known that *Impatiens glandulifera* (Himalayan Balsam) produces allelochemicals and can suppress the growth of natives. But up to now it is not known, whether already seedlings of the Himalayan Balsam affect the growth of native seedlings and if they are immune to their own allelochemicals. We investigated the impact of *I. glandulifera* seedlings on the early seedling development of the Himalayan Balsam itself, *Lepidium sativum* and four European native plant species, often growing in ecosystems invaded by the Balsam. Germinated seeds of the target species were placed on Agar together with seeds of *I. glandulifera* and radicle growth and biomass were measured. In a second approach the germinated seeds were grown on Agar containing (1) different amounts of dried and powdered *I. glandulifera* seedlings or (2) different concentrations of 2-Methoxy-1,4-naphthoquinone (2.MNQ), known as an allelopathic agent produced by *I. glandulifera*. Results indicate species specific growth suppression by *I. glandulifera* seedlings and by high concentrations of added 2-MNQ. In *Urtica dioica* and *Lepidium sativum* the radicles were up to 46% shorter under influence of the Indian Balsam. However *Geum urbanum*, *Salix fragilis* and *Filipendula ulmaria* were not affected. Notably *I. glandulifera* was immune to 2-MNQ. Although *Urtica dioica* was the only native species affected by *I. glandulifera* suppression of seedling development by the invader may be highly advantageous when colonizing bare soil, where plant recruitment from seeds is crucial. Co-occuring species may be outcompeted, facilitating the development of pure stands of the Himalayan Balsam.

Session 19-O8 - The good, the bad and the integrated. How different aspects of traits affect co-occurring invasive and native species?

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Traits of invasive and native species have often been compared, as they underpin their interactions and determine their ability to respond to environmental changes. Traits related to superior fitness and plasticity are generally considered to facilitate invasions, while differences in niche-related traits should mediate coexistence among invading and resident species. Furthermore, species-specific response to the environment often comprises multiple traits, but trait correlations may constrain plasticity in response to environmental drivers. Collective effects of fitness- and niche-related traits, their variability and integration are however unclear, especially in natural communities where multiple factors operate simultaneously. In this study, we compared mean values, intra-population variation and phenotypic integration of fitness-related traits and biomass allocation in three invasive-native pairs of congeneric annual species co-occurring in riparian plant communities of three river systems in Central Europe. We hypothesized that invasive species show higher values of fitness-related traits, while biomass allocation should reflect environmental conditions of riparian habitats. In addition, we expected phenotypes of invasive species to be less integrated. Invasive species showed larger plant height and biomass, and allocated more biomass to stems on the expense of leaves. We suggest that higher stem allocation leads to increased plant size and in turn to a competitive advantage of invaders. Within-population variation showed no differences between invasive and native species. We suggest that these annual invaders may be established long enough to display similar intra-population variability as native species. Although invasive species did not consistently differ from native species in the strength of phenotypic integration, patterns of trait correlation were different suggesting differences in the response to environmental fluctuations within each congeneric pair.

Session 19-O9 - Asymmetric trait-based niche overlap indicates a higher competitive ability of invasive flower visitors than natives

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Invasive species often outcompete native ones. The strong competitive ability of invasives is often attributed to their broad resource use and ability to rapidly and efficiently exploit resources. In plant-animal interactions, niche size (i.e. resource

use) and overlap (i.e. competion potential) of native and invasive animals is often estimated based on the number of (shared) plant species used as resources. However, whether an animal is able to exploit plant-based resources has been shown to be mediated by functional plant traits. In this study, we quantified the niche sizes and overlaps of native and invasive flower visitor taxa based on functional floral traits in the heavily invaded Hawaii Volcanoes National Park in order to reveal the ecological mechanisms underlying competition. Niche sizes and overlaps were quantified using a novel trait-based approach (*dynamic range boxes, dynRB*). *dynRB* adopts the concept of *n*-dimensional hypervolumes where each dimension of the hypervolume represents one floral trait that affects foraging choices of flower visitor species. On average, invasive flower visitors were more generalized in resource use (larger occupied trait-based niches) than natives, which is additionally exemplified by the absence of native flower visitors on invasive flowering plant species. Additionally, natives shared a larger proportion of their trait-based niches with introduced taxa than *vice versa*. This asymmetric niche overlap suggests higher competitive abilities of invasives. Predicted range expansion of invasive plant and flower visitor species may further reduce the availability of resources for native flower visitors and at the same time competition for the remaining resources may increase. Thus, the large niche sizes of invasive species as well as their strong competitive abilities pose severe current and future threats for native flower visitor species and the Hawaiian ecosystem.

Session 19-O10 - Invasion success of exotic plant species: merging global distribution data with results of two reciprocal multispecies common garden experiments

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Novel environments are especially challenging for introduced plant species, if local biotic or abiotic conditions are unfamiliar and plant species lack specific adaptations. At the global level, ultraviolet B radiation intensity fundamentally differs among regions with much higher levels in the southern than in the northern hemisphere. UVB radiation, thus, can act as an environmental filter, which might particularly apply for non-indigenous plant species from Europe in New Zealand. Plastic responses to high UVB at first can help exotic species to successfully establish in the invaded range and furthermore foster subsequent adaptations. Global species distribution data in response to UVB radiation may provide insights into the UVB niche breadth of plant species. Multi-species comparisons in

reciprocal common garden situations, in addition, are suitable to assess the relative importance of plasticity towards UVB for invasion processes at the local scale. Hence, we conducted a multi-species experiment with 29 herbaceous species in two common gardens located each in the native and in the invaded range. In Germany and New Zealand, respectively, we applied three radiation treatments to native (German) individuals of all species: (i) natural sunlight, (ii) exclusion of UVB while allowing natural UVA, and (iii) exclusion of both UVB and UVA. During one growing season, measures of growth and productivity, such as leaf traits were recorded for all individuals in both common gardens. In addition we obtained global distribution data for all species to calculate UVB niche characteristics and range size. Consistently for both common gardens, a linear mixed-effect model showed an overall limiting effect of UVB on growth and productivity, such as leaf length and plant expansion. We also found species-specific differences in response to the radiation treatments, indicating different levels of UVB sensitivity of species: Exotic species with a broad niche in response to UVB radiation seem to be able to cope with higher UVB levels in New Zealand via plastic responses. The relationship between plasticity to UVB radiation and global distribution patterns, and its implication for the species' invasion success will be discussed.

Session 19-O11 - Effects of drought timing, drought intensity and drought duration on the success of exotic plants in native communities

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Many plant species that are invasive today have been introduced as ornamentals, and we continue to bring a large number of exotic species to our parks and gardens. It is likely that ongoing climate change will enable even more of those species to escape cultivation and spread in native habitats. In a previous experiment we showed that some exotic species were more successful relative to the natives when exposed to drought. Here we explored in detail the role of several dimensions of precipitation change on the success of exotic species in native communities. In particular, we tested the effects of drought timing, drought intensity and drought duration on the success of four exotic ornamental plant species growing together with native grassland species in mesocosm communities. The exotic species are not yet established or invasive in Europe, but are frequently used as ornamental garden plants. We found that the relative success of ornamentals was influenced by timing, intensity and duration of the drought. Overall, drought timing seemed to play the greatest role. The ornamentals were particularly successful when they experienced early drought compared to late drought. This effect was most pronounced under strong drought, and when the plants were exposed to one long drought period rather than several shorter ones. Our results indicate that certain exotic ornamentals may become more successful

under future climatic conditions, depending on how precipitation will actually change. Our study also highlights the importance of considering different dimensions of environmental change in ecological experiments.

Session 19-O12 - Human impact on plant species diversity in functional floodplains of heavily modified rivers

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The term 'novel ecosystems', which has been introduced by HOBBS et al. (2006), describes ecosystems with species combinations not existing in nature that have developed under anthropogenic influence and that cannot be changed back to a natural state after the human influence has ended. Rivers and their floodplains under human influence might be an example for these systems. Natural riparian areas belong to the most species-rich systems in middle Europe. Due to anthropogenic alterations, they have lost most of their diversity and functionality. The phytodiversity of the banks and floodplains of German Federal Waterways was studied to ascertain whether plant species composition and diversity are influenced by humans and whether the detected patterns are visible across regions. Thus, we aimed to answer whether German Federal Waterways are an example for novel ecosystems. The results showed a shift in species composition with intensifying anthropogenic influence in the studied floodplains. Riparian species were replaced by terrestrial species. This invasion of species adapted to terrestrial habitats caused an increase in phytodiversity. The floodplains of Federal German Waterways are severely altered from their natural species composition, but some species of their natural vegetation still remain. Thus, they stand between hybrid ecosystems (systems containing both, 'natural' and 'novel' species) and novel ecosystems (with altered species composition). It remains questionable whether a transformation back to a natural state is possible.

Session 19-O13 - Rapid emergence of a novel ecosytem in a Pacific island forest reserve

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Oceanic island ecosystems are considered to have a poor resilience against biological invasions. In many Pacific island forests, for instance, introduced plant species have become dominant in recent decades. A new and, regarding its invasiveness, unprecedented example in Fiji´s forests is the ivory cane palm, *Pinanga coronata*, which is native to Java and Sumatra. There, it is one of the dominant species in its native habitat, which includes steep hillsides in montane forests and flat areas in lowland forests from sea level to 1800 m asl. The natural tendency to form mono-dominant stands implies that *P. coronata* can outcompete and displace other understory species. The palm was brought to Fiji for ornamental purposes in the 1970s where it started spreading from a single garden north of Colo-i-Suva forest reserve. Its invasive potential was first recognized in the early 1990s. Today, it forms dense stands in Mahogany plantations of Colo-i-Suva and spreads rapidly into neighbouring native forests in Savura. The main goals of this research include to 1) clarify to which extent *P. coronata* modifies the forest ecosystems in Colo-i-Suva and Savura; 2) predict the further spread and population growth of *P. coronata*; 3) deliver sufficient data for a solid risk assessment; 4) help capacity building for a sustainable management of Fiji's forests, and of biological invasions in Fiji and the South Pacific. We examined the palm´s population structure and the abundance of other understory species in 25 permanent plots established along an invasion gradient. *P. coronata* seedlings and saplings (individuals <5m) reach densities of up to 34250 individuals/ha. Our results show that *P. coronata* displaces native understory biota, such as native herb and tree fern species, fundamentally changes the forest´s structure and interrupts the life cycles of tree species. This suggests that the invasive alien palm has the potential to transform affected rainforests into novel ecosystems.

Session 19-O14 - Plant soil feedbacks stabilize plant community biomass against impacts of global change

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It is widely accepted that abiotic conditions, biotic interactions, and feedbacks between the two can concomitantly influence community composition and ecosystem functioning. However, most studies of global climate change depict the

direct effects of abiotic drivers on individual physiology, rather than legacy effects of previous interactions, as the main driver of changes in plant communities. In a two-stage experiment, we tested the influence of soil legacy on biomass production of model plant communities composed of eight common grassland species. In the first stage, we used a seven year field experiment to establish soils with a history of exposure to three leading factors of global environmental change (disturbance/plant invasion, elevated atmospheric CO_2, warming). Subsequently we compared the biomass and root-shoot ratio of plants grown in control sterilized, and fertilized soils from each soil history to quantify the magnitude, direction, and mechanisms driving soil legacy effects. Compared to control soils, plant communities produced 2.3 $\pm$ 0.1 and 1.4 $\pm$ 0.2 fold more biomass in sterilized and fertilized soils, treatments where biomass was also more sensitive to soil legacy scenarios. When we examined the contribution of each individual species to community biomass, we found that sterilization suppressed growth of the dominant plants across all soil history scenarios. However, growth of subdominant species was both enhanced and limited by sterilization, with the magnitude and direction of effects depending upon global change scenario, plant tissue (root, shoot, or root:shoot), and the plant species considered. Therefore, both by limiting biomass of dominant competitors and by swaying production of sub-dominant species, soil biotic legacies stabilize community production from influences of global environmental change. An important implication of this study is that soil history will contribute to the production and stability of plant communities in the future.

Session 19-O15 - Impacts of an exotic soil ecosystem engineer on soil biodiversity: a meta-analysis

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The spread of non-native earthworms is mainly attributable to human activities, such as the presence of forest roads, timber harvesting and fishing. Thereby, exotic earthworms exert strong effects on ecosystem functions of invaded areas. However, literature on exotic earthworm effects is mostly confined to their wide-ranging effects on soil chemical and physical properties. Information on effects of exotic earthworms on soil invertebrates and soil microbial communities is still scarce and has not been synthesized thus far. Here, we investigated the effects of different ecological groups of exotic earthworms on soil biodiversity across the globe by reviewing literature and conducting meta-analyses. The presence of endogeic earthworms significantly decreased taxa richness of soil invertebrates, whereas effects of epigeic and anecic earthworms were not significant. Endogeic earthworm species may outcompete other soil invertebrates in terms of food resources due to their greater size and mobility. Moreover, indirect mechanisms, such as modification of soil structure, may contribute to the detrimental effects.

Soil microbial biomass was not affected by the presence of any of the ecological groups of exotic earthworms. Notably, despite the manifold ecosystem consequences of earthworm invasion, the number of studies dealing with effects of exotic earthworms on soil biota is low. Our meta-analysis shows that exotic earthworms have the potential to change the functional composition and decrease the diversity of soil biota with potential consequences for ecosystem functioning. Functional dissimilarity between native soil biota and exotic earthworms may be responsible for pronounced earthworm effects and call for further investigation.

Poster presentations

Session 19-P1 - The effects of invasive *Verbascum thapsus* L. on plant-community composition in Chilean habitats

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The environmental effects of invasive species are widely debated. Many invasive species show – as the definition demands – a persistent dispersal but lack a clear evidence of an impact on the invaded ecosystem or on human well-being. We studied the ecosystem impact of Common Mullein (*Verbascum thapsus* L.) introduced in North and South America. The study was performed in central Chile in the 'Region de Bío Bío' and the 'Region de Maule'. We investigated the effect of Common Mullein on the vegetation by a comparative assessment design of neighbouring plots differing in scales. At the two scales, the paired plots differed in the presence or absence of Common Mullein. Additionally we stratified the plots into successional stages by dividing into different cover classes. We assessed the species number, coverage and proportion of native and non-native species in the plots. Furthermore we studied the similarity of communities. The community composition showed differences between successional phases independent of the presence or absence of Common Mullein. In general the coverage of aliens was on average six times higher and the species number three times higher than the coverage and species number of the native species. However, no decline in species number or coverage of native species was detectable by an increase in species number or coverage of the aliens. Our study provides new insights on plant-community structure of anthropogenic habitats rich in aliens and is a contribution to the discussions about the true "invasiveness" of alien-species.

Session 19-P2 - Why do some non-native lady beetles become invasive while others remain benign?

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Despite the growing scientific literature on detrimental effects of invasive species, we often lack a mechanistic understanding why some species become invasive while others remain benign. Possibly, invasive predators might remain undetected by native top-predators and thus suffer less intraguild interference (naïve predator hypothesis). In addition, invasive predators might benefit from the lack of predator avoidance by native prey (naïve prey hypothesis). The ability to recognize non-native predators and consequently the strength of intraguild interference and predator avoidance is expected to depend on cue similarity with native predators. Non-native predators bearing a unique set of cues might have the double advantage of naïve prey and naïve predators and thus outcompete native predators. Due to the strong trophic interdependence and the availability of similar (congeneric species in the invaded range) and novel (no congeneric species in the invaded range) non-native lady beetle species, the ant-lady beetle-aphid system is particularly well suited to test for predator-prey naïveté. Here, we will compare the aggression of ants towards lady beetles, the avoidance behavior of aphids, and the consumption of aphids by lady beetles currently occurring in Europe and in North America. In addition, we will analyze lady beetle cues to quantify cue similarity between native and non-native species. The intercontinental approach is crucial to evaluate the importance of predator-prey naiveté for the invasion success of a non-native species. The proposed project will further contribute to a general mechanistic understanding of biological invasions by relating species interactions to the cue similarity between native and non-native species. This joint approach will not only shed light on the semiochemicals that mediate these interactions but also improve our ability to explain and predict high-impact invasions of insect predators.

Session 19-P3 - A new approach in invasion ecology: using an alien-native continuum of Asteraceae species in Central Europe to simulate long-term dynamics

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Plant invasions present a major threat to biodiversity by reducing abundance and diversity of native species. Many studies on differences between native and alien species or between native and invaded ranges did not consider aspects of temporal dynamics. However, eco-evolutionary processes following the introduction of a new species may result in rapid changes of the invader or of the invaded community. Consequently, the degree of differences between natives and aliens and the performance and potential impacts of an invader may depend on residence time (time since introduction to a new area). Are proposed (initial) advantages of being introduced a temporary phenomenon? In place of investigations over longer timescales to answer this question, comparative multi-species experiments provide a very useful approach in searching for general patterns and mechanisms. Using such an approach, we aim to elucidate eco-evolutionary mechanisms causing differences in invasion dynamics along an alien-native species continuum comprising 49 annual Asteraceae species of different residence times in Central Europe (neophytes – archaeophytes – natives). In a common garden experiment, we will followestablishment and population growth of these species with or without native communities to investigate how residence time, abiotic dissimilarity between the native and invaded range and biotic dissimilarity between the invader and native community interact to determine species-specific performance and impacts. We use two “native” communities: a Central European community including mesic to dry grassland species, and a congeneric North American community. These two communities will highlight differences in biotic interactions between the invader and native species either never having co-existed or co-existed for differing lengths of time and thus possibly having adapted to the presence of the invader. From this comparative multi-species experiment we expect to gain new insights into both eco-evolutionary constraints of population growth and spread of the invader and the potential of the native community to accumulate eco-evolutionary experience with the invader over time.

END OF SESSION 19

Session 20 – Biodiversity and ecosystem functioning in urban landscapes

Short title: Urban ecology

Chairs
PD Dr. Eva Knop
Dr. Myles Menz

Session 20-O1 - Large-scale biotic homogenization and reduced ecosystem resilience due to urbanization

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Cities are growing rapidly, thereby expected to cause a large-scale biotic homogenization and reducing ecosystem resilience. Evidence for the homogenization hypothesis is mostly derived from plants and birds, whereas arthropods have so far been neglected. Further, not much is known on how urbanization alters ecosystem resilience. Here, we tested the homogenization hypothesis with three insect indicator groups. Further, we hypothesized that ecosystem resilience, calculated based on response traits of the three insect indicator groups, is lower in urban compared to rural areas. The indicator groups were bugs, beetles, and leafhoppers, which were caught on standardized birch trees in a total of six Swiss cities and six intensively managed agricultural areas nearby. Species turnover between cities was reduced for most indicator groups compared to species turnover between rural areas, suggesting that urbanization leads to a large scale biotic homogenization. Further, the analyses of response traits of the indicator groups suggest that in the urban ecosystem the arthropod communities are less resilient to disturbances compared to rural communities.Overall, the results show that urbanization has a negative large-scale impact on the diversity of native species, and that ecosystem resilience is reduced in cities compared to rural areas. Specific measures in cities targeted at increasing the persistence of species which are typical for the respective biogeographic region and vary in their response traits could help to stop the loss of biodiversity and ecosystem resilience.

Session 20-O2 - Settlements as a source for the spread of non-native plants into mixed deciduous suburban forests in Switzerland

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Urbanization is a major driver for biotic homogenization and can promote the dispersal of non-native plant species, which are considered as a threat to native biodiversity. The influence of settlements on the dispersal of non-native plant species into forests was scarcely investigated in Central Europe. In this study, we selected 15 mixed deciduous forest sites situated adjacent to settlements and 15 control sites far from settlements in two distinct regions of Switzerland (Southern and Northwestern part of the country) to examine the role of suburban settlements for the spread of non-native plants into forests. In each study site we recorded the number and abundance of native and non-native plant species, and we assessed various habitat and landscape characteristics in their surroundings (100 m radius). In both regions, forest sites adjacent to settlements harbored a larger number and a higher abundance of non-native plant species than forest sites far from settlements. Furthermore, non-native species were more frequent in forests close to roads and in sites surrounded by a large percentage cover of garden. All these effects were more pronounced in Southern Switzerland (Canton Ticino), a region with milder winter climate, than in Northwestern Switzerland (region of Basel). Considering the ongoing climate warming, also Northern Switzerland could experience in the near future an increased frequency of invasion of non-native plants. Our results showed that settlements are a source for the spread of non-native plant species into suburban forests, and that landscape characteristics such as traffic infrastructure and percentage cover of gardens in their surroundings also contribute to the establishment of non-native species. Increasing people awareness of the negative effects of non-native species and the choice of native plants instead of ornamental exotic plant species in their domestic gardens would help to reduce the on-going spread of non-native plants into natural habitats.

Session 20-O3 - Effects of road type and urbanization on the diversity and abundance of alien species in roadside verges in Western Siberia

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The spread of alien plant species by vehicles profoundly affects the roadside vegetation. Roads with high traffic densities in urban regions may facilitate the invasion of alien plants. The present study examined the effects of road type and distance to the city centreon native and alien plant species in both the aboveground vegetation and soil seed bank of road verges in originally dry steppe grasslands in the surroundings of Pavlodar, Western Siberia, Kazakhstan. This

region is characterized by a recent change of land use and rapidly expanding urbanization. Vegetation surveys were conducted at 12 sites distributed along roads with different traffic densities (national and local roads) and at two distances to the city centre (city edge and rural surroundings). The seedling-emergence method was used to examine the soil seed bank at each site. We found a larger percentage of alien species along national roads (42%in the aboveground vegetation, 57% in the soil seed bank) than along local roads (20% and 44%, respectively), which can be explained by differences in traffic density, location from which the vehicles come and habitat conditions. More alien species were found in road verges at the city edge than in the rural surroundings along both road types, probably due to the spread of propagules from residential areas. Our study demonstrates that national roads are important pathways for the introduction of alien species in this Western Siberian region.

Session 20-O4 - Importance of suburban areas for birds: a hierarchical meta-analysis

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Urbanization is one of the most extreme forms of environmental alteration, posing a major threat to biodiversity. We studied the effects of urbanization on avian communities in the frame of a systematic review using a hierarchical meta-analysis. Altogether, we found 33 observations of 30 case studies for species richness and 19 observations of 16 case studies for abundance. Urbanization had an overall strong negative effect on bird richness, but a small positive effect on their abundance indirectly showing a homogenisation effect on bird communities probably with increasing number of individuals of generalist species toward city centres. Negative effects on bird richness tended to be more expressed in small cities (population < 500 000) with no significant difference between small and large cities. Performing a subset analysis on the effects of Urban-Suburban vs. Suburban-Rural comparisons on bird richness instead of the previous continuous linear gradient, we found a strong negative effect of urbanization in Urban-Suburban comparison, but a non-significant, small negative effect in Suburban-Rural comparison. This suggests that the species loss happens especially at the Urban-Suburban interface. The same subset analysis on abundance data showed, however, a contrasting urbanization effect, i.e. a moderate negative effect in Urban-Suburban comparison, but a moderate positive effect in Suburban-Rural comparison. Although none of them were significantly different from zero, but they were significantly different from each other. This suggests a rather humped shaped distribution of overall bird abundances, with highest abundances in suburban areas compared to urban and

rural areas. Thus our study shows the importance of suburban areas, where majority of birds occur with fairly high species richness. City centres seems to act as concrete deserts, with which only few generalist species can cope with, and where the importance of green infrastructures might be the highest.

Session 20-O5 - Linking biodiversity and ecosystem functioning in urban gardens - First attempts and perspectives

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Human activities determine abiotic and biotic conditions in urban ecosystems, which influence the occurrence and the distribution of biodiversity. Investigating the link between biodiversity and ecosystem functioning (BEF) in human dominated systems allows the identification of the mechanisms behind key ecological processes that are also beneficial for people (i.e. ecosystem services) and improves our understanding of functional resilience (i.e. long term ecosystem functioning under perturbations). Here we present first results from a large and interdisciplinary study that aims to understand the human driven determinants of biodiversity and associated ecosystem processes and services in urban areas by using gardens as model systems (www.bettergardens.ch/en). In a first example, we show the effect of vegetation structure on pest-control by birds and demonstrate that predation rates are driven by the interaction between woody vegetation cover at garden and landscape scales. I.e., gardens with high woody vegetation cover in dense urban areas are likely to benefit from higher predation rates than other combinations of vegetation and landscape structures. This suggests that birds respond to contrasted structures of the vegetation at different spatial scales, with woody vegetated gardens acting as resource islands and thereby favouring pest control; especially in dense urbanised areas. In a further example we link biodiversity of different soil macro-detritivores (earthworms, woodlice, millipedes) with key soil processes, such as decomposition of organic matter, soil respiration, and nutrient cycling along two independent gradients; namely garden management intensity and the degree of urbanization in the surrounding area. We found contrasting patterns of BEF relationships among taxa and ecosystem functions, which shows the importance of including human decisions when trying to understand the mechanisms behind BEF relationships in human dominated ecosystems.

Session 20-O6 - Urban vegetation cover drives nest performance in *Bombus terrestris*

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Even in the light of the ongoing worldwide pollinator crisis, some species, like *Bombus terrestris* can perform well in urban areas. Previous studies have shown that colony growth of this bumblebee is enhanced in suburban areas compared to agriculture land. Still, little is known about which factors drive bumblebee survival and foraging dynamics in urban landscapes. In the present study we are particularly interested in the effect of vegetation availability within the main bumblebee foraging range (750 m). Within this range, city areas vary between predominant impervious surfaces containing low vegetation (grey areas) and areas with a substantial percentage of vegetation cover (green areas). In the three largest Swiss cities we set up a total of 18 commercial colonies of *Bombus terrestris* to evaluate if these variations in vegetation cover have differential effects on bumblebee survival, colony traffic rates and flight duration. Our results show that the colony incoming flight rate is lower in grey areas. This difference is driven by a prolonged duration of pollen foraging flights in grey areas compared to green areas. However, we observed the opposite for bumblebees which did not carry pollen. These results may indicate that foraging patches in grey areas are more limited in pollen compared to the ones found in green areas. In addition, we found that bumblebee colony survival in green areas was reduced, probably due to a higher parasite load of *Aphomia sociella*. We conclude that a high percentage of vegetation cover within cities facilitates foraging for bumblebees thereby increasing their fitness. However, the probably higher parasite load in vegetation rich areas might have an adverse effect on colony performance.

Session 20-O7 - Urban forests: Effects of area, shape and composition of the surrounding landscape on plant diversity

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Urban growth is considered to be a major driver of environmental change and can affect plant diversity in different ways. Forests represent one of the most common green areas in cities, but decreased in size and became highly fragmented as urban sprawl proceeded. To what extent these urban forests still contribute to local plant

diversity is hardly investigated. We examined the effects of forest area and shape and landscape composition in the surroundings on plant diversity of urban forests in Basel, Switzerland. We conducted vegetation surveys in 27 urban forest patches differing in size and history and determined the cover of various landscape elements within a radius of 500 m. The results showed that forest size per se had no effect on plant species richness. However, Shannon diversity of plant species increased with forest area. The shape of forest patches neither affected the number nor the Shannon diversity of plant species. Both plant species richness and Shannon diversity decreased with increasing percentage cover of sealed areas in the surroundings. Plant species composition was influenced by the size of the forest, its soil moisture and the percentage cover of woody area in the closer surroundings. Considering forest history, forest patches that were fragmented from originally continuous forests before 1884 were characterised by a plant species composition distinctly different from that of forest patches planted later. Our results indicate that even small urban forest patches contribute to the preservation of plant diversity in cities. However, large and old forest patches are of particular importance for the maintenance of plant diversity in urban landscapes.

Session 20-O8 - Ants in urban habitats: changes in ant communities along an urbanisation gradient

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Urbanisation is increasing globally. While urban areas provide habitat for many species, urban green spaces are very different from habitats in nearby rural areas. They thus harbour a changed species composition, which may affect ecosystem functioning. In particular the role of urban invertebrate diversity in urban ecosystems is not always understood. This study focuses on ants, which fulfil important roles in ecosystem functioning. They are ecosystem engineers that affect soils but also interact with many groups of organisms. Ant diversity was assessed along an urbanisation gradient in Basel, Switzerland. The 49 study sites ranged from forest and grassland sites in rural areas in the surroundings of Basel to small and isolated fragments in the city centre. The ground-surface active ant fauna was sampled in spring, summer and autumn of 2014 using pitfall traps. A broad range of environmental factors and landscape composition in the surrounding of the sites were also measured. Remarkable ant diversity, including some rare and threatened species, was found even in some small and isolated urban forest fragments, which are intensively used for recreation. However, species composition was changed in urban green areas when compared to rural areas. While typical forest species were found even in very small fragments, their share of the local ant community declined along the urbanization gradient with habitat generalists and grassland species contributing a larger share of the community in the urban forest fragments when compared to rural sites. The litter layer, soil humidity and soil organic matter

were all important factors in explaining the relative shares of habitat generalist, grassland and forest species. While even small urban forest fragments still had a varied ant fauna, worthy of being considered in biodiversity conservation planning, urban grassland was frequently species-poor and dominated by a few very common and widespread species.

Session 20-O9 - The influence of landscape context and habitat connectivity on plants and birds communities in grasslands along an urban-rural gradient

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It has been shown that urbanization, *i.e.* increased proportion of built-up areas in a landscape, acts as an ecological filter on species distributions, resulting in different species assemblages found in habitat patches within rural and urban landscapes. It is less well known if landscape context and habitat connectivity affect species communities similarly in agricultural or urban contexts. In addition, many studies have focused on woodlands and their species while herbaceous habitats have received less attention. We selected extensively managed grassland sites along urban-rural gradients in north-western France with varying proportions of built-up land, private gardens and permanent grasslands in the landscape matrix. In 2014 and 2015, 60 and 75 sites were sampled for plants and birds respectively. Using a combination of existing data sources, photo-interpretation and ground-truthing, we produced habitat maps for all study sites, paying particular attention to the accurate detection of permanent grasslands and private gardens. The effects of landscape context, amount and connectivity of permanent grassland were tested on species richness, composition and, for birds, total abundance. We also investigated the effect of woodlands or gardens as they may interact with grasslands. We hypothesized that (i) species richness and composition are different between agricultural and urban landscapes, (ii) increased proportion and connectivity of permanent grasslands have greater positive effect on species richness or abundance in urban landscapes, (iii) proportion and spatial organization of woodlands or gardens may alter species composition and increase species richness in grassland assemblage in both contexts, (iv) plant and bird responses may differ.

Session 20-O10 - Contrasting responses of migratory and non-migratory syrphid guilds to urbanization

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Anthropogenic landscapes, namely agricultural land and cities are expanding globally. Both are affecting biodiversity in different ways. Syrphids can be found in both ecosystems and are important pollinators and biological control agents. A special trait that differs between syrphids and many other pollinators is the fact that there are migratory and non-migratory species. We investigated how urbanization influences the diversity, abundance, composition, and temporal dynamics of syrphids, focusing on migratory and non-migratory syrphid guilds. This is the first study to specifically investigate the responses of migratory and non-migratory insect guilds to urbanization. We collected syrphids in eight urban-rural pairs including an urban and a rural site. Syrphids were sampled once a month at each pair from March until September, along a 2 km transect. The abundance of syrphids was significantly higher in the rural ecosystem, but there was no significant difference in species richness. Community composition was not significantly dissimilar between the urban and the rural sites. However, migratory species were more negatively affected by urbanization, than non-migratory species, as they may be more prone to temporal changes, and are often more specialized. Furthermore, syrphids were predicted to have a prolonged flight season in cities, compared to rural landscapes. This is the first study to specifically investigate the impact of urbanization on migratory insect communities. We showed that migratory and non-migratory syrphid communities respond differently to urbanization. For further studies focusing on animal groups including migratory and non-migratory species, it is important to consider that these guilds might respond differently to landscape change, such as urbanization.

Poster presentations

Session 20-P1 - Anthropogenic induced trait change in arthropods and amphibians along spatio-temporal gradients

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Anthropogenic activities, in particular agriculture and the establishment of urban areas, result in novel, "domesticatd" ecosystems. The triggers for the transition from natural to "novel" ecosystems, their stability and resilience against further disturbances are not yet understood, neither is it clear if and how species, persisting during this transition, alter their characters or not. We aim at investigating trait change of species occurring in (near) natural and novel ecosystems. Our approach extends along two spatio-temporal gradients. By using the collection of the Museum für Naturkunde Berlin we follow the traits for selected species in the Berlin-Brandenburg area during the last 150 years. On the same spatial gradient, from the city, across intensively used agricultural areas into near natural habitats, we investigate the same traits of the very species in the current landscape. Our approach comprises two different model systems: System 1 consists of selected, functionally different arthropod species. System 2 comprises two frog species with different ecological needs. We hypothesize that persistent species react to the challenges of "novel" environments and that this is visible in anatomical, morphological and histological traits. Such traits' change could be evolutionary or phenological adaptations to new ecological conditions and / or reflecting environmental stress. We predict that if such trait change occurs, it should be traceable through time and space, in case both gradients reflect the same change from natural to human altered habitats. We expect variability in trait changes between the different functional groups due to their different ecological roles.

Session 20-P2 - Water quality analyses of Marikina River based on its 2002-2014 water quality data

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Marikina River is in the state of water deterioration, and monitoring and analyzing its water quality is necessary and timely. This paper generally aimed to analyze the 2002-to-2014 water quality data of Marikina River obtained from Laguna Lake Development Authority and relate it to the perception of selected residents of Barangay Manggahan and Barangay Santolan, Pasig City. The following physic-chemical parameters were used to analyze and determine the water quality of Marikina River: pH, Total Suspended Solids (TSS), Total Dissolved Solids (TDS), Biological Oxygen Demand (BOD), Dissolved Oxygen (DO), Ammonia (NH_3), Nitrate (NO^{3-}), Phosphate (PO_4^{3-})*, Chloride, Turbidity, and Total Coliform Count (TCC). Results of this study showed that the 96 respondents generally perceived that the water quality of Marikina River changed over the past years from being *'Good'* then

to being *'Poor'* now, and that they *'Agreed'* and '*Strongly Agreed'* to the past and present importance of this quality to them, respectively.

The results of one-way ANOVA revealed that there were no significant differences in the values for TSS, TDS, DO, NH_3, NO^{3-}, chloride, turbidity and total coliform across years (2002-2014). On the other hand, only pH, BOD, and PO_4^{3-} showed significant differences in their values across years. Throughout the 2002-2014-study period, several physico-chemical factors (pH, biochemical oxygen demand, nitrate, phosphate, chloride, and turbidity) were positively correlated with the total coliform count. This entailed that the water quality of Marikina River could reduce the growth and population of aquatic organisms, such as plankton, which are the main food source of aquatic fishes. On the other hand, TSS, TDS, DO, and ammonia were the physico-chemical factors negatively correlated with TCC. But no single physico-chemical parameter showed a marked influence to TCC in Marikina River given a 0.05 level of significance. These findings suggest the poor water quality of the river both based on the perception of the local community and on the analyses of its 2002-2014 water quality data.

Session 20-P3 - Applying Animal-Aided Design for city park planning

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In the light of worldwide biodiversity loss due to growing land use the protection of biodiversity is of greatly concern. Cities have been shown to harbor rich biodiversity, in particular compared to species-poor agricultural surroundings. Because cities are growing, there is increasing pressure on existing urban green spaces and subsequently on the animals that depend on them. Animals in cities also provide opportunities for citizens to come into contact with nature in their everyday life. In today's planning of free spaces and new buildings, the requirements of animals play almost no role. In fact, the occurrence of animals in cities is left to chance, i.e. there is little or no planning of whether a certain species is able to repopulate the constructed space. We developed the concept of "Animal-Aided Design" (AAD) as a tool to make animals an integral part of the planning process. The basic idea is that when habitat requirements and critical needs of animals are included in a building project from the beginning onwards, it is possible to both serve for the need of humans and the need of animals. In addition, the requirements of animals can provide design opportunities for architects and planners. We test the applicability of AAD for large-scale urban planning in a case study of the city park development in Ingolstadt. The city of Ingolstadt intends to redesign the existing park structure alongside of the river Danube, with the aim to make the river and riverbanks more accessible for citizens. At the same time,

Ingolstadt hosts two Natura 2000 areas along the Danube in the West and East of the city park. There is thus a potential conflict between redesigning the park for human needs, and maintaining or enhancing the connectivity of the Natura 2000 areas. In our project we test if AAD can be applied to develop guiding principles for city park development that includes both human and animal needs. A first step is to identify species for which the city park is critical for connectivity. A second step is to derive design features of the urban spaces that will facilitate connectivity for these species. At the same time, it is vital to involve planners and citizens into the development of the joint concept. We present how we evaluate the role of the city park for connectivity and involve citizens, to identify suitable target species for city park planning.

END OF SESSION 20

Session 21 – Multitrophic interactions in terrestrial ecosystems: Advances in the understanding of complex interaction webs and consequences for pest control

Short title: Multitrophic interactions in terrestrial ecosystem

Chairs
Dr. Roman Bucher
Prof. Dr. Liliane Rueß

Session 21-O1 - Consistent increase of herbivory along two experimental plant diversity gradients over multiple years

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Global species loss has motivated research on the functional importance of biodiversity documenting that plant species richness increases many plant-related ecosystem functions. In contrast, there is little knowledge on the efects of plant species richness on functions related to higher trophic levels, such as herbivory. Previous studies have shown positive, neutral, or negative effects of plant species richness on arthropod herbivory. In the Jena Experiment, we investigated herbivory (the proportion of leaf area damaged and the amount of leaf biomass consumed by herbivores) along two experimental gradients of plant species richness ranging from 1 to 60 species (The Main Experiment) and from 1 to 8 species (The Trait-based Experiment) for five and three years, respectively. Additionally, plant functional diversity was manipulated as the number of functional groups in a community (The Main Experiment) or a gradient of functional dissimilarity (The Trait-based Experiment). Herbivory at the level of plant communities ranged from 0 to 31% (0 and 33.8 g/m²) in the Main Experiment and 0 to 8% (0 and 13.7 g/m²) in the Trait-based Experiment, and was on average higher in summer than in spring. For both experimental gradients and for up to five years, we found a consistent increase in proportional leaf damage and consumed biomass with increasing plant species richness. As mechanistic explanations for effects of plant species richness, we propose changes in plant quality and herbivore communities. The presence of specific plant functional groups significantly affected herbivory, but little evidence for effects of plant functional diversity, based on traits related to plant performance in communities. This illustrates the potential importance of plant functional traits for ecosystem processes and underlines the necessity to select

effect traits carefully. The results imply that increasing herbivory might be a mechanism contributing to effects of plant species richness on other ecosystem functions. Furthermore, effects of plant species richness are not restricted to herbivores but might cascade up the food-web affecting higher trophic levels.

Session 21-O2 - Linking community shifts to function in multitrophic system: influence of plant diversity on grasslands arthropods

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Biodiversity affect ecosystem functioning within but also across trophic levels. Many ecosystem functions are mediated by arthropods that interact in complex food webs. Expanding knowledge on the mechanistic links between biodiversity and ecosystem function to consumers in multitrophic systems in urgently needed to understand how diversity loss will affect the interactions between different ecosystem functions. However few studies have looked at the impacts of plant diversity loss on consumer-mediated ecosystem function through consumer community changes. In a long-term grassland biodiversity experiment manipulating plant species richness (the Jena Experiment), we sampled arthropod communities and measured two arthropod-mediated functions, i.e. herbivory and predation. Both herbivory and predation increased with increasing plant diversity. Similarly, there were positive effects of plant diversity on herbivore and predator abundance and diversity. We then applied a series of structural equation models to understand how the effect of plant diversity on these processes is mediated by changes in the composition of arthropod communities, as well as other variables such as plant community biomass. In a first set of models we found that herbivore richness responded directly to plant diversity; while carnivore diversity responded to increases in plant biomass rather than plant diversity. In a second set of structural equation models we linked plant diversity, arthropod diversity and arthropod functions to disentangle direct and indirect bottom-up effects of plant diversity on arthropod-related ecosystem functions. Models provided evidence for both diversity and abundance controlled pathways and underline the importance to consider properties of the arthropod communities when investigating effects of plant diversity on arthropod-mediated ecosystem functions like herbivory and predation. We discuss the implication of our results for the management of biodiversity at different trophic and the potential to enhance ecosystem services, like pest control, in agricultural landscapes by increasing plant diversity.

Session 21-O3 - Plant diversity affects multitrophic interactions in an experimental grassland

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Plant diversity has been shown to affect species richness and abundance of associated consumer communities. Species in diverse communities are likely connected by interspecific interactions. Omnivores, in particular, may link multiple trophic levels in interaction webs. However, it has remained unclear if and how changing plant diversity affects interactions of omnivores, because appropriate methods were lacking. A promising approach is the DNA-based analysis of gut contents using next generation sequencing (NGS) technologies in combination with universal primers allowing the detection of interactions from a wide range of taxa. Here, we use the framework of a grassland biodiversity experiment where plant taxonomic and functional diversity were manipulated to analyse how three species of ground dwelling invertebrates with varying degree of omnivory respond to plant biodiversity. We released and recaptured ground beetles (*Pterostichus melanarius*, and *Harpalus rufipes*) and sampled slugs (*Deroceras reticulatum*) in 138 fenced plots. Beetle regurgitates and slug faeces were collected and DNA from these dietary samples was sequenced (Illumina Miseq). We analyzed trophic- and non-trophic interactions using general primers for plants, animals, fungi, and bacteria. In a pilot study, we detected a wide range of taxa with the NGS approach in regurgitates of *P. melanarius*, including organisms representing trophic, phoretic, parasitic, and neutral interactions. Our findings suggest that plant diversity positively affects multitrophic interactions involving omnivorous consumers (Tiede et al. 2016, PLoS ONE). With the extended study we will elucidate this trend and advance fundamental biodiversity research by providing novel insights into ecological interactions.

Session 21-O4 - Plant species richness negatively affects root decomposition

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Plant diversity enhances several ecosystem functions. Compared to other well-studied processes, we know little about whether and how plant diversity affects root decomposition, which is limiting our ability to predict biodiversity-carbon cycling relationships in the soil. Plant diversity potentially affects root decomposition via two non-exclusive mechanisms: by providing roots of different substrate quality and/or by altering the soil decomposition environment. Within the frame work of the Jena experiment, one of the longest-lasting grassland diversity experiments in Europe, we conducted three decomposition experiments using litter bags to disentangle these mechanisms. We addressed the root substrate quality effect by decomposing community roots from all experimental plots in a single plot, the decomposition environment effect by decomposing standard roots in all experimental plots, and the overall plant diversity effect by decomposing community roots in situ. In addition, we applied structural equation modeling (SEM) on data from the in-situ decomposition experiment and integrated morphological and chemical traits of community roots as well as soil physical and chemical conditions and abundance of soil biota to understand the individual pathways in details. Results from the three decomposition experiments and the SEM all showed that with increasing plant species richness, root decomposition decreased. Both root substrate quality and soil decomposition environment contributed to the negative relationship between plant species richness and root decomposition. Functional group composition played an important role, with the presence of grasses reducing root decomposition while the presence of legumes enhanced it. In addition, SEM revealed important drivers underlying the diversity and composition effects on root decomposition. Plant species richness positively affected root decomposition via increased root K concentration and negatively affected root decomposition via increased abundance of oribatid mites in the soil. Functional group composition, in contrast, mainly affected root decomposition via affecting root chemistry. Presence of grasses negatively affected root decomposition via increased root lignin concentration, increased oribatid mite abundance and decreased root K concentration, while presence of legumes positively affected root decomposition only via reduced root lignin concentration. By unraveling the causes of a negative diversity-root decomposition relationship, our study provides novel insights into the mechanisms underlying the strong diversity effect on soil C storage in grasslands.

Session 21-O5 - Negative plant-soil feedbacks and competitive interactions as drivers of species coexistence and ecosystem functioning

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The identification of mechanisms that allow for species coexistence and ecosystem function has been a central challenge in ecology. Elevated intraspecific competition for abiotic resources is often invoked as the dominant stabilizing mechanisms explaining species coexistence; however, a growing body of evidence suggests the interactions between plants and their specialized soil-borne enemies might be equally as important. We performed a series of experiments to explicitly test the relative importance of resource competition versus plant-pathogen interactions as mechanisms for stable coexistence and ecosystem function. In the first experiment, tallgrass prairie plants grown in the absence of other plant competitors consistently performed poorer relative to other plant species when grown in soil with their own soil microbes (i.e, pair-wise negative feedbacks). The strengths of these pair-wise negative feedbacks were negatively correlated with the phylogenetic distance of each species pair. In the second experiment, six prairie plant species were reciprocally planted at low density in pots containing species-specific soil microbes and a higher density of either their own or other plant species, in the presence or absence of soil microbes. We found that species grew better when invading communities containing other plant species than when invading their own plant-soil environment. This was especially true when plant species were invading communities of more distantly related plants. Poorer success when invading a community dominated by a closely related species is expected if more closely related plants share similar suites of soil-borne enemies. When we eliminated soil organisms to isolate competition for soil resources, the advantage of being rare in a community diminished, as did the importance of plant phylogenetic relatedness. These findings suggest that intraspecific competition for soil resources maybe insufficient for stable coexistence. Further evolutionary relationships among plants may fundamentally mediate plant-microbial interactions in a way that influences community assembly and coexistence.How soil microbes affect ecosystem functioning is tested in an ongoing mesocosm experiment.

Session 21-O6 - Effects of tree species richness and canopy closure on trap-nesting insect community networks in a subtropical controlled tree diversity experiment.

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Plant diversity and site productivity shape the complexity of multi-trophic interactions. Trophic interactions can influence plant performance and community structure. Analyses of multi-trophic interactions are therefore crucial to understand the role of plant composition, diversity and extinction for ecosystem processes. Trap nests for cavity-nesting Hymenoptera are an ideal model system to study multi-trophic interactions. They provide the opportunity to directly observe cavity-nesting bee communities interacting with plants as pollinators and wasp communities which as predators of herbivores and their antagonists indirectly affect plant consumption. Moreover, trap nests are a standardized tool to measure the complex interaction networks between insect hosts and parasitoids. The BEF-China, located in sub-topical south-east China, is the largest tree biodiversity experiment. The experimental tree plantation includes 40 native tree species planted in 566 plots (25.83 x 25.83 m in size) in 2009 (Site A) and 2010 (Site B). To test Hymenoptera community responses to the planted tree diversity gradient, we installed two trap nests in each of 80 plots, 16 at each tree species richness level, with levels ranging from 1 to 2, 4, 8 and 16 species. In 2014/15, for 12 consecutive month monthly collection of hymenoptera nests yielded a total of 3500 nest from which 7000 hosts and parasitoid individuals hatched. With this data we measure species richness changes of trap-nesting bee, wasp and parasitoid communities along the tree species richness gradient. Moreover we construct interaction networks to identify how tree species richness affects network generality of host-parasitoid interactions. Additionally, using hemispherical pictures we assess the effect of canopy closure on bee and wasp communities with an expected shift of bee dominated to wasp dominated communities with decreasing understory sun exposure.

Session 21-O7 - The importance of resource distribution - Spatial co-occurrence of host plants and host ants limits continued existence in a myrmecophilous butterfly

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Understanding the relationship of resource availability and the occurence of species is one of the key tasks in nature conservation science. If several resources are needed simultaneously, their impact may be amplified. The occurrence of the Dusky Large Blue Butterfly *(Maculinea nausithous)* is strongly linked to two essential resources: the availability of the Great Burnet *(Sanguisorba officinalis)*,

which is known to be the only nectar source and larval food plant, and its host ant *Myrmica rubra* as food of late instar larvae. However, neither the amount of food plants nor host ant nests may individually explain resource limitation in a local butterfly population. Thus, reproduction capacity might better be estimated by recording areas of co-occurrence of *S. officinalis* and *M. rubra*. We tested this hypothesis by recording the distribution of host plants and host ants on 29 study sites in south-western Germany. Distribution patterns have been related to egg density of *M. nausithous*. While host plant availability showed no effect on butterfly egg densities, a positive relationship could be found between *M. nausithous* egg density and patterns of spatial co-occurence of host plant and host ant. Any such relationship could be caused either by location loyalty of *M. nausithous*, where females lay eggs close to their own eclosion sites or by the preference of *M. nausithous* females to depose eggs at host plants with high activity of host ants in the surrounding.

Session 21-O8 - Patch heterogeneity, mutualists and predators drive metacommunity dynamics in an aphid-plant system.

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A metacommunity is defined as a set of potentially interacting species inhabiting a single habitat patch, which is linked by limited species dispersal to other patches.The structure and diversity of such metacommunities are shaped by spatio-temporal dynamics and the occurring interacting species. Due to the complexity of local ecological communities, the mechanisms structuring these are for the greater part unknown or approached from a single perspective only, especially in terrestrial systems. We followed the population dynamics of a specialised aphid (*Metopeurum fuscoviride*), its mutualistic ants and natural enemies on the host plant (*Tanacetum vulgare*) in both a natural field site and a controlled exclusion experiment. We considered patch heterogeneity, reflected by plant traits (i.e. size, C/N ratio, location, surrounding vegetation and plant within-species chemical variation), abiotic factors (precipitation) as well as seasonality. We present results that highlight the role of mutualistic ants in shaping the metacommunity structure, especially in the initial colonisation of patches by aphids and during predation. Furthermore, we found that top-down predation did not strongly drive aphid extinction in patches as has been previously thought. In fact, a combination of many factors was important, and across the season these had a

stronger or weaker effect: here, we focus on role of plant within-species chemical variation (different chemotypes) in affecting the associated community.

Thus, to understand metacommunity dynamics we must approach such a complex system from various angles and consider different processes (metacommunity paradigms) working at the same time: we have to consider multiple factors including plant traits, i.e. patch variation (species sorting), mutualist and natural enemies (patch dynamics), source-sink dispersal (mass effects) but also dispersal limitations as well as stochastic extinction in the small populations often found in such systems.

Session 21-O9 - Land-use intensification decreases specialization of phytophagous insect - host plant networks

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Changing interactions between insects and plants and the resulting consequences for ecosystem processes and functions are an important research field in ecology. A long shared evolutionary history led to different feeding and interaction types, i.e. specialists vs. generalists and antagonists (e.g. phytophages) vs. mutualists (e.g. pollinators). In the context of increasing anthropogenic disturbance of natural communities (e.g. increasing land-use intensity) it is crucial to know, how interaction networks change with increasing human-induced pressure. We expect that land-use intensification favors generalist insects that are more flexible to cope with land-use changes. This should be reflected in more generalized interaction networks on sites with high land-use intensity. Since phytophagous insects are on average more specialized towards their host plants than pollinators, we expect a stronger effect of land-use intensification on plant-phytophage networks than on plant-pollinator networks. To test these assumptions we use a comprehensive dataset of phytophagous insects belonging to seven insect orders (Coleoptera, Heteroptera, Thysanoptera, Lepidoptera, Orthoptera, Hymenoptera and Diptera) and their host plant records from literature. We merged the dataset with land-use intensity and insect records (Heteroptera, Orthoptera, Coleoptera, Diptera, Hymenoptera and Lepidoptera) from 150 grassland sites in three regions in Germany. For each site we calculated a network specialization index, for both, phytophages and pollinators. Preliminary results indicate that phytophagous insect networks are more specialized than pollinator networks. Increasing land-use intensification leads to generalization of the phytophagous insect networks while there was no effect on pollinator networks.

Session 21-O10 - Landscape and management effects on biocontrol: Wooly apple aphids and earwigs

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In intensive fruit production systems, orchard management and agri-environmental schemes such as hedgerows and flowering strips are assumed to enhance biocontrol by natural enemies of key pests. Focusing on the populations of the wooly apple aphid, *Eriosoma lanigerum*, and its antagonist, the common earwig, *Forficula auricularia*, we analysed the influence of local management schemes and landscape patterns on an economically relevant predator-prey system. Earwigs are known to be sensitive to some insecticides applied in commercial orchards. At the same time they are expected to profit from heterogeneous, semi-natural extra-orchard habitats with woody structures and shrubs providing potential overwintering habitats. Earwig populations were surveyed in 30 commercial orchards (15 organic and 15 subjected to integrated production) in the apple cultivation area at lake Constance in Germany. Beating samples were taken at flowering and at ripening to measure earwig abundance. Earwig nests made of bamboo tubes were installed in the center of the orchard. Simultaneously, *E. lanigerum* colonies were surveyed along the beating transect. We tested whether untreated shelter habitats provided by agri-environmental schemes and forests may counteract potential negative influences of intensive management practices.

Session 21-O11 - The natural occurrence of aphid symbionts and effects of plant diversity

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Many insects host secondary bacterial symbionts that are known to have wide-ranging effects on their hosts, from host-plant use to resistance against pathogens and natural enemies. Aphids are pests of many crops species, affecting yield directly through feeding or indirectly through transmission of viruses. Aphid symbionts have the potential to enable aphids to feed on otherwise unsuitable host plants, affect plant defence signalling and reduce the efficiency of biological control methods. While there is growing appreciation of the role of symbionts in aphids, based on laboratory experiments, we still lack many field-based studies. We first present results from our global review of secondary symbiont occurrence in aphids focusing on the symbionts *Hamiltonella, Serratia, Regiella, Rickettsia, Spiroplasma, X-type, Arsenophonus* and *Wolbachia*. Our review found that 322 aphid species have been tested for at least one known symbiont and we discuss

effects of host-plant species and geographic region. Secondly, we present results showing that aphid symbiont communities vary along a plant species richness gradient, for three aphid species each feeding on their own unique host plant. Aphid symbiont communities have the potential to be quite dynamic in the field and respond to a variety of selection pressures. We conclude with a discussion on the role of plant-aphid-symbiont interactions on pest control in agricultural systems.

Session 21-O12 - On-line detection of plant VOCs after attack by phloem-feeding and chewing herbivores

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Plants respond to herbivore attack in a variety of direct and indirect ways. An indirect mode of defence includes the release of volatile infochemicals, which can be seen as a “call for help”. Volatile Organic Compounds (VOCs), acting as infochemicals, are released immediately upon the physical rupturing of oil reservoirs caused by chewing insects (constitutive VOCs). In parallel the attack by phloem-feeders or pathogens leads to changes in expression of VOC biosynthetic genes resulting in the emission of stress-induced VOCs. The emission patterns caused by these varying forms of damage are different, and are specific to both the physiology of the leaf and the involved biochemical pathways. Tansy (*Tanacetum vulgare*) is an aromatic herb that is well known for its chemical profile (chemotype) plasticity. In order to investigate the effects of both phloem-feeding aphids and leaf chewing herbivores upon the emission profile of different tansy chemotypes, we conducted an experiment using *Metopeurum fuscoviride* (a tansy specialised aphid) and *Spodoptora littoralis* larvae (a generalistic herbivore). Over the course of the experiment, tansy VOC emissions were monitored using Proton Transfer Reaction Time of Flight Mass Spectroscopy (PTR-ToF-MS) and Gas Chromatography – Mass Spectroscopy (GC-MS). Each round of the experiment lasted one week and consisted of the four following treatments: control (no aphids + no caterpillars, no aphids + caterpillars) and treatment (aphids + no caterpillars, aphids + caterpillars). We present data showing real-time VOC emissions and the changes in these upon addition of two different types of herbivore, and discuss the potential of plant “priming” in relation to the effects phloem feeders have on plant defences and VOC emissions. Furthermore, we highlight the diversity within tansy chemical profiles and explore their possible role in aphid-host selection.

Session 21-O13 - Systemic grass endophytes: A burden or a blessing?

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Endophytic fungi of cool season grass species are known to deter herbivores from damaging agricultural grass hosts. Phloem feeding aphids show a fitness loss when feeding on endophyte infected host grass, but knowledge on the mechanisms are fragmentary. It is also unknown; whether responses of aphids differ under laboratory and field conditions and how higher trophic levels are affected by the presence of such endophytes. We showed in our experiments that alkaloids, like peramine and lolitrem b, which are produced by the *Epichloë fescucae* var. *lolii* – *Lolium perenne* association can be assimilated by phloem-feeding aphids. These alkaloids do not only occur in aphids, but also cascade up the food chain and might be responsible for strong negative effects in predators and parasitoids of aphids reared exclusively on *Epichloë fescucae* var. *lolii* infected grass. However, strong effects of the fungus – grass association on trophic cascades in laboratory experiments could rarely be found in field experiments in Central Europe. Under field conditions aphid populations often depend on top down control and the environmental context, while higher trophic levels are mainly bottom up driven by the host grass biomass. We conclude that the alkaloids produced by the endophyte – grass association are responsible for fitness loss in different trophic levels, but that this effect is relatively low under field conditions in Central Europe.

Session 21-O14 - Fungal chemical diversity: an overlooked domain in multispecies interactions?

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Saprotrophic fungi have important functions as decomposers of dead organic material. Because of their ability to synthesize and release vast arrays of chemically complex metabolites, fungi likely influence the behaviour and performance of other organisms in their environment. Surprisingly, the connection between fungal chemical diversity, as determined by evolutionary and ecological factors, and other organisms has largely been ignored by research into multitrophic interactions. Our experiments designed to reveal such interrelationships show a strong influence of the interaction of fungal genotype and insect-induced shifts in chemical excretions on the behaviour and performance of the 'target' insects and microbial community members. Metabolic analyses revealed patterns of fungal genotype-dependent and insect-induced shifts in the organisms' chemical environment. Therefore, complex fungal genotype-by-environment interactions have the potential to impact multispecies interrelationships in the fungal-associated community.

Session 21-O15 - Seed germination and seedling performance in wild lima bean plants are enhanced by a seed beetle and its parasitoid

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For natural plant populations, pre-dispersal seed predation can have devastating effects on subsequent plant recruitment. However, the negative effects of seed predation may be only partial if damaged seeds are still capable of germinating and producing fit plants, or if the intensity of seed damage is reduced by the action of natural enemies such as parasitic wasps that kill or halt the development of seed predators. We examined the interactive effects of the intensity of pre-dispersal seed predation by a Bruchine beetle and parasitism, on seed germination and plant performance in wild lima bean *Phaseolus lunatus*. Naturally damaged seeds were obtained from field-collected pods in Mexico. Seeds were examined for beetle damage and parasitoid infestation, which can be distinguished by different size holes created by the newly emerged adults. Seeds with different number of exiting holes (both from beetles and parasitoids) were sown and monitored for germination success and seedling performance. We found decreased germination in seeds with high intensity damage, whereas seeds with low intensity damage germinated better than undamaged seeds. Moreover, the potential negative effects of high seed predation were reduced by parasitoid attack. Conversely, seedling performance (growth rate and shoot mass) was significantly higher for plants from undamaged seeds. It appears that although low intensity of seed damage can have positive effects on germination, beetle feeding diminishes reserves required for subsequent plant growth. Our results demonstrate that beetle infestation may enhance or reduce seedling recruitment depending on the intensity of damage and the presence of parasitoids. This study highlights the complexity of natural communities in which the success of one trophic level may be contingent on its interactions with other trophic levels.

Session 21-O16 - Indirect linkages between terrestrial and aquatic food webs

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Riparian food webs are connected to streams via cross-ecosystem movements of organisms. Thereby, aquatic prey can subsidize riparian predators. This has been

observed to indirectly increase predation pressure on terrestrial herbivores through the accumulation of terrestrial predators along streams. Oppositely however, the subsidies that aquatic prey provide to terrestrial predators might benefit terrestrial herbivores through a partial release from predation. We examined how aquatic subsidies affect terrestrial food webs consisting of plants, herbivores and predators. Three treatments were established in field microcosms. The first treatment was used as a control and consisted of five plants. The second treatment consisted of plants, herbivores and predators. The third treatment was based on the second treatment but included also the provisioning of aquatic prey that was collected with emergence traps from a nearby stream. To quantify herbivory, leafs were marked, photographed and subsequently evaluated. At the end of the experiment, the remaining herbivores and predators were collected and analysed for potential differences in survival across the treatments. In the presence of aquatic prey subsidies, more herbivores survived, most likely caused by a lower predation pressure. Unexpectedly, plant growth was reduced and herbivory increased in the treatment without aquatic prey subsidies in spite of the reduced numbers of terrestrial herbivores. We conclude that aquatic prey can satiate or divert predators from terrestrial herbivores and indirectly affect terrestrial food webs, especially in riparian areas close to surface waters.

Session 21-O17 - Plastic lowers the food quality of biofilm for the grazer *Radix balthica* (Gastropoda)

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Plastic contamination of running waters and lakes pose a potential threat to freshwater organisms. The effects of plastic on food chains in freshwaters are of particular interest concerning environmental functions and stability. But, investigations of plastic affecting more than one trophic level have not been carried out so far. In this study effects of plastic on primary production, i.e. biofilms, and primary consumers, i.e. an invertebrate grazer, covering two trophic levels of the aquatic food web were investigated. Two plastic types, Perspex (PMMA) and Polycarbonate (PC), and glass (control) were used as substratum for natural biofilm establishment. These biofilms were fed to the freshwater gastropod *Radix balthica* in a laboratory grazing experiment. Biofilm structure and composition were observed with confocal laser scanning microscopy. Sublethal effects on *R. balthica* were observed measuring consumption of biofilm (as faeces dry mass) and growth rates. Biofilm structure and composition were similar on control and PC substratum, but biofilm on PMMA substratum showed significant differences. After the grazing experiment patches of remained biofilm were found on both plastic substrata. On control substratum, the entire biofilm was consumed by *R. balthica*.

The consumption of biofilm was significantly lower in the PC treatment, compared to the control and the PMMA treatment. Growth rates were significantly lower in both plastic treatments, compared to the control treatment. The low growth rates in the PC treatment may result from the lower consumption of biofilm in this treatment. In the PMMA treatment, the altered composition of biofilm could have reduced growth rates. Furthermore, both plastics might have leached or carried adhered pollutants, which may have reduced growth rates directly, or indirectly through lower grazing activity. Concluding, it was shown that plastic as a substratum affects the composition of freshwater biofilms resulting in lower growth rates of a grazing benthic invertebrate. Thus, plastic in freshwaters has a direct effect on the primary production and an indirect effect on higher trophic levels.

Session 21-O18 - Skin bacteria in hybridizing European freshwater fish are shaped by environmental and host genetic factors

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Natural hybrid zones often emerge at habitat clines where distinct populations meet, mate and hybridize. The possible factors that govern the dynamics of a hybrid zone are insufficiently explored. For example symbiotic bacteria can induce selection pressure by influencing the host's immune system, nutrition, development and behavior. These interactions are in turn influenced by environmental factors making it difficult to disentangle all involved components. Here we use a secondary contact zone where two populations of European freshwater fish, *Cottus rhenanus* and invasive *Cottus*, hybridize at a habitat ecotone. This system enables to study the association of symbiotic microbiota, habitat and host genotype to infer whether host-bacterial interaction may act as evolutionary force. We extracted genomic DNA from fin samples of wild caught fish and assessed bacteria through pyrosequencing of 16S rRNA markers. The host genetic makeup was inferred based on 80 nuclear SNP markers that permit to classify all fish into parental forms and recent hybrids. By means ofadditional laboratory experiments we examined the host genetic influence on bacterial communities under controlled environments. Phylogenetic and statistical analyses revealed major differences in bacterial diversity and abundance in distinct habitats. However, we also identified minor host-specific variation independent from the surrounding indicating some core bacterial microbiota. These results indicate that bacterial communities in our system are shaped by both, host genetic and environmental factors, and can at least not solely act as selective force against migrants in a *Cottus* spp. hybrid zone.

Poster presentations

Session 21-P1 - Indication for bottom-up control: Fertilization but not semi-natural habitats indirectly enhanced spider abundance

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Semi-natural habitats often support a high abundance and diversity of predators. However, it is questionable whether these predators immigrate into adjacent agricultural fields. To obtain a better understanding of the colonization of agricultural fields by spiders, we sampled spiders along 21 transects from semi-natural landscape structures into the grassland in South-Western Germany. Thereof, seven transects originated at a hedge/forest edge, seven transects originated at a river/ditch, and seven transects were without any semi-natural structures serving as control. Spiders were sampled using pitfall traps and sweep netting at four distances from the semi-natural structure (0 m, 25 m, 50 m, and 100 m) along the transects. In addition, we counted individuals of the main arthropod groups from the sweep net samples. The presence or identity of semi-natural habitats did not affect spider abundance and diversity. In contrast to our expectations, spider abundance increased with increasing distance from semi-natural structures. This relationship was mainly influenced by the dominant spider species *Oedothorax fuscus* (Linyphiidae). Further analysis revealed a strong positive relationship between the fertilization of the fields and the abundance of spiders. We found a similar relationship between fertilization and leafhoppers which are an important prey for spiders. In our study system, semi-natural landscape structures did not contribute to the abundance or the diversity of spiders. The lower spider abundance towards the edge of the agricultural fields might be explained by increased intraguild predation or the avoidance of shading due to the adjacent semi-naturel structures. Our results indicate that open-land spider species benefit from high prey availability in agricultural fields. Leafhoppers that feed on plant sap are strongly limited by the nitrogen content of their food resource. Thus, fertilization can lead to a numerical increase in leafhopper individuals which in turn enhances spider abundance via increased prey availability. In addition to the understanding of changes in spider communities, further studies are needed to relate differences in predator abundance and diversity to predation rate and pest control.

Session 21-P2 - Carabid beetles feed more pest beetles at rising temperature

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As a consequence of climate warming, rising temperature was observed to affect herbivores and predators.For example, activity-density of abundant predatory carabid beetles, which are considered important natural control agents of agricultural pests, was observed to increase at rising temperature. The pollenbeetle *Meligethes aeneus* is one of the most important insect pests in European oilseed rape fields, and its larvae were observed to be important prey to carabid beetles. Therefore, we performed a laboratory experiment to detect whether rising temperature affects the number of pollen beetle larvae killed by five abundant carabids, and larval biomass ingested by carabids. In three climate chambers actual temperature (T1) was compared to temperatures increased by 3°C (T2) and 5°C (T3). This is the first study investigating the feeding of carabid predators on an arable pest insect spanning a realistic forecasted climate warming scenario of 3°C and 5°C, thus providing basic knowledge on that neglected research area. We hypothesized that carabids kill more pollen beetle larvae at rising temperature, and biomass intake by carabids increases with rising temperature. Both beetle species and temperature had significant effects on the number of killed *Meligethes* larvae and larval biomass ingested by carabids. *Amara ovata*, *Harpalus distinguendus* and *Poecilus cupreus* killed significantly more pollen beetle larvae at T2 and T3 compared to T1. *Anchomenus dorsalis* killed significantly more larvae at T2 than T1, and *Harpalus affinis* showed no significant differences among temperatures. Biomass intake by *A. ovata*, *H. distinguendus* and *A. dorsalis* was significantly larger at T2 and T3 compared to T1. Biomass intake by *H. affinis* and *P. cupreus* did not significantly differ among temperatures. Among the five carabids tested *P. cupreus* exhibited the highest values for both number of killed larvae and biomass intake. The lab results suggest a clear potential for higher feeding of pollen beetle larvae by carabid beetles at rising temperature. As rising temperature leads to increased activity of abundant arable carabids in the field, it may be expected that there is enhanced pest suppression under warmer field conditions.

Session 21-P3 - Free-living nematodes as prey for higher trophic levels as indicated by molecular gut content analysis

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Molecular methods are a novel tool to study trophic interactions between predator and prey on the level of species. They are particularly suited for analysing 'invisible

interactions', such as predators ingesting only liquids of their prey, the prey lacks of detectable hard remnants predators feeding on small prey or living in opaque habitats, as in interactions of microarthropods feeding on nematodes in soil. Although among the most numerous invertebrates, until today nematodes are an underestimated prey in soil food web studies. Molecular gut content analysis overcomes most of limits of other techniques investigating trophic links by analysing predator individuals in a PCR using molecular markers specific for certain prey taxa. General primers at the level of prey groups or families allow analysis of the dietary range of predators, whereas specific primers allow identifying trophic links at the level of genera or species. Development of specific primers, however, poses a challenge as target DNA fragments need to be short, allowing long detection of prey DNA in the gut of predators, but also need to be specific to the respective prey taxon. Further, the primers need to be sensitive allowing detection of even small amounts of prey DNA. Once established, however, specific primers allow screening of many individuals of predator species and thereby detection and comparison of the predator spectrum of the prey taxa the primers have been developed for. We designed and optimized three specific primer pairs for free-living bacterial-feeding nematodes abundant in forest and other ecosystems: *Acrobeloides buetschlii*, *Plectus* spp. (*P. minimus* and *P. velox*) and *Panagrellus redivivus*. The markers were tested for specificity, sensitivity and detection time of nematode prey in microarthropod predators in the laboratory and the field. They proved to be a promising tool to uncover the contribution of nematode prey to the nutrition of microarthropods, thereby allow answering some of the most challenging questions in soil food web ecology, i.e. the contribution of microfauna to the nutrition of higher trophic levels of soil food webs and the trophic links between micro- and mesofauna.

Session 21-P4 - Effect of temperature on biomass production in isolates of the entomopathogenic fungus *Lecanicillium muscarium*

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Lecanicillium muscarium (Petch) Zare et Gams is a widely occurring entomopathogenic fungus. Temperature is one of the principle factors limiting entomopathogenic fungi. The aim of this work was to study the effect of temperature on growth of four isolates of *L. muscarium* under in vitro conditions. *Lecanicillium muscarium* isolates Lm1, Lm2, Lm5 and Lm6 were originally obtained from infected *Issus* sp. (Rhynchota Issidae,) at Trabzon province (Black Sea Region of Turkey) and were maintained on potato dextrose agar (PDA) in Petri dishes at 25 °C and transferred to fresh medium in every month. Potato dextrose broth (PDB) medium was used in experiment to study the growth in liquid medium. Thirty milliliter of liquid medium was poured into a 100ml conical flask under aseptic

conditions and inoculated with 5 mm diameter identical culture discs of each isolate. The experiment was done by four replicates. Inoculated conical flasks containing PDB medium were incubated at 20, 25, 30 and 35°C. Ten days after the incubation, the mycelia cultured in each flask were harvested by passing through Whatman no. 1 paper and washed with distilled water. Then the collected mycelia were dried at 70°C for 48 hand weighted. The results of experiment indicated that optimum temperature for growth of isolates of *L. muscarium* ranged between 25-30 °C.

Session 21-P5 - Response of the parasitoid *Cotesia glomerata* to different HIPV blends in field conditions

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1. Herbivory induces changes in the composition of volatile blends emitted by plants. These herbivore-induced plant volatiles (HIPV) are detected by parasitoids which use them to locate their host. This phenomenon has been observed multiple times in laboratory, but the way these behaviours are translated in the field, where odour complexity is high, remains largely unknown. 2. We conducted field trials on the response of the parasitoid Cotesia glomerata to HIPV produced by Brassica oleracea var. alba upon herbivory by Pieris brassicae. In each trial, one plant infested or not infested with P. brassicae larvae was exposed at a fixed distance from an uninfested plant in a meadow. Individual female parasitoids were released at this second plant and observed until they landed on the first plant. Search time, i.e. the time between flight initiation from the release plant and landing on the test plant, was recorded for every individual. Two cultivars with assayed differences in HIPV attractiveness were used at four between-plants distances (1, 2, 4 and 8m), to test (1) whether these differences are detected by C. glomerata in the field and (2) over what distance HIPV are detected by C. glomerata. 3. Maximum perceptual range of this system could not be established, but we concluded that it is at least 10m as 30% landing success was measured at the distance of 8m. Landing success was higher on infested plants and on the attractive cultivar and decreased with distance from the release plant. Search time was shorter on infested plants and increased with distance but was not affected by cultivar. 4. Our results indicate that differences in HIPV blends between different cultivars are detected by parasitoids over large distances in field conditions. In spite of the olfactory noise, the most attractive cultivar was found by a higher proportion of parasitoids. This suggests

that genotypic differences in HIPV could be used in biological control to increase parasitoid recruitment.

Session 21-P6 - Host-preference and parasitic capacity of five *Trichogramma* species (Hym.:Trichogrammatidae) against some stored product lepidopterous pests

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The host-preference and parasitic capacity of four local *Trichogramma* spp. towards four species of stored product moth eggs were investigated in laboratory experiments in order to select new candidate species for inundative releases against lepidopterous pests in storages. Experiments were carried out by offering a single parasitoid female eggs of the Indianmealmoth *Plodiainterpunctella* (Hubner), the Mediterranean flour moth *Ephestia kuehniella* Zeller, the warehouse moth *E. elutella* (Hubner), and the almond moth, *Cadra cautella* (Walker) in choice and no-choice assays. The *Trichogramma* species were collected from arid and semi-arid areas in Egypt. These were *T. bourarachae*, *T. cordubensis*, *T. euproctidis*, *T. cacociae,* and their efficacy was compared with the common wasp used commercially for biological control of stored product pests (*T. evanescens*).The bioassay for host-preference of *Trichogramma* was carried out by offering a single wasp female the choice between equal numbers of host eggs on square cards and /or strip cards. In Petri dish tests, *E.kuehniella* was a highly acceptable host species for *T. bourarachae*, *euproctidis*, and *cacociae* wasps. While *elutella* and*cautella* eggs were more acceptable for *evanescens* and *cordubensis,* respectively. In strip card tests, *E .kuehniella* eggs were highly acceptable for *bourarachae , cacociae* and *evanescens.* Eggs of *elutella* and *cautella* were more acceptable for *euproctidis* and *cordubensis,* respectively. The comparative study of parasitic capacity of the *Trichogramma* spp. was carried out under 'no choice conditions' by exposing a freshly emerged single wasp to an unlimited number of host eggs. Significant differences were found among the parasitic capacity of the tested *Trichogramma* spp.: *T. cordubensis* and *T. euproctidis* showed a good parasitic potential against *P. interpunctella* and *E. kuehniella*; *T. borarachae* was most effectiveagainst *P. interpunctella, and T.evanescens* against *E. kuehniella.* However, dissection of host eggs with wasp-emergence holes showed that all tested wasps had a propensity to superparasitize the host eggs. *T. cordubensis*, *T. euproctidis* and *T. borarachae* showed promise for further investigation into selecting a biological control agent against stored product lepidopterous pests.

Session 21-P7 - Green islands caused by gall midges increase nutrient content of beech leaves and accelerate leaf litter breakdown

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Green islands are conspicuous green areas on otherwise senescence or dead leaves. While previous research focused on the origin of green islands and the biochemical processes involved, their effects on other organisms are less known. Here we analyze the effects of green islands induced by galls of the gall midge *Hartigiola annulipes* (Hartig 1839; Diptera, Cecidomyiidae) on the nutrient content and the decomposition of beech leaves (*Fagus sylvatica*). We predict that a higher nutrient content in green island leaves should cause a higher attractiveness to decomposers and therefore a faster decomposition. At 14 sites we sampled fallen galled and non-galled leaves under groups of beech trees. We estimated on both leaf types the proportion of removed leaf area by herbivores and on the galled leaf also the proportional area of differently colored leaf tissue (green, yellow, brown). To compare nutrient contents the carbon and the nitrogen content of galled and non-galled leaves and the differently colored leaf tissue were analyzed. Coarse-sized litter-bags containing galled and non-galled leaves were exposed in the field and the remaining leaf litter mass determined after eight months. Galled leaves on average showed higher nitrogen content than non-galled leaves and within galled leaves green tissue showed higher nitrogen content than yellow tissue and yellow tissue higher nitrogen content than brown tissue. We found no differences in herbivory between galled and non-galled leaves. The decomposition rate of galled leaf litter was on average 48.9% higher relative to non-galled leaf litter. Overall our results suggest that green islands shift nutrients that otherwise would be stored in the plant to the decomposer community. This nutrient pulse stimulates decomposition and may also increases abundance of decomposers.

Session 21-P8 - Role of cyanogenic glycosides in the seeds of wild Lima bean, *Phaseolus lunatus*: Defense, nutrition or both?

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Leaves and seeds of wild lima bean plants contain cyanogenic glycosides (CNGs) that have been shown to function as an effective defense against generalist leaf

herbivores. However, in recent work we found little or no effect of CNGs on several species of seed beetles that account for more than 90% of seed predation in wild populations throughout the natural range of this plant species in Mexico. On the other hand, few studies have suggested that CNGs could also serve as nitrogen-storage compounds that may be used during the development of the plant. In this study we examined the role of CNGs in Lima bean as defense and nutrient-storage compounds during seed germination and plant development. Seeds were obtained from field-collected pods in four natural plant populations that had been previously characterized for their low or high content in CNGs. Seeds were sown and followed from germination until the production of the 4th trifolium (approximately 5 weeks). During each plant developmental stage, plant structures were analyzed for their concentrations of CNGs. In parallel; another group of plants at each developmental stage was used for feeding assays with the generalist herbivore, *Spodoptera littoralis*. We found a positive correlation between the concentration of CNGs in the seeds and those in the cotyledons but not in the successivetrifolia, which in general presented low CNGs concentrations. Accordingly, larvae of *S. litoralis* preferred to feed on cotyledons with low concentrations of CNGs and no differences in preference were found for trifolia produced by the different seed types. We did not find any differences in germination and plant growth between plants produced from the different seed types. Our results show that the CNGs present in the seeds are transferred to the cotyledons, where they play a role in defense against this generalist herbivore. We did not find evidence for a nitrogen-storage role of CNGs at any plant developmental stage. These findings highlight the importance of studying the role of secondary compounds at different stages of plant ontogeny.

Keywords: *Spodoptera littoralis*, direct defense, plant ontogeny, secondary defense compounds

Session 21-P9 - Spatially heterogeneous plant-soil feedbacks promote plant diversity and hamper monocultures

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Plant-soil feedback (PSF) studies have become a central component of our understanding of many terrestrial plant community processes. Recent work has shown that spatially interacting PSFs can strongly influence the plant performance. However, emperical data on the role of the spatial scale (grain) of PSF heterogeneity is lacking. In a greenhouse experiment we placed soils with different PSF in patches in fine- (6x6cm patches), coarse-grained (12x12cm) and spatially homogeneous treatments. Monocultures and mixtures of six common grassland

species were planted on the soil treatments. We tested how the grain of spatial heterogeneity affected plant performance both with intra- and interspecific competitors. Spatial PSF heterogeneity had pronounced effects on plant performance. For monocultures performance was reduced in the heterogeneous PSF treatments (~10% reduction in biomass). Although the strenght of the effect of PSF heterogeneity varied across test species and soil conditioning, most were negative. When grown in plant mixtures, however, spatial heterogeneity seemed to offer refuge from antagonists for at least some species, as their direct PSF changed from strongly negative to neutral or even positive in the fine scale heterogeneity treatment. We conclude that spatial PSF heterogeneity strongly affects plant performance, particularly in interspecific competition. We think that both the likelihood of encountering patches with strong direct and/or indirect PSF as well as the potential rate of transmission of antagonistic effects (e.g. pathogen infection) importantly determine plant performance in competitive mixtures. While theory seems to hold up in some instances, however, in many cases the responses remained poorly predictable. Consequently, there is a need for studying plant-soil interactions in space and to do so by mimicing field conditions in more realistic ways.

Session 21-P10 - Trade-offs in plant size affecting the susceptibility to soil-biota effects with stabilizing effects on plant diversity

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Plants performance is differently affected by the presence of soil biota. This influence is known as soil-biota effect (SBE). Though, soil biota not only affect a single plant or conspecifics in monocultures (direct SBE), but also other plant species in plant communities (community SBE). To understand how SBEs influence the structure of plant communities and thus biodiversity in grasslands, direct SBEs have to be compared to community SBEs. Furthermore, little is known about the impact of SBE on plants local abundance (as a surrogate for establishment success) and/or spatial size (as a surrogate for light competitive ability). Therefore, a SBE-experiment was combined with a biodiversity-experiment, to foster the understanding of how SBEs can modulate species coexistence as a function of plants local abundance and spatial size. In addition, we applied a new method to estimate plants spatial size by analyzing four size-related plant traits. 16 plant species, varying in local abundance and spatial size, were grown as single plants, in monoculture as well as in mixtures in sterile and non-sterile soils to investigate SBEs of plant species. Overall, a negative correlation between SBE and local abundance, as well as with size was proven, with positive SBEs for rare resp. small

(weak competitive) plants. Further, an interactive effect of local abundance and size on SBE was found, whereas the relationship altered from direct to community SBE. Abundant and large (highly competitive) plant species are limited, however rare and small plant species are favored by specific community SBE. This suggests that plant species are not equally influenced by soil biota in a plant community, what could be a potential mechanism of how species coexistence is modulated by SBE and hence diversity is maintained in a grassland. Moreover, it is assumed that the importance of plants spatial size in terms of plant community structure was underestimated by now.

Session 21-P11 - Above- and below-ground coupling in plant-soil feedback modeling: the empiricist's perspective

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Soil has often been described as 'black box' due to its opaqueness and the various challenges arising when studying the complex interactions between soil biota, but also soil biota and the respective plant communities. However, there is a number of interesting processes and feedback mechanisms, which have a strong impact on the composition and performance of plant communities, and should hence be considered explicitly in modeling frameworks. In our poster, we present ideas from the empiricists' point of view and give short explanations of below-ground factors which we assume to be important drivers of plant communities and which hence should be included in plant models that are aiming to explicitly incorporate below-ground feedbacks. Amongst others, these include root functional types based on classical root traits to define the zone of interaction and hence competition between plants, symbiotic and pathogenic relationships between soil microorganisms and the respective plants as well as positive and negative plant-soil feedback mechanisms in general. We will discuss the issue of insufficient data in this context and possible generalizations of the complex habitat soil for implementation into individual-based community models.

Session 21-P12 - Above- and below-ground coupling in plant-soil feedback modeling: the modeler's perspective

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Plant-soil feedbacks are assumed to modify biodiversity patterns, ecosystem functions, and the resulting ecosystem services across temporal and spatial scales. To date such feedbacks have rarely been implemented in individual-based community models. To assess the effect of plant-soil feedback processes on above- and below-ground communities, we aim at a mechanistic understanding of the complex dynamics of above-/ below-ground relationships. In particular, we are aiming at understanding the influence of root traits on soil but also plant communities, the linkage of the respective traits, and the influence of changes in these traits on plant-soil feedback loops. For this purpose, we will extent the small-scale grassland model IBC-grass that explicitly simulates the fate of individual plants by additional traits related to below-ground processes. With this, we intend to assess the effect of plant soil feedback processes on trait composition and performance of plant communities and vice versa. Therefore, the model will be able to simulate the full feedbacks between plant and soil communities and to assess shifts in trait composition as a result of these feedbacks. In this poster, we will show a conceptual outline of the proposed model, as well as first results on feedback mechanisms.

END OF SESSION 21

Session 22 – Functions and mechanisms of the interplays between multitrophic interactions and tree growth

Short title: Tree growth and multitrophy

Chairs
Prof. Dr. François Buscot
Prof. Dr. Thorsten Grams

Session 22-O1 - Endogenous rhythmic growth, a trait suitable for the study of interplays between multitrophic interactions and tree development

Sylvie Herrmann[1,2], Thorsten Grams[3], Mika Tarkka[1,2], Oguzan Angay[3], Michael Bacht[4], Lasse Feldhahn[1,2], Marcel Graf[5], Florence Kurth[1,2], Hazel Maboreke[6], Sarah Mailander[7], Sabine Recht[1,2], Frank Fleischmann[3], Liliane Ruess[6], Martin Schädler[1,2], Stefan Scheu[5], Sylvia Schrey[7], François Buscot[1,2]

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As perennials, trees undergo phases of meristem activity ceases that control tree architecture and survival through seasons, and are linked to variations in plant resources allocation between below- and aboveground parts. This affects the multitrophic associations on trees, which feedbacks on plant growth and resource economy.Some major forest trees display an endogenous growth rhythm, and related pulses of variation in allocation of resources have been shown. As this trait makes it possible to separate growth into defined phases, it offers an opportunity to disentangle the complex regulation of growth and multitrophic interactions. We present the experimental platform “TrophinOak” that uses microcuttings of DF159, a clone of *Quercus robur*. *Q. robur* displays an endogenous rhythmic growth with alternating shoot and root growth flushes. We selected beneficial or detrimental above- and belowground partners in animals, fungi and bacteria, to synthesize interactions on DF159. At distinct growth phases, C and N allocation were monitored by stable isotope pulse labeling, and plant gene expression was analyzed by RNA-Seq in reference to a contig library specific of DF159. We found highest variations in gene expression in leaves and roots entering into growth cessation at the end of shoot and root flushing, respectively. Plants inoculated with

the ectomycorrhizal fungus *Piloderma croceum* displayed enhanced growth and resources without modifying the rhythmic growth. However in this treatment, the differential gene expression in leaves and roots entering into growth cessation dropped, especially in roots. This enabled us to detect that core genes ruling endogenous rhythmic growth correspond to internal clock processes. Comparing interactions with 7 biotic partners, we found only two patterns of differentially expressed contigs. Patterns 1 corresponds to increased levels of DEC upon shoot flush in both root and shoot, while in pattern 2 the increased level is during root growth flush. These patterns depend neither on the effect of the partners, nor on the targeted tree organ. We currently identify genes common and specific of the different biotic partners.

Session 22-O2 - Biotic interactions and endogenous rhythmic growth as drivers of oak gene expression

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Biotic interactions and endogenous rhythmic growth with alternating root and shoot flushes constitute major determining factors of performance of oaks in the environment. *Quercus robur* clone DF159, the clonal tree model of the platform TrophinOak, is used to investigate how a plant coordinates development and biotrophic interactions, synthesized under controlled lab conditions. From the oak associated organisms surveyed in the TrophinOak research program, interaction with the mycorrhiza associated bacterium *Streptomyces* AcH 505 stimulated the formation of mycorrhizal symbiosis and reduced damage by pathogens. The bacterium protected pedunculate oak from pathogenesis by oak powdery mildew *Erysiphe alphitoides*, and RNA-Seq analysis of bacterium inoculated oaks indicated an induction of a surprisingly large number of defense-related genes, including genes associated with jasmonic acid/ethylene-dependent and salicylic acid-dependent defense pathways. Oak defense gene expression was further enhanced upon the challenge with powdery mildew infection. The response to AcH 505 was specifically induced at shoot flush, which indicates that the physiology in roots is rather devoted to growth at root flush while the processes directed towards interactions are in most part attenuated. In contrast to the situation in powdery mildew infection, the gene expression response to AcH 505 was attenuated when a mycorrhizal fungus, *Piloderma croceum*, was co-inoculated, marked by differential expression of a few, specific microbe associated pattern receptors and transcription factors, i.e. candidate “core genes” of AcH 505 response. We conclude that the presence of multiple organisms may either buffer or amplify gene expression responses in oak, and that the response of the oak depends on the stage of growth.

Session 22-O3 - Transcriptome analysis in oak uncovers a strong impact of endogenous rhythmic growth on the interaction with plant-parasitic nematodes

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Quercus robur L., an important tree in temperate forests displays an endogenous rhythmic growth pattern characterized by alternating shoot and root growth flushes paralleled by oscillations in carbon allocation to below- and aboveground tissue. This plant trait has been largely neglected as a determining factor of plant biotic interactions. This study investigates the response of oak to migratory root-parasitic nematodes in relation to rhythmic growth and how the plant-nematode interaction is modulated by an ectomycorrhizal symbiont. RNA-Seq transcriptome of oaks inoculated with the nematode *Pratylenchus penetrans* solely and in combination with the fungus *Piloderma croceum* was assessed. Systemic response of oaks to the parasitic nematode was strongest during shoot flush, with a 16-fold increase in the number of differentially expressed genes as compared to root flush. Multi-layered host defence was induced at shoot flush comprising upregulation of reactive oxygen species formation, hormone signalling (e.g. jasmonic acid synthesis), and proteins involved in the shikimate pathway. In contrast, during root flush detoxification of oxygen radicals was enhanced indicating a repression of host defence. With the presence of the mycorrhizal symbiont, the gene expression pattern was vice versa with a distinctly stronger effect of *P. penetrans* at root flush, including host defence suppression and promotion of cell and carbon metabolism, likely a result to the enhanced carbon sink strength in roots induced by the presence of both, nematode and fungus. Meanwhile at shoot flush, oak defence related mechanisms such as sugar signalling pathways and protein synthesis were modified. Our findings highlight how gene response patterns of plants to biotic interactions, both negative and beneficial, are largely modulated by endogenous rhythmic growth and therefore such plant traits should be considered as an important driver of these relationships in future studies.

Session 22-O4 - Sweets for the foe - non-structural carbohydrates and the susceptibility of oak against *Phytophthora quercina*

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The root-rot pathogen *Phytophthora quercina* is a key player of the oak decline in Europe. The susceptibility of *Quercus robur* (pedunculate oak) to *P. quercina* has been hypothesized to depend on the carbon availability in roots as an essential resource for defense. We used an experimental system with microcuttings of *Q. robur* undergoing an alternating rhythm of root (RF) and shoot growth (SF). Study trees were inoculated with the ectomycorrhizal fungus *Piloderma croceum* and the root-rot pathogen *P. quercina* during both growth phases, i.e. RF and SF. Photosynthetic and morphological responses as well as concentrations of non-structural carbohydrates (NSC) were analyzed. Infection success was quantified by the presence of pathogen DNA in roots. NSC concentration in roots depended on the alternating root/shoot growth rhythm, being high and low during RF and SF, respectively. Likewise, success of infection was high during RF and reduced during SF, resulting in a significantly positive correlation between pathogen DNA and NSC concentration in roots as opposed to the hypothesis. We conclude the alternating growth rhythm (RF *vs.* SF) to play a crucial role for the susceptibility of lateral roots to the root-rot pathogen. NSC availability in oak roots has to be considered as a benchmark for susceptibility rather than resistance.

Session 22-O5 - Temporal dynamics of host-parasitoid foodwebs in relation to spruce budworm outbreaks

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Most species are connected to others by complex networks of interactions. Many studies focus on static descriptions of foodweb structure, which may conceal functional relationships. Studies mechanistically describing food web dynamics across multiple years are extremely rare. Here, we quantitatively describe the dynamics of the host-parasitoid web associated to spruce budworm in forests of Eastern Canada over 13 years. Spruce budworm is one of the most devastating insect herbivores in forests of Eastern North America, with large, long-term density fluctuations. We show strong turnover of the diverse parasitoid community both within and across years. In consequence, parasitism rates during different life history stages showed contrasting relationships to budworm density. Overall parasitism rate on budworm was reduced during peak budworm density. Interaction rates of species indirectly linked to budworm changed depending on their life-history. Other herbivores tend to be weakly linked to budworm dynamics, due to the high specialization of herbivore-parasitoid interactions. Nevertheless, different indirect effects of budworm density on their parasitism rates were observed. In difference, the more generalized higher-order parasitoids link the dynamics of different primary parasitoids. Increased hyperparasitism rates during

peak budworm densities might limit effects of primary parasitoids. We will discuss implications for the potential regulation of spruce budworm populations by different parasitoids: the most frequent parasitoid species are likely not the most important ones. In conclusion, studies of host-parasitoid foodwebs should more explicitly consider temporal dynamics and the temporal scope of their study in relation to population dynamics of species of concern.

Session 22-O6 - Contribution of endophytic fungi to litter-decomposing communities

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Endophytes are defined as microorganisms colonizing healthy plant tissues without causing any signs of infection or damage to the host plant. Fungal endophytes are reported to be taxonomically diverse and inhabit all plant species analysed so far. Composition of endophytic communities varies with time, host identity, organ and tissue type, geographical location and environmental factors. While impacts on host plant fitness have been reported for certain species, growing evidence suggests that many endophytic fungi play a role in litter decomposition. The transition from an endophytic to a saprotrophic life stage, however, has not yet been studied on spatial and temporal scales relevant for ecosystem processes. In the Exploratories for functional biodiversity research (DFG Priority Programme 1374) we analysed the endophytic fungal communities in leaves of *Fagus sylvatica* collected in two consecutive years across Germany and compared them with those in one-year-old litter. Using metagenomic barcoding we obtained >37 million sequences from 358 samples, representing 518 fungal OTUs. Almost all OTUs detected as endophytes co-occurred in one-year-old litter and dominated in the (transcriptionally) active litter-decomposing fungal community. Transition of endophytic to litter-decomposing communities will be discussed based on comparative analyses of community structures revealed by co-occurrence networks.

END OF SESSION 22

Session 23 – Effects of agricultural land use on ecosystem services in cultural landscapes

Short title: Ecosystem services in cultural landscapes

Chairs
PD Dr. Péter Batáry
Dr. Silvia Winter

Session 23-O1 - New challenges in conservation of pollinators in traditional agricultural landscapes in Transylvania (Romania)

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Traditional agricultural landscapes in Central and Eastern Europe have high value for farmland biodiversity. Accession to the European Union, however, may change agricultural practices and lead to the disappearance of traditional farming due to new subsidies re-structuring agriculture. We studied insect pollinators, which have essential role in pollination providing one of the most important ecosystem services for agriculture. The studied traditional agricultural landscapes were in the Transylvanian Basin, Romania (EU accession in 2007). Landscape scale effects of semi-natural habitats, land cover diversity, the effects of heterogeneity and woody vegetation cover of the surrounding landscape and on-site flower resources were tested on pollinator communities in arable fields and grasslands. Our results showed: (i) semi-natural habitats at the landscape scale have a positive effect on most pollinators, especially in the case of low heterogeneity of the direct vicinity of the studied sites; (ii) both arable fields and grasslands holding abundant flower resourcesare important to sustain pollinator communities; (iii) the currently non-protected areas can be important conservation areas for the studied pollinator insects. We compared management data from the more intensively managed old EU member states, and we established hypotheses and research questions on the potential consequences of the EU accession, for further, larger scale studies. We hypothesise that although several management practices are similar in our traditional study areas and in fields in old EU countries with agri-environment schemes (AES), the corresponding biodiversity values are largely different, with much higher diversity including rare species in the traditional fields. This hypothesis needs further study, which include more traditional landscapes providing baseline and exploration of other factors behind the lower than baseline level biodiversity values of AES fields.

Session 23-O2 - Berries, herbs and mushrooms - mapping and assessing wild food as an ecosystem service in Transylvania

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The importance of food and medicinal products gathered from the wild is often neglected in developed countries. However, gathering wild species is a widespread practice in several relatively developed parts of the world, where surviving traditional knowledge meets local economic motivations and a significant ecological heritage. This is the case in the Niraj and Târnava Mică valleys in Eastern Transylvania, where the gathering of wild products was ranked third among 12 ecosystem services (ES) in a preference assessment in 2015. We performed a series of surveys among local stakeholders engaged in collecting wild products, based on which we recorded 35 plant species and 21 mushroom species that were gathered. We linked these species to the major habitat types of the region, which made it possible to compile ES capacity maps for all major groups of collected species (wild edible plants, mushrooms, and medicinal plants). We also attempted a simple economic valuation for the harvest of wild products based on official permits and market prices. Collecting wild food is important to broad layers of the local society, ranging from direct use for own nutrition as a necessity through making money by selling the collected goods to a mere pleasure activity or a self-evident part of every-day life. Both preserving traditional ecological knowledge as well as the natural environment in which it can be exercised are important issues. The concept of the ES “wild food” is relatively direct and tangible and can therefore easily be used in order to communicate messages on the importance of preserving natural ecosystems along with the importance of maintaining the traditions that make sustainable use of these cultural landscapes.

Session 23-O3 - Grassland degradation in a mountain ecosystem: Impacts on plant diversity, vegetation cover, and site conditions

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The Caucasus region is one of the global biodiversity hotspots which comprises highly diverse mountain grasslands. These grassland ecosystems were shaped from

a long tradition of human land use and provide multiple services such as food supply for grazing animals, recreational sites and erosion control. Erosion control is substantially influenced by biotic environmental conditions such as vegetation cover, vegetation composition and species richness, which are in turn dependent from abiotic site conditions and management practices. Changes of land use practices have induced grassland degradation in the Georgian Caucasus regions. Overgrazing during Soviet period and recent increases in recreational activities resulted in a reduced grass cover, an increased abundance of unpalatable plant species and soil erosion. Due to an expansion of grassland degradation, the loss of services provided by healthy ecosystems can be expected. The aim of our study was to evaluate the relationships between plant diversity, vegetation cover and site conditions for the Upper Aragvi valley, where degradation events can be observed on a landscape level. We used NMDS ordination and cluster comparison of functional plant groups to describe a gradient of grassland vegetation cover. We found increasing occurrence of ruderal pasture weeds and tall herb vegetation on abandoned hay meadows. Additionally, a decline of plant diversity can be observed on sites of reduced vegetation cover. Further, we tested the natural restoration potential from seed bank analysis. Due to a low potential of the grassland ecosystem to balance further vegetation cover damage, the long-term loss of diverse habitats can be expected. Therefore we proposed potential native plant species for revegetation to restore and conserve the valuable mountain grassland habitats.

Session 23-O4 - Impacts of land-use change on the diversity of bumblebees, bugs and grasshoppers in semi-dry alpine meadows

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In different European countries land use abandonment of traditionally managed semi-dry meadows, especially in alpine regions, is an ongoing problem due to poor accessibility, low economic yield and high labour input. Due to abandonment of traditionally managed semi-dry meadows it is assumed that very valuable habitats that harbour a high biodiversity get lost, affecting both the faunistic and floristic diversity by altering the habitat quality for species depending on this habitat type. In June and August 2015, we assessed the influence of land-use abandonment on bumblebees, grasshoppers and heteropteran bugs in three regions across the Alps with study regions in Biosphere Reserve Val Müstair (Graubünden, Switzerland), Biosphere Reserve Großes Walsertal (Vorarlberg, Austria) and in the LTSER-region Eisenwurzen (Styria, Austria). Within each study region three abandoned and three extensively managed semi-dry meadows (mown once a year, no fertilizer use) were

investigated measuring richness, abundance and species assemblages of bumblebees, grasshoppers and bugs. Grasshoppers and bugs are known to be influenced by land use change due to the loss of favourable habitat conditions especially for larvae. Bumblebees are important pollinators that need flower-rich habitats for foraging and these insects may strongly be affected by land use abandonment of traditionally managed meadows. We hypothizised that there is a difference in species richness, abundance and species assemblages of bumblebees, grasshoppers and bugs between managed and abandoned semi-dry meadows. We found out that bumblebee species richness was higher in managed meadows whereas bug and grasshopper species richness showed no differences among both management types. On the contrary, managed and abandoned meadows harboured different species assemblages of bugs and grasshoppers but none of bumblebees. The results reveal that both managed and abandoned semi-dry meadows contribute to the establishment of different species assemblages and both habitat types seem to be important for maintaining species diversity of bugs and grasshoppers within the alpine landscape, whereas bumblebee diversity can be fostered by maintaining traditionally managed meadows by providing foraging grounds.

Session 23-O5 - The potential of irrigation to combine high yields and high species richness in lowland meadows

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Grassland is an important component of the European cultural landscape and contributes strongly to biodiversity. The intensification of grassland management (e.g. increased mineral fertilizer applications) in the last decades aims at maximizing the ecosystem service of yield (hay biomass), but, at the same time, has often a negative influence on species diversity. However, the conservation of species diversity in cultural landscapes is necessary to protect overall biodiversity and to maintain ecosystem services, which are ensured by high species diversity. Finding wildlife-friendly farming systems which enables the coexistence of rewarding agriculture and high biodiversity is therefore urgently needed. Across Central Europe, meadow irrigation was a widely used land use form to enhance hay yield until about 100 years ago. In our project we empirically investigated the relationships between hay yield and species diversity in lowland meadows with different management. We analyzed the effects of irrigation (yes/no) and fertilization (from 0-80 kg N/ha year) on hay yield and identified the most important determinants of species diversity for multiple taxa comprising a broad range of trophic levels and mobility (plants, isopods, carabids, grasshoppers, and butterflies). Our results suggest that irrigation can enhance hay yield by about 20% in the investigated grassland system. Species richness of most taxa was not related

to yield and irrigated meadows contained similar species numbers than non-irrigated ones. The only exception was orthopteran species richness, which decreased towards more productive meadows. Besides higher yield, meadow irrigation can have benefits on additional ecosystem services such as flower richness (aesthetic value) or for species of conservation concern. Our results suggest that irrigation might be a land use form which can combine high yields and species diversity in grassland ecosystems.

Session 23-O6 - Assessing the impacts of different grassland management treatments on insect-pollinated plants using long-term experiments

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Traditionally managed, species-rich grasslands are highly threatened by either intensification of agricultural practices or abandonment. Both processes lead to changes in plant community composition towards a lower proportion of flowering plants, therewith negatively affecting pollinating insects that provide an essential ecosystem service in cultural landscapes. Here, we investigated the effects of different types of management on plant species richness and richness of insect-pollinated plant species at three grassland sites in Thuringia (Germany) representing different grassland types.At each site, identically designed long-term management experiments were established in 2000/2001. The experimental design included five different treatments reflecting traditional management (two cuts per year without fertilization), extensification (mulching once a year and succession, i.e. without any management) and intensification of grassland management (two treatments with up to five cuts per year and different fertilizer regimes). The experimental design was a randomised block and the treatments were replicated four times per site. Linear mixed-effect models were used to analyse the effects of treatment, site and year on the total number of plant species and the number of insect-pollinated plant species.The results demonstrated that the effects of management treatments on plant species richness and richness of insect-pollinated plants differed between sites. Across all sites, grassland management with two cuts per year without fertilization increased both total plant species richness and richness of insect-pollinated plants, while mulching and succession led to a decrease in species richness. To conclude, grasslands cut twice a year without fertilization can provide a constant and diverse food supply for pollinators in cultural landscapes in Thuringia. Using long-term experiments facilitates the formulation of general management recommendations for different grassland types.

Session 23-O7 - Land-use intensity as a driver of insect communities and their functions

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Semi-natural grassland ecosystems in Europe have developed over centuries of low intensity traditional management. Now, the highly diverse plant and animal communities which evolved in these grasslands are becoming increasingly threatened by both land abandonment and land-use intensification. Both phenomena lead to dramatic changes in plant communities and their associated animal communities. Arthropod communities (insects and spiders) are known to react very sensitively and rapidly to changes in grassland management. I will present results from a six-year monitoring of grassland arthropods in 150 grasslands of varying land-use intensity in Germany. I will show that land-use intensity (grazing, mowing and fertilization) decreases the species richness of arthropod communities and that different functional groups are affected through different mechanisms. In particular, herbivores and predators show marked differences in their reaction to land-use intensity. Such changes affect ecosystem services, as shifts in functional traits within the arthropod community are closely related to several ecosystem functions including pest control, pollination or nutrient cycling. I show that not only species richness is affected by land-use intensity, but also community composition, functional diversity and community stability. All those changes affect the potential of the arthropod communities to provide the stability and resilience of ecosystem services.

Session 23-O8 - Historic and recent land use affects ecosystem functions in subtropical grasslands in southern Brazil

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Land-use changes such as conversion of semi-natural grasslands to agriculture, silviculture, and high-intensity pastures affect biodiversity and ecosystem functions, threatening the ecosystem services they provide. This study investigated the effects of historic land use and recent management practices on ecosystem functions in traditionally managed and altered grasslands in southern Brazil. Traditional management included burning of accumulated biomass at the end of the growing season and moderate levels of grazing. These reference grasslands were compared to four categories of modified grasslands: permanent grasslands with low management intensity (no burning and little grazing), permanent grasslands with high management intensity (no burning, intensive grazing, fertilizing, and overseeding with forage species), secondary grasslands after agricultural use, and secondary grasslands succeeding silviculture. In total, 80 sites were surveyed, measuring 12 proxies for different ecosystem functions using rapid ecosystem function assessments (REFA). These included above- and belowground primary and secondary production and several species interactions. Functions differed significantly among land-use categories, most distinctly between permanent and secondary grasslands. Temporary land-use changes to agriculture or silviculture led to altered functions in the succeeding grasslands, including lower root and microbial biomass, lower aboveground secondary production, lower seed dispersal capabilities, and higher vulnerability to invertebrate herbivory. Recent management practices, including grazing intensity, burning and mowing regime, overseeding, and fertilizing, explained additional variation in some functions, including strong positive effects of intensified management on aboveground secondary production. The findings suggest that conversion of rangeland to more intensive land uses has long-term consequences for many ecosystem functions, with effects persisting many years after reconversion and uncertain recovery to pre-conversion levels.

Session 23-O9 - Mechanisms of soil organic carbon and nutrients decrease by degradation of the world-largest alpine pastoral ecosystem

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Approximately 1.5 million km² of the Tibetan Plateau are covered with grasslands. Thereof one third is occupied by the world's largest pastoral alpine ecosystem (*Kobresia* pastures). Paleo-records indicate the grazing-induced origin of this ecosystem since more than 8000 years or at least since yak domestication since 4000 years. Long-term moderate grazing by yak and sheep increased belowground C allocation of *Kobresia pygmaea*, caused the development of dense root-mats and finally lead to an accumulation of soil organic carbon (SOC) and nutrients such as nitrogen (N) and phosphorus (P) in the topsoil. These pastures, however, are increasingly affected by large-scale degradation caused by overgrazing of these highly sensitive ecosystems. Loss of the topsoil threatens several ecosystem

functions: i.e. SOC and nutrient storage, biodiversity, provision of grazing-ground and supply of clean water for large parts of SE-Asia. Here, we present a conceptual model and results of degradation processes combining anthropogenic and natural amplifications. To evaluate losses of SOC and nutrients we synthesize field observations and surveys in the highlands and validates this with own analyses in the *Kobresia* core area. We show that drought- and frost-induced polygonal cracking opens the root-mats, already weakened by overgrazing. This initiates a dying of the *Kobresia* turf, extends the surface cracks, triggers soil erosion and promotes SOC mineralization and leaching losses. Soil erosion caused further high losses of SOC and nutrients from the topsoil (i.e. 0-10 cm: ~5.1 kg C m^{-2}), whereas SOC loss beneath the surface cracks was primary caused by both, decreasing C-input and SOC mineralization (mineralization-derived SOC loss: ~2.5 kg C m^{-2}). The root biomass decreased with intensity of pasture degradation and lower C input constrains the ecosystem recovery. A negative $\delta^{13}C$ shift of SOC reflected intensive decomposition and corresponded to a relative enrichment of ^{13}C depleted lignin components. In sum, degradation triggered high SOC loss (up to 70% of intact soil in 0-30 cm: ~7.6 kg C m^{-2}) from this ecosystem with profound consequences for carbon sequestration, atmospheric CO_2, water quality and ecosystem stability.

Session 23-O10 - Do soil-borne ecosystem services react to landscape diversity in agriculture?

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Biodiversity has the potential to buffer ecosystems against change and stabilise ecosystem functions and services. However, the suitable level of biodiversity to maximize ecosystem services in agricultural landscapes is not yet known and quantified. Soil organisms are major deliverers of soil-borne agroecosystem services by decomposing organic materials and recycling nutrients for crop production. We investigate in the Quillow catchment (Northeast Germany) how landscape heterogeneity and natural landscape elements impact the diversity of soil organisms and related ecosystem services for crop production. We quantified abundance and diversity of earthworms and mesofauna (Acari and Collembola) along transects from hedgerows and kettle holes into wheat fields in both heterogeneous and homogeneous agricultural landscape units and measured decomposition rates for different organic materials. This allows us to relate earthworm and mesofauna abundance and diversity directly to an ecosystem service along transects from natural habitats into agricultural fields and enables us to develop landscape management suggestions.

Session 23-O11 - Past and present access of rural households to ecosystem services in a rapidly changing cultural landscape in Ethiopia: winners and losers

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Rapid land use changes in cultural landscapes around the world alter the access of local communities to farmland and forest ecosystem services. In developing countries, where the rural poor often heavily rely on ecosystem services to fulfil basic well-being needs, such development can create winners and losers among local communities. Here, we present findings from our study of past and present access of rural households to farmland and forest ecosystem services in the SW Ethiopian highlands. We show that current patterns of households' land use and access to ecosystem services in combination with past access to ecosystem services lead to distinct groups of beneficiaries in rural cultural landscapes. We discuss our findings in the light of social and ecological implications, and raise the question whether current landscape trajectories are sustainable and just.

Session 23-O12 - Epiphyte diversity in wooded pasture landscapes in central Europe: Connectivity matters for lichens but not for bryophytes

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Sylvo-pastoral systems are man-made biodiversity hotspots, but are nowadays severely threatened by land-use changes. Trees in these systems are more or less isolated from each other and represent habitat islands for epiphytic species such as bryophytes and lichens. The effect of ecological conditions on the diversity of these organisms might differ among species with contrasting dispersal capacities, habitat preferences and rarity. On sycamore maple (*Acer pseudoplatanus*) wooded pastures in the northern European Alps we assessed the effect of tree parameters, environmental variables and connectivity measures on the diversity of epiphytic bryophytes and lichens and on the occurrence of three species of major conservation concern: two bryophytes (*Tayloria rudolphiana*, *Orthotrichum rogeri*) and one lichen (*Lobaria pulmonaria*). The biodiversity on the trees was unexpectedly high. On average 29 bryophyte and 44 lichen species were recorded per tree. Species richness of bryophytes and lichens as well as of various subgroups was differently affected by tree-size and -age related variables and environmental factors. Interestingly, connectivity to neighbouring trees was very important for lichens but not for bryophytes. This indicates that local dispersal is crucial for lichens whereas for the colonisation with bryophytes long distance dispersal seems to be more important. Of the three target species only *T. rudolphiana* was found to

depend on connectivity. With respect to tree-related variables and environmental factors, the three target species showed different relationships. Our results show that different conservation measures have to be applied depending on the taxonomic and functional species group, or the individual species which is addressed. For the conservation of a high, overall diversity in sylvo-pastoral systems it is thus crucial to sustain not only old and large trees but rather a wide range of tree sizes and ages as well as sufficient tree densities.

Session 23-O13 - Do we gain more than wine from a viticultural landscape? - A closer examination of the Moselle river valley

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Viticultural landscapes seem to be very monotonous on first sight. And it appears that there is not much more than the wine, we consume, to be gained from them. On the contrary, viticulture means lots of pesticides and low biodiversity - or so most people think. On closer inspection, we see a highly fragmented landscape with special climatic and topographic characteristics and a long historic development starting in Roman times. Therefore, many xerothermophilic organisms find suitable habitats on the steep slopes - among them many red-listed species. The use of pesticides is reduced nowadays and there are many useful creatures, esp. insects that help reduce pest species and spare the environment. In addition, old vineyards are also a source for old ungrafted vine that helps to maintain the genetic diversity of different grape varieties which would be lost otherwise. Furthermore, the scenery of the Moselle river valley attracts millions of tourists every year to spend their vacation there and enjoy the variety of cultural, scenic and culinary possibilities. Therefore, this overview shows that there are more ecosystem services hidden in a viticultural landscape like the Moselle region than we expect.

Session 23-O14 - Management intensity or landscape diversity: What matters most for wild bee diversity in wine-growing areas?

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Vineyards provide a range of essential ecosystem services and habitats for various animal and plant species. However, recently intensive agricultural management, like frequent soil tillage, has resulted in a simplification of the landscape, the degradation of biodiversity-based ecosystem services, and a loss of habitat quality. In cultural landscapes wild bees enhance ecosystem services like pollination and the provision of functional biodiversity. Wild bees depend on floral resources and suitable nesting habitats, both being influenced by management practices at the field and landscape scale. We investigated 32 vineyard plots in Austria and Spain differing in inter-row tillage frequency resulting in bare soil, temporary or permanent vegetation cover. Each vineyard was centred in a landscape circle of 1.5 km diameter of which landscape diversity was mapped in the field and further analysed using a geographical information system. Wild bee diversity was assessed by a semi-quantitative transect method on the plot scale. First results from Austria showed that permanent vegetation cover increased wild bee species diversity by 22% compared to temporary vegetated inter-rows mainly due to a higher diversity of below-ground nesting bees. Higher flower coverage of the inter-rows resulted in a significantly higher wild bee diversity. Further analyses will reveal whether management intensity or landscape diversity have the strongest effect on wild bee diversity. This study is part of the European BiodivERsA project “VineDivers – Biodiversity-based ecosystem services in vineyards”.

Session 23-O15 - Effects of vineyard management intensity on - insights from a meta-analysis

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Vineyards are permanent agro-ecosystems, which could potentially provide a range of different ecosystem services. Traditionally, vineyards have been embedded in diverse cultural landscapes, which can be considered as high nature value farming systems. Within the last 50 years, mechanization and increasing use of external inputs have altered cultural landscapes as well as vineyard management. Nowadays, vineyards are often high intensity agricultural systems with bare soil or inter-row vegetation consisting of only a few plant species. This kind of management is often associated with ecosystem disservices such as high rates of soil erosion, degradation of soil structure and fertility, contamination of groundwater and decline of biodiversity. Aside from some local case studies, the consequences of establishing diverse cover crop mixes or tolerating spontaneous vegetation in vineyards for ecosystem services (including yield and wine quality) has not been investigated yet. This meta-analysis provides an overview of all published studies comparing the effects of different vineyard management practices (e.g. vegetation cover versus bare soil) on a range of ecosystem services like pest control, pollination, soil conservation, carbon sequestration and biodiversity per se. We used a predefined search string covering all contents of the PICO scheme in the databases Web of Science and SCOPUS, which resulted in overall 1434 articles. Afterrigorous title, abstract and full-text screenings data from 58 articles could be extracted for the meta-analysis. Most articles presented grape yield and quality, followed by biodiversity and soil fertility data. The log response ratio of the biodiversity subset showed a slight positive effect of low intensity vineyard management. The summary effect size of all studies form a hierachical meta-analysis model will point out, which management measures can provide the best overall net sum of ecosystem services.

Poster presentations

Session 23-P1 - SusTaining AgriCultural ChAnge Through ecological engineering and Optimal use of natural resources - the STACCATO project

Anja Schmidt[1], Beatriz Rodríguez-Labajos[2], Erik Öckinger[3], Juliana Dänhardt[4], Laszlo Rakosy[5], Niklaus E. Zimmermann[6], Pavel Stoev[7], Razvan Popa[8], Tatyana Bileva[9], Tibor Hartel[10], Vlada Peneva[11], Walter Schmidt[12], Josef Settele[1,13]

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In order to advance long-term sustainable development of land use systems against risks arising from multiple aspects of global change STACCATO plans to quantify the sensitivity of ecosystem functions (ESF) and the services (ESS) to environmental pressures in representative agriculturally dominated landscapes in Europe. The focus is on local as well as regional land use intensity (including the socio-economic background) and biodiversity, and the potential impacts of future climate and land use change. Following the framework of the Millennium Ecosystem Assessment (MEA) we define supporting services as ESF and deal with selected characteristic elements defined by the MEA, namely a) Provisioning Services (PS): nutrient cycling & crop production; b) Regulating Services (RS): biocontrol & pollination; and c) Cultural Services (CS): identity with cultural landscapes. Studies are planned in representative regions across Europe in landscapes along a gradient reflecting changing geo-climatic and land use intensity and socio-economic conditions. Focus will be on landscapes shaped by annual crops and semi-natural grasslands. In particular, we intend to investigate the interactions between annual crops and the surrounding landscapes including the sprawling urban areas and the potentials of ecological engineering as a tool for eco-functional intensification. As core output STACCATO will develop guidelines for optimizing ESF and ESS provision and their stabilization under future climate and land use change. To achieve this STACCATO will analyze the potential of ecological engineering as a tool for eco-functional intensification. Ecological engineering can in principle be applied in conventional and integrated as well as organic agriculture. STACCATO will test the implementation and transferability across regions. The latter is to be achieved through inclusion of e.g. local agricultural agencies and extension services as associated partners. Implementation will include assessments of ESS risks and opportunities in the light of changes in land use priorities and intensity accompanied by the loss of natural and semi-natural habitats, biodiversity and climate.

Session 23-P2 - Are Coteaux du Layon (France) vineyards a good place for Biodiversity?

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In the transdisciplinary BiodivERsA project “VineDivers” we will examine essential ecosystem services provided by viticultural landscapes that result from diverse communities of above- and belowground organisms and their interactions. Four viticulture agroecosystems along a west-eastern transect through Europe, Spain, France, Austria and Romania, are investigated in this project. Main scientific interests of VineDivers are analyzing interlinkages between plants, pollinators, soil biota and soil-water erosion as a function of landscape complexity and vineyard management intensity. Here we show to what extent different soil management in vineyards in the French AOC “Côteaux du Layon” affects the activity and diversity of soil biota, such as earthworms, collembola, and microorganisms (litter decomposition rate, stabilisation index), and how this feeds back on aboveground biodiversity, such as vascular plants and pollinators, in different landscape contexts. On the basis of these results, VineDivers will also investigate ecosystem services associated with soil faunal activity and biodiversity such as pollination, mitigation of soil erosion, soil fertility, and grape quality as well as aesthetic and recreational value of different vineyard landscapes.
Aknowledgement. This research was founded through the 2013-2014 BiodivERsA/FACCE-JPI joint call for research proposals. Assessment of regional policy & development of policy scenarios using data acquired in this project will be implemented, and recommendations will be developed for the Common Agricultural Policy, the new Biodiversity Strategy of the EU.

Session 23-P3 - Effects of vineyard interrow soil cultivation and soil properties on soil biota appear to be altered by the surrounding landscape

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Ecosystem services provided by viticultural landscapes result from interactions between management intensity, soil properties, organisms inhabiting these landscapes, and the structure and diversity of the surrounding landscape. However, there is actually very little known to what extent these different factors influence the abundance and diversity of various soil biota. In this study we examined (i) to what extent different soil management intensities of vineyard inter-rows affect the activity and diversity of soil biota (earthworms, Collembola, litter decomposition), (ii) the role of soil properties influencing these effects and (iii) whether the landscape structure and diversity is altering these interactions. We collected data in 16 vineyards in Austria embedded in landscapes with varying structure (i.e. from structurally simple to complex) and assessed earthworms (hand sorting), Collembola (pitfall trapping and soil coring) and litter decomposition (tea bag method). Additionally, soil physical (water infiltration, aggregate stability, porosity, bulk density, soil texture) and chemical (pH, soil carbon content, cation exchange capacity, potassium, phosphorus) parameters were measured. The landscape surrounding the studied vineyards within a radius of 750 m was assessed by field mapping and analysed using geographical information system. Results showed that different soil biota/processes are differently affected by soil cultivation intensity and soil properties. Preliminary analyses suggest that the surrounding landscape appear to alter some of these interactions. These investigations are part of the transdisciplinary BiodivERsA project VineDivers (www.vinedivers.eu) and will ultimately lead into management recommendations for various stakeholders.

Session 23-P4 - Relationships between wild bees and pollination success in apple orchards with different landscape contexts in Hungary

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Pollination is an important ecosystem service, thus many agricultural crops such as fruit trees are pollinated by insects. However, agricultural intensification and landscape fragmentationlead to decline of pollinators, such as bees, bumble bees, and hoverflies. The landscape heterogeneity around the agricultural areas often enhances the pollinator biodiversity because pollinators are strongly influenced by vegetation, e.g. number of flowers in the adjacent environment. In this study pollinator communities were examined in twelve apple orchards with homogeneous and heterogeneous landscape in Hungary, 2012. The studied orchards had the same age and variety of apple trees with similar management. Pollinators were monitored in the flowering period of apple trees. The well-recognizable pollinators were recorded, others were captured for determination. Landscape heterogeneity was characterized in circles of 300, 500 and 1000 m radius around each orchard using Shannon's diversity and Shannon's evenness indices. Diversity of the surrounding landscape matrix had a marginal positive effect on the species richness of hoverflies at 300m, positive effect on the species richness of wild bees at 500m radius circle, while evenness of the surrounding landscape enhanced the abundance of wild bees at 500m radius circle. Flower resources in the groundcover within the orchards supported honey bees. Therefore maintenance of semi-natural habitats within 500m around apple orchards is highly recommended to enhance wild pollinator communities and apple production.

Session 23-P5 - Benefits and costs of diversified farming systems

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Rapid world-wide population growth and associated agricultural intensification leads to social, economic and ecological problems. These problems exacerbate the existing challenges of agricultural management to maintain ecosystem functions and their associated ecosystem services. To mitigate these problems, scientists propose a new model called "Diversified Farming System" (DFS). The DFS model aims to promote critical ecosystem services with a range of agricultural management practices, such as reduced tillage, intercropping, crop rotation,

maintenance of hedges or flower strips, across multiple spatial and temporal scales. These management practices may have economic costs as they reduce the amount of land under cultivation or otherwise reduce crop yield. To test the economic costs and ecological benefits of DFS practices we will use a systematic review to rank practices according to ecological benefits and economic costs for all selected European countries. The next step is to measure the overall effect size to determine which management practices, or combination of management practices, is best for Europe and also for each European country. The overall aim of this study is to evaluate the ecological and economic potential of different DFS management practices and highlights how they can be designed to enhance ecosystem services while being economically viable.

Session 23-P6 - Recent land-use changes in managed grasslands of the Swiss Alps and their impact on plant diversity

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Land-use changes motivated by socio-economic pressure are among the most important drivers for biodiversity change in grasslands worldwide. In the Swiss Alps the impact on grasslands through intensification and abandonment was particularly strong during the decades since world war 2. We explore plant diversity in 216 grassland parcels at three altitudinal levels in 12 villages of three cultural traditions (Romanic, Germanic, and Walser). Twelve years ago, biodiversity of these grassland parcels was assessed a first time and suggested that a high land-use diversity promoted plant species richness in villages. Moreover, the type of land-use influenced species-richness of parcels the most. The land use changes observed 12 years ago reduced farmers' workload but decreased plant species diversity in parcels. Since then, the system of financial incentives for farmers was changed promoting among other things biodiversity of alpine grassland. We therefore re-examined the formerly studied parcels again in 2014/15, to assess, (1) whether changes in land-use had occurred, (2) if they occurred what their impact on plant species richness was, and (3) how much the observed changes were motivated by former and current financial incentives towards farmers. We found a surprisingly high change in land-use over the relative short time of 12 years. Although intensification and abandonment is still taking place, transitions to less-intensive land-use types were predominant indicating a positive response to incentives. Most recent land-use changes occurred in the mountainous valley bottom, were intermediate in subalpine regions, and least at the alp level. The shift towards less-intensive land-use types had a positive influence on maintenance and re-establishment of plant species richness including a gain of rare and threatened Red List species.

Session 23-P7 - The influence of cultivation practices on vegetation change within grasslands in communal areas of the Eastern Cape, South Africa

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Communally managed land in South Africa is regarded as degraded mainly due to high population pressures, mis-management and a lack of coherent spatial planning. Although the impact of overgrazing is not disputed, the influence of cultivation practices as driver of degradation is underestimated. The study investigates the impact of cultivation practices as a transformer of natural grassland into semi-natural grassland. Seven communities (Dudumashe, Kubedlana, Ntibaneni, Nyandeni, Qumanco, Roxeni and Tora) within the Moist Sub-escarpment Grassland of the Eastern Cape Province are used as study areas. Detailed land cover and herbaceous species data are analysed to investigate the effect of cultivation on ecosystem changes within communal land, using chrono-sequences of SPOT-5 natural colour pansharpened imagery from 2005 to 2011 and vegetation surveys. Detailed land cover maps indicate that up to 40% of the land has been cultivated and only 27% remains as natural grassland. About 18% is classified as settlements and 4% of the land is seriously eroded. The majority of the erosion is associated with streams and drainage lines and occurs within or adjacent to cultivated land. It is estimated that more than 70% of cultivated areas were not utilized during the 6 year study period. Natural grassland has 48% climax grass species (*Themeda triandra*, *Tristachya leucothrix*, *Alloteropsis semialata* subsp. *eckloniana* and *Andropogon appendiculatus*), abandoned old fields less than 10% climax grasses and recently cultivated land has no climax grasses. When considering the abundance of climax, key fodder grasses as veld being in a “good” condition, it is perceived that rangeland condition declined from 82% for natural grassland to 44% for old fields. According to the village chief, some of the old fields surveyed were abandoned for more than 40 years. The study indicates that the impact of shifting cultivation and ineffective use of cultivated lands had a negative long-term impact on availability of natural grassland for grazing and the capacity to maintain grazers. A majority of the cultivated land have reverted to old fields or are only periodically cultivated. Existing grassland areas used for grazing land are a mosaic of old fields and small patches of remnant natural grasslands. Abandoned old fields have developed into sub-climax semi-natural grasslands with little resemblance to the original grassland systems.

Session 23-P8 - A structurally enriched agricultural landscape maintains reptile diversity in southwestern Madagascar

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A heterogeneous anthropogenic landscape has the potential to contribute to biodiversity conservation by providing suitable habitat for many species. To find options for reconciling land use and biodiversity conservation, we evaluated reptile diversity of two areas that contained three types of habitat: cultivated areas, degraded forest, and protected forest. In the first area a network of man-made hedges surrounding crop fields provided possible habitat for reptile species and all habitat types were connected by suitable landscape elements. The second area lacked such landscape elements. On 48 transects, we recorded a total of 24 reptile species, of which 18 occurred in both areas. Reptile species richness was higher in habitats with higher structural richness, irrespective if structures were provided by hedges or natural vegetation elements in forests. Reptile assemblages were more similar between habitat types in the area in which agricultural sites were structurally enriched by hedges and connectivity was high, than in the area lacking such structural enrichment and connectivity. Differences in species assemblages in the latter area were largely the result of species losses. These may result from impeded movement between habitats. In contrast the higher similarity in the structurally enriched and highly connected area indicates facilitated movement between habitats. Connectivity and structural complexity in the human used landscape contributed to the maintenance of reptile diversity. In particular hedges that are integrated into agricultural areas provided structures that are suitable habitat for many reptiles. Besides their value for reptile conservation, hedges also provide important benefits to the local human population (food and livestock fodder). Thus, the integration of hedges in agricultural areas may be a valuable tool for conservation management.

Session 24 – Biodiversity and ecosystem services in intensive agricultural landscapes

Chairs
PD Dr. Martin Schädler
Prof. Dr. Ilona Leyer

Session 24-O1 - Land-use intensification alters the relationship between biodiversity and multiple ecosystem services

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The ongoing loss of biodiversity due to agricultural intensification is often accompanied by a decline in ecosystem service delivery. The Intergovernmental Panel for Biodiversity and Ecosystem Services (IPBES) therefore identified the assessment of relationships between biodiversity and ecosystem services as one major aim for future research. Empirical studies that address relationships between multi-taxon biodiversity (multidiversity) and the simultaneous provision of multiple ecosystem services (multifunctionality) in a land-use context are however rare. Here we relate the diversity of five major taxonomic groups (641 plant, vertebrate and invertebrate species) to multiple ecosystem services (eight supporting, regulating, cultural and provisioning) along a landscape complexity gradient in agricultural landscapes in Southern Sweden. Landscape complexity and multidiversity, but not landscape complexity and multifunctionality, were positively related. Several ecosystem services, but only few biodiversity components were related to each other across study sites. Multidiversity can be promoted by an increasing landscape complexity in our study area. However, we found no support for simultaneous positive effects on the majority of individual ES potentials or on multifunctionality. These results suggest that landscape management will not simultaneous promote multiple ecosystem services and biodiversity components. It further challenges the view that biodiversity in agricultural landscapes should primarily be conserved due to its role for the provision of ecosystem services.

Session 24-O2 - Biodiversity and associated ecosystem services in the woody networks of an intensive agricultural landscape

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Woody elements such as hedgerows and tree lines are important features of many landscapes around the world. However, they are disappearing and become fragmented at high rates because the biodiversity they host and the services they provide are generally undervalued. We focus on the woody networks in a very intensively used agricultural region (northern Belgium) to explore spatial and temporal variation in the plant communities associated with these networks. First, in a detailed survey at the scale of a province, we studied the importance of the network for plant species diversity in agro-landscapes (> 800 network elements). We explored the driving factors of its species diversity, composition and associated ecosystem services 'pollination value' and 'edibility' derived by the herb layer, with a focus on abiotic, structural, landscape and historical variables. The network hosted approximately 45% of the floral diversity covering only 0.7% of the land. Second, through a resurvey (41-year time interval) in one landscape within the same province, we studied the temporal changes in floristic composition of wooded banks and quantified the shift in biodiversity and abundance of species groups. A total of 55 out of 81 original wooded banks were resurveyed (26 had been removed). Biodiversity increased significantly over time and habitat patches became more heterogeneous. Based on our findings, we argue that protecting the woody network is key in order to safeguard biodiversity in the countryside.

Session 24-O3 - Relative importance of farmland structure and crop diversity for honeybee persistence: predictions from the model BEEHAVE

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Several stressors such as diseases, pesticides and forage availability are widely suggested as major drivers behind decline in honeybee health (*Apis mellifera* L.), but spatiotemporal variation in forage availability directly assessed from landscape context and its effects on colony success are poorly known. Here, we systematically varied, in a factorial design, farmland context in terms of farmland structure and crop diversity (crop species number, identity and abundance) using a modelling approach to quantify honeybee colony persistence. For this purpose, we compiled data on phenologies and floral rewards of frequently cultivated crops, implemented two contrasting real farmland structures and assumed hypothetical patterns of crop composition and rotation by means of a newly developed landscape generator. We applied the colony model BEEHAVE, which links within-hive dynamics and foraging, to these scenarios to analyse colony persistence in

terms of survival probability, and colony's honey and pollen requirements satisfied by farmland forage availability. We found that crop species number and identity have strongest effects on colony persistence; best chance for colony persistence is given in farmland systems which comprise eight crops heavily depending on crop identity providing continuous forage supply over the colony development season. In contrast, farmland structure and crop abundance had the least impact on colony persistenceimplying that abundance of such crops as phacelia and buckwheat of 2 or 1 % might be sufficient to meet honeybee colony's food requirements, but this heavily depends on accompanying crops. Increasing the number of rewarding crop species at the landscape-scale could help to ensure honeybee pollination services. Examples of such practices are: allowing self-dispersion of dandelion in pastures, increased cultivation of trefoil-grass mixtures as forage crops, and cultivation of phacelia on set-aside even at small abundances.

Session 24-O4 - Oilseed rape, boundary and weed floral resources support pollinators in cereal-dominated landscapes in NE Spain

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Agricultural intensification has been described as one of the main causes of the decline of biodiversity, as well as related ecosystem services. The provision of pollination services are dramatically compromised in agricultural landscapes dominated by intensively managed cereal fields, which do not offer food resources for pollinators. The presence of mass flowering crops together with patches of natural habitats could compensate for the limitation of food resources, thus supporting pollination services. Oilseed rape (OSR) is one of the most common flowering field crops and it is visited by a wide range of insects. However, studies that evaluate the joint effects of mass flowering crops and landscape complexity (in terms of density of linear features of natural habitats) are scarce. The purpose of this study was to evaluate the effect of OSR fields, floral resources at the field boundary and landscape complexity on pollinator abundance in a cereal-dominated landscape. We hypothesized that the presence of OSR fields, as well as the density of field boundaries and floral resources, should enhance pollinator abundance. We evaluated the abundance and diversity of pollinators and floral resources at the edges of 21 cereal and 21 OSR fields in a highly intensified landscape with a varying density of non-cropped habitats at the landscape scale. We recorded flower-visiting insects and identified insect-pollinated plants present in field edges and boundaries. The total pollinator abundance, especially the Apoidea (Hymenoptera), was higher in field boundaries adjacent to OSR fields. At the landscape scale, the density of non-cropped habitats did not have a significant effect neither on total pollinator abundance nor the Apoidea. However, floral resources of field boundaries and OSR field edges had a positive effect only on the Apoidea. Thus, the

presence of OSR crops and floral resources benefits pollinators in cereal-dominated landscapes.

Session 24-O5 - Effects of mass-flowering crops on pollination success of minor crops: Facilitation or competition?

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Agricultural intensification is changing our landscapes with often negative effects on pollinator populations and their ecosystem services such as seed set and yield of crops and wild plants. Declining nesting and food resources provided by semi-natural habitats can limit pollination success, but also mass-flowering crops such as oilseed rape (OSR). High OSR cover in agricultural landscapes may enhance wild bee abundance, but also disadvantage pollination of wild plants flowering at the same time. Hence the question arises whether superabundant OSR flower resources may counterbalance (i) bee abundance and species richness in concurrently flowering minor crops such as strawberries and (ii) pollination success of strawberry fruits. In this study we address the hypothesis that mass-flowering crops such as OSR are strong competitors for minor crops and their pollination success, in particular when pollinator species with large body size and social bees are involved. We investigated how landscape dominance by OSR affects strawberry pollinators differing in traits such as body size and sociality. We sampled bee communities in strawberry fields and analyzed the collected pollen as well as crop yield and fruit quality of strawberries. Preliminary results contradict our initial hypothesis and show that greater amounts of OSR in the landscape enhance total bee abundance in strawberry fields over the whole strawberry flowering period. However, competition between the dominant OSR and minor crop is occurring when strawberry flower cover is low, for example at the beginning of their flowering period. Despite potential competition, overall strawberry yield might be positively influenced by OSR. This study should help to develop recommendations for farmers to enhance pollination success of minor crops such as strawberries by specific measure promoting wild bees, bumble bees and honeybees.

Session 24-O6- Sustainable control of lepidopterous pests in olive groves: integration of egg parasitoids and pheromones

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Prays oleae Bern, the olive moth (OM), *Palpita unionalis* Hub., and the jasmine moth (JM) are the most important lepidopterous pests in olive orchards in Egypt.The sex pheromones of OM [(*Z*)-7-tetradecenal)], JM E-11-hexadecenyl acetate and E-11-hexadecenal, and ZP (*E,Z*)-2,13-octadecenyl acetate were used for monitoring and mating disruption (MD). Inclusion of photostablizers into the pheromone-clay complex of OM and JM improved substantially the release rate and maintained adequate level of pheromone. The local egg parasitoid species *Trichogramma bourarachae* Pintureau and Babault, *T. cordubensis* Vargas and Cabello, *T. euproctidis* Girault, collected in olive groves, as well as the commercially available *T. evanescens* Westwood, were released in several applications in an intensively managed olive plantation for biological control of these pests. Indigenous *Trichogramma* species accomplished higher egg parasitism (up to 91%) than the commercial strain. Larval densities of target pests were significantly reduced up to 83% on *Trichogramma* release trees in comparison to control trees. Fruit damage ranged below 10% infested fruit. The results suggested that releases of the indigenous wasps and applying MD could improve control of lepidopterous pests on olive. Fruit yield from trees where sex pheromone and *Trichogramma* releases had been applied increased significantly compared to control ones.

Session 24-O7 - Managing trap-nesting bees as crop pollinators: interactive effects of floral resources and antagonists at local and landscape scales

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Wild bees require appropriate nesting and foraging habitats to sustain their populations that, however, the transformation of agricultural landscapes has degraded. The decline of managed honey bees and the rapid expansion of mass-flowering crops (MFCs) increase the risk of pollination limitation in crops and raise questions about novel management approaches for wild pollinators in agroecosystems. In two European regions, we exposed artificial trap nests in paired field boundaries adjacent to oilseed rape (OSR) fields or non-flowering crops for two years within 32 landscapes covering two independent gradients of OSR cover and semi-natural habitat (SNH) cover in the landscape. We analysed the effects of local and landscape-wide floral resource availability, land-use intensity, landscape complexity and natural antagonists on community composition and population dynamics of trap-nesting bees. Community size showed a strong, three-fold

increase in response to the additional nesting sites. Species richness and abundance of cavity-nesting bees that were active during mass-flowering increased significantly with increasing amount of OSR in the landscape. Later foraging species benefited instead from the availability of alternative flower resources or SNH cover once the mass-flowering had ceased. A positive density-dependent parasitism was found after mass-flowering, while no density-dependent effect was found during mass-flowering. Structural equation modelling revealed that floral resource availability indirectly through community size impacted community growth rate. Community size showed a strong negative effect on community growth rate. Despite positive density-dependent parasitism, antagonists had only weak regulating effects on community growth rate. To enhance pollinator diversity and abundance it is essential that both nesting and floral resources should be targeted by management practices. In this context, trap nests as additional nesting resources can be a simple off-field practice to boost crop pollinators and potentially to optimize pollination services for insect-pollinated crops. Trap nests may benefit not only early generalist bees but also species with later phenology if accompanied by other pollinator-supporting practices. Further studies will be required to better explore which crops benefit from this supporting practice.

Session 24-O8 - Bee pollinators of faba bean (*Vicia faba* L.) differ in their foraging behavior and pollination probability

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The grain legume faba bean is grown for production of protein-rich seeds. Its numerous ecological benefits include fixing nitrogen and effectuating optimal soil conditions as well as the potential of improving pollination services in croplands by enhancing floral resource availability. In agricultural practice and plant breeding of faba bean, bee pollinators play an important role by transferring cross-pollen and improving seed set. Here, we aimed at answering the following question: What is the most effective potential bee pollinator of faba bean? We studied, first, the abundance and foraging behavior of bee pollinators by standardized transect walks, second, seed set and degree of cross-fertilization using exclusion cabins and phytometers, and third, flower constancy based on the pollen analyses of both the corbicular pollen (from pollen basket) and the pollen load on the bees' bodies (from hair). The three most frequently recorded species were *Apis mellifera* (56% of all observed individuals), *Bombus terrestris* agg. (37%) and *Bombus hortorum* (4%). We found that the species differed in their behavior: *A. mellifera* and *B.*

terrestris agg. were mainly robbing nectar, while *B. hortorum* was a regular pollinator. Seed set was significantly higher when the flower was visited by *B. hortorum* which additionally caused a higher degree of cross-fertilization than the other two most common common bee species. The pollen analysis and pollination probability index for pollen carried on the body indicate all three species exhibited high pollination probability for faba bean, although *B. terrestris* agg. less so. We conclude that the behavior of pollinators is crucial for pollination success and most abundant pollinator species do not always provide the best pollination service. The less frequent species *B. hortorum* turned out to be potentially the best pollinator for faba bean.

Keywords: bees, pollination, *Vicia faba*

Session 24-O9 - Grassland Intensification negatively affects Carabid Beetles, Rove Beetles and Spiders

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Intensification of grassland management by enhancing fertilizer application and cutting frequency influences plant composition, biomass and diversity, which can also affect ground-dwelling arthropods through bottom-up effects. Over the past decades, grassland intensification resulted in declines of plant and invertebrate diversity. We designed a grassland management experiment to disentangle the effects of mineral fertilization, cutting frequency, and plant functional group composition on diversity, abundance and community composition of predatory arthropods (Carabidae, Staphylinidae, Araneae), which are providers of important ecosystem services in agricultural systems. We established a full factorial randomized block design (three levels of cutting frequency, two levels of fertilization, three levels of experimentally manipulated plant functional group composition) on an ancient grassland site in northern Germany (Neuhaus, Solling). Predatory arthropods were sampled between May and October 2011 using 10 rounds of pitfall funnel trapping. Species richness of all three arthropod groups and the abundance of Staphylinidae were reduced by higher cutting frequencies, presumably due to a reduction of food-resource and shelter availability. In contrast, fertilizer application had a positive effect on diversity of all three groups and on abundance of Carabids and Staphylinidae. We conclude that an increase of aboveground plant biomass associated with higher resource availability for herbivores increased the food availability to predatory arthropods. An increase in grass cover resulted in changes of the community composition of all three groups and had a slight negative effect on spider diversity. Since predatory arthropods are positively affected by fertilizer induced increases of resource availability and

negatively affected by higher cutting frequencies, adapting grassland management toward lower cutting frequencies can maintain high levels of arthropod diversity and abundance.

Session 24-O10 - Effects of tillage and fertilization on vegetation, soil microbial communities, and soil functions in a 35-years' vineyard experiment

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Management practices in vineyards are characterized by intensive usage of chemicals and machinery. Tillage of inter-rows as well as fertilization alter the microbial community in the top soil as well as density and composition of the cover vegetation. These communities contribute to essential ecosystem services like the maintenance of soil fertility. Moreover, these communities mediate important soil functions such as litter decomposition, build-up of soil organic matter, and mobilization of plant available nutrients. We investigated the effects of nitrogen fertilization and soil treatment in a long-term vineyard experiment, where these practices are constantly applied for more than 35 years. Plots in this vineyard (Rheingau region near Wiesbaden, Germany) are treated with different amounts of nitrogen fertilizer (0, 30, 60, 90, 120, 150 kg N/ha and year) in four replicates in combination with two types of inter-row soil treatment (tillage vs. permanent vegetation cover). We conducted plant community assessments of the inter-row vegetation twice during the season. The microbial community (bacteria and fungi) of the top soil (0-10 cm) was analyzed using a metagenomic approach. Further, soil functions and properties such as litter decomposition (Tea Bag Approach), soil organic matter content, C:N ratio, and plant available P, K, and Mg were measured. Results show that the ground cover treatment has strong effects on plant biodiversity, decomposition rate, soil organic matter and plant available nutrients, while amount of nitrogen fertilization affect these variables to a much lesser extent.

Session 24-O11 - Greenhouse gas emission intensity depends on the history of earthworm bioturbation in the rice soil

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Introduction of ecosystem engineers into rice soils drastically changes the substrates' physical and chemical properties and consequently C and N stocks. It is however unknown how dependent the level of greenhouse gas emission from rice ecosystems is on the history of soil bioturbation associated with the earthworm

colonization. We conducted a microcosm experiment to quantify the impact of long term bioturbation by a tropical earthworm *Pheretima sp.* from the Philippines on greenhouse gas emissions (CO_2, N_2O, CH_4) in rice paddy soils collected at the fields of the International Rice Research Institute (Philippines). We applied a full factorial design with three levels of the initial soil bioturbation (non-, short term-, and long term-bioturbated) and three levels of earthworm abundance (no, one, and two earthworms per microcosm). We hypothesized that GHG emission from long term bioturbated soils will be less dependent on the actual earthworm activity due to more stable C and N stocks. The main effect of the actual earthworm bioturbation on CO_2 emission was positive. However, it was observed only in initially non-bioturbated soils. Nitrogen emissions (in the form of N_2O) were boosted by earthworm activity in the initially non-bioturbated soils, but were relatively reduced in the long term bioturbated soil. No consistent effects of earthworm activity were revealed on CH_4 emissions which remained stable across all treatments. Our results suggest dramatic differences in the short term and long term stabilization effects of earthworms associated with their bioturbation activity. The initial C and N release into the atmosphere from non-bioturbated soil is compensated by their immobilization in the longer term perspective. The study was supported by ICON project within the DFG-Research Unit FOR 1701.

Session 24-O12 - Determining the degree of seed limitation in an annual weed on maize fields

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In natural ecosystems, plant populations tend to be establishment limited. However, annual weed populations in agricultural fields are expected to be predominantly seed limited, because of frequent disturbances and the lack of competition during seedling establishment. Post-dispersal seed predation is an ecosystem service that has the potential to reduce weed abundance. When mainly seed limited, seed predation will have a large impact; when mainly establishment limited, seed predation will be less effective. Therefore, in this study the relative importance of seed vs. establishment limitation in a weed population was determined. An experiment was conducted in two maize fields, with a history of at least three years of maize cropping, over the course of two years. In the summer of 2014, populations of *Echinochloa crus-galli* (L.P. Beauv.) (Poaceae) were seeded at 0, 300, 600, 1200 or 2400 seeds per m², in 72 plots of 1.5 by 1.5 m, per field in a complete randomized block design. We deliberately eliminated some factors that could contribute to establishment limitation by choosing a weed species with a semi-persistent seedbank (reducing dormancy), using minimal soil management (preventing unfavourable seed placement in the soil) and protecting half of the plots from seed predators by surrounding them by 60 cm high plastic frames. For plots excluded from predation, the effect size for seed limitation was calculated

(Clark et al. 2007) and a recruitment function that quantifies seed limitation, density independent and dependent processes (Poulsen et al. 2007) was fitted to the number of seedlings emerging in 2015. In agricultural fields, seed limitation was high in comparison to that in natural environments. This means that seed predation can be an effective tool for reducing weed population development. As a next step, the degree of seed limitation in plots with and without access to seed predators will be compared, to verify their effect on weed population development.

Session 24-O13 - Usage of the floristic diversity by goats in the course of grazing

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Intermediate feeders in general tend to mix their diet when they were given free choice. However, it is not known, to which extent those animals are able to discriminate between plant species. The aim of this study is to show whether goats react on the floristic diversity under the natural field conditions. The study took place in Northern Germany on a yearlong abandoned grassland that has never been grazed. Four goats at the age of five months were used in a two-factorial design (time of grazing, time in the year). The animals grazed on three adjoining plots (67 -70 m²). The composition of the vegetation was measured by estimation of the yield (100% = total mass). Within 15 minutes (=100%) the instantaneous intake rate with two goats on plant species level was recorded on five consecutive times in July (record 1 – 5), and three in October (record 6 – 9).The duration, each animal spent eating a certain plant species, was recorded and calculated in percent of the total observation time. Statistical analysis was done with SAS-SPSS. The more species were present the more were selected by the goats during record 1. In contrast, there was no correlation of the two variables from record 2 on. At record 1, the goats consumed at least 12.8 species out of the 25.5 ones present in the vegetation (50.3%), while the animals selected only 6.7 (26.5%) during record 6. During record 1 the most abundant *Poaceae* (70% of the vegetation) were less often eaten (6.7%) than those plants as *Artemisia* (0.5% of the vegetation compared to 16.9% eaten). During record 9 this relation turned out to be vice visa. The results show that goats exploit floristic diversity at least in the beginning of grazing with 'new' vegetation (selective phase) for reasons of curiosity or dietetic preference but not due to a disability to discriminate, and later on concentrate on the most abundant species, only.

Session 24-O14 - Spatial mismatch between ecological deficits and agri-environmental subsidies across Germany

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The intensification of agriculture over the past century has caused severe declines in farmland biodiversity, which affects the delivery of ecosystem services. In response to this trend, agri-environmental schemes (AES) have been introduced in Europe “to apply agricultural practices that contribute to climate change mitigation and adaptation and that are compatible with the protection and improvement of the environment, the landscape and its features, natural resources, and the soil and genetic diversity” (Regulation (EU) No 1306/2013). However, the effectiveness of AES is debated; common criticisms include that they are not sufficiently rigorous, that their implementation is not always spatially targeted and that they do not consider synergies and trade-offs among their objectives. We extracted data on payments of the European Union agricultural funds in Germany that were made in 2014 to detect spatial patterns in the implementation of AES and compare them to documented patterns of environmental issues (nitrous oxide emissions, threats to soil biodiversity, ammonia deposition, soil erosion risk of arable soils). The objective of this study is to assess whether AES were targeted towards locations with known environmental deficits. We addressed the following research questions: (1) Where are areas of high and low implementation rates of AES across Germany? (2) Are measures implemented in locations with high environmental deficits? Our results show a pronounced spatial mismatch in the implementation of AES and multiple environmental deficits. AES were mostly taken up by land managers in regions with favourable environmental state. By contrast, in regions facing environmental problems due to intensive agriculture, only few measures were implemented. These results suggest that mechanisms to optimize the spatial allocation of measures are needed to meet environmental needs and enhance overall effectiveness and efficiency of AES.

Poster presentations

Session 24-P1 - Investigating the consequences of climate change under different land use regimes - the Global Change Experimental Facility (GCEF)

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Climate change and land use changes are considered to be the most important threats to biodiversity and ecosystem functioning. Besides empirical studies and modelling approaches, manipulative field experiments are urgently needed to understand underlying processes, deduce indicators, develop strategies for sustainable land use, and steer some key processes. Previous experimental approaches have often considered individual global change factors separately, and the few multi-factorial experiments conducted so far used a rather small plot size. Their results, however, suggest that combined effects of global change factors may be profoundly different from the sum of single effects. None of the previous experiments did explicitly consider different land use options in combination with climate change scenarios. Further, experiments conducted on a smaller spatial and temporal scale may ignore key processes of ecosystem responses to global change. We therefore established a field-based experimental platform which allows the parallel manipulations of land use scenarios and a selected climate change scenario. Increased night temperatures in combination with a changed precipitation pattern (e.g. summer drought) is applied to different types of farming (conventional, organic) and grassland management (intensive vs. extensive, mowing vs. grazing). The ultimate aim of the experiment is the assessment of the combined effects of climate change and land use on ecosystem functions and ecosystem processes. We will especially focus on biotic and abiotic soil processes, biotic interactions as well as microevolutionarey changes of plant species and their consequences for ecosystem dynamics, stability and productivity. The results will help to develop strategies for sustainable land use under global change.

Session 24-P2 - Comparing ecosystem service supply in Germany and Japan based on public statistics

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In the context of ecosystem service assessments, comparative analyses at large spatial scales are gaining importance as the need for international collaboration and information exchange increases, e.g. through the assessments carried out by the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES). Data availability and data quality in terms of thematic coverage as well as spatial and temporal scales (extent and resolution) usually varies in different countries, and it is necessary to explore for which ecosystem services available information from public statistics will allow first approximations of ecosystem service supply. We chose Germany and Japan for our case study, because they differ in certain aspects of environmental and socio-economic variables, but they have comparatively well-developed systems of public statistical monitoring of key variables that are relevant for ecosystem services. We acquired publicly available data sets at NUTS (Germany) and prefectural (Japan) levels and examined spatial distribution and relationships among the selected common ecosystem service indicators. We aim to explore patterns of ecosystem service supply under different environmental and socio-economic conditions and to suggest meaningful indicators that can be gathered from different monitoring systems to compare the status of ecosystem service supply at the international level.

Session 24-P3 - Can wildflower strips positively influence pollinator visits and yield in adjacent pollinator dependent crops?

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The intensification of agricultural practices has led to a decline of wild bee diversity. Recently, concerns have raised that the ecosystem service pollination may be at risk. As a consequence, wildflower strips are more and more commonly used as a measure for counteracting the negative consequences of anthropogenic activity and promoting pollinators. It has been shown that wildflower strips have the potential to enhance wild pollinators in the surrounding, but the efficacy and economic benefit of them remain relatively unknown. We thus asked whether experimentally established wild flower strips adjacent to strawberry fields enhance a) the abundance and diversity of pollinators on the strawberry fields, b) their pollination success and consequently yield, and c) how far does the expected positive effect of the wildflower strip spill into the strawberry field. To do so, we established 10 wildflower strips adjacent to commercial strawberry crops and recorded the abundance and visitation rates of pollinators and the fruit set and quality of potted strawberry plants in different distances within the crop field and

compared it with 10 fields without wildflower strips. We will show preliminary results on fruit set and the quality of strawberry fruits in crops with, and without, adjacent flower strips. We expect that the provision of a forage habitat like a wildflower strips have the potential to lead to higher crop yields in adjacent pollinator dependent crops.

Session 24-P4 - FRAGMENT III: Effects of spatio-temporal resource availability on ecosystem services in fragmented agricultural land

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Biodiversity loss in intensively managed farmland may disrupt pollination and pest control services. Research about fragmentation on functional biodiversity mostly uses a dichotomous “non-crop” or “semi-natural habitat” classification as fragmentation metric, but findings remain inconclusive due to strong differences between taxa and studies. The project aims at improving the mechanistic understanding of fragmentation drivers to increase the predictive power of ecosystem service research in farmland. Using strawberry as a model crop in Swiss and German landscapes, we will examine the resource requirements of key insect pollinators and natural enemies and their responses to resource spatio-temporal distribution, ultimately affecting ecosystem service delivery to the crop. We are currently quantifying resource use by bees *(Osmia bicornis*, *Bombus terrestris*) and aphid predators (*Coccinella septempunctata*, *Harmonia axyridis*, *Chrysoperla carnea*) collected in 23 focal crops whose surrounding landscape varies along a gradient of urban and forest habitat. By analysing aphid DNA in predators plus determining pollen in bees and predators we will ascertain the most important plants determining their occurrence, thereby adopting the perspective of ecosystem service providers for landscape mapping. On the next stage, we will use this information to develop functional habitat maps for 48 landscapes that consider the spatio-temporal availability of resources for one bee and one predator species. Hence, we will quantify the effect of plant resources available both before and simultaneous to strawberry flowering on the densities of these insects and on the pollination and pest control services they provide. The basic ecological knowledge on spatio-temporal resource fragmentation affecting plant-pollinator and predator-prey communities will contribute to the design of agri-environment schemes to promote functional biodiversity and ecosystem services in agricultural land.

Session 24-P5 - Utilization of subsidized flowering fields by spider-hunting wasps

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Habitat fragmentation causes species loss in agroecosystems. Subsidized flowering fields are thought to counteract this loss and promote ecosystem services. While their benefits for pollen-collecting insects are obvious, little is known about other ecosystem service providers. Here, we studied whether flowering fields provide not only nectar for adult individuals but also larval prey for spider-hunting wasps and how this depends on landscape structure. Nine woody semi-natural habitats in central Germany were selected as trap-nest locations forming independent gradients in distance to flowering fields and surrounding grassland. Trap nests were controlled weekly for new nests from May to July 2013 and the number of spider individuals and species per cell recorded. Additionally, spiders were collected on the associated flowering field and determined to species level. Bray-Curtis-Similarities between communities of spiders on flowering fields and in nests were calculated. Similarity decreased interactively with the amount of grassland and the distance to the next flowering field. This concurred with an observed positive effect of grassland on the number of spider species in trap nests, especially if flowering fields were far away. Spider species richness on flowering fields was not influenced by any landscape factor. While in all study sites *Phylloneta impressa* was the most abundant spider in breeding cells and on flowering fields, its proportion in cells increased with the amount of surrounding semi-natural habitat. In conclusion, flowering fields are used by wasps for hunting larval prey, especially if they are close to nests and no alternative grasslands are available. Since spider richness was unaffected by the surrounding landscape, flowering fields seem to offer stable resources to spider-hunting wasps independent of their landscape context. Thus, subsidized flowering fields promote not only species richness and ecosystem services but possibly disservice, too.

Session 24-P6 - The forgotten flies: Effects of local and landscape factors on predatory Diptera

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Apart from Syrphidae many other Diptera species can be important predators of several pest species in agriculture and forestry. However, little is known how they

can be supported with seminatural habitats on the local and landscape scale. We caught adult predatory flies (Dolichopodidae, Empididae and Syrphidae) with pan traps in 188 seminatural habitats (linear herbaceous, areal herbaceous, linear woody, areal woody) in agricultural landscapes in Italy, Germany and Switzerland. The abundance patterns were not consistent across countries or families. Overall reactions to the local seminatural habitat type were driven by the German patterns. Empididae and Syrphidae were most abundant in woody habitats, whereas woody areal habitats contained only few Dolichopodidae (significant in Switzerland and Germany). We found positive effects of seminatural habitats on the landscape scale across all countries and predatory Diptera groups, but effect strength differed among countries and predatory Diptera group. For Dolichopodidae the landscape effects interacted with the local seminatural habitat type. Further, the distance to the next stream negatively affected Dolichopodidae in Italy and Empididae in Germany. Predatory Diptera can be supported by seminatural habitats on the landscape scale and woody (linear) seminatural habitats on the local scale. It should be taken into account that seminatural habitat types as well as abundance and preferences of predatory flies differ between countries and therefore patterns for other groups or countries cannot easily be predicted.

Session 24-P7 - Infection rates and alkaloid concentrations of the endophyte *Epichloë festucae* var. *lolii* in perennial ryegrass along a land use gradient in Germany

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Grass endophytes are due to their economic importance of high interest. The systemic fungal endophyte *Epichloë festucae* var. *lolii* often infects *Lolium perenne* and produces defensive alkaloids, which also affect grazing livestock. We hypothesize that intensive management increases occurrence, abundance and alkaloid levels of the endophyte. Therefore we sampled *L. perenne* populations in three regions of Germany along a land use gradient. Infection rates were significantly higher on pastures. Alkaloid toxicity thresholds were occasionally reached, but not on population levels, so intoxication risk for livestock is rather low. Land use intensity did not affect abundance or alkaloid levels. We conclude that grazing increases infection rate, but other factors, e.g. season and endophyte/host life stage, have a major impact on symbiosis and have to be included in further field studies.

Session 24-P8 - Morphological and chemical diversity on Turkish cultivated Mint landraces

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Genus *Mentha* contains aromatic plants, and some of them are cultivated for spice and essential oil productions. Mint oils from cultivated *Mentha* species comprise second amount in world essential oil production after *Citrus* species. Major species are *Mentha arvensis, M. piperita* and *M. spicata*. Chemical compositions of *Mentha* species determine using area of them such as medicinal using, spice, food etc. Carvone-rich chemotypes of *Mentha* species are named as spearmint. Cultivated mint landraces in Turkey are classified as “spearmint” and the species are *M. spicata, M. longifolia, M. villoso nervata*. Morphological and chemical similarities of the species are having spike flowering and carvone as major components, respectively. As a review results of our previous studies, it was determined that *M. spicata* was most cultivated mint species with 80% of all mint landraces in Turkey. *M. villoso nervate* with carvone rich chemotypes were characterized firstly in cultivated mint landraces. Peppermint group mint species in Turkish mint landraces are *Mentha dumetorum* and *M. piperita*. *M. dumetrum* have high linalool content and cultivated as ornamental plant in some locations of Turkey. *M. piperita* with high menthol and menthone are cultivated in limited area of Turkey, and oil of the species is imported for medicinal and other using. Available morphological and chemical diversity of Turkish cultivated Mint landraces will have provided an opportunity for breeding of *Mentha* cultivar.

END OF SESSION 24

Session 25 – Citizen Science in ecology - An applied tool for biodiversity monitoring in Europe?

Short title: Citizen Science in ecology

Chairs
Daniel Dörler
Prof. Dr. Josef Settele
Florian Heigl

Session 25-O1 - Crazy for birds? School children observe birds in their backyards

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Gardens represent important habitats for many species in intensive agricultural landscapes. Scientists may not have access to private gardens, therefore citizens are needed to report bird observations at those sites. Most bird species occurring in private gardens can be easily identified and work well for citizen science projects. In our project “Nature in your backyard – citizen science for schools” we work together with pupils from 16 Austrian schools of different school types and ages. We aim to relate the presence and relative abundance of hedgehogs, wild bees, bird and butterfly species with the garden structure and management as well as the surrounding land use. Pupils used survey forms to gather information on garden size, management and structural diversity. Scientists provided identification guides, experimental protocols and training on spot. Pupils learned to identify birds by appearance and voice. They were asked to observe bird species and abundance of birds they see and hear within a time frame of 30 minutes. Furthermore the experimental protocol requires taking notes on behavior of the recorded birds. Within the first year, pupils observed birds in 50 private and school gardens. On average, 8.0 ± 5.0 bird species and 12.6 ± 9.0 individuals where found in each garden. The most common bird species was the blackbird (found in 82% of the gardens) followed by great tit (66%), house sparrow (58%) and collared dove (54%). The reliability of the obtained bird data sets and the influence of garden management and surrounding land use on bird species diversity will be discussed.

Session 25-O2 - Tracking ‚punks' in your backyard - citizen science on hedgehogs in gardens

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Hedgehogs are known as a synanthropic species living in the close vicinity of human settlements. Due to intensification of land use, cultural landscapes are often no longer attractive habitats for wildlife species. Therefore, gardens and public green in rural and urban areas may represent important refugia. Despite hedgehogs' popularity, only little is known about their general abundance. One of the two hedgehog species in Austria, *Erinaceus europaeus*, is classified as near threatened. As private gardens are usually not accessible to researchers, a citizen science project offers the opportunity to obtain information on wildlife species in people´s backyards. In our citizen science project ‚Hedgehogs in gardens' citizens observe these nocturnal animals with so-called hedgehog tracking tunnels (developed by Dr. Richard Yarnell) in private and school gardens all over Austria. The triangular shaped tunnel, equipped with bait, non-toxic 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 can also be reported. For data entry, citizens complete an online form on garden structures, management intensity, garden type, as well as a personal evaluation on the abundance of hedgehogs in their surrounding over the last 5 years. The presence or absence data of hedgehogs are uploaded together with scans or photographs of the animals' footprints. Hedgehog presence or absence will be related to garden parameters and the surrounding land use. Best-practice examples and suggestions for a 'hedgehog-friendly' garden management will be derived. Here, we present results of the first two years (2015/2016) of hedgehog observations all over Austria. In the first year more than 70 garden questionnaires and more than 80 hedgehog observations were reported, whereby in 60% of all studied gardens a presence of hedgehogs was determined.

Session 25-O3 - Citizen Science in urban wildlife ecology - lessons learnt in Berlin

Miriam Brandt[1], Leon Barthel[1], Anne Berger[1], Pierre Gras[1], Sarah Kiefer[1], Sophia Kimmig[1], Stephanie Kramer-Schadt[1], Sylvia Ortmann[1], Anke Schumann[1], Milena Stillfried[1], Heribert Hofer[1]

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Urban habitats harbour high levels of biodiversity and thus will become pivotal areas for conservation. The government of Berlin's biodiversity strategy, for example, provides a framework within which the IZW contributes results on the ecology of urban wildlife, which may in future assist conservation oriented measures. In June 2013, the IZW began with a Citizen Science component in studies on the adaptability of wildlife to urban environments. In addition to broadening our sampling coverage within Berlin, our goal was to increase people's awareness of nature, since urban dwellers are increasingly alienated from nature. We started with Citizen Science projects monitoring wild boar and hedgehogs. Our engagement has since steadily expanded, benefiting greatly from the experience gathered. In the beginning, we used an online form and printed flyers to collect wildlife sightings. In 2015, we conducted a joint campaign with the public broadcasting company rbb to increase the reach for distributing information and collecting data on red foxes. Currently, we are establishing an interactive map of Berlin to assign tasks to citizen scientists and a smartphone app to record presence data of wildlife. Here, we will present lessons learnt in projects with varying levels of citizen participation and the advantages and limits of different setups. Firstly, a strong and regular media presence is a key factor for participant recruitment and motivation. Secondly, Citizen Science has high potential for some topics such as multi-species-monitoring, but this does not replace the need to closely scrutinize its suitability for specific research questions. Thirdly, it is important to implement measures of data validation, e.g. by comparing citizen scientists' data with those collected with established methods. Finally, it is absolutely essential to allocate sufficient time and manpower to any Citizen Science project to communicate with and provide the necessary feedback to participants.

Session 25-O4 - Habitat modelling of the returning wolf to Lower Saxony by means of two citizen science programs

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The wolf population in Germany shows an almost exponential growth rate and the authorities are struggling to keep up with this rapid development. Active monitoring programs are sparse and most data in Lower Saxony rely on the passive monitoring program initiated in 2011 by the Hunting Association of Lower Saxony (LJN). As a part of this program, every citizen was asked to report wolf cues. These may have included pictures, videos, livestock or wildlife kills, scat, urine, estrous blood, tracks or hair. For the modelling part we excluded pictures and videos because they are more likely to be spatially biased. There are hardly any species as

controversially discussed as the wolf, thus, for a rigid quality assessment only C1 and C2 categories of the SCALP criteria were selected, which resulted in 172 spatially explicit cues. These were compared to random pseudoabsences. The results were compared to a second program in order to valid them. The wildlife survey (WTE – WildTierErfassung Niedersachsen[a]) was initiated in 1991 by the LJN. All hunting district holders in Lower Saxony were asked to provide estimates or counts of wildlife species. Over the past 25 years participation in this citizen science program was very high (>80% of hunting district holders and >90% of area throughout). Starting in 2014, the WTE also asked for information on regular wolf presence in the districts. The two programs showed a high correspondence. Both habitat models revealed a preference to areas with lower road density, whereas the collinear human population density explained less variance of wolf presences. However, wolf cues have been found at significantly increasing road and human population densities over the years. Whether this is attributable to habituation to humans, or a higher chance due to a larger wolf population, is not easily answered. Nevertheless participation of the general public, under rigid scientific control, may have not only increased knowledge on habitat use, but also increased acceptance due to involvement, and in so doing, weakened partialities.
[a]funded by hunting charges - Ministry of Agriculture

Session 25-O5 - Co-creating a generalisable web platform for citizen science camera trap ecological monitoring

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With recent technological advances, crowdsourced projects have enlisted citizen scientists to tackle major scientific challenges, from protein folding to galaxy spotting. However, much of these efforts use volunteers as mere “mobile sensors”. Here we present MammalWeb, a pilot web platform which attempts to take citizen science to the next level by co-creating camera trap ecological monitoring. Since mid-2015, over 50 trained volunteers have deployed camera traps across north east England for over 6600 days and produced more than 50000 images of local fauna. As of April 2016, more than 32000 of those images have been classified by 129 users on our website. In addition to enlisting citizen scientists to collect and process camera trap data, we are developing data exploration and visualisation facilities on our web platform for users. By involving our volunteers in all phases of camera trap ecology, we hope to deepen citizen science engagement beyond

merely an enjoyable activity to increased ecological sensitivity and critical thinking. Crucially, MammalWeb is being developed as an open source modular platform that can be deployed by other others to organise their own citizen science camera trap surveys. This decentralised approach alleviates the overhead of administering a large volunteer project, while still producing standardised data that contribute to ecological monitoring over wide spatial and temporal scales. We hope this effort will not only improve general science literacy, but become the starting point for a European citizen science camera trap network.

Session 25-O6 - Lebendiger Atlas - Natur Deutschland

Aletta Bonn[1,2,3], Josef Settele[1], Martina Löw[5], Eick von Ruschkowski[4], Johannes Wahl[6], Andreas Wiebe[7], Andrea Andersen[5], Volker Grescho[1,2], Susanne Hecker[1,2], Helga Inden-Heinrich[8], Angelika Lischka[4], Roland Kraemer[1,2], Anett Richter[1,2], Johannes Schwarz[6]

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Biodiversity observation initiatives in Germany are largely carried out by volunteers, many of them taxonomic experts. Data collection and storage on the variety of taxa and spatial coverage is organized by different learned societies, NGOs, national and local authorities, natural history museums, universities and other scientific institutions. Many of these institutions collect and maintain their data by the aid of Citizen Science projects, which operate at different spatial and temporal scales. Moreover, projects follow own survey designs, taxonomic concepts, data standards and host their own database, not necessarily digital or accessible through a web portal. Following the urgent need for a more comprehensive approach we are currently carrying out a feasibility study for a 'Living Atlas Nature Germany' that aims to bring together the multiple projects and data sources in one online portal to visualize and enhance biodiversity monitoring and conservation efforts in Germany. We develop a framework for such a portal in dialogue with representatives of all relevant institutions, through workshops, questionnaires and personal conversations. The first and foremost objective of the atlas platform is to build up a network of taxonomic experts, conservation organisations, scientists, authorities and citizens to enhance communication, coordination and knowledge exchange. Additionally, consensus is that the Living

Atlas initiative should harmonise heterogeneous data to achieve interoperability and to provide services to enhance the visibility of projects and initiatives and to develop analysis tools or applications. A major goal of the Living Atlas is also to serve as a tool for environmental education and to foster and enhance taxonomic knowledge as well as to facilitate training in citizen science project coordination. In progressive phases the portal aims to provide links to supportive abiotic data, such as climate and socio-environmental data, too, to facilitate an added value through professional and meaningful analyses opportunities. The presentation will serve as starting point to discuss how the GfÖ may become part of this Atlas network.

Poster presentations

Session 25-P1 - Wildlife survey in Lower Saxony 1991 – 2016[a] - a base tool for description of biodiversity of our cultural landscape -

Egbert Strauß[1,2], Katrin Ronnenberg[1], Inga Klages[1,2], Reinhild Gräber[1]

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In 1991 the wildlife survey (WTE = WildTierErfassung Niedersachsen) was established by the Hunting Association of Lower Saxony with the goal of monitoring long-term and area-wide occurrences and development of wildlife populations in the cultural landscapes. The WTE was conducted by the Institute for Terrestrial and Aquatic Wildlife Research. All hunters and foresters receive an annual questionnaire in order to estimate or count the occurrence or abundance of several wildlife species (game species) in their hunting district. Furthermore, hunters were asked to provide data on hunting bags, reproduction, diseases, road kills, crop damages, and other topics, as well as on the human dimensions, e.g. hunters´ opinions and attitudes. With participation rates of roughly 90% of hunting districts (equal approx. 8000 districts, 3.7 Mio ha), the hunters built a highly motivated and competent group. Plausibility checks were part of the yearly program and a larger scientific evaluation study was conducted for the grey partridge, which confirmed the reliability of estimates. Data are analysed on a municipality level or several regional levels (e.g. natural regions, administrative districts). Over the 25 years, 53 wildlife species were included. 10 species were continuously monitored and another 10 were regularly monitored every few years. The data have allowed statements on the occurrence and the long-term development of populations on a local and regional level. Additionally the database forms a comprehensive baseline for studying the causes of decline of wildlife populations in our cultural landscape. Links between the common game species such as pheasant, fox and deer and indicator species such as partridge, hare, wild cat or the neozoa as raccoon,

raccoon dog and nutria can be identified to describe biodiversity and biotic interactions. We not only present on the advantages of the database, which show large-scale and long-term population development for example on the hare, but we will also discuss its limitations.
[a]funded by hunting charges - Ministry of Agriculture

Session 25-P2 - Wireframes and Prototype App for a longterm monitoring of land use change impacts based on Citizen Science Approach

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The stability of South American grassland ecosystem and it's biodiversity has been reduced by enhancing production of food and fibres. We develop a Prototype App for a sustainable monitoring by students of rural schools in Uruguay. The App will help to integrate the long term monitoring into scholars curricula and facilitate the implementation of a network of monitoring sites and a multi-use evaluation framework of land-use change related to ecological impacts by adopting principles of Citizen Science. Our 'Student Science' approach offer a country wide case study for developing 21st Century Skills and new concepts to move beyond the current stalemate of environmental education. The Prototype App is mainly focused on the UI and UX Design/Development. The conceptual design involves 4 different services: In order to achieve this, an interactive learning tool with graphical animation and relevant definitions was created. In the Monitoring Section the user's input allows the developed System recollecting biotic and abiotic parameters from different Uruguay regions. Recording data over long periods of time will promote new scientific practice at the Schools Curriculum and will also improve the ecological database on land use change impacts. Alternative land use scenarios are shown in the Application's Strategies Section. Features may be added to integrate expert knowledge into Landscape Planning.

END OF SESSION 25

Session 26 – Envisioning multifunctional sustainable landscapes in urban and rural areas

Chairs
Dr. Ina Säumel
Lauranne Pille
Dóra Csizmadia

Session 26-O1 - Mind the detail - Citizens, administration and urban green in Baden-Württemberg

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Urban green is well-known as a factor attenuating consequences of climate change in cities. Green spaces for example buffer temperature and diminish flooding by improving infiltration. Moreover, they have various positive effects on health and social activities of citizens. Nevertheless, green spaces still often fall victim to construction projects. City planners have to integrate demands from all parts of society. They need to satisfy the needs of workers as of businessmen, of young families as of old people. They are expected to allot space for residential areas, industrial parks, shopping, educational, cultural and administrative facilities and various other kinds of infrastructure. In Baden-Württemberg, many cities are growing rapidly as people follow economic success, access to cultural facilities and educational opportunities. Because cities need taxpayers to maintain their infrastructure, politicians naturally appreciate growth. But it is becoming increasingly difficult to find space for it. What is left is often local recreation area, valuable farmland or protected area. Prioritized in-city development as a consequence has slowed down land consumption outside of cities, but increases pressure on free spaces within cities. Urban green, as though administration recognizes its importance, does still not gain priority in this situation. It ends up "squeezed in", causing technical difficulties. Urban trees, container plants and vertical greening are expansive; moreover, this kind of greening suffers from irrigation problems and, generally, increased environmental stress. Species selection is dominated by aesthetical arguments or accessibility, ecological criteria are often neglected, making plants short-lived and little efficient regarding city climate. The research project "Urban Green – Fit For Future" (funded by the German Federal Environmental Foundation), investigates the position of urban green in administrative, political and social processes. Promotional and inhibiting factors for implementation of diverse, adaptable green are identified. Following this, green-based climate adaptation modules are designed to overcome inhibition

thresholds. These modules will be stored in an information system which might strengthen communication of protagonists on the long run.

Session 26-O2 - Planning a water sensitive and biodiversity friendly city

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Urban water managers are being confronted to complex and multi-faceted challenges resulting from increasing urbanization along with environmental degradation, a complex organization within the water infrastructure and the climate change. There is growing awareness of the critical need for strategic investments in long-term solutions for a sustainable and adaptive urban water management. Key strategies to shift the paradigm from traditional water management to more sustainable concepts and thus to envision a ‚blue revolution' are related to ecological design principles (i.e. reducing engineered structural components, development of adaptive non-permanent design, incorporating and bio-mimicking nature's approaches and enhancing habitat diversity). Rainwater management measures such as ponds, swales, green roofs, green façades or rain gardens represent techniques for ecological design and engineering and are crucial elements for the re-conceptualization of the water infrastructure.Such measures can harbor biodiversity, which is widely underestimated despite its potential to foster ecosystem services and optimize the water infrastructure functioning.Thus, here we amplify the current concepts of a Water Sensitive City towards the 'Biodiversity Friendly and Water Sensitive City' by integrating biodiversity targets into the sustainable urban water management approaches. The aims of this paper are to discuss steps towards the 'Biodiversity Friendly and Water Sensitive City' based on strategic rainwater management measures implementation strategies. Undoubtedly, infrastructure investment and replacement will be a gradual process using hybrid technologies due to economic and environmental impacts. To optimize not only the water services but also the biodiversity of rainwater management measures, a planning at a local and landscape scale is necessary, such as a coordination of the different actors of the rainwater management.

Session 26-O3 - Strategies for sustainable urban water management in European metropolises

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Impacts of extreme weather events are increasing due to climate change and daily growing proportion of impervious areas. Floods in the urban areas not just damage

properties but also threat human life. Coping with these challenges in metropolises of old Europe is difficult as the existant building structures and combined rainwater and sewage systems originating from the 19th century. We compare three old European capital cities (Berlin, Budapest and Paris) regarding rain water management concepts. We identify important spatial land use types of blue-green infrastructure and corresponding measures for the implementation towards a more water sensitive management by using the case study approach (e.g. from KURAS (Konzept für Urbane Regenwasserwirtschaft und Abwassersysteme) database).

Session 26-O4 - Blue Green Infrastructure in Theorie und Praxis

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Im Rahmen des Verbundforschungsvorhaben Kuras, Konzepte für urbane Regenwasserbewirtschaftung und Abwassersysteme, wurden Maßnahmen der Regenwasserbewirtschaftung evaluiert und bewertet. Neben Effekten auf die Umwelt wurden Effekte auf Ökonomie und Bewohner analysiert. Auf Basis dieser Analyse wurde, anhand von zwei Beispielquartieren, die Wirkung verknüpfter Maßnahmenkombinationen modelliert und ausgewertet. Neben den wissenschaftlichen Institutionen wurden bei Kuras auch Partner mit Praxis-Bezug beteiligt. Im Rahmen des Vortrages werden Ergebnisse aus Kuras vorgestellt. Außerdem werden aktuelle und umgesetzte städtische Planungen, mit integriertem Regenwassermanagement, der Praxispartner gezeigt. Eine Bewertung auf Basis der multikriteriellen Bewertung von Kuras wird vorgenommen. Synergien und Zielkonflikte zwischen den unterschiedlichen Effekten werden aufgezeigt.

Session 26-O5 - Comparing the cooling benefits of different urban tree species at contrasting growth conditions

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With ever increasing urbanization we are continuously changing our landscapes and altering the ecological processes to make our cities warmer. The extreme summer of 2003 and the prolonged heat waves of 2015 in Europe are indicative of the challenges that lie ahead. Planting trees – greening cities– therefore seems to be one of the most feasible options to mitigate those problems. Our experiments have shown that tree shading can cool hard surfaces by 15-20°C and reduce radiant temperatures by 5-7°C thus improving human comfort; meanwhile evapotranspiration can absorb up to 50% of the energy from incoming solar

radiation and reduce local air temperatures by 2°C. However, our recent studies have also shown that the benefits of urban vegetation vary greatly with tree species, growth conditions and climate. Street canyons showed significant influence on the micro-meteorology hence on the cooling benefits of trees even they are only 100 m apart from each other depending on the orientation and surface properties. Fast growing species such as *Pyrus calleryana,* with their dense and wide canopy showed cooling up to 2.2 kW tree^{-1}, 3-4 times that of *Sorbus arnoldiana*. Furthermore, when *Pyrus* were planted in less compacted structural soil with open top rather than in sealed pavement they provided evapotranspirational cooling of up to 7 kW, 5 times higher than those grown in compacted or sealed pavements. However, nocturnal cooling was higher from trees grown over sealed surface compared to those grown on grass lawns. Nevertheless, more research is urgently needed to transfer the results of experimental investigations on the cooling effect of trees into regional climate models. We also need to further investigate the effects of tree species, size and growing conditions, and the weather on the cooling effectiveness of individual trees, and to test the theory that the cooling benefits of trees are directly proportional to their growth.

Session 26-O6 - About the complexity of BEF relationships and why beta-diversity is more important than alpha diversity

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Biodiversity is crucial to maintain ecosystem functioning. However, for most functions it is still unknown which facet of the functional composition of a plant community - functional diversity (FD, complementarity hypothesis) or functional identity (FI, mass ratio hypothesis) -is the most important driver. This knowledge will enhance our mechanistic understanding of biodiversity-ecosystem functioning relationships and improve ecosystem management and conservation. We studied 43 ecosystem functions, measured within the same biodiversity grassland experiment, to answer the following questions: (1) Which ecosystem functions are best predicted by the functional composition of plant communities? (2) Which facet of functional composition (FD or FI) is more important? (3) How many and which trait dimensions (PCA Axes) drive individual functions? We performed a PCA based on 37 plant traits and calculated FI and FD indices of the first eight axes. From these 16 potential predictors we selected the most parsimonious linear model for each function. We found that biotic above ground functions (e.g. primary production, fauna diversity) responded stronger to functional composition than abiotic below ground functions (e.g. soil carbon, -porosity). Most biotic functions were equally affected by FI and FD, whereas abiotic functions were primarily

explained by FI. Overall, a PCA axis driven by the functional identity of legumes (PCA axis 3) was the most important predictor for the majority of functions. However functions differed largely with respect to the number and composition of predictors. Our results support both, the mass ratio and the complementarity hypothesis, but with large differences between individual functions. Most importantly, however, our results clearly reveal that no single functional composition maximizes many functions simultaneously. Instead, different sets of functional traits as well as their identity and diversity trigger multiple ecosystem functions.

Session 26-O7 - Tradeoffs in maintaining plant and invertebrate biodiversity and hay productivity in montane semi-natural grasslands

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In the Alps, semi-natural grasslands have been maintained by farming activities over many centuries. A long history of traditional management has resulted in a rich assemblage of species in these habitats. However, in recent decades, pressure to increase agricultural productivity has led to management intensification involving aerial irrigation and slurry application, a practice that is known to have negative impacts on grassland biodiversity. To help address this problem, our research group initiated a replicated manipulation experiment in montane and subalpine meadows across the Swiss Alps in 2010. The aim of this ongoing research project is to determine if there is a management tradeoff (degree of intensification) that would generate acceptable hay yields while maintaining grassland biodiversity. Surveys carried out in 2014 and 2015 demonstrated that plant species richness and phylogenetic diversity decreased under high intensification, but were maintained at low and medium intensification levels, compared to control plots with input. Impacts on native invertebrate communities varied depending on the groups considered. For instance, the abundance of ground beetles was positively correlated with intensification, while that of spiders was highest at low and medium intensification levels. No effect of management was detected on beetle or spider species richness. As expected, hay production increased with management intensification. The study's results indicate that a tradeoff between biodiversity and yield is possible at low to medium management intensity level, where an acceptable yield can be obtained while retaining considerable grassland biodiversity along with the ecosystem services it is known to provide, such as nutrient cycling, pollination and pest control. The study outcomes are being advertised to farmers and other involved stakeholders, and will contribute to the development of new guidelines for the future development of montane and subalpine agricultural systems.

Session 26-O8 - Fostering landscape multifunctionality by spatial optimization?

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The implementation of sustainable land use practices regularly fails due to limited understanding and uncertainty of dynamic processes in our changing world and due to the lack of integrated visions for land use outcomes. The 'magic toolbox of modeling' is offering approaches for understanding landscape functioning, for envisioning future landscapes and for integration of scientific and decision-making communities by participative and transdisciplinary techniques. Optimizing land use distribution at landscape scale is a key issue for enhancing regional sustainability by balancing economic development, environmental conservation and socio-cultural development of the communities and thus towards multifunctional landscapes. Therefore, in recent years the development of methodologies, techniques and algorithms for spatial optimization of land-use came into the research focus worldwide. Here we (i) compare algorithm used in the optimization of land-use, (ii) evaluate their application in landscape design and planning and (iii) analyze the main causes that limit and/or promote their use at landscape scale.

Session 26-O9 - Landscape change impacts on health and 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 agricultural landscapes are currently subjected to expanding afforestation using mainly non-native *Eucalyptus* species for the globalized market. In the face of high afforestation rates and lacking studies on related impacts on honey bees and their pollinating services we assess impacts of land-use changes on pollinator health, 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 in changing landscapes across Uruguay. Here we present first results from pan traps,

and PDMS / gas chromatography for plant volatile analysis. We will establish 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.

Session 26-O10 - Facing the challenge of accelerated land use impacts on temperate wetlands in Northern Iran

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Accelerated land use changes by intensive cultivation are considered as main drivers of global change that often reduce ecosystem resilience and negatively affect a sustainable use of natural resources and overall socio-economy. Northern Iran experienced major land use changes within the last decades including deforestation, overgrazing and the conversion of rangelands or wetlands to intensive crop production that consequently affected the hydrological cycle and local wetlands. Scientific studies on impacts of these land use changes are scarce but crucial to balance between the human need for economic development, food supply and nature conservation. Using the case study approach we address the land use change at selected sites in Northern Iran and identify main drivers and impacts of land use change from literatures and expert consultation. Based on this we outline steps towards multifunctional, biodiversity friendly, and sustainable productive landscapes.

Poster presentations

Session 26-P1 - Citree: a database supporting tree selection for urban areas in temperate climate

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Urban sites can be characterized as very variable according to the user entitlement and also include a wide variety of growth conditions. Therefore, the selection of planted trees and shrubs in cities has to incorporate these location-specific factors aiming to minimize the negative influences and increase the positive effects as well as the aesthetic acceptance by urban residents. Additional challenges in the selection of trees and shrubs are user requirements and growth conditions at urban sites. Therefore, the selection of planted trees and shrubs in cities has to incorporate these location-specific factors. Based on an extensive literature research, more than 390 woody plants were investigated to obtain a comprehensive view on specific characteristics by integrating especially urban aspects. A database was developed that allows users to simultaneously consider site characteristics and natural distribution, tree appearance, ecosystem services, management activities, and the risks and interferences caused by urban woody plants. The developed Citree database (http://citree.ddns.net/index.php) is useful for preventing mistakes in planning, which would otherwise result in high ecologic and economic costs. Choosing the right species for the right location will also increase the floristic biodiversity within urban tree plantings and the sustainable uses of urban trees.

Session 26-P2 - Only cooling air and saving water? - Effects of rainwater management measures on biodiversity: a meta-analysis

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Fostering adaptation to global warming is a main challenge of urban planning and design. Crucial techniques for ecological design and engineering are rainwater

management measures such as ponds, swales, green roofs, green façades, pervious pavement or rain gardens. These measures can provide a wide range of ecosystem services to city dwellers beyond handling urban rainwater (e.g. enhancing the urban landscape's aesthetic and life quality, or cooling down buildings in summer while keeping them warm in winter). Here we studied the effects of different urban rainwater management measures on biodiversity and determined their influencing factors (e.g. design and management), in order to enhance biodiversity-friendliness of these measures and elaborate guidelines for planners and architects. Data on biodiversity indicators (e.g. Alpha-diversity, Beta-diversity, rare species occurrence, neophyte species occurrence, habitat diversity, connectivity, *etc*.) and characteristics of rainwater management measures were collected from literature and reported into a common database to allow a statistical analysis. The results show that rainwater management measures provide habitat for a wide range of plant and animal species, among them many neophyte species, and thus represent *novel urban ecosystems*. Rainwater management measures also play an important role in the urban biodiversity conservation since they can host rare or endangered species. The design and management options strongly influence the quality of habitats and thus directly impact diversity. Rainwater management measures in general are civil engineering structures with highly regulated design and management standards that have to be adapted to optimize the biodiversity friendliness of rainwater management measures.
Keywords: rainwater management measures, biodiversity, green roof, green façade, swale, pond

Session 26-P3 - Strategies for sustainable urban water management in European metropolises

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Impacts of extreme weather events are increasing due to climate change and daily growing proportion of impervious areas. Floods in the urban areas not just damage properties but also threat human life. Coping with these challenges in metropolises of old Europe is difficult as the existant building structures and combined rainwater and sewage systems originating from the 19th century. We compare three old European capital cities (Berlin, Budapest and Paris) regarding rain water management concepts. We identify important spatial land use types of blue-green infrastructure and corresponding measures for the implementation towards a more water sensitive management by using the case study approach (e.g. from KURAS (Konzept für Urbane Regenwasserwirtschaft und Abwassersysteme) database).

END OF SESSION 26

Session 27 – Biodiversity and society: A plea for social-ecological biodiversity research

Short title: Social-ecological biodiversity research

Chairs
Dr. Marion Mehring
Dr. Alexandra Lux

Session 27-O1 - Biodiversity and wildlife tourism in Southern Africa: a cultural ecosystem service assessment

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The concept of cultural ecosystem-services (CES) represents a great opportunity to investigate the interaction between people and biodiversity. CES assessments therefore require approaches that involve both ecological and social factors in order to understand how biodiversity contributes to the delivery of ecosystem services. Here we study wildlife tourism as an important CES in Southern Africa. We simultaneously gathered data on large mammal abundance and sighting probabilities using transect counts and performed a social survey using questionnaires in four protected areas (Etosha, Chobe and Kruger National Parks and Hluhluwe-Imfolozi Game Reserve) in Namibia, Botswana and South Africa. We had three objectives: 1) understanding which biodiversity metrics are relevant in CES assessments, 2) identifying the supply and the demand of CES and test the potential supply-demand mismatch in the four protected areas, and 3) assessing wildlife tourists' attitudes towards savannah landscapes in the context of global change. Our results demonstrate that subcomponents of biodiversity (*i.e.* charisma and rarity of species) need to be considered for CES assessments. We also found that supply-demand frameworks are particularly useful for CES studies and for guiding long-term management of African protected areas. We further show how wildlife tourists perceive vegetation during their safari drives and discuss how changes in vegetation may impact the viewing experience of wildlife tourists in the future.

Session 27-O2 - Can we enhance ecosystem services by protecting biodiversity in urban areas or do we just hope it is that easy?

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The current debate in urban environmental research is focused on urban ecosystem services (UES). UES are crucial for human safety and wellbeing and thus strong determinants for the quality of life of urban dwellers. Often, the term 'biodiversity' is mentioned together with the term 'ecosystem services': Urban biodiversity is generally considered fundamental to the generation of UES and enhancing UES is considered beneficial for protecting biodiversity. If these assumptions were true, then these win-win situations will facilitate urban planning. However, a closer look at existing research on the relationships of UES and biodiversity also reveals trade-offs among the two. The general assumption that more biodiversity means more UES might be misleading because it is simplifying complex interrelations. Still, increasing urbanization close to biodiversity hotspots, an increasing share of humans living in urban areas and changing environmental conditions urge us to consider ways of enhancing both biodiversity and the provision of UES. Here, we provide an overview of the current knowledge on the relationships of urban biodiversity and UES. We show that no general synergy among UES and biodiversity exists. Urban planning has to be case-specific, include novels ways of green space design, and provide – within and close to cities – space for UES, space for biodiversity and multifunctional areas.

Session 27-O3 - ESS trade-offs: How integrated modelling can help

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The functions and processes of an ecosystem can become ecosystem services (ESS) only if there are humans benefiting from them. In recognition of this, we can state that to effectively manage ESS we need to rely on natural- and social-scientific knowledge. Especially if we consider trade-offs between different ESS, we need to ask questions like: Who can make use of an increased harvest yield? Who is actually using a picturesque landscape for recreation? Who can be reached by financial incentives? By solely relying on higher scale processes like economic or demographic development (as many studies do), these questions can hardly be answered. Based on the concept of social-ecological (supply) systems, we study strategies of northern Namibian households to shift between different water resources in the cycle of rainy and dry season. Facing an interdisciplinary issue, we combine two modelling approaches to integrate knowledge from social- and natural sciences: On the one hand, Bayesian networks, as a parameter free statistical method that explicitly considers uncertainties, have a particular strength to integrate different types of data, while they are less useful to model (spatially and temporally) dynamic processes. On the other hand, agent-based models, as a very elaborate method with numerous examples of application for land use change and use of common resource pools, display spatial and temporal dynamic. Using this combination of integrated modelling methods, we are able to disentangle socio-economic from natural drivers for human decision making and to depict different adaptation strategies on household level.

Session 27-O4 - How pollinator species diversity affects the probability distribution of pollination and of farm income

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Food production depends partly on insect pollination as about 35% of the world crop production volumes rely to some degree on crop pollination services. Many fruit producing farmers rely solely on pollination services by the honey bee (*Apis mellifera*), although wild pollinating species are known to be effective pollinators, too. Here, we study how wild pollinators such as several wild bee species (e.g., *Andrena* spp., *Osmia* spp.) and hover flies (Syrphidae) affect the probability distribution of pollination services and thus, of farm income. Therefore, we analyze

data from an existing data-set about species-specific flower visits in almond orchards in California (Klein et al. 2012). Our study is novel and innovative for three reasons: 1. We assume an underlying Poisson-distribution of flower visits by pollinators to temporally and spatially upscale the data – from the scale of field observation during a limited time interval in limited parts of some trees to the scale of an entire season and an entire tree. Here, we include data on species specific pollination effectiveness on a per-visit basis. 2. Using agronomic and economic data, we convert this pollination probability distribution into an income probability distribution. This allows us to do an evaluation in monetary terms. 3. We analyze the resulting income probability distribution in terms of its statistical moments, namely its mean, standard deviation/coefficient of variation and skewness. Thus, we analyze the effects of pollinator diversity on the expected income and income risk for farmers. Preliminary results show that wild pollinators lead to an increase in mean farm income, especially when the surrounding habitat has a high percentage of natural habitat. Additionally, wild pollinators increase the standard deviation of income, yet decrease the coefficient of variation, i.e. normalized standard deviation. They lead to a more right-skewed income distribution, that is, they enlarge the range of the income distribution and shift probability mass to higher incomes.

A.-M. Klein, C. Brittain, S. D. Hendrix, R. Thorp, N. Williams and C. Kremen. 'Wild pollination services to California almond rely on semi-natural habitat'. In: Journal of Applied Ecology 49.3 (2012), pp. 723-732.

Session 27-O5 - Tensions between conservation and production. Environmental vulnerability and ecology in Valle del Lunarejo Protectec Landscape, Rivera, Uruguay

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Uruguay has been promoted internationally as environment friendly by using the touristic slogan "Uruguay Natural". However tensions and contradictions emerged related to this development model, considering the dichotomy "economical growth vs conservation". In the last decades agrarian intensification was an important factor of change in Uruguay´s environmental and social matrix, associated with increase of afforestation and soy culture. This process in spite of widely documented, very little is known about the impacts on the environmental systems. Through different expressions the government attempted to regulate natural resources use by public policies on this matter, such as the generation of representative natural areas by the creation of a protected areas system. So, agrarian intensificatión process coexist in space with initiatives of protected areas. We use this cases to study the tensions between conservation and production. Vulnerability concept is used as a methodological approach in many knowledge

areas, including natural resources, being widely used as a strategical tool for management, allowing integration of different variables and the identification of threat of special susceptible sites, improving management strategies, recovering degradated areas and moving toward production - conservation articulation. This work aims understanding spacial projection of this process in Valle del Lunarejo (Uruguay). So, we joined the mentioned vulnerability approach, to GIS tool, allowing the articulation among biological and physical variables as well as land use system variables from a time section perspective. Also, the results allowed moving forward in comprehension of the process. Primary data has shown that afforestation has contributed to generating vulnerable patches in this area, with possible ecological and social impacts. However, a major part of it still keeps significant areas of conserved natural goods, related to the preservation of historical land use (i.e. extensive cattle raising).

END OF SESSION 27

Session 28 – Prospects on integrating societal dimensions into ecological research - setups, methods and theory

Short title: Societal dimensions in ecological research

Chairs
Dr. Ronald Bialozyt
PD Dr. Jens Jetzkowitz

Session 28-O1 - Print mass media coverage of wildlife in the developing world

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We studied wildlife related news coverage by the Indian print news agencies and we quantify its patterns. We reviewed 766 news items across 50 newspapers in the year 2011. We found a considerable size bias towards large bodied species (1:8 times) in portrayal of wildlife news items. A tendency towards controversial portrayals with respect to species such as leopards and elephants was observed. The Indian print media was also more likely to report large, endangered, terrestrial mammals when they were reporting about wildlife. Nearly half of the wildlife reports by dailies were on Tigers (>250) and other endangered large felids (>150). We found similar pattern of reporting between national, regional and business newspapers with respect to species and themes covered ($p = 0.09$, $t\ stat = 1.85$, $t\ crit = -1.45$). Business dailies rarely carried wildlife related news (5 items). Wildlife news reports by most Indian dailies has affinities with a market driven approach and the priorities of reporting are derived from urban stewardship. A balanced approach to conservation coverage with respect to conflict species and enhancing coverage in business dailies is essential for wider awareness.

Session 28-O2 - Group approaches for targeted implementation of Agri-Environmental Measures (AEM) on the landscape level in Hesse / Germany.

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The increasing intensification of agricultural production and the associated simplification of landscape structure is a major threat to biodiversity especially in favorable arable farming areas. The current Agri-Environmental Measures (AEM)

funding structure is missing the incentive for farmers to actively participate in the shaping and achieving environmental objectives. The aim is to show that group-oriented compared to individual AEM approaches possibly have higher degrees of achievement in the provision of suitable priority areas for species conservation in a landscape. The inter-company or municipal level could be achieved through a combination of land users, landscape planners and ecologists, who acts as a coordinated working group. From existing national and international AEM group oriented approaches an Agri-environmental and biodiversity concept (AUBI) for a region in Hesse (Germany) was derived. With a Case Study the suitability of AUBI should be controlled and is to be considered what modifications are necessary in order to use successfully group oriented approaches. The idea behind the case study is not only to coordinate bilaterally AEM between the public sector and individual farmers and to reward them. It is more about sharing knowledge on biodiversity issues with farmers, causing farmers to cooperation and thus to obligate to mutual commitment in regional habitat and species protection. For the research approach the methodology of action research was chosen, to react best on the ongoing communication and interaction of several different stakeholders.

Session 28-O3 - Determinants of agro-pastoralists' valuation criteria of forage resources in West Africa's Sudanian savannas-an ethnobotanical approach

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In the region where climate change presents unprecedented challenges for sustainable agriculture, local people from West Africa tend to respond differently to these daunting challenges over the years by using their experiential knowledge. Thus, local ecological knowledge (LEK) on forage resources is one way that can provide insight into criteria for sustainable natural resources management and understanding why these natural resources are sometimes overexploited in the face of climate change. However, factors which influence local agro-pastoralists' decisions on whether forage resources are good or not for sustainable livestock production still remain elusive. To partly fill this gap, an ethnobotanical survey of 526 informants across 16 villages in Ghana and Burkina Faso were sampled to test which socio-cultural and climatic factors dominantly affect citation of agro-pastoralists' criteria for valuation of forage resources. Using generalized linear mixed-effects models (GLMM) and model selection procedures, the results revealed that it was rather aridity class, but not socio-cultural (ethnic, age, gender and educational) background, which significantly influenced how many criteria for valuation of forage resources were cited, irrespective of whether it was for rainy or dry season or for cattle, goats and sheep types (ps < 0.001). Thus, agro-pastoralists who were resident in humid and dry sub-humid locations gave many different reasons for judging their forage plants while those in semi-arid villages cited few.

Better understanding of such a place-based knowledge system may help us to either conserve or restore forage plantsfor sustainable livestock production in the region.

Session 28-O4 - Integration practitioners' knowledge in ecological research - insights from Namibian farmers

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Rangelands provide a living space for 370 million people worldwide and 80 per cent of the nutrition for livestock. In these ecosystems societal processes are intrinsically tied to natural processes through land management and the benefits people derive from the ecosytem. Degradation of Ecosystem Services (ESS), fostered by maladapted land use and climate change, has become a serious challenge, negatively impacting ecosystem functioning and the livelihoods of the people. To prevent further degradation of ESS, adapted management strategies are vital. However, these ecosystems are very complex with regard to ecological interactions, posing challenges for good management choices. Furthermore, ecologically desirable management options may be hindered by social or economic incentives, believes and preferences. We present how our concpet of social-ecological systems (SES) (according to Hummel et al. 2011) can be applied to integrate local knowledge into scientific research and how it complements process-based modeling approaches. Within the transdisciplinary OPTIMASS project, Namibian livestock farmers were interviewed regarding their motivations for action and the dependencies between societal utilization interests, ESS and management options. We will present preliminary results of the empirical study and the analysis. In a next step practical knowledge of farmers will be related to the results of process-based ecological models in order to elucidate adapted drivers for management. We argue that applying the SES concept allows for a more detailed exploration of mechanisms within the social-ecological model, while improving iterative communication of research results to practitioners. Progress in rangeland ecology can be achieved by integrating local and scientific knowledge with regard to the impact of land use and environmental variability on ESS. This also opens the opportunity to mutual learning processes - for scientists and pratictioners.

Session 28-O5 - Integrating human livelihood needs when developing nature conservation strategies - a case study of Kitui district

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Biodiversity decline due to habitat destruction is a major global concern. Many tropical forests are biodiversity hotspots, but also provide various ecosystem services, which are crucial for the local human population. This leads to livelihood – ecosystem conservation conflicts. To establish efficient nature conservation programs that maintain habitats for endangered species, as well as intact ecosystem services for the local human population, holistic conservation approaches, joining research of social and natural scientists, need to be considered. An interdisciplinary research project was undertaken in the riparian gallery thickets along the Nzeeu River in semi-arid Kitui to answer the question: How may nature conservation become long-term effective in an area where agricultural activity is high, without gating nature? The land along the river lacks conservation regulation, is under private ownership and severely used for food and goods production. Nature conservation is therefore based on individually engagement. The study delved into biodiversity research and the assessment of people's current land utilization, their knowledge of biodiversity and ecosystem sensitivity and their willingness to change resource utilization patterns.Farmers cultivating along the river were interviewed (N=200) through structured questionnaires in March 2016. The purpose was to understand people's livelihood, their ecological behavior and potential knowledge gaps, for developing effective long-term nature conservation. Our results show that awareness of ecosystem services is high. Yet, there are high knowledge gaps, especially when locals need to differentiate between native and invasive species. Hardly any information on simple nature protection possibilities is communicated from the government, even though locals would be very willing to acquire knowledge on nature-friendly agricultural practices. From the scientific findings, practical advises on how results of the survey will help to develop successful conservation strategies will be given. We argue that including social sciences into conservation research as a holistic approach is of high relevance, especially in human-dominated regions. The idea is to make the local community partners in conservation through ownership of such efforts.

Session 28-O6 - Changing perspective - insights from five years of social-ecological research in Southern Transylvania

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Ecological research often is not only driven by curiosity, but also motivated by the desire to reduce or prevent the negative impact of human activity on the biosphere. This desire is particularly strong in the fields of conservation biology and the environmental sciences, where ecological research seeks the proximity to human society. This proximity provides many opportunities but also poses some

challenges for (ecological) research. While on the one hand it holds the promise to contribute to the conservation of biodiversity, it on the other hand requires to broaden the perspective and to engage with people and with other disciplines. Based on our findings from a five year interdisciplinary project in the rural landscape of Southern Transylvania, we will discuss the benefits of combining ecological with social research. Southern Transylvania still maintains many species that are rare, endangered or extinct in many other parts of Europe. The high biodiversity of the region is particularly maintained by a small-scale, low-intensity land use, which strongly resembles traditional farming methods, but it is threatened by ongoing land use abandonment and intensification. In order to foster the conservation of species and ecosystems in Southern Transylvania, agri-environment schemes and conservation areas have been put forward. However, the implementation of these suffer from serious shortcomings and we argue that a broader perspective is required to achieve a sustainable land use in this region. For this, we will highlight some of our findings from the social-ecological research that we did in the Southern Transylvania in order to show how combining ecological and social perspectives can fundamentally change the way we do research.

Session 28-O7 - Biodiversity Monitoring System (BMS): Understanding bird species occurrence patterns in Philippine Protected Areas

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The Philippines is one of the world's hot spots for biodiversity. Over time, natural and anthropogenic activities have changed the biodiversity structure of the country. Understanding the drivers and impacts of these events involves the assessment of the dynamic socio-ecological systems and the structural and functional changes they have undergone. In the Philippines, the greatest challenge often lies in the limited availability of robust data on species diversity and abundance. The Biodiversity Management Bureau (BMB) of the Department of Environment and Natural Resources (DENR) developed the Biodiversity Monitoring System (BMS) in 2000 to engage local communities in contributing to the improved conservation and sustainable use of forests, grasslands, cultural landscapes and freshwater and marine wetlands by periodically monitoring Protected Areas in the country. The DAAD BioLuz project organized, encoded and developed BMS Quarterly Reports into an electronic database in preparation for analysis and synthesis of this biodiversity data. With the data gathered from 2000-2014 Quarterly BMS reports from around 68 Protected Area (PA) sites nationwide, initial analysis focused specifically on available data on bird species. Areas for analysis involved: (a) developing biodiversity maps depicting the PA areas most populated with specific bird species and (b) conducting logistic regression to predict species

occurrence using data on the presence and absence of birds over time. The existence of biodiversity monitoring and data collection efforts at a national level provides great strides in closing the gaps in biodiversity information in the country. The data from the BMS database has the potential for analyzing other aspects such as species-area curves to identify the rare birds and correlating it to the minimum areas within these species occur to assess the area size needed by endangered/enigmatic species to thrive. Analysis on other flora and fauna species can also be done, however the quality and robustness of data may be inferior to the information provided on bird species. Moreover, on a managerial-level, however limited the provided information is in the BMS reports, preliminary analyses can be done on park management issues.

Session 28-O8 - The societal dimensions in ecological research - a sociological perspective

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The integration of the societal dimensions into the scientific study of interactions among organisms and their environment has come badly in the past 150 years of ecology. Due to phenomena like biodiversity loss and global change one might argue that ecologists' awareness for including human agency into their research agendas and designs is constantly growing since the 1970's. However, a methodological discourse on connecting biological and sociological research is still missing. In most cases interactions between ecological and social systems appear as mere episodic aspects in motivating ecological research projects and drawing concluding remarks. In the current discussion of human impacts on biophysical structures and on socio-ecological systems the concept of complex adaptive systems (CAS) can be used as a starting point. CAS are characterized by so called emergent properties, which are resulting on the macro-level from the interaction of their components, but can not be observed at the micro-level. Hierarchical organisation is such an emergent property which can be discovered in both ecological and societal systems. Further emergent properties will be identified if we systematically include feedback interactions between social and ecological sub-systems in our consideration. The talk will give a sociological perspective on modelling socio-ecological systems, what interactions and processes to include and how such systems may be created. It will therefore also highlight the importance of the interdisciplinary discourse between ecologists and sociologist as basis of the model building process. Finally, a preliminary framework on selecting and incorporating parameter and processes will be presented.

END OF SESSION 28

Session 29 – Natural history discoveries - lessons from the past?

Short title: Observing nature

Chairs
Prof. Dr. Nico Blüthgen
Dr. Sara Leonhardt

Session 29-O1 - Unusual associations: the Red-Rubber Frog lives and its arthropod hosts

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The Red-Rubber Frog, *Phrynomantis microps*, exhibits a variety of outstanding adaptations to its West African savannah ecosystems. Adults adjust their reproductive strategy to the amount of actual and total annual rainfall, breeding site features and time in season, thus maximizing developmental success of their offspring. Their tadpoles are further able to recognize and discriminate between different predators and react appropriately. When adults are not reproducing, they live terrestrially, often far from savannah ponds. There they can be encountered in the nests of aggressive ponerine ants or sitting side by side with huge and/or highly venomous scorpions. The respective arthropod hosts are known to kill and eat on other frogs, the Red-Rubber Frog however, remains completely unharmed. The talk discusses the different strategies of the frogs needed to co-occur in ten arthropod hides and the possible reasoning for this unusual behavior.

Session 29-O2 - Soil mites disperse with high-speed in the guts of slugs

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We recently discovered live soil mites in the feces of slugs collected in a riparian forest in Germany. We assume that slugs ingest mites inadvertently along with various food sources, such as soil, litter, bryophytes, and lichens. A total of 135 oribatid mites comprised of 35 species were discovered in the feces of 40 slugs (*Arion vulgaris*). Overall, 69% of the mites, belonging to 24 species, were still alive after gut passage, whereof 15 species were always dispersed alive, and 11 species were always dead. Extrapolation of this data suggests that at least 39 species of

oribatid mites could be dispersed alive by slugs in our study forest ecosystem, accounting for approximately 58% of all oribatid mite species in riparian forests. Complementary lab experiments confirmed that oribatid mites ingested by slugs along with food material survive consumption and gut passage. Notably, egested oribatid mites can escape from slug feces to colonize the soil. Oribatid mites are strongly dispersal-limited. We assume that slugs disperse oribatid mites through endozoochory and help them to cross dispersal barriers, and to reach new habitat patches. In the guts of slugs, oribatid mites might disperse up to ~49,000 times faster than compared to their own movement. In our survey, we also found that other soil organisms such as mesostigmatid mites, collembola, and nematodes were dispersed alive by slugs. We conclude that this newfound interaction of aboveground and belowground organisms may help soil biota to overcome dispersal limitations and to colonize new habitat patches.

Session 29-O3 - Unique arthropod communities on conspecific trees: explanations and consequences for local arthropod diversity

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The African savannah tree *Combretum adenogonium* (syn. *C. fragrans*) is host to speciose arthropod communities. Complete inventories of arthropod communities from neighbouring *C. adenogonium* trees revealed that the more abundant arthropod species were generally not randomly occurring on conspecific host trees but aggregated on particular individuals. The same tree individuals were consistently recolonized by specific arthropod species after complete removal of arthropods. The apparent preference of arthropod species for particular plant individuals was persistent within the same year (over a 3 months period) and between two different years. Although reasons for selection of individual trees may differ between different taxonomic groups and guilds of arthropods, it is assumed that intraspecific variation in physical as well as chemical tree traits is a main trigger of “intraspecific host plant specialization”. This specialization led to establishment of distinguishable arthropod communities on neighbouring trees and may be considered as an important driver of local arthropod diversity.

Session 29-O4 - Discovery of fairy circles in Australia supports self-organization theory

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So-called 'fairy circles' are round bare-soil patches within dry grassland of arid Namibia. Until the year 2016, researchers thought for decades that these mysterious circles would solely occur in southern Africa. However, a recent publication in PNAS shows that fairy circles also occur in the arid spinifex grasslands of Western Australia. This new discovery 10,000 km away from Namibia supports the general view that highly ordered gap patterns in such drylands emerge due to vegetation self-organization with plants strongly competing for scarce soil water. Their apparent global occurrence is also in line with a fundamental universality principle of pattern-formation theory. As their Namibian counterparts, these vegetation gaps are extremely regularly spaced, and in this talk we will emphasize the importance of the detailed signature of spatial regularity based on the example of the mysterious fairy circles. It will be shown that their pattern is unlikely the result of abiotic gas leakage or the activity of termites and ants. Instead, we demonstrate that their typical hexagonal spacing concurs with the hypothesis of vegetation self-organization. We substantiate our findings by comparing directly the spatial patterns of fairy circles, termite, and ant nests and show that the extremely ordered fairy circle patterns have nothing in common with the distribution of social insects that occur in the same area. We further show that fairy circles may be induced by different biomass-water feedback mechanisms such as soil-water diffusion or overland-water flow but that their spatial distribution pattern is identical because of the same instability type that triggers the vegetation pattern formation.

Getzin, S. et al. (2016) Discovery of fairy circles in Australia supports self-organization theory. PNAS, 113, 3551–3556.
Getzin, S. et al. (2015) Adopting a spatially explicit perspective to study the mysterious fairy circles of Namibia. Ecography, 38, 1-11.

Session 29-O5 - A question of data quality - testing pollination syndromes in Balsaminaceae

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The existence of pollination syndromes, predicting a guild of pollinators based on flower morphology, colour, reward and scent, has been controversially discussed in the last two decades. We are investigating pollination syndromes using a quantitative and categorical data set of flower morphological and reward traits for 86 Balsaminaceae species, applying Cluster analyses in combination with

independent pollinator observations and published syndrome assignments. Using quantitative data we retrieve six plausible pollination syndromes but one additional, well-supported cluster comprises highly divergent floral morphologies. This cluster represents a non-syndrome of flowers, not differentiated in the specific data analysed. However, using categorical data we are not able to clearly retrieve pollination syndromes, similar to several earlier studies. This demonstrates that an understanding of data quality can not be replaced by sheer data volume. With this caveat, it is possible to test for pollination syndromes in large datasets and extrapolate them reliable for taxa, for which direct observations are not available.

Session 29-O6 - Saving the injured: Rescue behaviour in the termite hunting ant *Megaponera analis*

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The ant *Megaponera analis* is a specialized termite predator, solely raiding termites of the subfamily Macrotermitinae at their foraging sites. During our observations of these raids, at the Comoé National Park North-Eastern Côte d'Ivoire, we noticed that some ants were carrying nestmates back from the hunting ground to the nest. Closer inspection allowed us to identify injuries on these carried nestmates. This observation led to various interesting research questions and according cooperation's in chemical ecology, behavioural biology, modelling and evolution of rescue behaviour. Here we show that a unique rescue behaviour in *M. analis,* consisting in carrying injured nestmates back to the nest reduces combat mortality. After a fight injured ants, that either lost a limb or have termites clinging to them, emit two pheromone components, dimethyl disulphide and dimethyl trisulphide, harboured in the mandibular gland reservoir, as a call for help. These injured ants amount to 12-20 individuals per day, a quantity similar to the birth rate in a colony (13.3±3.8 ants per day). If these injured ants are forced to return without help they die in 26% of the cases. A model accounting for this rescue behaviour quantifies the value of it to allow for a 23% larger colony size. Our experiments show a clear reduction of combat mortality, with pheromones in the mandibular gland triggering the rescue behaviour. Thus showing the adaptive value of rescue behaviour in a social predator specialized on highly defensive prey. A behaviour successful enough to have co-evolved in widely different social systems using distinct mechanisms, like chemical communication in ants or empathy in humans. This convergent evolution allows us to identify the evolutionary drivers necessary for selective rescue behaviour to evolve in animals.

Session 29-O7 - Historical records or fish tales? Comparing natural history accounts with quantitative field data on Neotropical ants

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Natural history accounts played a fundamental role in the development of ecology. However, the shift to quantitative precision and statistical significance put those "anecdotic" records in second place. It is questionable how much they truly represent species features. Quantification is a central value in science, but sometimes ecologists forget to care about their little working units, when looking at general patterns. This is remarkable in species-rich taxa from less-known regions, such as ants in Neotropics. Much data is lost on morphospecies lists, thus one would find little information linked to actual species names. The aim of this work is to (1) contribute to the knowledge of natural history of ants and (2) compare quantitative data from fieldwork with observations found in scientific literature. I focused on two main axis of ecological niche, use of trophic resources and daily activity, using baits and pitfalls, in an area of Atlantic Rainforest in south Brazil. From 77 species found, 51 were identified, and 28 presented enough data for quantitative inferences. The natural history accounts were retrieved from original descriptions, taxonomic reviews and ecology studies. For many species, particularly from taxonomically difficult genera, there was only a short statement, or none at all, thus this is the first information about their biology. For species with information available, the match with field data was quite variable. Even for a few well-studied species, such as *Odontomachus chelifer*, *Pachycondyla striata* and *Wasmannia auropunctata*, the results were often discrepant. This analysis highlights (1) the need for a stronger taxonomic effort in modern ecology studies, (2) the context-dependence of the ecology of each species, and (3) the urge to value and include qualitative records in published studies. Only with many accounts from different observers it would be possible to tell what is a reliable historical record and what is just a big fish tale.

Session 29-O8 - Exocrine secretions: internalized medicine?

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Antimicrobial gland products secreted into the environment of an organism play a major role in mediating the outcome of several host-parasite interactions. These compounds improve an organism's survival and manipulate the microbial community surrounding it. Although external immune defence in the form of such secretions can be found in many different taxa, such as frogs, earwigs, beetles and

even humans, the extension of parasite defence to the environment is especially well documented for antimicrobials from exocrine glands in social insects. After observing a puzzlingly low pH in the crop of workers of the ant *Camponotus floridanus* (which ruined some experiments) we started to explore whether the ant also potentially ingests antimicrobials from exocrine glands and uses them as internalized medicine. In a series of experiments ranging from behavioural observations to experimental manipulation and microbiological tests, we evaluate benefits and costs of ingesting antimicrobial active compounds from exocrine glands. With this, our study complements the growing list of studies that have shown self-medication with environment derived compounds in several different, distantly-related, insect taxa and adds to our understanding of parasite defence and resistance in social insects.

Poster presentations

Session 29-P1 - Vertical stratification of interactions with diurnal and nocturnal Nectarivors and Frugivores in a Neotropical liana species

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Plant-animal interactions in tropical rainforests are crucial for pollen and seed dispersal, and thus, for gene flow within plant populations. In tropical rainforests vertebrates play a particular crucial role as pollinators and seed dispersers. Plants benefit from pollination by vertebrates in many ways as these are often more reliable visitors than insects and may carry larger pollen loads over larger distances. Additionally, birds and bats exceed insects in promoting outcrossing. Therefore, hummingbirds and phyllostomid bats are among the key pollinators in Neotropical forests. The Phyllostomidae also include numerous frugivorous species, which are - together with other vertebrates such as primates and birds – among the key seed dispersers in Neotropical forests. The Neotropical liana species *Marcgravia longifolia* is an ideal species to study vertical stratification of plant-animal interactions since it provides nectar and fruit resources from the forest floor to the canopy for a large number of diurnal and nocturnal nectarivorous and frugivorous vertebrate species. With *M. longifolia* as a model species we seek to study whether there is a vertical stratification in animal assemblages involved in pollination and seed dispersal as well as the impact of these interactions on pollination and seed dispersal, and thus, on gene flow. We conducted focal observation of nectarivores and frugivores that interact with *M. longifolia* to determine visitation rates and

species composition of diurnal frugivores and nectarivores. We complemented this with video camera observations to infer data on nectarivorous and frugivorous bats that visit the liana inflorescences and infructescences at night.

The results of these investigations suggest that many of the diurnal visitors of *M. longifolia* limit their activities to certain strata, and as a consequence that these plant-animal interactions are vertically stratified.

Session 29-P2 - The kleptoparasitic behaviour of Miltogramminae (Diptera: Sarcophagidae)

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The majority of Miltogramminae are known as kleptoparasites of the ground-nesting solitary bees and wasps utilizing the stored food that these hymenopterans provide for their own progeny and the fly larvae, being primarily kleptoparasites, devour the host larval food. They are often separated into two groups on the basis of kleptoparasitic larvipositing behaviour. The “satellite flies” pursue provisioning female wasps and larviposit on the prey while the host female is in flight, or as she is entering her nest. The females deposit their larvae or incubated eggs directly on the prey or they follow the host returning with its prey and glue some eggs on to body of the host. In this group compound eyes of females have conspicuously enlarged. Larviposition can take place directly on the prey before this is pulled into the burrow, the female fly may follow the provisioning wasp down the burrow, or she may wait until the wasp returns, where after she quickly slips into the nest. The second group consist of “hole searchers” seek out nests, enter them and deposit larvae, their ommatidia are not enlarged anteriorly. The female seeking out the host nest using visual cues during a characteristic searching flight. After finding the hole in the ground, the female checks it for presence of the wasp and stored prey using olfactory cues and the fly larviposits directly on host’s prey or in most cases the first instars actively seek out the food, but others may re-excavate closed entrances with their flattened fore tarsi. *Senotainia* spp. larvoposits on prey as the host wasp pauses at the nest entrance and they were recorded from the nests of Sphecidae and Apidae. *Metopia* spp. locates open nests and deposit larvae on prey in the nest chamber and *Phrosinella* spp. digs into closed nests to larvoposit on prey. All species of *Taxigramma* are known as kleptoparasites in the nests of sphecid, or rarely, pompilid wasps. The genus *Craticulina* was reported associated with *Bembix* wasps. *Metopia* are kleptoparasites of a wide range of solitary wasps and bees (Vespidae, Sphecidae, Pompilidae, Crabronidae, Halictidae, Apidae). The

females enter the host burrow for a short distance and there lay their larvae, which have to find their own way to the cells, sometimes several feet away.

Session 29-P3 - Inflexible versus flexible: Influence of temperature and photoperiod on pre- and post-eyespot development time in Libellulidae (Odonata)

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Temperature and photoperiod are important environmental parameters for organisms. This study tests the hypothesis that during embryogenesis, temperature and photoperiod influence pre-and post-eyespot development time in in dragonflies of the family Libellulidae differently. Eggs are used from eight species (five different genera, from Africa/ Europe, and lentic/ lotic habitat preferences). The eggs are reared under different constant or fluctuating temperature and light conditions. There are no general species-specific degree-days for the pre-or the post-eyespot development in these species. In all study species, the variance within and between the treatments of the duration in days and the degree-days of pre-eyespot development is lower than that of post-eyespot development. Pre-eyespot development appears to be less flexible in its reaction to environmental influences. By contrast, post-eyespot development seems to react more flexibly to environmental influences. All eight species show the same pattern. This indicates strongly that this flexibility is a general pattern in Libellulidae that might help the species within this family to cope successfully with variations in environmental conditions. Since eyespot development and katatrepsis occur close to each other, the above-described pattern might also appear in other odonates and in other insect groups that exhibit katatrepsis. For all of them, it is essential for survival to match the time of hatching with adequate external temperature and photoperiodic conditions.

END OF SESSION 29

Session 30 – Revitalizing the long tail of science - increasing data visibility, access and fitness for use

Short title: Data visibility, access and fitness for use

Chairs
Claas-Thido Pfaff
Dr. Marco Schmidt

Session 30-O1 - Edaphobase automated tools for analysis of ecological data: the ambivalence between data mining and data meaning

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In the big data age, databases become increasingly important in ecological research. Often these repositories hold mixed-origin data, promising an additional benefit for ecological analysis. Although this makes databases as information tools more powerful, it gets increasingly cumbersome to retrieve structured data, directly suitable for ecological assessment. Plausibility and quality of data retrieved from large databases are difficult to evaluate. Growing ecological databases require more effort to develop algorithms and tools working as an interface between complex database structures and ecologists aiming at the analysis of integrated data. Edaphobase is a non-commercial data warehouse combining information on quantities of soil organisms, geographical references, vegetation and environmental parameters. Data sources include museum collections, literature, unpublished results and field data from research institutions. To make this data usable for ecological interpretation, we developed an interface that performs several steps of data cleansing, data formatting and assessing the plausibility of the outcome. As a result, the data is re-structured to allow for user interaction (e.g. to select species and environmental parameters of interest) and automated analyses. This includes outline of species preferences for soil parameters (C/N, pH), species settlement in ecological niches as well as indicator species. Our tools address the needs of official institutions or contract researchers, who are interested in a regional monitoring of the actual biological soil status. Here, we provide instruments to assess soil biodiversity compared to reference states such as vulnerable biotopes for nature conservation purposes or agricultural soils for sustainability assessments.

Additionally, researchers that are interested in stress ecology (e.g. climate change) are offered tools for the analysis of shifts of ecological niches.

Session 30-O2 - The Global Naturalized Alien Flora (GloNAF), a new resource for understanding plant invasions worldwide

Holger Kreft[1], Wayne Dawson[2], Franz Essl[3], Petr Pyšek[4,5], Jan Pergl[5], Mark van Kleunen[6], Patrick Weigelt[1], Marten Winter[7], GloNAF Data Providers & Collaborators[1]

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Plant invasions are arguably one of the most prominent features of the Anthropocene and have far-reaching ecological and economic consequences. Despite intensive research on plant invasions, key global-scale patterns, drivers and processes have remained elusive. Here we introduce the Global Naturalized Alien Flora (GloNAF) database, an effort to mobilize alien plant information from regional floras and checklists. Currently, the GloNAF database summarizes information for over 840 terrestrial regions at >80% global coverage. This database allowed us to quantify, for the first time, the biogeographic, taxonomic and phylogenetic patterns of naturalized alien plants worldwide. We revealed that ~13,000 plant taxa, corresponding to ~4% of the extant vascular flora, have become naturalized somewhere on the globe. Furthermore, the exchange of species was investigated showing that Europe and North America have accumulated the largest numbers of naturalized species and that the Northern Hemisphere is also a major donor of naturalized plants to other parts of the world. The GloNAF database has served already as a unique data source for testing various aspects of invasion ecology. In this talk, we highlight the challenges related to the mobilization and integration of different data sources and outline how GloNAF can be a key tool to better understand human-mediated changes in plant diversity by integrating species distributions with phylogenetic and functional trait information.

van Kleunen M. et al. (2015): Global exchange and accumulation of non-native plants. Nature 525: 100–103

Session 30-O3 - Integrated management of biodiversity data in German Federation for Biological Data (GFBio)

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The German Federation for Biological Data (GFBio) aims to set up a sustainable, service oriented, national data infrastructure facilitating data sharing and stimulating data intensive science in the fields of biological and environmental research. GFBio follows a holistic approach including technical, organizational, cultural, and policy aspects. The development of the infrastructure is essentially based on the collective experience and expertise of leading researchers from multiple disciplines as well as on a network of complementary and professional data facilities in the biological and environmental sciences communities, including PANGAEA, major German natural history collection data repositories, and selected facilities from the molecular biology research community. GFBio is currently in its 2nd phase and we focus on bringing GFBio into its full-featured operational state. In the future this infrastructure will address data management requirements of a large range of stakeholders including individual scientists and larger research networks. GFBio will be capable to handle highly interdisciplinary heterogeneous data. Special consideration will be given to genome data, ecological and environmental data as well as museum collection related data. Services provided by the GFBio covers the full life cycle of research data from field or real time data acquisition to long term archiving and publication as well as analysis and re-use of these data. GFBio especially aims to encourage and support individual scientists to embed good data management practices in their daily scientific work to improve the availability and quality of long-tail of science data. Citable data and associated new scientific reward mechanisms will foster these efforts. As a consequence, the entire scientific community as well as the individual scientist will benefit by gaining additional credits and recognition for their work.

Session 30-O4 - VAT - A fast interactive biodiversity research environment for managing spatio-temporal data

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The increasing availability of spatio-temporal data enables biodiversity researchers to work more and more in a data-driven way. Therefore, scientists need a flexible and performant system for exploring and analyzing spatio-temporal data. We present the Visualization, Analysis & Transformation system (VAT), which features a web-based virtual research environment and a high performance processing backend. The VAT system provides multiple ways to access data sets: As an integral component of the GFBio portal (German Federation for Biological Data; http://www.gfbio.org/), users can directly access many established data sets from German data centers and research projects mobilized by GFBio. In addition, popular environmental data, like SRTM and GBIF occurrences are available in a local cache. Finally, users can also upload private data sets to create ad-hoc overlays and to conduct meaningful analytical tasks. Users can work with the VAT system in an exploratory, GIS-like way by adding data sets and applying operators on them. They can immediately review the results and continue by adding additional operators and data sets. The system keeps track of all processing steps in form of reusable and sharable workflows. These workflows also facilitate cooperation between users, e.g. within a project. Sharing a result requires only exchanging a link. The system also allows to call workflows from external programs written in R and other programming languages. A unique feature of the VAT system is the powerful support for time-series. A user can select a reference time, which determines the data the system uses for computations. Changing the reference time triggers a reprocessing of the workflows which are immediately visualized. It is also possible to execute workflows over an entire time period and deliver a time series as a result. For this we provide the required fast access to very large data sets, e.g. remote sensing data, and advanced processing algorithms that exploit the parallel capabilities of modern hardware.

Session 30-O5 - Comprehensive Annotation For Ecology (CAFE)

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Ecology has become a data intensive science that often relies on reusing existing data or research results. The reuse requires efficient data discovery mechanisms which work the best with good quality metadata. Faceted navigation is a popular way to search for data that is used in a wide range of applications today. We here introduce a vocabulary, that has been designed to be used for faceted data discovery in ecology, and an XML annotation schema based on the vocabulary. The schema complements existing and established metadata standards available in life sciences (Access to biological collection data, Ecological Metadata Language, Darwin Core). It has the potential to significantly improve the discovery of data in ecology finding data suitable to answer a specific research question more easily.

Session 30-O6 - How to improve data visibility, re-use and fitness for use - technical and non-technical approaches while developing a data management software

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In this presentation we will address the three main topics of the session from the perspective of a data infrastructure provider. Thus, the key question of the talk is: What technical solutions (i.e. tools, infrastructure) would improve data visibility, encourage re-use, and help to assess the fitness for use. However, many challenges in these areas are of non-technical nature and should be addressed as such. For example, if sharing and re-use of data is not common practice within a research community, it might be more effective to address these socio-cultural aspects first, before developing advanced tools. Since these two perspectives are interconnected, we will also discuss a number of non-technical issues in the presentation. The approaches and experiences we present in this talk result mainly from the development of the BEXIS 2 data management platform. BEXIS 2 has been designed to support large research consortia (e.g. DFG CRC's) during the active project phase on all aspects of data-life-cycle management. The software is being developed based on requirements from the biodiversity and ecology domain, but it is generic

enough to serve other domains using similar data types as well (heterogeneous, but mostly tabular data). BEXIS 2 is currently part of the data infrastructure of the iDiv Research Centre, the CRC AquaDiva, and will facilitate data publishing through GFBio. An earlier version of the software is used by the Biodiversity Exploratories, Jena Experiment, EFForTS, Kilimanjaro. BEXIS 2 is being developed as a community effort lead by the Friedrich-Schiller-University Jena and funded by the German Science Foundation through the BExIS++ project. BEXIS 2 is freely available under a LGPL Licence (http://bexis2.uni-jena.de/).

Session 30-O7 - Few data, many predictors - comparing model selection, averaging and regularization in underpowered regression studies

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Ecologists are often faced with sample sizes that are small compared to the number of potential explanatory variables. Using all these variables in a regression model leads to unfavorable consequences, such as large variance, uncertainty and Type II error for regression coefficients and predictions. Standard remedies are model selection (usually via AIC), model averaging, and regularization with shrinkage estimators, such as the lasso and ridge regression, but analysts are often uncertainty which of these methods is preferable. Here, we use theoretical arguments and extensive simulations with linear, Poisson and logistic regression models to show that 1) all three methods (selection, averaging, regularization) are capable of reducing predictive error, with model averaging and Lasso being typically superior to model selection. 2) All three methods lead to biased parameter estimates. The strength and direction of the bias, however, is most favorable and predictable for shrinkage estimators. 3) For parameter averaging, several non-identical methods (conditional and unconditional average) are in use. We show that unconditional averaging leads to shrinkage towards zero, similar to a lasso regression, which is preferable in typical ecological situations. 4) Standard p-values and confidence intervals after model selection and averaging are not reliable. In particular model selection tends to inflate Type I error, which is concerning given its popularity in ecological studies. We conclude that there is little reason to prefer model averaging or model selection over shrinkage estimators. Predictive performance of shrinkage estimators is comparable to model averaging and better than model selection, and they clearly outperform averaging and selection regarding the reliability of parameter estimates. We

therefore strongly advocate a wider use of shrinkage estimators, in particular if ecological interpretation of the estimated effect sizes is the goal.

Session 30-O8 - Plant photographs as a source of trait data - automated trait recognition from ‚African Plants - a photo guide‘

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The botanical online resource 'African Plants - a photo guide' is a photo repository and identification tool for African plants, documenting c. 5000 species of vascular plants with c. 40 000 photos and a set of 18 morphological traits (c. 90 000 trait encodings) used for identification purposes via a multientry key. Our study is using this combination of photos and traits in a deep learning approach for automated recognition of traits from photos. In a first step, the photos are assigned to different types of 'views', like a flower closeup, whole plant photo etc. Depending on the view, the photos are then used for the recognition of those traits that are likely to be well documented by the view, e.g. flower symmetry in 'flower closeup' photos. Part of the photos are used for training the algorithm, another part for testing purposes. At present, trait recognition works with accuracies of 70%-80% for most traits and is still subject for improvement. We see huge potential in our approach for plant identification purposes as well as for the generation of trait data for ecological studies, especially given the popular use of digital photography in citizen science communities.

Session 30-O9 - Talking about data: the Helmholtz Open Science Webinars on research data

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An internal workshop of the Helmholtz Association on research data management and information infrastructures in 2012 provided a starting point for a series of web seminars on research data projects, research data management, and access to research data. The Helmholtz Open Science

Webinars on Research Data **(**http://oa.helmholtz.de/bewusstsein-schaerfen/workshops/webinare-zu-forschungsdaten.html**)** are directed at scientists and data practitioners who use the webinars to participate in expert talks via the internet and discuss questions in a live chat. Technically, the webinars are realised with a server-based video conferencing software service offered by the German National Research and Education Network (DFN). The webinars proved a valuable tool for sharing best practices when working with research data and for networking between scientists and staff from 18 Helmholtz Centres and external institutions. To date, more than 35 Helmholtz Open Science Webinars on Research Data have been organised by the Helmholtz Open Science Coordination Office on topics like, for instance, access to research data in environmental research, data management tools, citizen science, and data mining. The webinar series will be continued. The Helmholtz Association is Germany's largest scientific research organisation. More than 38,000 staff work in its 18 scientific-technical and biological-medical research centres. The Helmholtz Open Science Coordination Office is offering support and advice to Helmholtz scientists and staff on the implementation of open science.

Poster presentations

Session 30-P1 - How to make data from biodiversity experiments publicly available? - A case study from the Jena Experiment

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Biodiversity experiments, where biodiversity is manipulated experimentally to test its effects on ecosystem processes such as element cycling or species interactions, are a main tool in investigating the importance of biodiversity for ecosystem functioning. In these experiments, researchers of many disciplines measure variables on the same plots allowing linking data of many processes and many taxa to plant diversity and to each other. Most biodiversity projects have project-specific databases that facilitate data search and the combination of particular datasets for multi-variable analyses. These databases are not just tools to store data, but they also provide functionalities for data analysis and synthesis. On the other hand, these databases have

drawbacks, e.g. they cannot provide long-term archiving of data and are, therefore, not recognized by scientific journals as an official data repository. Yet, upon publication, researchers are obliged by most scientific journal to deposit their data in a recognized data depository. While these depositories ensure long-term availability of the data they often provide little functionality for data search or amalgamation of different datasets. We detail how the Jena Experiment consortium has solved the problem of making data publicly available while maintaining the functionality of data search and data amalgamation by cooperating with PANGAEA, a data publisher and member of the GFBio consortium. We show how the metadata structure of the Jena Experiment database has been converted to a format suitable for integration into the relational databases of PANGAEA. Currently, more than 5037 datasets have been made publically available this way, with citable DOI and maintaining the search capabilities of the Jena Experiment database. Through publishing data papers in Pangaea and additional data descriptors in specialized data journals, a full description of the data is available independent of the Jena Experiment database. This workflow ensures data availability for synthesis work both now and in the longer-term future when individual project-specific database will cease to exist.

Session 30-P2 - An online database of chromosome numbers of the flora of Germany

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We present a new online database on chromosome counts and flow cytometric ploidy estimations of the flora of Germany with a detailed documentation of the material examined and its sampling location. Our chromosome database builds upon a relational database and includes taxon identification, date, location and collection material as well as published literature on the chromosome count. In order to reach best compatibility with other botanical products of the study region, concepts of species and higher taxa follow the 'Rothmaler', a widely accepted field flora and standard list of plants in Germany. Our online data portal is available at http://chromosomes.senckenberg.de/ and consists of the main page with project information, a semantic search tool, an interactive map display, a contact and a data submission form. The zoomable map display shows the

data locations of the search result and allows to refine the geographic search and to select individual data points. Data sets and search results can be exported in CSV format.

Session 30-P3 - An easy and widely-applicable method for residual diagnostics of generalized linear mixed models

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I present an R package that uses a simulation-based approach to create easily interpretable scaled residual for a wide array of generalized linear and generalized linear mixed models, including mixed Poisson and logistic models. The resulting residuals allow a straightforward diagnosis of potential regression problems, such as over- and underdispersion, heteroscedasticity, spatial and temporal autocorrelation or structural model errors, and can be interpreted as intuitive as standard residual diagnostics for the linear regression.

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