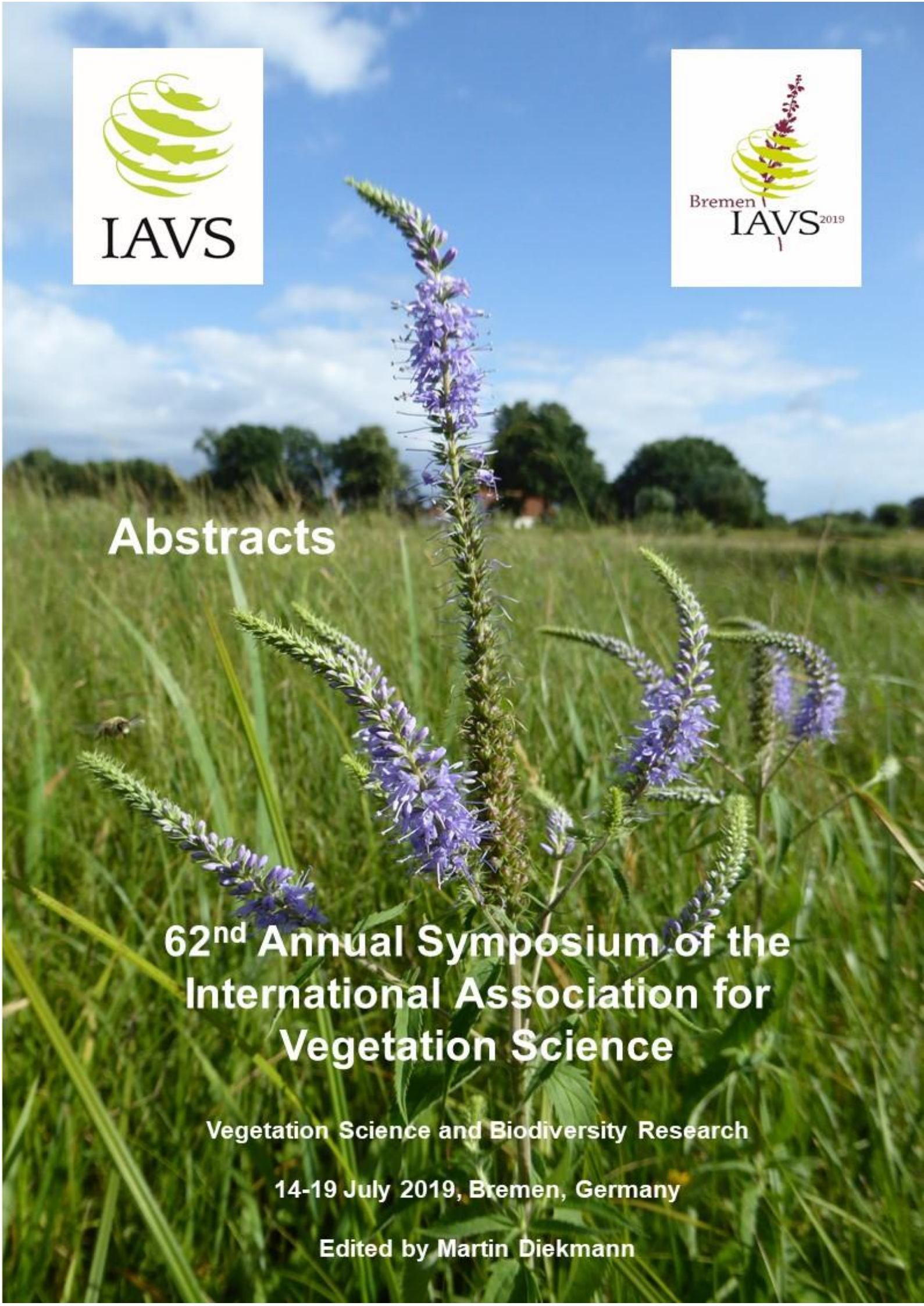

Abstracts

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Keynote talks and Award lectures

Pierre Legendre

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Temporal beta diversity: identify sites where species communities have changed in exceptional ways

Aim This paper presents the statistical bases for temporal beta diversity analysis, a method to study the changes in community composition through time from repeated surveys at several sites. Surveys of that type are presently done by ecologists around the world. A Temporal Beta-diversity Index (TBI) is computed for each site, measuring the change in species composition between the first (T1) and second surveys (T2). TBI indices can be decomposed into losses and gains; they can also be tested for significance, allowing one to identify the sites that have changed in composition in exceptional ways. This method will be of value to identify exceptional sites in space-time surveys carried out to study anthropogenic impacts, including climate change.

Innovation The null hypothesis of the TBI test is that a species assemblage is not exceptionally different between T1 and T2, compared to assemblages that could have been observed at this site at T1 and T2 under H_0. Tests of significance of coefficients in a dissimilarity matrix are usually not possible because the values in the matrix are interrelated. Here, however, the dissimilarity between T1 and T2 for a site is computed with different data from the dissimilarities used for the T1–T2 comparison at other sites. It is thus possible to compute a valid test of significance in that case. In addition, the paper shows how TBI dissimilarities can be decomposed into loss and gain components (of species, or abundances-per-species) and how a B-C plot can be produced from these components, which informs users about the processes of biodiversity losses and gains through time found in space-time survey data.

Applications An application of the method to the Barro Colorado Forest Dynamics plot (BCI, Panama) will be presented in detail, comparing the 1985 and 2015 surveys. Applications of the method to other ecological communities will be mentioned, including a study of paleo-ecological data. This method is applicable worldwide to all types of communities, marine and terrestrial. R software is available implementing the method.

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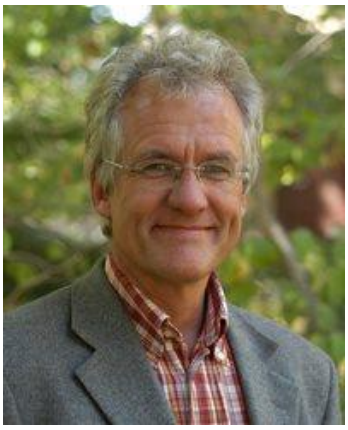
A burning issue: Understanding the imprints of humans on the ecology and biodiversity of coastal heathlands

As both the magnitude and the drivers of the climate crisis and the biodiversity crisis are becoming increasingly well documented, it is uncontroversial that human activities pose an urgent threat to biodiversity and ecosystem functioning across the globe. However, both the public and scientific debates are often polarized into a 'people *vs* nature' dichotomy, and in doing so, we fail to acknowledge that significant components of the biodiversity and ecosystems that we value, depend on, and struggle to conserve and restore are also partly shaped by human imprints. One reason for our lack of recognition of human's role in shaping what we perceive as natural biodiversity is the long time-scales involved; these human legacies operate on time-scales we cannot directly observe, from decennia to millennia. The consequences of this lack of recognition of human imprints on our natural ecosystems are a suite of missed opportunities; we limit our understanding of the evolutionary and ecological dynamics and functioning of these systems, we lose important sources of knowledge for nature management and restoration, and we deprive people of opportunities to connect with and feel related to nature.

The coastal heathlands of North-West Europe are one iconic example of a landscape that has emerged under, and is shaped by, millennia of anthropogenic forcings. These heathlands have been continuously managed by traditional low-intensity burning and grazing regimes for up to 6,000 years, and as a result support characteristic ecosystems and biodiversity. Understanding the ecology and evolutionary biology of the heathlands requires understanding of how the interplay between natural and anthropogenic forcing has shaped heathland ecosystems and their flora and fauna through ecological and evolutionary history. We combine different scientific approaches, including palaeoecological reconstructions, macroecology, community ecology, field experiments, ecosystems ecology, functional ecology, ecosphysiology, and fire science to explore the roles of climate and human land-use in shaping heathland biodiversity, ecology and ecosystem functioning. In contrast to the often stated 'biotic homogenization' paradigm, we find that the species favored by burning heathlands are not widespread generalists, but a characteristic set of relatively narrow-range species representing a characteristic subset of the local and regional flora. The traditional heathland management, such as grazing and management burning, thus contributes significantly to the biodiversity of the heathland landscape across a range of spatial and temporal scales. We also demonstrate that past human manipulation of coastal heathland fire-regimes have triggered evolution of smoke-responsive seed germination in the keystone species *Calluna vulgaris*. Such evolutionary imprints of (pre)historic anthropogenic impacts are severely under-studied, and research is urgently needed to inform decision-making in conservation science and ecosystem management. Finally, we explore how ecosystem knowledge harnessed from a combination of these scientific approaches and

traditional management practices can be used to facilitate ecosystem resilience and landscape ecosystem service delivery in face of climate change. Coastal heathlands thus illustrate how explicitly acknowledging and taking into account the longer-term human imprints on what we now perceive as natural ecosystems can facilitate ecological and evolutionary understanding of these systems, inform management and restoration, and afford people a broader range of ways in which to connect with and feel related to and dependent on nature. This broad knowledge base is urgently needed to inform decision-making as heathlands are facing increasing pressures and heated discussion over trade-offs between different land-use and management options to meet the climate and biodiversity crisis.



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Biodiversity mechanisms drive inter-trophic relationships in subtropical forests

Effects of biodiversity on ecosystem functioning (BEF) have been found for numerous ecosystems and most BEF experiments have demonstrated that BEF effects are positive. More recently, such effects have also been shown for forest ecosystems. One example is the BEF-China experiment, which was established in 2008 in subtropical China (Xingangshan, Jiangxi Province) by planting 40 broad-leaved tree species in 566 plots varying in tree species richness from 1 to 24 species. So far, research in BEF-China has focussed on the underlying mechanisms of positive BEF relationships that take place at the trophic level of the producers. However, in BEF-China the whole ecosystem has been studied, also including soil microbes, herbivores, predators, pathogens and parasitoids. I here ask how these different levels are linked to each other and whether these links contribute to ecosystem functioning.

Since Whittaker, a common assumption is that biodiversity begets biodiversity. Most findings from BEF experiments support this statement, as they generally report positive relationships of species richness of higher trophic levels, such as herbivores, predators and parasitoids, with producer richness. However, when comparing relationships between different trophic levels, species richness is often only a poor predictor as compared to species composition. The findings from subtropical forests revealed a much closer match in species composition between different trophic levels than in species richness, pointing to numerous links between different species at different trophic levels. In BEF-China, the number of these links increase with tree species richness, resulting in more links between levels with increasing producer richness. As a consequence, the trophic networks become more general, and thus, more stable.

While this pattern seems to be universal, it is much less clear to which degree the trophic networks are involved in positive BEF relationships. For example, do herbivores, by controlling their hosts, exert a top-down control on the producers? Or more general: how does species diversity at higher trophic levels contribute to ecosystem functioning? So far, the findings from BEF-China are equivocal, pointing to contrasting effects of herbivores and pathogens on the producer level, with pathogens decreasing and herbivory increasing tree growth. However, herbivores and pathogens were found to be strongly dependent on each other, and their effects on tree growth also depended on tree richness, leaf traits and the climatic niche characteristics of the tree species. Overall, these interactions between trophic levels seem to be more complex that previously assumed.

In conclusion, there is no doubt that higher trophic levels affect ecosystem functioning at the producer level. However, the net effects on ecosystem functioning are not simply additive effects of different trophic levels. It will be necessary to understand these complex trophic links to achieve a deeper mechanistic understanding of positive BEF relationships in general.

Oral and Poster presentations

Source area(s) of pollen - synthesis of four pollen-vegetation studies in the Czech Republic

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Importance of pollen analysis among (palaeo-)ecological methods is increasing thanks to the decadal to millennial perspective on the changes of plant diversity, vegetation cover and ecological interactions. Recent quantitative approaches started to enrich the traditional diachronous viewpoint by spatial reference. Our aim is to compare source areas of pollen calculated in 4 datasets on pollen-vegetation relationship (Krivoklát, Kosatky, Bohemian-Moravian Highland and White Carpathians) by 5 different methods and discuss implications for the interpretation of pollen analysis.

Methods: Relevant Source Area of Pollen (RSAP sensu Sugita 1994) for several taxa in a dataset is a best-fit-radius between pollen and plant abundances considering the fundamental parameters of pollen-vegetation relationship. Distance of Necessary Pollen Transport (DNPT) for each taxon in a dataset is a radius between the nearest source plant and the site where the corresponding pollen type is present. Distance Beyond Pollen Transport (DBPT) for each taxon in a dataset is a radius between the nearest source plant and the site where the corresponding pollen type is absent. Source Area of Pollen Pattern (SAPP) for each taxon in a dataset is a best-fit-radius between ordered pollen abundance and ordered plant abundance. Source Area of Pollen Diversity (SAPD) for a dataset is a best-fit-radius between the number of all pollen taxa and all plant species around sites.

Due to the feasibility of the fieldwork we collected the data in two ways. We always started at the site of pollen sampling and mapped vegetation in two transects of 1 km. Firstly, we recorded in a polygon the presence of newly appearing species. Secondly, we recorded abundance of selected taxa in all polygons of both transects.

RSAP accordingly with other studies seems to be controlled by patterns of vegetation patches. RSAP in forested areas is smaller (<10 m) than RSAP in open and semi-open areas (hundreds of meters). SAPP describes distance at which pattern in pollen percentages corresponds to the vegetation pattern and lies between DNPT and DBPT. Considering the most abundant taxa in each dataset, SAPP tend to be low by herbs (<20 m) and high by trees (multiples of 10 to hundreds of meters). SAPD show in all datasets two distances, first within 20 meters and second within hundreds of meters. Connection of the pollen grains with the source plants at each site showed that the first SAPD distance is controlled by alpha diversity of the sites (herbs), but the second SAPD distance is connected by vegetation pattering in each area.

Our analysis showed that multiple pollen sites can capture vegetation diversity and patterns. Widely used concept of the RSAP is a useful tool, but only for analysis of vegetation consisting of species with similar pollen transport (trees in forests or herbs on the meadow).

This project was supported by Czech Science Foundation (project no. 17-07851S).

Talk Vegetation patterns and processes

Burning again? A never-ending story of dark days, landscape regeneration and novel environments in Portugal

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October 15th, 2017 placed Portugal in the top of number and area of wildfires in Europe, owing 60% of the total EU burnt area and surpassing the already dramatic record of 471,750 ha burnt area on the 2003 wildfires. Fire-prone climate, heat waves, land-use and societal changes along with deficient forest management were regarded as main drivers. Nine thousand and four hundred hectares, 86% of total area, of the "King's Pine Forest" (KF), the largest Portuguese public forest, were consumed in six hours on that date, including 85% of the maritime pine stands, emblematic ancient pines in coastal areas and riparian forests. This work represents a first attempt to characterise the post-fire KF communities of pine stands and fluvial corridors aiming to evaluate the natural regrowth and assess potential hot-spots of plant invasions.

Sampling was carried out 6 months after the fire in spring-summer of 2018 and it is planned to be repeated 18 months after (April-May 2019) in 28 plots distributed in transects at pine stands (3.5 x 3.5 m^2) and 24 plots (5 x 20 m^2) in fluvial corridors (channel and riverbanks). It includes the exhaustive inventory of the flora and the count of alive maritime pine seedlings. Pre-fire surveys and non-burnt areas, both in the river that crosses the KF pine stands and inside the pine stands, were used as referential for interpreting plant regeneration. Fire severity (three classes), the age of pine stands and the position of the plot on the river network were some of the considered independent variables. Six months after the fire, 60% of the recorded species pre-fire at fluvial corridors (macrophytes and riparian woody species) were observed, and 93% of the species at pine stands. Fire severity variation in plots could not be related to differences in flora composition, nor with species richness. Control sites had a lower floristic richness and were significantly different from the burnt sites, where plants with diverse regeneration strategies were observed, from resprouters to obligate seeders. However, the hierarchical classification and the analysis of similarities revealed the effect of the longitudinal gradient of the river. Regeneration of maritime pine stands older than 65 years was significantly more abundant than younger stands, but no differences were observed in the regeneration of understory vegetation. There is a risk of the emergence of novel riparian landscapes, homogenised by the invasive exotic species *Acacia melanoxylon*, which resprouts from surviving stumps and by post-fire seeding. The present work represents a seminal study to integrate pine forest management and conservation actions in freshwater environments.

What drives biomass in dry rangelands? The role of climate, grazing and biodiversity for biomass production in Mongolian grasslands

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The provisioning of biomass for forage production is a key service for livestock managers in rangeland ecosystems, which are the main form of land-use in drylands. Recent models of future climate predict an increase in dryland area of up to 7% by 2100, with 10% of global surface becoming drier and 4% becoming wetter. This will affect biomass production in time and space and increase the uncertainty about the capacity of grasslands to sustain a specific amount of livestock. Understanding patterns of plant biomass production in rangelands along climate gradients is therefore crucial for the conservation of dry rangelands.

It is well studied that plant biomass availability in rangelands is mainly determined by the amount of precipitation, the intensity of grazing and biodiversity. However, it remains largely unclear how grazing effects interact with inter- and intraannual climate variability, and which facets of biodiversity influence plant biomass under which conditions. We designed a multi-site study in Mongolian rangelands with the aim to get a better understanding of possible interaction effects between climate and grazing on dry grassland vegetation. We sampled vegetation on 15 grazing transects along a 600 km climate gradient with mean annual rainfall between 100 and 250 mm in two consecutive years, collected biomass, soil parameters and measured several plant functional traits. A first study suggested that grazing caused stronger effects on biomass under moister conditions than under dry and variable climate conditions. In a second study, we could show that differences in functional diversity and differing community assembly processes caused these results. First results of a third study showed that a delayed start of the vegetation period in the second year caused a sampling bias in our data. We were able to correct this bias by using NDVI data and construct a model which proves the magnifying effect of climate on grazing effects. In this talk, we will present our findings from the analysis of the distribution of plant biomass in time (within and between two years) and space (along climate and grazing transects) and discuss the role of species and functional diversity for observed patterns.

Poster Vegetation patterns and processes

Diversity and structure of a mature riparian forest in the warm-temperate region in Shikoku, southern Japan

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Riparian forests in mountain valleys have higher species diversity than surrounding forests on mountain ridges and slopes in cool-temperate broadleaf deciduous forest zones. This is because riparian areas are often disturbed by sedimentation and erosion caused by running water due to heavy precipitation that shape the unique forest structure and species composition. The restoration and rehabilitation of riparian forests are believed to aid biodiversity conservation; however, little is known about whether the species diversity of riparian forests is higher than in the surrounding forests in warm-temperate broadleaf evergreen forest zones. To reveal the tree species diversity and structure of riparian forests, this study assessed tree species composition and distribution along mountain topography, including ridges, slopes, and valley bottoms, in a mature warm-temperate evergreen broad-leaved forest in Ichinomata, Shimanto-cho, Kochi, Japan. A 0.47-ha survey plot was established on a valley bottom in the study site, and all living trees with a diameter at breast height (DBH) exceeding 5 cm were identified and their positions were surveyed. Tree census data for mountain ridges and slopes at the study site were obtained from a long-term forest monitoring project of the Ministry of the Environment (Monitoring sites 1000). The analysis of tree species-site preference based on the Monte Carlo method revealed that most tree species grew on all topographical units (i.e., ridges, slopes, and valley bottoms); however, there were obvious differences in the numbers of living trees among the species. The species preferring mountain ridges were *Pieris japonica*, *Chamaecyparis obtusa*, *Tsuga sieboldii*, *Symplocos myrtaceae*, and *Rhododendron weyrichii*, while *Symplocos prunifolia*, *Castanopsis* spp., *Illicium anisatum*, and *Quercus sessilifolia* preferred mountain slopes. Common trees in the riparian forest on the valley bottom were *Machilus japonica*, *Distylium racemosum*, and *Litsea coreana*. Tree density was lowest in the valley bottom. Among the micro-topography units within the valley bottom, the tree density was highest on the debris flow terraces, following by the foot slope/talus, landslide scars, lower valley slope, and active channel. The number of broadleaf deciduous trees was highest on the debris flow terraces. These results suggest that debris flow terraces serve as a habitat for broadleaf deciduous trees, even in warm-temperate riparian forests. In the species-area curve, the tree species diversity was lowest on the valley bottom; however, the rarefaction curves for the three topographical units showed almost equal diversity. These results suggest that the riparian forests in warm-temperate broadleaf evergreen forest zones may not necessarily have higher species diversity, unlike those in the cool-temperate broadleaf deciduous forest zones.

Poster Vegetation patterns and processes

Occurrence of North-American Green Ash (*Fraxinus pennsylvanica* MARSH.) in natural, temporarily flooded creeks of a Central German riparian forest

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The UNESCO Biosphere Reserve "Mittelelbe" extends along the river Elbe and harbors one of Europe's largest continuous riparian forest complexes. These forests are of high value for nature conservation due to the great diversity in habitats and species. A special habitat associated with the riparian forests is formed by temporarily flooded creeks. Under natural conditions these habitats are unforested, i. e., woody species are not able to establish permanently. However, the non-native tree species *Fraxinus pennsylvanica* regenerates and establishes in these low-lying areas of the floodplain. In Germany as well as in other European countries, this neophyte is excluded from forestry and listed as an invasive alien tree species, because of its high reproductive potential and active spread in alluvial habitats. Up to now, however, there are no studies on the vegetation and structural changes associated with the establishment of *F. pennsylvanica* in the temporarily flooded creeks.

We conducted a study in five temporarily flooded creeks in two sub-regions of the biosphere reserve to investigate the vegetation structure and plant species composition of the creeks. In 75 plots (15 per creek), we sampled data on the hydrological regime, plant species abundance and cover, and counted the saplings of woody plants. This way, we aimed on the characterization of the creeks, where *F. pennsylvanica* occurs. Furthermore, we wanted to determine ecological preferences of this neophyte more precisely.

There is some zoning of the herbaceous layer, indicated by preferences of several species to the deepest-lying middle or to the higher embankments of the creeks. On the latter, isolated shrubs and larger nests form the shrub layer, while a tree layer has not yet evolved. Twelve woody species were found in the creeks, most of them grow on the upper areas and remain in the herb layer.
F. pennsylvanica is the most frequent woody species. It dominates the shrub layer and shows a clear preference to the lower zones of the creeks.

With the successful establishment of *F. pennsylvanica*, we can substantiate a tendency of this species to become dominant in temporarily flooded creeks. Thus, a forest succession and an associated accelerated silt-up of these creeks could be the consequence. Further, prospective, studies should focus on the long term effects of *F. pennsylvanica* colonization on the structural and species diversity of the creeks and the adjacent riparian forests.

Poster Long-term studies in vegetation science

Long-term vegetation composition and diversity trends in reclaimed open-cast coal mine in Spain

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Despite advances in the revegetation methods of anthropogenic disturbed ecosystems in recent years, treatments are not always successful in producing stable plant communities with some resemblance to those of the surrounding areas at long-term. In this context, the revegetation treatment successes and effectiveness have been always evaluated at short term, with a lack of knowledge of long-term patterns of these newly created communities. Here, we used extensive long-term research monitoring at a reclaimed mine in northern Spain (2004-2018, 15 years) to describe the vegetation composition and diversity patterns. The monitoring was carried out in 9 permanent plots (20 m^2 each) monitoring annually for each plot the vascular plant species cover. Simultaneously, these plots were structured to account for mine site aspect (north, south and flat), also three identical permanent plots were established in the surrounding reference community and monitored in 2004 and 2009. Our results showed that all permanent plots showed a successional trend towards the reference community through time, although speed of convergence differed, being faster for taxonomic diversity than for beta diversity (species-based dissimilarities). However, the restored sites' composition had diverged significantly from each other, and this compositional divergence was greater than the dissimilarity reduction with respect to the reference community. It seems that vegetation diversity rapidly converged towards the reference community, whereas compositional parameters needed a much longer time frame. In this regard, the independent correlations for each site dissimilarities based on beta-diversity and abiotic variables, together with compositional differences between sites suggest environmental filtering as main driver of colonization. Here, we also discuss the effectiveness of long-term monitoring programs for designing plant restoration approaches.

Poster Vegetation patterns and processes

Species competition or environmental filtering: Which is more important in determining rare species distribution in Mediterranean ecosystems?

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Rare species are characterized by a small ecological niche and a low abundance, however, they play important roles in ecosystem diversity, function and services. Therefore, it would be of interest to determine which factors are the most important limiting them; i.e. whether environmental and spatial factors or species competition shape species presence. In this work we hypothesized that, in Mediterranean ecosystems, the presence of rare species would be higher in communities experiencing some niche limitation, either by environmental or species competition. This can be of special relevance within the framework of the ongoing climate change, which can lead to local extinctions. Here, we study the community structure of Mediterranean Basin woody species in each 10x10 UTM coordinates of Valencia Region by using the data collected by the "Banc de Dades de la Biodiversitat" created by the regional government of Valencia. We observed that the spatial and environmental processes were the most influential factors over rare species. At the same time, phylogenetic clustering dominates in more arid areas, since coexisting species are closely related and share a trait which confers them some advantage. In contrast, wetter areas showed phylogenetic overdispersion, that is produced when species are not closely related, and community assembly is driven by competitive interactions trying to avoid niche overlap. Our results showed that rare species were more abundant on clustered communities, suggesting that among the analyzed factors environmental and spatial processes have an important role shaping rare species presence in Mediterranean communities.

Talk Vegetation patterns and processes

Plant-soil feedback contributes to predicting plant invasiveness of 68 alien plant species differing in invasive status

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Understanding what species characteristics allow some alien plants to become invasive while others fail to is critical to our understanding of community assembly processes. While many characteristics have been shown to predict plant invasiveness, the importance of plant-soil feedbacks (PSFs) in invasions has been difficult to assess since individual studies include only a few species and use disparate methodology.

We studied PSFs of 68 invasive and non-invasive alien species in a single two-phase garden experiment and compared the relative importance of PSF, residence time, phylogenetic novelty and plant traits for plant invasiveness. Additionally, we tested for relationships between PSF, residence time and phylogenetic novelty.

PSF for seedling establishment belonged to the five best predictors of plant invasiveness, along with specific leaf area, height, seedling growth rate, and residence time. Invasive species had more positive PSF for seedling establishment, but not for biomass, than non-invasive species. Phylogenetically novel species experienced less negative PSF than species with native congeners, suggesting they benefit more from enemy release. PSF of non-invasive species, contrary to that of invasive species, was becoming more negative with increasing residence time.

We demonstrated that PSF plays a role in predicting invasiveness that is comparable with other species characteristics that are more commonly studied. PSF should thus receive more attention in studies predicting community structure and in programs assessing the likely invasions of aliens.

Drivers of multi-scale plant community structure in agricultural field margins in South Korea

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In agricultural landscapes field margins are important for the conservation of biodiversity and resulting ecosystem functions and services. Management decisions across scales may affect plant diversity both in local field margins (alpha-diversity) and at the landscape scale (gamma-diversity). Both scales need to be considered jointly if we are to estimate threats to plant diversity: constant local diversity under decreased landscape scale diversity warns against homogenization and decreased local diversity under constant landscape-scale diversity warns against an extinction risk due to amplified demographic stochasticity.

Here we use a multi-scale approach to study effects of land management on plant diversity in field margins in the Haean-myun catchment in South Korea. We quantified the effects of local-scale management (recently managed vs unmanaged field margins) and landscape-scale land-use (percentage of non-farmed habitats) on plant community structure at the community level (alpha-diversity), the meta-community level (beta and gamma-diversities), and the species level (species rarity, growth form and dispersal). We collected data on species richness, species cover and species abundance in 300 sub-plots located in 100 different field margins.

We found that recent local-scale management of field margins resulted in lower alpha-diversity but contributed to increased beta and gamma-diversity of plant communities, indicating that different plant species were affected in different field margins. Trait analyses showed that negative effects of local-scale management specifically impaired the rarer perennial and/or abiotically dispersed species. At the landscape scale, higher percentages of surrounding non-farmed habitats increased alpha-diversity of managed field margins and thus buffered negative local-scale management effects. However, this positive effect was highest for the more abundant annual species, independent of their dispersal mode, and thus did not benefit the more threatened perennial species.

Our study demonstrates the strong effect of both local and landscape scale land management on plant community structure in agricultural landscapes. Even so the negative effects of local management on local diversity can be partly counteracted by landscape-scale land abandonment, species from some functional groups (perennials) won't be able to benefit from this and will still suffer from increased extinction risks. Results highlight, that only a multi-scale approach supported a full and coherent portrayal of biodiversity responses to land management in our study system.

11.500 years of *Nothofagus obliqua*-type history and vegetation changes near Lake Lácar basin: a pollen record from Laguna Vizcacha (40°12'S; 71°30'W)

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Nothofagus alpina and *Nothofagus obliqua* have been largely investigated in genetic studies while palaeoecological studies have hitherto not addressed their history along the eastern distribution limits, especially at 40°S, where both species (same pollen type) have their largest abundance. We present a pollen record for the last 11.500 years from a small lake located within the main population of both species: the Lake Lácar basin in the Lanín National Park, Argentina. Our results indicate that the *Nothofagus obliqua*-type was present around the site since the beginning of the Holocene at low abundances and increased gradually in abundance towards the present. This gradual expansion may be due to changes in precipitation seasonality, as it is suggested for other taxa in the region. The pollen diagram was subdivided into four zones using a depth-constrained cluster analysis, and these zones were used to group the samples in a PCA. A visible separation between groups suggest a transition from (1) a dry stage, characterized by the dominance of steppe taxa (*Chenopodiaceae*, *Asteraceae* subfam. *Asteroideae*, and *Poaceae*); (2) a wet and warm phase characterized by the presence of the *Nothofagus dombeyi*-type and *Austrocedrus chilensis*; 3) a cold and rainy phase characterized by cold-resistant taxa such as *Podocarpus nubigenus* and *Saxegothaea conspicua* and 4) a warm stage characterized by the *Nothofagus obliqua*-type and the appearance of the human indicator taxa *Rumex acetosella* and *Plantago lanceolata*. Our research provides the first account of the Holocene history of *Nothofagus obliqua/alpina*, suggesting that one or both species were already present close to our site since 10,000 years ago. In addition, *Austrocedrus chilensis*, representing just 0.6% in modern samples, exhibit short-term percentage fluctuation along the Holocene with a maximum of 16% 8,000 years ago. Microcharcoal particles show their maximum during the first zone, which coincides with the dry period suggested by the vegetation composition. Despite the evident fire activity, and the frequent deposition of volcanic ash the vegetation composition remained stable with only gradual compositional changes during the Holocene.

Distribution pattern of the epiphytic orchids in urban area of Yogyakarta, Indonesia

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Indonesia has among the highest orchid biodiversity in the World. These orchids can be found both in the natural habitat and urban areas under altered environments that affect its distribution pattern. Yogyakarta city is one of the most touristic cities in Indonesia and has a large number of domestic immigrants by university students that may improve human disturbance in the city. Despite of high human activities, Yogyakarta is being home for some natural orchids spread across the city. Therefore, in this study, we explored the distribution pattern of epiphytic orchids in urban areas of Yogyakarta, Indonesia.

We established a 1 km grid net across the city and recorded any epiphytic orchid growing naturally on each point. On each discovered orchid, we measured bark water-holding capacity, bark pH, and bark roughness of its host trees. Among 36 points in total, epiphytic orhids are spotted in 15 points, mostly within settlement area. Natural orchid species found within the city are *Aerides odorata* Lour., *Dendrobium aphyllum* (Roxb.) C.E.C. Fisch., *Dendrobium crumenatum* Sw., and *Eria retusa* (Blume) Rchb.f. *A. odorata* is the most widely distributed orchid (2,077 individuals in 10 locations), while *E. retusa* is the most abundant (2,677 ind) despite of being found only in one site. The most common host-tree is *Manilkara zapota* which has a rough stem, neutral pH (6,6-6,7) and water holding capacity around 53% - 82%. All species are not host-specific species. To sum up, remaining host trees need to be protected because losing one tree can mean losing hundreds of orchid individuals. Planting of host-trees is also suggested to provide habitat and to improve the distribution of orchids in the urban area.

Talk Long-term studies in vegetation science

Interaction of stochastic and deterministic factors driving diversity of semiarid grasslands - insight from a long-term study

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Plant community assembly is controlled by biotic and environmental filters and influenced also by stochastic processes. Extreme climatic events (e.g. droughts) are specific stochastic perturbations that potentially alter community processes.

Long-term observations are important to detect the resulting community trajectories and legacy effects. We analyzed data from a long-term study established in 1995 in the Kiskunság, Hungary. Diversity and community organization were monitored in natural, unmanaged open perennial sand grasslands with high spatial resolution (5 cm x 5 cm) and relatively large spatial extent (52 m). Four permanent transects were sampled annually at two grasslands sites using standard sampling protocol. Presence of species in 1,040 contagious 5 cm x 5 cm microquadrats were sampled in each stand. The base-line transect data were re-sampled with different resolutions and the resulting patterns were analyzed by variography and information theory models. The contributions of deterministic and stochastic factors were assessed by comparing realized patterns of species combinations to null models. We developed a series a null models separating effects of interspecific associations, spatial aggregations, relative abundances and environmental heterogeneity. Consistent spatial associations were found between dominant grasses (*Stipa borysthenica*, *Festuca vaginata*, *Koeleria glauca*) and the subordinate functional types (winter and summer annuals, ephemer perennials, perennial forbs, dwarf shrubs and cryptogamic species). However, the strength of spatial associations was highly variable in space and time.

Number and diversity of species combinations were mainly determined by the relative abundance and spatial aggregation of species. Drought caused mass mortality of dominant grasses, disassembly of community structure and it synchronized local dynamics of populations. In contrast, local community trajectories diverged and spatial heterogeneity increased shortly after drought with temporal peaks of alpha diversity and peaks in abundances of annuals, ephemers and perennial forbs. The strongest effect of deterministic factors (strongest spatial associations) appeared *ca* 3-4 years after drought during the recovery of grasses. The lowest diversities appeared in some wet years. Strong spatial and temporal autocorrelations were found by geostatistics highlighting the importance of spatial and temporal contingencies in vegetation patterns and dynamics. Our study provides evidence about the role of extreme climatic events controlling diversity in these unmanaged natural grasslands. The study was supported by the GINOP-2.3.2-15-2016-00019 project.

Poster Long-term studies in vegetation science

Long-term vegetation change in a 100-years old conservation site: The ‘Garchinger Heide’ calcareous grasslands in southern Germany

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For evidence-based conservation management of grasslands, long-term monitoring is necessary, while still only a handful of suitable datasets exist. This study describes vegetation change in ‘Garchinger Heide’, the oldest nature reserve in Bavaria that has been managed for conservation since 1914. Potential management effects were analyzed based on individual species, target-species richness, and species composition in 42 plots with frequency records (1973–2018), and in 40 plots with vegetation relevées (2003–2018). Monitoring included Ellenberg indicator values, functional plant traits, graminoid ratio, and pollination types. Within 45 years there was considerable vegetation change, as abundance of 14–17% plant species increased and of 19–32% decreased. Target species richness and red list species (e.g. *Anemone patens, Adonis vernalis*) decreased while graminoid ratio increased. Nevertheless, most target species of conservation were still common with over 95% of species richness and coverage, and no change in N indicators was detected. However, N deposition and a shift from grazing to mowing could have contributed to higher graminoid cover on expense of small-seeded species. The decline of insect-pollinated species in favour of plants with other pollination mechanisms is in line with the overall decline of pollinators in cultural landscapes. Overall, conservation management is beneficial but cannot keep the calcareous grassland in its original state.

Integrating topoclimatic and human-related disturbance factors to model the invasion dynamic of the non-native grass *Poa pratensis* (Poaceae) in polar environments

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Biological invasions are a growing conservation issue, especially in polar environments such as sub-Antarctic islands. In these areas, the introduction rate of non-native species has considerably grown over the last decades due to both increasing human presence and rapid changes in temperature and precipitation regimes. In particular, because of their remoteness and their recent discovery, French sub-Antarctic islands remained essentially free of human presence until the beginning of the 20th century, when the establishment of human settlements triggered the colonization by non-native species. This traceable history of introduction of non-native species, together with the environmental features typical of the southernmost latitudes, make French sub-Antarctic islands an ideal model to analyze the influence of both human presence and climate change in shaping invasion processes in cold environments.

Aim of this study was to model the invasion dynamic of the non-native grass *Poa pratensis* (*Poaceae*) in the French sub-Antarctic island La Possession (Crozet archipelago), accounting for the relative role of topoclimate and human-related disturbance. To this aim, geographically weighted regression models were first used for downscaling coarse-scale bioclimatic variables (mean annual temperature and mean annual precipitation) from 1-km to 30-m resolution as a function of a set of topographic (elevation, slope, northness, eastness) and environmental (NDVI, insolation time, distance from waterbodies and from the shoreline) predictors.

Then, the downscaled bioclimatic layers were used as explanatory variables in a binomial generalized linear model to predict the probability of occurrence of *Poa pratensis* across the whole island (150 km ^{2}). In addition to the bioclimatic variables we included as predictors the least-cost distance from human settlements as a proxy for propagule pressure, and the sampling year to capture the potential dynamic of invasion of *Poa pratensis*. Finally, model performance was evaluated through a 5-fold cross-validation by computing for each run the amount of deviance explained and the Kappa statistic.
Results highlight that *Poa pratensis* occurs in the driest and warmest areas of the island, with the species presence being highly favored in proximity of human settlements. Overall, the model explained 70% of the deviance and showed a good predictive performance, with the average value of the Kappa statistic being higher than 80.

The implemented approach suggests that both topoclimate and human presence play a key role in affecting the occurrence of *Poa pratensis* on La Possession Island. This evidences the importance of accounting for both climatic drivers and human-related proxies of propagule pressure to predict the potential future spread of non-native species in polar environments.

Poster Global Biodiversity of plant science, plant forms and plant communities

Composition and pattern of wild trees and shrubs in Egypt

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The present study aims to study the floristic characteristics and conservation status and measures of the native trees and shrubs (with height ≥50 cm) in the Egyptian flora. The floristic characteristics include taxonomic diversity, life and sex forms, flowering activity, dispersal types, economic potential, threats and national and global floristic distributions. Nine field visits were conducted to many locations all over Egypt for collecting trees and shrubs. From each location, plant and seed specimens were collected from different habitats. In the present study 228 plant taxa belonging to 126 genera and 45 families were recorded, including 2 endemics (*Rosa arabica* and *Origanum syriacum* subsp. *sinaicum*) and 5 near-endemics. They inhabit 14 habitats (8 natural and 6 anthropogenic). Phanerophytes (120 plants) are the most represented life form, followed by chamaephytes (100 plants). Bisexuals are the most represented. Sarcochores (74 taxa) are the most represented dispersal type, followed by ballochores (40 taxa). April (151 taxa) and March (149 taxa) have the maximum of flowering plants. Small geographic range - narrow habitat range – non-abundant plants are the most represented rarity form (180 plants). Deserts are the richest regions for trees and shrubs (127 taxa), while many species were Sudano-Zambezian (107 taxa) and Saharo-Arabian (98 taxa). Medicinal plants (154 taxa) are the most represented good, while salinity tolerance (105 taxa) was the most represented service and over-collecting and over-cutting the most represented threats. Plants with spiny organs such as spiny stipules, leaves, branches, inflorescences and fruits or woody branches with spine-like terminates are the most represented (64 taxa). There are 3 extinct, 1 extinct in the wild, 12 critically endangered, 59 endangered, 27 vulnerable, 12 near threatened (1 indeterminate) trees and shrubs. In addition, conservation measures were taken towards 91 taxa.

Key words: Woody plants, rarity form, goods and services, Egyptian flora.

Long-term vegetation and plant diversity dynamics in Neotropical ecosystems

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Palaeoecological studies based on pollen analysis in different Neotropical ecosystems provide inside on past vegetation dynamics and biodiversity changes. Several examples on past vegetation and plant diversity changes will be given.

Long pollen record from eastern Amazonia, covering several glacial and interglacial periods, show marked changes between Amazon rain forest and savanna vegetation. The Amazon rain forest must have been markedly reduced during glacial periods. There is evidence of lower pollen and spore diversity reflecting lower plant diversity during periods of dry climatic conditions and high diversity during wetter ones.

Pollen records from the SE Brazilian Atlantic lowland show the replacement of savanna (cerrado) by semi-deciduous forests during the Holocene. Plant diversity increased markedly.

Palaeoecological data from the SE Brazilian Atlantic mountain forest and high elevation grassland (campos de altitude) region show that drier climatic conditions and a higher fire frequency during the early Holocene caused an expansion of the high elevation grassland and a reduction of the local biodiversity.

Studies from the Araucaria forest region in S Brazil document that the former grasslands (campos) on the southern highland have been replaced since the late Holocene. Drier climatic conditions during glacial and early Holocene times and the marked increase of fire frequency, probably of anthropogenic origin, during the early Holocene, caused a decrease of plant biodiversity.

Relationships between vegetation and site conditions to identify reference communities for mountain grassland restoration in the Haute-Durance valley

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In montane grassland ecosystems, plant communities change at relatively small scales due to differences in microclimate and soil conditions. This complicates the identification of reference communities representing the ecological restoration target in disturbed ecosystems. We present an approach to improve our knowledge on the influence of site conditions on grassland communities in order to identify the most appropriate reference communities to serve as source sites for hay or seed transfer.

In our study area, the Haute-Durance valley in the Southern French Alps, the construction of a high-voltage transmission line led to a local destruction of species-rich mountain grassland communities. We aim to identify the key features influencing community assemblages in these systems in order to obtain information on the species composition that can be expected without such soil disturbance (reference communities). More specifically, we ask the following questions: (1) Which abiotic factors are relevant in determining the species composition of extensively grazed mountain grasslands? (2) What is the spatial distribution of the factor combinations characterizing restoration sites?

In floristic surveys, the cover of all vascular plant species was estimated in three randomly chosen quadrats within each of 19 sites. The altitude was between 1,000 m and 1,400 m above sea level corresponding to the altitude of the restoration sites.

Aspect, slope, pH, moisture, carbonate and soil nutrient (NPK) content were measured to relate species composition to soil and climatic conditions. A heat load index was calculated from latitude, slope and aspect. The first results show that soil pH and heat load index are the variables that best explain the community composition. Despite the small altitudinal range between sites, altitude still explains a part of the variation in community composition. These three factors do not correspond to the major geographical zones thus suggesting that reference sites are not necessarily close to restoration sites but can be found in different geographical zones of the study area.

Benchmarking plant diversity of Palaearctic grasslands

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Background and aim: Knowledge on typical levels of plant species richness of plant communities is required both for fundamental research and biodiversity conservation. Vegetation ecologists and practitioners need reference richness values to be able to assess the diversity value of specific plant communities. Palaearctic grasslands are known to host high plant diversity at small spatial scales, some of them being the world record holders. However, there are also some very species-poor Palaearctic grasslands. In any case, maximum and minimum richness values are only a small part of the story. It is evident that for a robust knowledge on plant diversity mean values averaged using many replicates are needed.

As plant diversity is strongly dependent on spatial scale, we aimed at providing benchmarks of plant richness values of different Palaearctic grassland types at eight grain sizes: 0.0001 m^2, 0.001 m^2, 0.01 m^2, 0.1 m^2, 1 m^2, 10 m^2, 100 m^2 and 1000 m^2.

Previous studies have already proved that richness of vascular plants, bryophytes and lichens is not congruent across vegetation types, therefore, besides total plant diversity, we assessed separately vascular and non-vascular plant diversity, as well as the two components of the latter, bryophytes and lichens.

Location: Palaearctic grasslands and other non-forested habitats. Taxa: Vascular plants, bryophytes and lichens.

Methods: We used data extracted from the GrassPlot database, which stores standardized vegetation-plot data sampled in precisely delimited plots. They make a total of 117,777 plots of the eight standard grain sizes, which will be analyzed together with 1,051 additional plots from M. Chytrý and colleagues. The 118,828 plots span a wide range of grassland and low scrub types, including rocky, sandy, xeric, meso-xeric, mesic, wet, Mediterranean, and alpine grasslands, as well as heathlands, thorn-scrubs, ruderal communities and azonal grasslands such as dune grasslands, salt marshes, wetlands, and rocks and screes. All these vegetation types are distributed across eight biomes throughout the Palaearctic realm.

Results and discussion: We will provide mean, minimum and maximum values of species richness for the included 18 grassland types, 8 biomes, 3 taxonomic groups, 8 grain sizes and their combinations. The results will be visualized in tables, figures and maps and be published open access in an online database. Our data will allow researchers and practitioners throughout the Palaearctic biogeographic realm to assess whether the biodiversity of a certain grassland is above or below average.

Talk Plant phenology and plant traits

Seasonal dynamics of wet-meadow vegetation

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The vegetation of grasslands is predominantly studied at the time of most species' expected optima, and even the research of within-year dynamics often focuses on the time of main plant growth and development. It is well established that time is a crucial factor for understanding species coexistence due to differentiation of temporal niches. We focused on the rarely studied period of seemingly no activity of plants and described the permanent species pool, i.e. species photosynthetically active also in winter.

We monitored wet-meadow vegetation (*Molinion*) on a long-term experimental site with mown and unmown plots. Living plant biomass was sampled on 10 dates within one year (February 2017 - January 2018) from subplots of 20 cm x 25 cm in 16 and 12 replicates of mown and unmown plots, respectively.

As expected, the species richness in the 0.05 m^2 subplots was the highest in summer, but the lowest winter species richness was still interestingly high (mown plots: May, mean 16.4 species, max 23; January, mean 10.9, max 16. Unmown plots: August, mean 10.9, max 19; February, mean 4.8, max 9.) The dominant grass species *Molinia caerulea* showed the most pronounced seasonality, being strongly dominant from June to September and completely missing in the community from November to March. This pattern enabled other species to dominate at the time when *M. caerulea* was absent: *Festuca rubra* in mown plots and *Juncus effusus* in unmown plots. Other species frequently occurring in winter include in mown plots: *Agrostis canina*, *A. capillaris*, *Anthoxanthum odoratum*, *Avenula pubescens*, *Briza media*, *Carex pallescens*, *C. panicea*, *C. pilulifera*, *C. pulicaris*, *Holcus lanatus* and *Luzula campestris*, and in unmown plots: *Carex hartmanii*, *Galium uliginosum* and *Poa pratensis*.

We used community weighted means of species functional traits to generalize the properties of the species assemblages throughout the year. Winter communities were characterized by lower canopy height (higher in unmown plots), earlier onset of flowering (later in unmown plots), absence of geophytes, lower d13C (higher in unmown plots) and higher d15N (higher in unmown plots). Only unmown winter communities also showed lower LDMC, and higher C/N ratio compared to summer values. Species with green biomass in winter use the temporal niche with lower competition for light due to the absence of summer dominants. These species also use earlier flowering niche. Only species with regenerative buds on or above the ground are active in winter. The winter and summer communities also differ in the species' resource acquisition strategy and water use efficiency. Mowing has a strong effect on the species composition and consequently on the seasonal dynamics of the prevailing functional traits in the community throughout the year. However, the trait values represent the species summer performance, and seasonal trait variability should be further discovered to explain the underlying processes of temporal niche separation.

Talk Patterns, drivers, and conservation opportunities of grassland biodiversity

Effects of fire frequency on bud banks and belowground organs diversity in savanna ecosystems

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Tropical savannas cover around 20% of land across the globe, an area where one-fifth of the world's population live and get their resources from. These ecosystems are characterized by a species-rich herbaceous layer, most of which have fire and herbivore-related traits, such as the presence of developed and specialized underground structures that enable them to resprout repeatedly. Resprouting ability is the most important regeneration strategy, ensuring the persistence of the population under regular disturbances. Such adaptations are commonly associated with a viable bud bank (BB). Understanding savanna resilience and the different strategies of plant regeneration in flammable ecosystems, we intend to perform a global comparison among tropical savannas to understand how disturbance history impacts the bud bank and belowground organs (BO) diversity. We hypothesize that BB density and also BO diversity will be negatively correlated to length in time of fire exclusion. Such responses to fire exclusion furthermore imply changes in the structure of the plant communities that evolved with fire. To test our hypotheses, we assessed the BB size and BO's diversity in areas with different fire histories located in the Cerrado (Central Brazil), and in the South African Lowveld Savanna Bioregion. At each locality, three fire frequencies were selected for sampling: long-term fire exclusion (E), intermediate fire frequency (IF), and high fire frequency (HF). In each site and fire history, ten plots (0.5 m x 0.5 m x 0.1m) were randomly sampled during wet season. All belowground biomass was washed and fixed in 70% alcohol, which were used for buds counting (number of buds m^{-2}). Furthermore, the belowground biomass was sorted in the lab into different growth forms (graminoids, forbs, and shrubs) and according to BO type. For the Cerrado site, bud bank size increased with fire exclusion (E = 2452.2 buds/m^2; IF = 701.6 buds/m^2; HF = 1241.6 buds/m^2). Such increases may be ascribed to changes in species diversity in the system, since the bud bank was dominated by grass rhizomes at the expense of belowground organs such as xylopodia, at the fire exclusion sites. For the more mesic Cerrado site, fire exclusion may lead to diversity losses. Data from the drier South African savanna revealed lower belowground organ diversity and richness compared to the Cerrado system. With these data sets we hope to contribute to the current knowledge on tropical savanna resilience, since the characterization of the regeneration potential should allow for an improved understanding of tropical savanna community dynamics.

Mediterranean and Submediterranean pine forests: what do we know so far?

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Since October 2017 we are working on a project entitled "Formalized classification of European Mediterranean and temperate pine forests". In this presentation we will show the preliminary results of the first synthetic classification of Mediterranean and Submediterranean pine forest types.
We initially requested vegetation-plot records (phytosociological relevés) stored in the European Vegetation Archive (EVA) dominated by native European *Pinus* species, excluding the high-mountain species *Pinus cembra* and *P. mugo* subsp. *mugo*, and the mire specialist *P. mugo* subsp. *rotundata*. We thus obtained 41,593 vegetation plots that fulfilled our criteria. Subsequently, we created an electronic thematic database of 6,317 vegetation plots, called CircumMed Pine Forest Database, with the aim to fill the gaps in EVA. The database comprises Mediterranean (including Oromediterranean) pine-forest vegetation plots from both published and unpublished sources. Merging these two sources of data, we obtained a dataset of 47,910 vegetation plots. By means of an ad-hoc created expert system, using the criteria of presence of Mediterranean pine species with a cover greater than 15% and no other tree species with greater cover than the pine(s) in the plot, we identified temperate *vs* (Sub-)Mediterranean vegetation plots. After cleaning and stratification of the data, we obtained 3,512 vegetation plots with 1,301 species. We classified these plots by means of an unsupervised divisive classification (Twinspan with 3 pseudospecies cut levels: 0-5-25% cover), resulting in 16 clusters. Some of these clusters were subsequently merged due to similarity in species composition and geographical distribution. Phi coefficient was used to obtain diagnostic, dominant and constant species.

The main division separated central-eastern versus central-western Mediterranean and Submediterranean pine forest communities. The types were characterized, in most cases, by the dominance of one pine species. However, in some cases, more types with the same dominant pine species were identified based on the understory species composition. For both the Mediterranean and Submediterranean types our analysis showed that some communities did not correspond to any previously described syntaxon. In addition, our results showed that long-established pine plantations (especially those of *Pinus pinea* in the central-western Mediterranean) that until now have not been classified, were grouped into the same cluster. This sheds light on the long-debated issue of Mediterranean pine forest plantations as "ecological deserts".

Individual-based simulation of community assembly based on traits allowing intraspecific trait variation: a toolbox in R

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Simulating ecological processes may help to better understand the consequences of simulated rules, and to test methods before using them in analysis of real data and by this way to avoid applying methods with too high type I error or too low power. Botta-Dukát & Czúcz (2016) have proposed an individual based simulation of community assembly applying trait-based rules. The main step of this simulation were: (1) initialization, (2) death of one individual in each community, (3) seed production, (4) dispersal, (5) establishment: one seed grown up for adult, while the others die. The death of adult individuals is fully random, the number of produced seeds depends on the strength of resource competition, while the success of establishment depends on habitat suitability. Strength of competition between two individuals and habitat suitability depend on traits.

I am working on a new version of this simulation, where these basic properties remains unchanged, but the simulation will be more flexible. Therefore, instead of including all steps in one function, a modular structure will be applied where users can define their own modules (i.e., R functions); for example, defining new forms of competition. The original version simulates spatially implicit, “classic” meta-community, where dispersal between local communities is independent from their position. A new version will allow using more realistic, spatially explicit dispersal models using different dispersal kernels.

The most important novelty of the new version is allowing variation of trait values within species. This source of functional diversity is more and more often studied, however its importance is sometimes debated. The new simulation system will help to explore the importance of intraspecific trait variation and to test properties of methods developed for analyzing such data.

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Botta-Dukát, Z., & Czúcz, B. 2016. Testing the ability of functional diversity indices to detect trait convergence and divergence using individual-based simulation. Methods in Ecology and Evolution 7: 114–126.

Studying biodiversity at different biological levels

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Just as diversity involves more than species counts, it also involves different structural and functional aspects at different levels of biological organization. These may include structural or functional attributes per se, generalized plant types, functional patterns and types, and plant communities, as conditioned by non-climatic as well as climatic factors. Study also involves different geographic scales. Study of some aspects, such as taxa and "traits", requires detailed field inventory; study of some other aspects, such as generalized plant or vegetation types, may require models – which, however, still need field corroboration and perhaps more formal verification. Studies with models may also require models of the effective environment and its spatio-temporal "diversity". This talk focuses on plant and vegetation types, and their characteristic attributes (characters). Richness in plant forms and main structural characters appeared to be highest in warm but not equatorial climates with some degree of dryness and seasonality. To some extent this may translate into diversity in the physical structure of vegetation stands, which has implications not only for competition and niche packing but also for animals. Does 'functional diversity' follow a similar pattern? Finally, inventory of and richness in different potential vegetation structures may contribute to the current discussion of biome definition and types.

Fern dispersal across the Pacific

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Fern dispersal has long been described as anemochorous; assuming that microscopic spores can travel long distances, including crossing oceans, by wind. Only the smallest spores (<25 µm diameter), however, have been sampled atmospherically at sea (<300 km from shore), and rarely have fern spores been sampled above 100 m of elevation. Experimental work has shown that spores of ferns with short-statured sporophytes (max 80 cm) will only travel a distance of 2–3 m, compared to spores of tree ferns which travel between 30–100 m in forest (although probably up to 2 km in an open landscape). Furthermore, unlike lichens, mosses and liverworts, insular and continental fern communities across the southern oceans are closely correlated to geographical adjacency and not at all to wind patterns. The idea of anemochory in ferns developed from observations on the distribution of fern species across Pacific islands in the 1960s, before GPS tracking of migratory and sea bird journeys confirmed the dispersal extent of these species. Our project is examining the hypothesis that wind dispersal is limited and birds also disperse fern spores at multiple spatial scales from within forests (vertically and horizontally) to long-distance across the Pacific region. To identify resilience traits of fern spores that will help frame the ecological significance of wind and or bird dispersal, we are looking at spore persistence (temporal: extraction from soil cores), resilience (tolerance to freshwater / saltwater / extreme temperatures) and dispersal potential (establishing dispersal kernels / wind-speed for lift), as well as sampling feathers and skins of migratory birds and some sea birds. Initial sampling shows that migratory birds do carry fern spores, but work to fully comprehend the ecological implications of this are ongoing.

Regional seeds for restoring plant communities

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Restoring plant communities requires a large amount of seeds of native plants. Optimally, these seeds should be locally adapted to allow good performance under the current environment, while genetically diverse to allow adaptation to a novel environment that will the population face with ongoing climate change. In Germany, there is a developed system providing seeds for (mainly) grassland restoration, where seeds are collected from multiple populations in a region (seed transfer zone), mixed to achieve genetic variability and propagate a field as crops to increase the seeds. We have used a series of common garden experiments and molecular methods to study characteristics of the commercially available regional seeds. The seeds provide enhanced genetic diversity in comparison with individual natural populations and thus, improved adaptive potential. Although cultivation does cause unintended selection and affects plants both on the level of phenotype and molecular markers, we detected regional adaptation in the sense that regional plants perform on average better than foreign conspecifics. Moreover, plant origin affects interacting organisms across two trophic levels. In summary, our results indicate that the commercially available seeds are an effective tool for restoring grassland communities.

Talk Plant phenology and plant traits

The timing of phenological events changes along elevational gradients and is influenced by leaf functional traits

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Patterns in plant phenology, i.e. flowering phenology or senescence events, can have ecological and economic effects in natural and agricultural landscapes. Phenology has been referred to as a fingerprint of climate change and the species-specific nature of response will influence future community compositions and ecosystem functioning. For instance, increasing flowering duration increases a plant species' chance to get pollinated and perform better under warmer conditions but changes in flowering phenology might increase the susceptibility to a mismatch with pollinator species. A delay in senescence on the other hand would prolong the vegetation period and consequently lead to higher carbon gain and thus higher species' performance. However, these changes are highly species specific. With our research we aim to explain these species specific patterns with the help of plant functional traits which will make future predictions of plant phenology, biodiversity and ecosystem services resulting from changing climate more accurate.

For analysing changes in phenology with temperature changes, we observed 29 species on a weekly basis along two elevational gradients ranging from 700-1,700 m a.s.l. in two consecutive years. The study was located in the northern limestone alps near Garmisch-Partenkirchen where temperature decreases -0.55 °C per 100 m a.s.l.. We monitored plant populations every 100 m increase in elevation on up to three populations per elevational band. To test whether eco-morphological leaf traits (specific leaf area (SLA), leaf dry matter content (LDMC), leaf N and C content, stable isotope composition namely D13C as well as stomatal pore area index (SPI)) were linked to phenological events and drove species specific responses, we measured those in parallel for the same populations at peak flowering.

We found that elevation, i.e. temperature, influenced phenology and the response was highly species-specific. There was an overall advance of first flowering day, an overall elongation of flowering duration and a delay of senescence with an increase in temperatures. Leaf nitrogen was shown to be associated with stronger changes in the first flowering day and an earlier senescence along the elevational gradients, LDMC was associated with longer flowering duration whereas D13C, i.e. water-use efficiency, was associated with later senescence. These findings give further insight into the species-specific changes in phenological patterns and thus plant performance and distribution under changing climate regimes. Their ecological impact on natural and agricultural landscapes will be discussed.

Talk Long-term studies in vegetation science

Establishment of long-term monitoring with bryophytes and lichens in three National Parks in Germany

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In three forest National Parks (NP), Eifel, Kellerwald-Edersee and Hainich in the northern part of Germany, monitoring of bryophyte and lichen vegetation has been established. The monitoring focuses on the observation of long-term changes after cessation of tree harvesting. The monitoring is set within larger programs of the NP, a fact that supports continuity.

Monitoring is carried out on circle-shaped plots (12.62 m radius) around fixed points for the permanent forest inventory. In a circle all trees species are studied, but at most five trees of a species. Three datasets are recorded: (1) bryophyte and lichen vegetation on the trees (cover values of species separately for trunks & trunk bases); (2) a relevé to study the vegetation and (3) presence of bryophyte and lichen species on different substrates (epiphyte, soil, dead wood, rock) in the circle. The data are kept in Turboveg.

In total 211 circles have been analysed with 50 plots in pioneer vegetation and 161 in older forests. The majority are beech forests. Altogether 216 bryophyte and 211 lichen species were recorded with a mean value of 38 species / circle. In the circles 1,360 trees were studied also, mostly beech together with 21 other tree species.

The epiphyte vegetation is typical of subacidic to neutral bark, while highly acidophytic and nitrophytic vegetation is quite rare. The species data (presence, cover, richness) on scale of the NP, circles, tree species and trees are related to environmental factors (e.g. climate factors, stand age & structure, forest community, tree species, DBH) in combination with species related characteristics (indicator species) by multivariate analyses (aim is an R protocol for the monitoring). This step of analysis is still in progress.

A NMDS analysis of the circles shows a large coherent cloud of stands with two smaller groups opposed on the first axis which seem interpretable as most base-rich and most acidic forests.
Trends known from existing long-term data of monitoring lichens for air quality in the surroundings of the study areas can be used as a background for interpretation. The standardized monitoring for air quality is based on isolated trees not forests. Epiphyte vegetation improved after reduction of SO_2 air pollution (since the 1980s). Since the 2000s thermophytic species have been oberserved, now established as indicators of climate change. Since the late 2000s or early 2010s high nitrogen immission causes dominance of nitrophytic vegetation in towns. The data from the NP also show remigration of pollution sensitive species and the arrival of thermophytic species. The nitrophytic species are less prominent, especially in the older forests, where they are confined to the tree crowns.
Hopefully this contribution can encourage interest in the monitoring of epiphytic bryophyte and lichens, because they are highly sensitive very suitable indicators to changes.

Talk Long-term studies in vegetation science

128 years of post-fire succession records in the New Zealand Southern Alps

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Long-term plot networks that have been repeatedly measured are an invaluable resource for understanding plant community change. However, some, such as chart quadrats, have been underutilised as they were conducted on areas that are now structurally diverse and too large to remeasure using the original methods. One such dataset, one of the longest-known records of post-fire succession globally, was created after Leonard Cockayne visited Arthur's Pass, in New Zealand's Southern Alps, in 1897. He recorded both the vegetation regenerating after an 1890 fire and his interpretation of the pre-fire vegetation in this subalpine area. Under his supervision permanent transects were established in 1932; these were remeasured in 1965 and 2001. All plants were mapped and hand-drawn to scale using the chart quadrat method. We digitised, modernised, and in 2018 reassessed this rare, spatially-explicit dataset that quantified plant cover. Despite the idiosyncrasies of these plots, we demonstrate their scientific value and how they were successfully remeasured and analysed to show distinct temporal changes in composition. We combined the plot data with pre-existing trait data to describe the trajectories of the vegetation and recovery rates. Although we found no evidence of species convergence, we did find evidence of trait convergence after the first two measures, and a continual shift away from the first baseline measure, with indications of a slowing of succession over time.

Successional indicators that continually increased over the entire study period included species richness, structural diversity and frequency of trees (from 30% to 90%). Although compositional change was relatively low, we found associated shifts in trait composition towards woodiness. Ongoing change in these indicators between 2001 and 2018 indicate that post-fire regeneration is still occurring on these transects, some 128 years after the fire event.

Talk Plant reproduction and dispersal: A trait-based approach

Effects of standing vegetation on seed inputs and outputs are independent of its composition: consequences for seedbanks

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Seeds present in the seedbank can impact the composition of the standing vegetation by providing a species pool from which individuals can establish through species turnover or after a disturbance. Thus, factors that control seedbank composition can have important implications for community structure and stability. The available seedbank is the result of inputs, such as seed rain, and outputs, such as seedling establishment and seed mortality, which can be impacted by the presence of standing vegetation. However, there are few studies testing the importance of standing vegetation presence and composition on these factors. Here we used seed addition, seed rain collection, seed predation, and seedbank experiments to test how the presence, composition, and traits of the standing vegetation alter seedbank dynamics. In 16 paired plots, with standing vegetation kept intact or removed, we examined seed inputs, seedling establishment, seed predation, and seedbank composition in a rough fescue grassland in central Alberta, Canada over two years.

Overall, the presence or absence of standing vegetation led to two distinct seedbank communities. Standing vegetation reduced net seed inputs through seed rain compared to plots where the standing vegetation was removed. Additionally, the standing vegetation reduced germination rates of added seeds but had no effect on seed predation rates. Combined, these results suggest the reduction in net seed inputs through seed rain was due to the vegetation limiting seed entry into the seedbank, rather than increasing outputs. Thus, after a disturbance where the standing vegetation is removed, changes to seed inputs could drive compositional changes in the seedbank, which could explain the compositional differences between seedbanks where standing vegetation was present or absent. However, despite lower short-term net seed inputs through seed rain, seedbanks with standing vegetation had, on average, a higher number of seeds and species richness. This suggests the long-term effects of suppressed germination of seeds outweighs the effects of reduced seed inputs and that composition differences between seedbanks were due to output rather than input differences. This is further supported by the fact that the presence of standing vegetation had no impact on the compositional similarity between it and its seedbank such that a species abundance in the seedbank was typically independent of its abundance in standing vegetation. Furthermore, the effects of standing biomass on seedling establishment and predation rates were independent of the composition of the community. Together, this suggests that the effects of standing biomass on seed inputs and outputs are independent of its composition and that the presence of standing biomass alone may be enough to drive changes to seedbank dynamics. Thus, the removal of vegetation is more important than changes to standing vegetation composition in preserving seedbank dynamics.

Poster Global biodiversity of plant species, plant forms and plant communities

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

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The genus *Fagus* is one of the most representative broad-leaved deciduous trees in the Northern Hemisphere. While phylogenetic relationships of different *Fagus* species have been studied, much less attention has been given to their niche breadth. We hypothesized that the biotic niche breadth is much larger in species with a large geographic range size and broader climatic niche, such as in *F. sylvatica* and *F. grandifolia*, compared to species with confined geographic and climatic ranges, such as the Chinese beech species. We tested this hypothesis with a total of 108,441 vegetation plots with beech trees in East Asia, Europe and West Asia, and North America, compiled mainly from the sPlot database and a database in China based on field surveys. The biotic niche breadths of 9 *Fagus* species worldwide were estimated based on the species co-occurrence data of the tree layer and the climatic niche breadths by climate envelopes. Against expectation, the Chinese beeches *F. lucida* and *F. longipetiolata* had relatively larger niche breadths compared to other beech species, while *F. japonica* and *F. hayatae* had the narrowest niche breadths, while those of European and North American beeches had intermediate positions. Our results suggest a recent evolution of biotic niche breadth, which is independent of the age of the clade, suggesting that the biotic niche breadth is not phylogenetically conserved.

Talk Macroecological vegetation science: large grain patterns and processes of plant diversity

Environment and evolutionary history control phylogenetic turnover in atlantic coastal white-sand plant communities

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In the light of the accelerated decline of biodiversity due to habitat loss, understanding diversity patterns is of paramount importance for conservation. The Brazilian Atlantic rainforest is ranked among the top biodiversity hotspots for conservation worldwide. It is a complex ecosystem which includes also coastal white-sand woodlands, i.e. restingas, of Quaternary origin. Restingas are marginal ecosystems notably distinct both floristically and environmentally, and they have suffered extensive fragmentation due to human occupation. Despite several floristic studies, little is known about their evolutionary history. Here we use angiosperm tree species lists of restingas communities coupled with climatic data and phylogenetic analyses to test two hypotheses: (1) there will be low phylogenetic turnover at deep phylogenetic levels across restingas, indicating colonization of plant families with widespread geographic ranges across the Atlantic rainforest sensu lato (e.g. *Myrtaceae*, *Fabaceae*), and (2) high phylogenetic turnover at shallow phylogenetic levels due to very recent speciation and lack of time to disperse out of their original region. Results revealed strong significant patterns of phylogenetic turnover across restingas. As expected, we found (1) weak deep-level phylogenetic turnover across restinga communities after accounting for the effect of geographic distance, suggesting colonization of widespread lineages into restingas. (2) These lineages probably were prevented from further dispersal and as a consequence underwent local speciation, generating new genera and species, reflected by high phylogenetic turnover across communities at shallower phylogenetic levels. These results are relevant for the conservation of restingas as they show the uniqueness of contemporary coastal ecosystems across the Atlantic rainforest. Also, the ongoing habitat loss has remarkable consequences on the evolutionary history of these ecosystems, since the loss of endemic species in local communities may lead to the loss of evolutionary history unique to a particular region.

Talk Vegetation patterns and processes

Invasion drives plant diversity loss through competition and ecosystem modification

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Invasive alien plants are increasingly spreading in natural environments, causing impacts such as loss of plant diversity and alteration of ecosystem processes. The mechanisms through which invasive plants filter species out of native communities are still poorly understood. Community ecology theory has typically emphasized competitive displacement as the driver of invasion impact on vegetation. However, invasion-driven ecosystem modifications can also determine cascading effects on plant diversity (indirect impact mechanism), because ecosystem processes constrain the locally successful plant strategies (e.g., nutrient cycling rates determine the best adapted root systems). Yet, it is unclear whether such ecosystem modifications can be as important as competition in determining plant community changes. To answer this question, we studied the variation of invasion impacts across meadows of the Rouge National Park (Toronto, Canada), focusing on multiple sites invaded by the introduced Eurasian vine *Vincetoxicum rossicum*. In each site we quantified 1) the amount of invasion-driven community impact, 2) the potential for competition with the resident community (as the degree of niche-overlap and competitive differences with the residents based on their functional traits) and 3) the amount of invasion-driven modifications to nutrient cycling and soil chemistry. Invasion by *V. rossicum* consistently lead to species losses within sites, as invader abundance always negatively affected species richness, and often influenced community functional composition and diversity. We found that these effects were stronger not only in those sites where the invader overlapped markedly in niche space with the residents (or was competitively superior), but also in those sites where it strongly altered local ecosystem processes and chemistry (soil N, moisture and pH).

Though competition could explain a large part of the invasion-driven impacts on community characteristics, including measures of ecosystem modification increased the amount of variability explained, often considerably. For example, species losses in invaded communities were explained in roughly equal measure by competition with *V. rossicum* and by invasion-induced ecosystem modifications. These results confirm that competition is an important driver of invasion impact, but also suggest that considering a combination of direct and indirect mechanisms is likely to better explain invader induced changes of the vegetation.

Scrub communities on transition between two macroregions: Mediterranean and temperate in the southern Balkan

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During the 19th century, plant assemblages were treated as plant formations, groups of plants with specific, distinct physiognomic features (e.g., meadow, forest etc.) characterized by species that possess some common features (e.g. Grisebach). The vegetation of the southern Balkans was studied according to this approach at the beginning of the twentieth century by Adamovic, who also elaborated the transition between Mediterranean evergreen and continental deciduous scrub formations.

Here we can find a close contact of two macroregions, as Mediterranean and Temperate. The research tried to catch the same gradient as Adamovic in the same formation and the same area. Therefore, we sampled three scrub communities/formations in the southern Balkans: maquis, pseudomaquis and shibljak, and their changes along the main climatic (macroecological) gradient. We performed DCA analysis and, since the first axis correlates with climatic data, the projection of relevés on this axis was accepted as proxy for the (macro)ecological gradient, and the species turnover along this gradient was elaborated. Linear regression was used to test the turnover of life forms, chorotypes and the life strategy of species (syntaxonomical affiliation). It was found that life forms, except hemicryptophytes and nanophanerophytes, do not change significantly along the gradient change; most chorotypes change significantly; among species, life strategies (syntaxonomical affiliation), the proportion of species of deciduous and evergreen forests and scrub, as well as species of dry grassland, change significantly. The classification established three clusters, representing three formations and we tested differences among them. It was established that stenomediterranean and Eurasian species and species of perennial grasslands differentiate all three clusters and some groups only two of them. We found that discontinuous formations can be established along a continuous gradient.

Communities were also classified within the present synsystematic system.

Source:
Carni, A., Matevski, V., Kostadinovski, M., & Custerevska, R. (2018). Scrub communities along a climatic gradient in the southern Balkans: maquis, pseudomaquis and shibljak. Plant Biosystems 152(5), 1165-1171.

Poster Plantphenologyandplanttraits

Dry spells and its effects on seedlings performance of two species from the Brazilian savanna

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Precipitation seasonality is among the major determinants of plant growth. While dry seasons have profound impacts on plant growth and survival, wet seasons provide opportunities for recruitment and biomass gain. However, in several regions the occurrence of dry spells during the wet season may also impact plant development, in particular seedling growth, a bottleneck in plant's life. IPCC models for South America project longer dry spells in the future, although the total precipitation is not expected to be profoundly affected by the climate changes. Also, average temperatures are expected to be from 1.5 °C to 5 °C higher than the current temperatures. To understand how these scenarios may modify recruitment patterns of native vegetation, we tested two dry spells treatments on the initial growth of two savanna species from the Cerrado: *Qualea grandiflora* and *Tabebuia aurea*. Germinated seeds were selected by uniformity and planted in plastic bags filled with Red Latosol taken from the first 20 cm layer of areas of species' occurrence. After 60 days of growth at 28 °C under 12 hour white light and continuous water supply, the seedlings were transplanted into PVC tubes 1 m long and 0.1 m wide filled with the same soil. The tubes were placed in a closed walk-in chamber (FITOTRON) set for 70% UR, 38°C/28°C (day/night thermoperiod) and under a 12h photoperiod. The total amount of water for irrigation (670 mm) was the same for every treatment and based on the historical data of rainfall from December to February. Besides the daily irrigation (control) there were two watering regimes to simulate different dry spells: every 8 days (8d), and every 15 days (15d); using drip watering that remained opened respectively for 1'40" (58 ml); 14' (478 ml); 26' (670 ml) according to irrigation frequency. After 90 days of growth, all the living plants were uprooted and cleaned for measurements. We measured shoot, root and total biomass; shoot and root length; SLA; RGR; chlorophyll and carotenoids. To detect differences between treatments, we applied Anova followed by the Tukey test (0.05). According with the increase in dry spell length, plants of *Tabebuia aurea* showed a significant decrease in root but not in shoot biomass, suggesting a reduction in root reserves with increasing stress. Increasing dry spells did not affect consistently the other growth parameters and traits of both species. Irrespective of the watering regimes, plants of *Qualea grandiflora* showed normal development, with a progressive increase in the number of leaves, and high with time but not according to irrigation frequency. These results indicate that a higher frequency of long dry spells during wet seasons may not be a major pressure factor against the growth of these species. More species need to be tested to understand if changes in rain frequency can drive changes on the Cerrado vegetation.

Poster Plant phenology and plant traits

Sex ratios, inter-year variation in sex expression, and spatial distribution of *Diospyros philippensis* in a subtropical evergreen forest, Taiwan

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Flowering activity, sex expression, and spatial distributions of males and females of *Diospyros philippensis*, a dioecious tree species, were investigated for 2 years in a subtropical forest, Taiwan. In both years, the sex ratios of populations were male biased. We found evidence for sex changes, 4.1% of individuals showed sex changes; this has not been reported previously. Sex changes were observed in both directions but a larger percentage of male trees became female. The sex ratio was male-biased in most DBH size classes, except for the 10-15 cm DBH class which was female-biased, suggesting that males tend to be more precocious in sexual reproduction. As evidenced by DBH, male trees grew significantly larger than female trees. Point pattern analysis of the spatial distribution of reproductive trees showed that both males and female trees were randomly distributed. The results of bivariate point pattern analysis showed males and females showed significant repulsion at a distance of 0-14 m, whereas at long distance there was no interaction. Inter-sexual competitive interference was observed within short distances, which may be caused by the limited seed-dispersal range of this species, thereby promoting coexistence with other species.

Poster Vegetation patterns and processes

Spontaneous regeneration of vegetation on landslides in low-elevation region in Central Taiwan: environmental drivers and recommendations for restoration strategy

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Detailed knowledge of spontaneous vegetation recovery represents useful information for designing a realistic restoration strategy on landslide scars. In this study, we 1) investigate and describe species composition of vegetation that has recolonized landslides of different successional ages and its relationship to environmental variables, and 2) propose a set of plant species and restoration strategies applicable to speed up the restoration process.

The studied area is located in low-elevation regions of central Taiwan (East Asia), with altitudes between 240 m and 1350 m a.s.l. We delimited the boundary of landslide area using aerial photographs and conducted detailed investigations of species composition in 52 plots sampled in spontaneous vegetation. To identify environmental factors that influence vegetation recruitment, we recorded seven topographical and 13 soil factors at each plot and estimated successional age of each plot to quantify the recovery stage.

Cluster analysis and transformation-based redundancy analysis were performed to determine the vegetation groups and corresponding environmental characteristic. Analysis of variance (ANOVA) was then applied to evaluate the differences in the major environmental factors between different vegetation types.

We recorded 419 species in 273 genera and 109 families from 52 plots. Nine pioneer species occur in more than 50% of the plots, indicating that they can occur in all kinds of habitat in landslide scars. We classified the spontaneous vegetation into four vegetation types that are related to successional age, landslide position and soil pH, Mn and Mg content. Two early successional vegetation types mainly occur on steep slip zone, which is dominated by pioneer woody species at canopy layer and has high coverage of grasses, forbs or ferns thickets. Spontaneous vegetation with 16-40 years of succession can reach the "stem exclusion stage" which consists of pioneer species in the canopy layer and seedlings or saplings of shade-tolerant species in the understory. By referring to the composition of spontaneous vegetation, we propose three restoration strategies on landslide scars applicable in our study area. Firstly, the flat habitats or deposition zone within 16-40 years of succession can reach a relatively stable condition, the technical restoration or afforestation is not necessary and thus not suggested. Nevertheless, shade-tolerant woody species can be used as supplementary species in the restoration of early successional habitats suffering from dispersal limitation. Secondly, landslide scars surrounded by orchards or betel nut farms in the south-west part of the studied region suffer from poor local species pool and dispersal limitation, and widely distributed pioneer species can be selected as candidates for restoration. Thirdly, to solve the problem of regeneration blocked by *Miscanthus* and fern thickets, pioneer species may be directly sown on landslide scars to speed up the succession.

Habitat and island area and isolation as drivers of community assembly in an archipelago

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Islands represent one of the most attractive study models in biogeographical and ecological research, and are often considered as natural laboratories. In fact, islands are well defined ecosystems that permit to clearly model most of the variables controlling the diversity and composition of the local biotas. The advent of large plot databases offers new possibilities for investigating assembly patterns in plant communities in such ecosystems. Aim of this paper is to investigate the spatial scaling patterns in the plant communities of the Tuscan archipelago, one of the most thoroughly investigated areas of the Mediterranean basin in terms of vascular flora and having been subject to intense vegetation sampling. The specific hypotheses that we wish to test are: 1) Habitat area predicts species richness within island as island area predicts total species richness; 2) habitat type and extent are more important than island identity in controlling species composition.

The Tuscan archipelago is composed of 7 major islands, one “fossil” island connected to the continent by 2 sand strips, and several smaller islets. During the Pleistocene part of the archipelago was connected to the Italian Peninsula due to the repeated variations of sea level. We assembled a database including all the vegetation relevés (hereafter referred as plots), sampled in various periods. We geo-localised all the plots for which it was possible to have spatial information and we classified all the habitat types of the plots according to EUNIS classification. We then used island and habitat Species-Area Relationships (ISAR and HSAR), and beta diversity to quantify their role in controlling the changes in turnover and replacement for native and alien species.

The assembly of the database resulted in as much as 23,657 occurrences of 867 plant species in 1,563 plots concerning 17 EUNIS habitat types. Despite the methodological limitations due to the lack of a specific sampling design, the size of the data base is enormous and quite well balanced in terms of number of plots per island and habitat type. The analyses of ISAR and HSAR highlighted the major role of habitat area in controlling species richness patterns within island and community composition, even if the island identity signal was also clear as predicted by island biogeography theories.

Poster Vegetation patterns and processes

To understand the statistical behavior of richness estimators based on Good-Turing theory

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Species richness is the simplest and most intuitive concept of diversity. All biodiversity studies and analyses are based on sampling data taken from focal assemblages. However, due to practical limitations, it is virtually impossible to detect all species, especially in hyper-diverse assemblages with many rare species. In almost every biodiversity survey and monitoring project, some of the species that are present fail to be detected. There are many non-parametric richness estimators proposed to correct the bias, including the Chao1 estimator, first order and second order Jackknife approaches. However, there are no theoretical evaluations about these widely used richness estimators in the literature. The Good-Turing frequency formula, originally developed for cryptography, estimates, in an ecological context, the true frequencies of rare species in a single assemblage based on an incomplete sample of individuals. Here, we used the theory of Good-Turing frequency formulas to reveal the conditions under which the estimators are nearly unbiased and to theoretically elaborate the statistical estimator's behavior when increasing sample size.

Based on Good-Turing frequency formulas, it becomes intuitive and easily understood that (1) the Chao1 estimator is unbiased not only in homogeneous but also in other models, (2) there is no species frequency model to fit the unbiased conditions of the Jackknife estimators, (3) the Jackknife estimators are always underestimated when sample size is small and overestimated when sample size is large enough. Finally, simulation results are reported to numerically verify the performance of the investigated estimators in this study.

Is the *Opuntia ficus-indica* community in Korea indigenous?

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Jeju Island, the largest island in Korea, has a small area of native cactus community. There have been many scientific discussions, but we still do not have an answer to this origin. The purpose of this study is to evaluate the natural potential of Jeju island cactus and how it forms a natural habitat from the difference of biomes. Furthermore, it was discussed whether the distribution of this community is maintained under the habitat environment. In order to understand the environmental characteristics and distributable areas of cacti, we applied the MaxEnt model of MaxEnt 3.3.3k to extract the analytical values. The emergence data and environmental factors of the species have been analyzed using the previous research data and the possibility of global distribution and domestic distribution possibility. Climate data was obtained by upscaling 19 Bioclim (version 1.4) provided by Worldclim with a spatial resolution of 30 minutes ('). 5-fold cross validation was performed to increase the statistical reliability in modeling. The result of the model was output in a logistic format where the distribution probability is expressed as 0 ~ 1. Based on 4,826 spots in the world's natural sprawl, the potential distribution area of the worldwide sought - for cactus has been derived. As a result of the probability distribution analysis, equal training sensitivity and specificity logistic threshold was 0.492. Potential distributions were found to be representative of the Central American Tropics, southern South America, the Mediterranean surroundings, North Africa, South Africa, the Galápagos Islands, Southwest Asia, Australia and New Zealand. In the East Asian region, Philippines, Taiwan, Myanmar, Thailand, Cambodia, Vietnam and Japan's South Kyushu region were found to be relatively high distribution areas. The AUC value for location analysis is 0.823, and the analysis of the model is considered to be significant. Eventually Jeju showed a very low possibility that the results can be analyzed probability distributions indigenous presence. The environmental factors that determine the distribution of the world were the mean temperature (Bio11: coldest quarter) and temperature seasonality (Bio04: 48.5% and 29.3%) in the coldest quarters. In the area of Wolryeong-ri, the coldest quarterly average temperature was estimated to have a low distribution probability of 7.16 degree during the last 30 years. Three areas in the west coast area of Cheju Island were extracted from the available distribution area, and the AUC value was extremely high. Equal training sensitivity and specificity logistric threshold value was 0.6334, and in western parts of Korea including Wolryeong-ri.

Exposure-related forest-steppes in the northern Pannonian Basin

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Forest-steppe landscapes are formed of a complex mosaic of physiognomically contrasting habitats (forests and grasslands) and thus are generally species-richer than the landscapes formed of habitats of similar physiognomy. In the northern Pannonian Basin, the majority of forest-steppes are exposure-related, i.e. steppe is occupying the south exposure of otherwise forested hills. Historically most of these sites were influenced by extensive farming but nowadays are mostly abandoned or managed for conservation purposes. They harbour a high number of rare or endangered species and supply a wide spectrum of environmental services. This study is aiming: (i) to identify sites in the northern Pannonian Basin in which the exposure-related forest-steppe vegetation mosaics are well developed; (ii) to describe individual habitats of the exposure-related forest-steppe ecosystems; (iii) to characterize vegetation dynamics at the forest-steppe boundary in the exposure-related forest-steppe by analysing the pattern of woody species regeneration; (iv) to compare plant species diversity of exposure-related forest-steppe sites on different bedrocks. The study was conducted in different regions of the northern Pannonian Basin: the hilly landscape of southern Moravia (CZ), limestone hills of the westernmost Carpathians (AT, CZ, SK), Hungarian Central Range (H) and the Transcarpathian Lowland (UA). Sites with well-developed exposure-related forest-steppe ecosystems (n = 16) were chosen, and on each of them, all physiognomy-defined habitats (i.e., forest, steppe and the ecotones between them) were sampled along a transect. All individuals of woody species including juveniles were sampled in 1 m intervals. The floristic differentiation of forest-steppe habitats was assessed using principal coordinate analysis (PCoA) and through the fidelity of species to certain habitats. The density of woody seedlings was compared among all the habitats. The floristic differentiation between habitats in the forest-steppe mosaic is relatively low, and a high number of species is shared between neighbouring habitats. Species composition of ecotones was observed to be intermediate between steppes and forests. The species richness of ecotones was observed to be higher on forest-steppes developed on hard rocks, while on deep soils, it was rather similar to those of both steppes and forests. Juveniles of woody species occurred most frequently in forests, while in steppe they were sparse or missing. Several woody species appeared to have an affinity to some forest-steppe habitat. This study contributes to the understanding of the patterns and processes that maintain plant diversity in the exposure-related forest-steppe landscapes by comparing individual components of this landscape mosaic in various regions at the western border of the Eurasian forest-steppe biome.

Expert system for the EUNIS Habitat Classification: an ecoinformatic approach to define and characterize European grassland, shrubland and forest habitats

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The EUNIS Habitat Classification is a widely used reference framework for natural, semi-natural and man-made habitat types in Europe. However, clear definitions of individual habitat types that would enable unequivocal assignment of each site to a habitat type have not been available. Therefore our goal was to develop a classification expert system for assigning vegetation-plot records to the EUNIS habitat types of grasslands, shrublands and forests, use it for classification of a European vegetation-plot database, deliver lists of statistically-defined indicator species for all of these habitat types, and provide maps of European distribution of these types based on the available vegetation-plot data. The expert system contains definitions of 55 grassland, 43 shrubland and 46 forests habitat types based on their species composition, the dominance of individual species, and geographic distribution. We applied this expert system in the Juice program to classify approximately 1.5 million vegetation plots from the European Vegetation Archive (EVA) and other databases, of which 661,864 plots were classified as grassland, shrubland or forest. Then we determined indicator species for each habitat type based on the phi coefficient of association and calculated occurrence frequencies of species for the groups of plots classified to each type. Finally, we mapped the localities of plots of each type. This study demonstrates how ecoinformatic approaches, involving the use of large vegetation-plot databases, tools for their automatic classification, and statistical analysis of the classified vegetation plots, serve nature conservation, in this case by considerably improving the applicability of the EUNIS Habitat Classification in nature conservation planning, monitoring and assessment.

Does the age of the oldest hawthorns reflect the age of a hedgerow?

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As linear wooded habitats, hedgerows are potential habitats and even potential corridors for forest species. Earlier studies reveal that most forest herb species were able to establish in hedgerows, but that the more ancient a hedgerow (i.e., the longer the time it has continuously existed, independently of the age of the shrubs and trees which live in this hedgerow), the higher the forest species richness. This has been explained by the fact that ancient hedgerows exhibit higher habitat quality and provide a longer time for colonization and species accumulation. However, it is challenging to determine how ancient a given hedgerow is. The techniques that are classically used for woodlands, such as the regressive analysis of landscapes using old maps and cadasters, can hardly be applied since hedgerows were rarely mapped in the past. In this study we asked whether the age of a long-living shrub species, namely monogynous hawthorn (*Crataegus monogyna* L.), could be used as a proxy for the age of the hedgerow hosting it. To answer this question, we sampled 65 hedgerows in north France for which relevant archives were available to date them quite accurately. We then implemented a dendrochronological approach: in each hedgerow we selected hawthorn individuals which exhibited a higher stem diameter at the ground level and cored them using an auger at *ca* 15 cm aboveground. In the lab, we counted tree rings. Data analysis mainly consisted of investigating relationships between stem diameter, tree ring number and hedgerow age (as reconstructed using archives). We found no significant correlation between hawthorn age and hedgerow age. Dendrochronological analyses suggest that repeated pruning strongly impacts hawthorn growth, and hence decouple stem diameter from age. We conclude that the age of a hedgerow cannot be estimated based upon the age of its constituting woody species.

Talk Using plant traits for the recovery of ecosystem functions and services: Trait-based ecosystem engineering?

Plant intra- and inter-trait interactions in Mediterranean shrublands recovering from a variable regime of wildfires in SE Spain

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Wildfires induce spatial heterogeneity on ecosystems, with important ecological effects on soil, vegetation and succession. During succession, the increasing biological activity generates additional spatial pattern through soil-vegetation and community interactions. Here we focus on how differences in fire regime affect the shape and formation of vegetation spatial patterns. More specifically, we examine whether certain plant-growth morpho-functional traits (Raunkiaer life forms: Phanerophyta-P, Chamaephyta-Ch, Hemicryptophyta-H, Therophyta-T, Geophyta-G) dominate the development of vegetation pattern along succession. We also evaluate the relative importance of intra- versus inter-trait relations on pattern formation. Plant species cover and soil properties were measured along 61 m-long transects located perpendicular to the slope in each of four, formerly homogeneous, *Pinus pinaster* forest stands (Almijara Natural Park, Malaga, Spain). Each stand was burned 0, 1, 2 or 3 times, respectively, depending on the extent of three wildfires during 1975-1986. We performed variance partitioning based on principal coordinates of neighbour matrices (PCNM), complemented by spatial analysis with direct multi-scale ordination (MSO). To account for spatial autocorrelation in species distribution, we performed the spatial version of the variance test. MSO and the variance test showed positive interactions (association) between species mainly at the two extremes (3 and 0) in burning frequency of the sequence (H, T versus P & Ch, T), while negative interactions (competition) mainly occurred at the intermediate stages (P, Ch; especially P & H and P & T). Patches with particular species of perennial herbs and shrubs occurred at these two extremes (Ch versus P), and in no case shrubs (P, Ch) were associated with grasses (T, H). The overall spatial structure of vegetation was dominated by woody species, at high fire frequencies by post-fire seed-regenerated low shrubs and re-sprouting perennial herbs-forbs, and at low frequencies by slow-growing tall shrubs, whose inter-specific interactions controlled the development of spatial pattern. From the Units B-C to A, it was observed a decrease in cover (not conditioned by the environment) of these both groups, and an increment in H; from B-C to D, an increment in P and H, and a decrease in Ch and T. As a result, processes which occurred in the Units A and D showed certain parallelism: in the Unit A (around 1 and 5 m), due to re-sprouting and seeders colonization of the more favorable soil patches, that originated the early formation of 'islands'; in the Unit D (around 10 m), due to the final configuration of mature patches mainly dominated by shrubs or grasses. Increasing facilitation between shrubs and unwoody/perennial herbs at older stages may be allowed by niche separation (tiers) as shrubs increase in size, and by change of nutrient strategy of both P and Ch species from 'accumulation' to 'dilution' as succession advances.

Linking spectral and functional diversity to predict ecosystem functions at community scale

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Given the present rate in global change, biodiversity assessments at different scales and on a real-time basis are of prime importance. Similarly, it is crucial to unravel biodiversity's relationship with ecosystem functions and related ecosystem services. Recent years have seen rapid advances in two fields that have great potential for these purposes: remote sensing and functional trait-based approaches. New remote-sensing platforms have increased the availability of spectral data with high spatio-temporal resolution at both local and global scales, while functional trait ecology has come of age, providing a solid framework for understanding how species contribute to ecosystem functioning. When surveying vegetation, spectral data represents an aggregated signal of how light interacts with the chemical and structural composition of the canopy, which in turn is underpinned by a plant's biochemical and morphological traits. This means that the spectral diversity (SDiv) of a certain plant community, defined as the variation of the spectral signal over space, should reflect its plant functional diversity (FDiv) and therefore its ecosystem functions. To test this, we used 80 different 1.5 m x 1.5 m experimental mesic grassland communities expressing different levels of functional diversity but having the same species richness. We gathered the spectral information of the field site using an UAV (multicopter Kingfisher, Robodrone industries) mounted with a Tetracam Mini-MCA6, which provides canopy-level spectral data across six bands across the visible and NIR wavelengths (490nm, 550nm, 680nm, 720nm, 800nm, 900nm) with 10 nm of bandwidth at 3 cm spatial resolution. We summarized the spectral information by selecting the first axis deriving from a PCA on all the bands. For each community, we measured SDiv using the mean Euclidean distance of the values of the first PCA axis of all the pixels in each plot; FDiv was calculated as weighted mean species pairwise distance, which was calculated through Gower distance considering plant height, specific leaf area, leaf dry matter content, seed mass, life form, growth form, life span, flowering period and nitrogen fixation ability; and total standing biomass was measured to quantify primary production ecosystem function. Using linear mixed effect models, we found that SDiv was significantly negatively correlated to the FDiv of the communities, although the model explained a low variance (R2m=0.052). Surprisingly, total biomass production was significantly positively correlated to SDiv (R2m=0.369) but was not significantly correlated to FDiv. Our results suggest that SDiv at community level might be a better predictor of primary production compared to FDiv. This might depend on the fact that SDiv, in contrast with our measure of FDiv, better represents both the intra-specific variability and the canopy trait diversity crucial for primary production.

Poster Long-term studies in vegetation science

Which plant species are affected by a perennial invasive species (*Asclepias syriaca*) on secondary grassland?

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The invasion of alien species can cause long-lasting effects on plant communities, on their diversity, functioning and regeneration ability. However there is a discussion, how to measure and evaluate effects of invasive species. Many times the process and effects of invasion are concluded from a presently observed pattern, however, this can be misleading.

Our aim was to study the spontaneous regeneration of abandoned arable lands and the role of neophyte species in this process. We asked whether the neophyte species, especially the invasive herbaceous species *Asclepias syriaca*, have any effect on this process; whether it really outplaces other species or whether it is just a new perennial species among others?

We conducted our study in Hungarian lowlands, in the sandy area between the Danube and Tisza. We studied old fields of 4 different age groups (35-26, 25-13. 12-7, 6-2) from 2000 to 2010. In 2015 there was a management by the nature conservation service again on invasive species in the study area. We looked also for first effects of this management.

We found that the abundance of neophyte species decreases with time, however, the abundance of *Asclepias syriaca* increases in every age group. In the mean time the abundance of other perennial species did not increase. There was a correlation between the changes of *Asclepias syriaca* from 2000 to 2010 and the changes of perennial or sandy specialist species from 2000 to 2010. It clearly indicates a negative impact of perennial invasive species on the regeneration of sandy grassland species which are hampered because the perennial specialist species can not disperse. The mechanism underlining this is not clear, it needs further study. Maybe the better resource use of *Asclepias syriaca* is the reason for it.

Semi-open landscapes as biodiversity hotspots and refugia for rare and endangered species and their role in nature conservation

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Semi-open landscapes are defined as structural transition zones between open landscapes and forests in which open habitats (e.g. heathlands, semi-natural grasslands) are interlinked with scrubs, single or groups of trees building up a fine-scale spatial mosaic and creating different degrees of shading (25-80%) with small-scale changes in microclimatic conditions. As a result of high habitat diversity within a small area, semi-open landscapes harbour a substantial proportion of the regional species pool. Furthermore, they contribute to the connectivity between habitats with the same attributes (stepping stones) and may facilitate dispersal. In Central Europe, such type of landscape historically emerged from extensive grazing and was formerly widespread. Today, semi-open landscapes have nearly completely vanished from the normal landscapes and are mainly restricted to nature reserves. Therefore, specialists adapted to semi-open landscapes count towards the rarest and most endangered species on the national and European levels.

The DBU Natural Heritage comprises ca. 70,000 ha of nature reserves all over Germany. On average, 20% within each heritage area are semi-open landscapes. Based on detailed habitat surveys with plant species mapping on 51,000 ha and additional territory mapping of birds on 43,000 ha, I investigate: (1) the configuration of semi-open landscapes within nature conservation areas, and the different types of maintenance measures currently applied (e.g., grazing, mechanical treatment, degree of natural dynamics); (2) the composition of habitat types in semi-open landscapes (gamma diversity), and their summarized vegetation structure (degree of shading); (3) the diversity of open land and forest plant species, and the presence of rare and endangered plant specialists to such ecotones; (4) the diversity of rare and endangered bird species in semi-open landscapes in comparison to open landscapes and forests, and the dependence of specialists to structural habitat configurations. Based on these results, I draw general conclusions on the role of semi-open landscapes in nature conservation.

How fire affects vegetation community in Cerrado?

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Fire is an important factor influencing vegetation dynamics in many different ecosystems including grasslands. Fire events are responsible for maintaining the physiognomy, structure and diversity of grasslands ecosystems. However, grasslands have been continually threatened by policies that exclude fire, the replacement of the original cover with agricultural areas and the planting of trees as happens at Cerrado. Change in fire regime will imply significant changes in parameters of plant community, both in structure and diversity. Taken together, this study aims to understand the effect of fire exclusion on vegetation dynamics in areas with different fire histories. We hypothesized that the absence of fire leads to the accumulation of vegetation biomass, leading to the loss of plant species of the herbaceous layer. Were established 30 plots in each area with a distinct fire history, being delimited: an area excluded from fire for 6 years (E6); an area excluded from fire for 12 years (E12) and an area undergoing biennial prescribed fire events (F2). We found that areas with exclusion of fire had less percent bare soil (E12=2±1.5, E6=11±9) and higher accumulation of dead biomass (E12=87±37 g/m², E6= 97±49 g/m²) when compared with areas with frequent fire events (F2=25±14 and 16±7 g/m², bare soil and dead biomass, respectively). The herbaceous layer declined with longer time of fire exclusion (E12=16±7 g/m², E6=35±12 g/m², F2=46±22 g/m²). Further, areas with frequent fires present higher diversity of species (index of Shannon - H'F2=2.33) when compared with exclusion areas (H'E6= 1.59 and H'E12=1.61). Thus, fire is an important factor structuring the Cerrado ecosystem by maintening physiognomy and diversity, and its ecological importance as a management tool for grasslands conservation.

Worldwide invasions by *Urochloa* species: quantification and characterization from a scientific literature review

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Invasive species are an important component of vegetation dynamics in all types of ecosystems due to their ubiquity across the globe. In tropical savannas, the genus *Urochloa* is one of the most spread across natural areas where it hampers native vegetation, altering ecosystem services and compromising, thus, biodiversity conservancy. Aiming to understand the process of invasion by African grasses on Neotropical savannas, represented via one common invasive genus (*Urochloa*), we conducted (November 20108) a literature review on the topic. We used (urochloa OR brachiaria) AND (invasi* OR alien OR exotic OR non-native) as a search expression on ISIS Web of Science and Scopus databases. In the first case, we found 131 results, from which 26 were eliminated as not related to the topic. The Scopus database added 48 new entries not encountered by ISIS, from which 22 were not related to the topic. Using the abstract, and when necessary the entire text, the 131 remaining entries were classified according to location, study type (about *Urochloa* impact, trait, invasibility, management, or if it was theoric) ecosystem and the species evaluated in each study. We found studies from 18 countries (all continents except Europe) about fourteen *Urochloa* species. Studies were concentrated at Brazil (n=80, 62%) and Australia (n=24, 18%), evidencing the problem these grasses pose to tropical grasslands and savanna conservation. The most studied types of ecosystems were savanna (n=31, 24%), pastures (n=23, 18%), wetlands (21, 16%) and aquatic systems (19, 15%), showing the concern about these invasive grasses in a wide range of habitats. However, we must be cautious about these results since some studies were primarily related to traits of *Urochloa* species, independently of its behavior as an invasive species. This was evidenced by the number of studies about *Urochloa* spp. traits (n=29, 22%) in relation to those about their impacts (n=48, 37%) and management (n=20, 15%). One point to be highlighted by this literature review is the fact that despite the great quantity of studies, the overwhelming majority only addressed one species (n=104, 80%), or did not clearly state the investigated species (n=13, 10%) hampering generalizations about this controversial genus and its implications on nature conservation worldwide.

Stronger influence of anthropogenic disturbance than climate change on century-scale compositional changes in northern forests

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Predicting future ecosystem dynamics depends critically on an improved understanding of how disturbances and climate change have driven long-term ecological changes in the past. Here we assembled a dataset of >100,000 tree species lists from the 19th century across a broad region (>130,000 km ^{2}) in temperate eastern Canada, as well as recent forest inventories, to test the effects of changes in anthropogenic disturbance, temperature and moisture on forest dynamics. We evaluate changes in forest composition using four indices quantifying the affinities of co-occurring tree species with temperature, drought, light and disturbance. Land-use driven shifts favouring more disturbance-adapted tree species are far stronger than any effects ascribable to climate change, although the responses of species to disturbance are correlated with their expected responses to climate change. As such, anthropogenic and natural disturbances are expected to have large direct effects on forests and also indirect effects via altered responses to future climate change.

Key small-seeded New Zealand tree species utilise tree ferns as an alternative regeneration niche to disturbed areas

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Aims: A well-documented paradigm in seedling recruitment ecology is that shade-tolerant species have larger seeds than light-tolerant species. These light-preferring species with smaller seeds utilise their better dispersal ability to colonise lighter, more-disturbed areas of the forest. We aim to show that smaller-seeded species utilise an alternative strategy in southern temperate rainforest of recruiting on the trunks of tree ferns.

Location: Wellington region, North Island New Zealand

Methods: To assess whether small-seeded tree species rely on tree fern epiphytism for recruitment we quantified population structure of both epiphytic and terrestrial subpopulations in 14 woody plant species across a range of seed sizes. We used a paired study design where we surveyed all woody plants occurring on 330 tree ferns and in matching forest floor plots of equivalent area. Using linear models, we then assessed the relationship between species' seed size and their epiphytic reliance.

Results: Tree species show significant differences in population structure between the forest floor and tree fern-based subpopulations, with a few small-seeded species heavily reliance on tree ferns for adult recruitment. Species' seed size negatively correlates with seedling epiphytic reliance, with smaller seeded species germinating on tree ferns. However, species' adult epiphytic reliance does not show a significant relationship with seed size, suggesting other demographic processes alter species abundance following this initial seed size filter.

Conclusion: Interspecific differences in the epiphytic reliance of New Zealand tree species are pronounced, with only small-seeded species using this regeneration niche. Seed size is sufficient to predict the relative abundance of seedlings of species on tree ferns. In summary, tree ferns provide a crucial regeneration niche for smaller seeded tree species in southern temperate rainforest.

Vegetation Map of South Africa, Lesotho and Swaziland: Progressive improvements on a historical map of biodiversity, 2006 to 2018

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The National Vegetation Map is a model of the historical extent of South Africa's vegetation. This model is a valuable resource for the management of South Africa's natural resources as it provides a baseline dataset for threat assessments, national and provincial strategies, and conservation targets. Hence it is essential to ensure that the data is based on the best available information. However, mapping vegetation patterns nearly 300 years into the past can be a challenge as the data to inform the mapping of many regions is not available in South Africa and even the most advanced technology can only provide a snapshot of the current distribution of communities. The South African National Vegetation Map is updated periodically with improved data and the 2018 version, the third update since 2006, was recently completed. For this version we employed several different approaches to resolve coarsely mapped regions of the map. Techniques included a combination of surrogate abiotic maps, expert knowledge, mapping off orthorectified 1930's imagery. The map has also been improved by reducing errors. Previous versions included non-terrestrial features from other environments. However, stand-alone maps for these other environments were developed for the country's National Biodiversity Assessment 2018 and the vegetation map was edited to focus on terrestrial vegetation. We reported changes to the 2018 version of the National Vegetation Map and provided the rationale, data sources and contributing authors. We also quantified and corrected spatial and classification changes and errors since 2006. Changes made to the map using ArcMap 10.4 included the following: (i) the correction of spatial errors; (ii) edits were made to existing vegetation type boundaries; (iii) new vegetation types were added where communities were too coarsely classified; (iv) polygons that overlapped with non-terrestrial environments were identified or removed; (v) non-terrestrial landscape features that mapped ocean or modern structures such as harbours were deleted. Changes between versions were quantified using ArcMap, R and Excel. Version 2018 had the largest changes by area, and number of types added and deleted since 2006. Changes in the 2018 version included the addition of 47 new types, boundary edits to 107 existing types, and the removal of 35 vegetation types and features, and affected nearly 5% of the total map area, compared to 2.6% and 0.5% for previous versions. Several sources of error were fixed and prompted protocols for future work. We have made progress in refining coarse areas of the map from 2006 to 2018. These progressive improvements lead to greater accuracy in National Ecosystem Assessments and National and provincial conservation planning.

Plant traits consistently relate to species' temporal fluctuations: evidence from a global compilation of long-term communities

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Functional trade-offs across coexisting species can foster long-term maintenance of biodiversity by causing different temporal fluctuations across species. Different strategies to cope with stressors can result in different ways of buffering against the effects of environmental temporal variability, ultimately perpetuating the populations of multiple species within communities. Using a global compilation of long-term vegetation plots and trait data, including different types of habitats and treatments, we tested whether different traits related to functional trait trade-offs could predict (1) species' populations temporal stability patterns and (2) species pairwise temporal associations (synchrony). We used data from 78 datasets with permanent plots (~8,000) of natural and semi-natural vegetation repeatedly sampled over a timespan of 6 to 99 years. To quantify temporal stability of resident species, we calculated the coefficient of variation (CV) of species' abundances (excluding shrubs and trees) in each plot and related it to different traits. Species pairwise correlations, estimating synchrony, were associated to trait dissimilarity. Trait data was retrieved for ~ 3,000 species from the TRY plant trait database for 7 continuous and 4 categorical traits. Among the different traits, leaf dry matter content (LDMC) was consistently related to species stability across different vegetation types. The more conservative the strategy of species (high LDMC), the lower their CV, i.e., the more stable their abundance through time. On the contrary, species with more acquisitive strategy were more unstable, likely fluctuating more strongly over favorable and less favorable environmental conditions. Higher trait dissimilarity between pairs of coexisting species generally led to non-synchronous fluctuations between them. Hence within communities trait trade-offs provided a mechanisms by which different species cope with long-term local coexistence. The study demonstrates how simple plant trait can provide crucial and consistent insight on the temporal fluctuations of species and their coexistence.

Even a transient conversion of silviculture in the past leaves a signal in the present understory vegetation of a managed broadleaved high forest

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Evidence is accumulating that past forest management still has an impact on herbaceous plant communities in terms of species richness and composition. On the first hand, all else being equal (e.g., climate, soil type, relief, regional species pool), different sylvicultural systems have been associated with different plant communities. On the other hand, even a transient change in land use type (e.g., conversion of woodlands into arable lands) has been shown to durably impact the ground flora and the soil seed bank. Whether a transient change in management type can durably alter understory plant communities in the absence of land use change remains an unanswered research question. This study was conducted in the ancient forest of Saint-Gobain, in north France. This forest is a former royal forest dominated by oak and beech which has been continuously managed as a regular high forest (HF) for wood production and stag hunting. However, some stands were converted into coppice-with-standards (CWS) during the 16th century to produce fuel for royal glass factories; these stands were managed as such until the second half of the 19th century, when they were converted again to regular HF. In this study, we compare understory plant communities and soil properties between two series of paired stands (N= 2*12): HF stands that were continuously managed as such since the Medieval times *vs* HF stands that experienced a transient (*ca* 300 years) CWS conversion, all located on luvisols. We recorded all vascular plant species in 400 m^2 plots and took a composite soil sample for further chemical analyses. Remarkably, despite the lack of difference in soil chemical properties (with the notable exception of the content in exchangeable cations), we observed strong differences in species richness and composition between the two types of stands. More specifically, former CWS stands host a higher species richness and more neutrophilous species than historical HF stands. These differences might be explained by the transient suppression of beech in the canopies, which likely improved light and litter conditions at the forest floor, hence allowed some species unable to cope with a thick litter layer and/or deep shade to establish and persist. We conclude that even a transient conversion of silviculture in the past can have long-lasting impacts on understory vegetation and thus on forest ecosystem functioning.

Poster Remote sensing of vegetation for biodiversity research

Unmanned Aerial Vehicle (UAV) surveys for the study of plant ecology in Mediterranean cliffs: the case study of a maritime cliff in Cabo de San Antonio (Denia, Spain)

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Premise of the study: Cliffs are defined as zones with relatively high and very steep slopes. These zones are considerably different from the surrounding habitats both for physical factors and for the distinct flora inhabiting them, which is called chasmophytic. Aerial surveys with small Unmanned Aerial Vehicles (UAVs) are nowadays a standard approach for many environmental studies and they could be used for a wide variety of applications in plant ecology. The study aimed to develop a procedure for conducting an ecological aerial survey over a vertical and inaccessible surface and to show the capabilities of UAV surveys for plant ecology and conservation on steep terrains.

Methods: Aerial surveys were carried out with a Phantom 4 by DJI along vertical transects on the side of a maritime cliff in Cabo de San Antonio, Denia, Spain. Aerial close-range images (<3 m) were taken to identify and geolocate plant species and to reconstruct a 3D digital model of the cliff area. The 3D digital model was used to create a map of surface inclination. Vegetation coverage was estimated from aerial images and from 3D digital model for the entire area and for 5 classes of inclination. Five random sample plots of 2 m² for each class were created using 3D model data and plant markers locations.

Results: Aerial close-range images allowed to identify and geolocate in the 3D digital model a total of 1,202 plant specimens. Only 3.4% of plants were marked as unclassified. Comparison of visual and photographic plant classification confirmed that the mapping methods were accurate. Our hypothesis is that inclination is an ecological variable acting as niche segregator for different types of vegetation patches, differentiating chasmophytic assemblages from the other ones. The total surface area and the surface area of vegetation cover for the whole cliff and for each class of inclination was calculated. Statistical ordination was then performed to correlate surface inclination to the species composition of the observed vegetation patches.

Discussion: This study demonstrates that small UAVs are suitable for gathering large amounts of ecological information for plant growing on inaccessible terrains. A single survey provided data on niche segregation and habitat selection for chasmophytic floras in the Mediterranean basin, endemic plants distribution and abundances and vegetation composition along a gradient of inclination. UAVs have the potential to provide a no-risk, cheap alternative to far more expensive survey techniques on steep terrains.

The role of functional seed traits in foredune community assembly

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The processes that rule species assemblage have long been investigated on adult plants, while early phases of plants' life cycle have often been neglected. However, seed traits such as the germination response to abiotic factors may play a major role in different phases of community assembly. To integrate seed traits into community ecology, we investigated germination patterns at community level. In particular, we analyzed to what extent temperature and photoperiod act as abiotic filters for seed germination across species in foredune communities.

We performed a cluster analysis on a database of 504 plots x 155 species of coastal dune vegetation carried out in NE Mediterranean coast (Veneto, Italy). According to this procedure, we identified the group of plots representative of the foredune community and selected all the species listed, including aliens, for a total of 19. To distinguish typical foredune species from those that thrive in other communities (e.g. annual grasslands of semi-fixed dunes), but can be accidentally found in the foredune, we used the fidelity (Phi coefficient) and frequency values. For each species, we analyzed the germination response to constant temperature (5, 10, 15, 20, 25°C) and photoperiod (12/12 light/darkness, and 24h darkness), through GLMM. Species were then grouped according to their germination response through cluster analysis and NMS ordination.

We identified four groups: two of them showed either high or very low germination at all tested conditions ("high-germinating" and "non-germinating" group, respectively). The other two groups had higher germination at warm temperature either in the dark ("dark warm-cued") or in the light ("light warm-cued").

Typical foredune species were both "non-germinating" (e.g. *Ammophila arenaria* and *Cakile maritima*) and dark warm-cued (*Salsola kali* and *Elymus farctus*). Species of semi-fixed annual grasslands were "high-germinating" (*Hypochoeris radicata*, *Medicago littoralis*, *Vulpia fasciculata*), while alien species were light warm-cued (*Erigeron canadensis*, *Oenothera stucchii*, *Xanthium orientale*).

Typical foredune species showed a narrow regeneration niche (high temperature and darkness) or complex germination requirements (e.g. "non-germinating", might require an overwintering period to germinate). On the contrary, annual species of semi-fixed dunes had a much wider regeneration niche, germinating under different conditions with high percentages. Alien species occupy an own regeneration niche, with optimum at high temperature in the light. Climatic events, as rising temperatures, or shifting seasons could alter germination patterns of foredune species, in turn favoring the regeneration by seed of species with a wide regeneration niche or those requiring high temperature (e.g. alien species). Our results provided new insight to forecast foredune ecosystem community assembly and its responses to changing environments.

Patterns and drivers of fine-scale beta-diversity in Palaearctic grasslands

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Aim: Species-area relationships (SARs) describe how species richness increases with area. SARs that are based on series of nested plots are efficiently modelled with power laws, where the exponent (z-value) is a measure of standardised multiplicative beta diversity. Using this approach, we asked which biotic and abiotic characteristics influence fine-scale beta diversity of grassland communities across a broad biogeographic gradient.

Location: Grasslands and other tree-less vegetation of the Palaearctic biogeographic realm. Major taxa studied: Vascular plants, bryophytes and lichens.

Methods: We extracted from the GrassPlot database, containing standardised vegetation-plot data from a wide range of grassland types across the Palaearctic, the nearly 5,000 nested-plot series with at least four grain sizes. Besides vascular plants, terricolous bryophytes and lichens were often sampled, allowing evaluation of differences in beta diversity among these ecologically contrasting taxonomic groups. Power-law SARs were fitted to each of the datasets with non-linear regression to determine the z-values. These were then related to biotic and abiotic characteristics.

Results: We found that fine scale z-values were highest for lichens, intermediate for vascular plants and lowest for bryophytes. Biome and grassland type had no consistent effect on z-values. By contrast disturbance-related characteristics influenced z-values: they were higher in grazed *vs* mown grasslands and increased with slope angle (which is connected to increasing erosion). Also various measures of small-scale heterogeneity, such as microrelief, positively affected z-values.

Main conclusions: The exponent z of power law SARs from nested plots turned out to be a sensitive measure of fine-grain beta-diversity. Taxonomic groups significantly differed in their beta-diversity similar to previous findings at much larger grain sizes, i.e. vascular plants showed a much higher spatial species turnover than bryophytes which could be related to the much better dispersal abilities of spores *vs* seeds. For lichens (which also have spores) this effect seemingly is overwritten by their extreme specialisation to localised micro-habitats. We found that habitat characteristics related to productivity or benignness had no consistent effect on small scale beta-diversity, but small scale heterogeneity or disturbance types that could cause such had a positive influence.

Drivers of plant species richness in Bulgarian dry grasslands vary across spatial scales and taxonomic groups

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We investigated both vascular and non-vascular plant fine-scale species richness patterns in dry grasslands of two distinct mountain regions with contrasting bedrock and altitude in Bulgaria. We asked: (i) what is the species richness of vascular plants, bryophytes and lichens of dry grasslands and how does it change across different grain sizes? (ii) how does species richness differ among different life forms and functional groups? (iii) what are the main environmental factors driving the observed diversity patterns?

We sampled environmental data and all vascular plant, terricolous bryophyte and lichen species in 68 10 m ^{2} plots and 15 nested-plot series with seven grain sizes (0.0001-100 m ^{2}) located within dry grasslands in Northwestern and Central Bulgaria. As a measure of beta-diversity we used z-values of power law species-area relationships. To assess the importance of environmental variables as predictors of species richness and z-values, we used generalized linear mixed models (GLMMs), generalized linear models (GLM) and multi-model inference.

Maximum species numbers in 10 m² were 60 vascular plants, 9 bryophytes and 12 lichens. The highest species richness for all taxa together was 6 species in 0.0001 m ^{2}, 62 in 10 m ^{2} and 89 in 100 m2. The most important factors affecting total species richness in 10 m ^{2} plots were soil pH (unimodal), conductivity (positive), inclination (negative) and heat load index (negative relationship). The species richness of non-vascular plants was strongly affected by the litter cover (negative), proportion of sand (positive), cover of stones and rocks (positive) and inclination (negative relationship). The z-values for all taxa across all the scales ranged from 0.196 to 0.341 with a mean of 0.240. The only predictor having a relationship (positive) with the z-values was elevation.

We found a strong spatial-scale dependence of the impact of most variables on plant species richness. In several cases (pH, grazing intensity), the impact of variable was opposite at various scales. In case of grazing, this varying effect of spatial scale may be attributed to the different interaction between grazing intensity and the intrinsic spatial structure of the vegetation. In agreement with results of similar studies from other Palaearctic dry grasslands we found that the importance of environmental factors strongly differed among taxonomic groups and across spatial scales.

Steppe islands: where island biogeography meets the reality of a severely fragmented habitat

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Steppe is one of the most transformed and fragmented biomes of the world, but compared to European semi-natural grasslands, the studies on the impact of habitat loss and fragmentation on these zonal grasslands are relatively scarce. We asked how size of habitat island, its isolation and other landscape and local factors influence species richness of vascular plants, within small steppe patches located in intensive agricultural landscape.

We recorded all species of vascular plants and assessed environmental conditions of 112 kurgans (burial mounds) in southern Ukraine. We analysed species-area relationships (SARs) for total richness, habitat specialists and generalists separately. Then, we assessed the importance of environmental factors in explaining the residuals of the SAR models.

Patch area explained a large share of variance in species richness, particularly of steppe specialists. The estimates of a slope of the power function SAR (z-values) were highest for steppe species. Connectivity measures: the distance to the large habitat enclave and share of habitat in the surroundings, were particularly important for shaping specialist richness, while for generalists, which seemed to be more controlled by the direct kurgan surroundings, they were unimportant.

We found that the steppe 'islands' function for specialist richness in accordance with the theory of island biogeography. We attribute this for grassland patches unusual result to the peculiar features of the studied system. We conclude that the maintenance of the conservation value of these islands in the long-term is unachievable without the presence of large steppe areas in the landscape and enlarging their areas through restoration.

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Poster Patterns, drivers, and conservation opportunities of grassland biodiversity

Invasion of *Calamagrostis epigejos* in sandy dry grasslands: effects on biodiversity and effectiveness of restoration measures

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Aims: Usually, the term invasive is used for non-native species. However, there are also some native species with similar attributes, such as rapid spread in many natural and semi-natural ecosystems combined with negative impacts on biodiversity and ecosystem services. *Calamagrostis epigejos*, a rhizomateous tall grass native mainly to the temperate zone of the Palaearctic realm, is one of these native invasives. Thus, conservation practitioners have taken different approaches to counteract *Calamagrostis*, mostly with limited success. Based on a comprehensive, 6-year study, we here describe the expansion of *Calamagrostis* and its effects on plant biodiversity, and evaluate the effectiveness of seven different management strategies.

Location: Biosphere Reserve "Niedersächsische Elbtalaue", Lower Saxony, Germany.

Methods: To quantify the expansion dynamics of *Calamagrostis*, radial transects of 1 m² plots were established in six differently sized *Calamagrostis* polycormons and followed through the six years of the study. In a second, experimental study, seven different treatments (control, mowing once, twice and four times a year with removal of biomass; intensive sheep grazing, soil turning and top-soil removal at the start of the experiment) were applied to *Calamagrostis*-infested grasslands. Vascular plant, bryophyte and lichen composition, as well as *Calamagrostis* cover were monitored annually at two spatial scales, 1 m² and 100 m². We then tested the effects of *Calamagrostis* cover on species richness in these taxonomic groups, and particularly their red-listed and dry grassland specific taxa. Moreover, we analysed treatment effects on *Calamagrostis* cover, plant species richness and community-weighted means of functional traits.

Results: The lateral spread of *Calamagrostis* varied greatly between the polycormons from stagnation to 8 m within 5 yr. The experimental study showed that also in controls *Calamagrostis* cover decreased and plant species richness increased. At both spatial scales *Calamagrostis* cover was strongly negatively correlated with plant species richness in general, and particularly that of specialized and red-listed taxa. After five years the most effective measures in reducing *Calamagrostis* and facilitating target species were mowing 4x per year and top-soil removal. In contrast, intensive sheep grazing did not reduce *Calamagrostis* cover. Regarding the functional composition, mowing 2x and 4x had strongest effects with increasing values of specific leaf area and seed mass.

Conclusions: This 6-yr study showed that *Calamagrostis* invasions are not as mono-directional as generally thought. Instead, *Calamagrostis* polycormons can stagnate or even get less dense without treatment. Among the treatments tested here, only the very intensive measures of 4x mowing and top-soil removal provided clear long-term reduction in *Calamagrostis* cover, indicating that it is important to initiate countermeasures while invaded areas are still small.

Species-area relationships in continuous vegetation: evidence from Palaearctic grasslands

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Aim: Species-area relationships (SARs) are fundamental scaling laws in ecology although their shape is still disputed. At larger areas power laws best represent SARs. Yet, it remained unclear whether SARs follow other shapes at finer spatial grains in continuous vegetation. We asked which function describes SARs best at small grains and explored how sampling methodology or the environment influence SAR shape.

Location: Palaearctic grasslands and other non-forested habitats. Taxa: Vascular plants, bryophytes and lichens.

Methods: We used the GrassPlot database, containing standardised vegetation-plot data from vascular plants, bryophytes, and lichens spanning a wide range of grassland types throughout the Palaearctic and including 2,057 nested-plot series with at least seven grain sizes ranging from 1 cm ^{2} to 1024 m². Using non-linear regression, we assessed the appropriateness of different SAR functions (power, power quadratic, power breakpoint, logarithmic, Michaelis-Menten). Based on AICc, we tested whether the ranking of functions differed among taxa, methodological settings, biomes or vegetation types.

Results: The power function was the most suitable function across the studied taxa. The superiority of this function increased from lichens to bryophytes to vascular plants to all three taxa together. The sampling method was highly influential as rooted-presence sampling decreased the performance of the power function. By contrast, biome and vegetation type had practically no influence on the superiority of the power law.

Main conclusions: We conclude that SARs of sessile organisms at smaller spatial grains are best approximated by power functions. This coincides with several other comprehensive studies of SARs at different grain sizes and for different taxa, thus supporting the general appropriateness of power functions for modelling species diversity over many grain sizes. The poor performance of the Michaelis-Menten function demonstrates that richness within plant communities generally does not approach any saturation, thus calling to abandon the concept of minimal area.

Talk Vegetation patterns and processes

How much do alien plants produce floral resources for pollinators? A year-round study in riparian herbaceous communities in Japan

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Alien plant species have become major constituents of plant communities in many ecosystems. Alien plants may have established some functional roles in their new ecosystems, but this possibility has been largely overlooked in conventional ecosystem management. Alien plants often have large numbers of flowers and/or long flowering periods; therefore, they may act as a valuable food source for pollinator insects offering abundant nectar sugar and pollen for an extended period. If pollinators are dependent on alien floral resources, the eradication or density control of alien plants may pose negative impacts on pollinator populations and pollination services. To clarify the roles of alien plants for pollinators, we investigated the amount of floral resources and pollinator visitation for alien plants compared to native plants throughout the year in riparian herbaceous communities, where various alien and native plant species were grown in mixture.

We selected four riparian sites in Ibaraki, Japan, and established five 1 m x 1 m plots in each site. In each plot, we counted the number of bloomed flowers of every species and recorded visitation of bees, hoverflies, and butterflies to each bloomed species at a two-week interval in 2018. Based on the observed number of flowers and the mean sugar and pollen amount per flower for each species, we estimated the per-plot standing crop of floral resources derived from alien and native plants.

Standing crop of alien floral resources was larger than that of native floral resources throughout the investigation period in all the sites. Alien floral resources increased from April to July and then decreased, while such a seasonal fluctuation was not observed for native floral resources. Contrary to the visits to native plants, the number of bees visited to alien plants significantly increased in May, suggesting that abundant alien floral resources benefitted bees in spring. However, visits of bees to alien plants decreased in September, and contrarily, visits to native plants increased. The numbers of hoverflies and butterflies visits to alien plants did not differ from those to native plants and were constant throughout the seasons. These results suggest that alien plants act, not always but seasonally, as a main food source for bees; in our systems, alien floral resources support bees in spring, possibly by offering convenient forages after overwintering. The present study underscores the need for practical alien plant management considering their seasonal roles and potential benefits for population maintenance of pollinator insects in invaded ecosystems.

Important plant areas - California Central Valley pilot model

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Background and Methods: The state of California is a globally recognized biodiversity hotspot with over 6,500 native taxa, a third of which are endemic. It's rapidly growing population coupled with a housing shortage, increased demand for resources, and a changing climate has led to regional planning assessments to streamline the ability to meet such pressing and complex demands. To ensure that plants and their habitats are adequately represented and protected in such assessments, tools are needed to identify the most important areas to target conservation activities. An assessment of available data sets representing rare species, rare vegetation types, and areas of significant biodiversity was performed in California's Central Valley Ecoregion. This region was selected as a test case due to the increasing demand for housing, ground water, and renewable energy development, and an abundance of relevant resource datasets. Data was combined with regional expert input into 1 km^2 cells forming a grid over the entire study region using ESRI ArcGIS software. The compiled dataset was input to a relativistic model structure built using the Environmental Evaluation Modelling System developed by Conservation Biology Institute to produce a conservation index value for each cell. A 5-mile buffer was used around the study region to mitigate artificial edge effects, which was clipped out during analysis.

Results and Conclusions: Initial model outputs highlight wetlands, riparian corridors, former lake beds, and terraces lining the eastern edge of the valley floor as having highest conservation value for plant biodiversity in California. Due to the highly modified nature of the landscape, these features represent remaining areas within the California Central Valley Ecoregion which have not yet been converted to housing, energy development, or intensive agriculture. Model outputs will likely be more sensitive to changes in model attributes when run for ecoregions with largely unmodified landscapes. The transparent model structure facilitates collaboration among diverse stakeholders who may place different values on conservation attributes, and helps end users understand and interpret model results. This model can therefore be applied as a collaborative planning tool to efficiently target conservation activities where they will have the greatest impact for advocacy, conservation planning, and/or development of land management policies and regulations. Next steps include further model iteration based on comments received during peer-review, repeating this analysis for other California ecoregions including neighboring portions of the California Floristic Province in Oregon and Mexico, and assessment of compatibility with other efforts to identify Important Plant Areas.

Talk Long-term studies in vegetation science

Cool to be poor? How to preserve oligotrophic forest legacies in affluent industrial societies

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Intersection of lists of forest species, Ellenberg indicator values for nutrients and red lists of vascular plants highlights eutrophication as one of the chief threats to woodland biodiversity in Central Europe. A review of temporal and spatial patterns in the loss of oligotrophic forest habitats suggests that it is not solely a result of nitrogen-immissions from agriculture and combustion, but equally one of self-melioration in the course of primary and secondary succession. Acknowledging the importance of historical legacies (the "ghost of degradation past") has crucial implications on the preservation, restoration and management of forest ecosystems and their functions.

I suggest a baseline model of N-supply and soil acidification during postglacial vegetation history, whose epochs have each added characteristic legacies to the species pool, which call for complementary management paradigms in the face of eutrophication. I review effectiveness and feasibility of primary succession (postglacial), no-intervention reserves (prehistorical), conservation of species and habitats (preindustrial) and function-oriented silviculture (industrial reference period) for the conservation management of oligotrophic forest sites and their biotic communities.

In the face of continuing high N-immissions from agriculture and combustion, measures to reduce deposition and increase uptake and storage in forests must be supplemented by local conservation-oriented N-extraction through biomass (coppicing, wood pasture and litter removal) and topsoil as already practiced in grassland management and restoration.

Ecological and agricultural evaluation of different grassland management strategies

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Semi-natural temperate European grasslands inherit the highest plant species diversity on small spatial scale in the world, but their area and biodiversity is continuingly decreasing. The decline of species richness in semi-natural grasslands is mostly due to changes in management, both its intensification and abandonment, since the traditional management is no longer economically sustainable. We aimed to find a management strategy which is effective in conservation of species-rich grasslands and simultaneously fulfils the farmer's economical interests for the quality and quantity of their harvest. An eight-year experiment on a two-cut *Arrhenatherion* grassland in the South-West of the Czech Republic was established combining a different date for the first mowing (May, June, July, alternating) with low amounts of different organic fertilisers (none, liquid manure, compost, alternating; all at about 50 kg N / ha / year). We tested the effect of the treatments on the species composition and the amount and quality of herbage. The natural species composition was best supported by an early and alternating first mowing in plots fertilised with compost and manure, while there were little differences between mowing dates for unfertilised and alternately fertilised plots. All treatments applying fertilisation reduced the abundance of target species and increased the abundance of species showing degradation in some years. The influence of the fertilisation treatment on the species composition was more pronounced in the plots that were regularly mown later than in May. Nitrophilous species, especially tall grasses and *Apiaceae*, could utilise the higher availability of nutrients in the ground for faster growth and were able to outcompete other species most successfully in plots fertilised with liquid manure and mown in July. The early mowing in May was the treatment yielding the most nutritious herbage both for the first and also the second cut in October, providing the highest measures of digestibility, which were decreasing in the course of the year. Fertilisation had a significant influence on the biomass production in most years, showing highest yields in plots fertilised with liquid manure and alternately. Our results suggest that a two-cut mowing regime with an annually alternating first mowing date, with focus on a harvest in May, can combine the conservation of the natural species community of the studied semi-natural grassland with reasonable-quality herbage. In this mowing regime, even low organic fertilisation rates (as the ones tested) can be applied to increase the yield, having only a low negative impact on the development of the natural species community.

Scale effects on grassland dynamics of the Qinghai Tibetan Plateau observed from space

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The Qinghai Tibetan Plateau (QTP) plays an important role in the climate and hydrological system of Asia and is composed of a unique composition of grassland, steppe and desert ecosystems. Its vegetation cover provides important functions including erosion prevention, water retention and fodder for livestock. Observing and analysing vegetation trends across the QTP is crucial to understand effects of recent climate and land-use changes. However, earlier studies based on field or remote sensing data often reported contradictory trends. One important reason for these contradictions may lay in scale effects (both, extent and grain) which hamper the integration of local field knowledge with remote sensing-based observations covering larger extents.

Most remote sensing studies covering the entire Tibetan base on data with a coarse spatial grain. Here, we present findings from a high-resolution (30 m pixel size) Landsat-based NDVI vegetation product delivering information on the occurrence of negative and positive vegetation trends for the entire Tibetan Plateau and for the time period 2000-2018. We tried to explain the fractional cover of negative vegetation trends in a 0.085° grid using environmental variables related to topography, climate and anthropogenic influence via a random forest regression in a South-West to North-East transect across the complete QTP. We conducted the analysis for the complete transect and in within a moving window approach for smaller subsets within the transect. We also compared the results based on the Landsat product to the results obtained with an identical product derived from MODIS data (500 m pixel size).

Our results for the complete transect show that the environmental variables can explain over 70% (Landsat) and 50% (MODIS) of the variance of the fractional cover of negative vegetation trends. The most important variables were similar for Landsat and MODIS but the corresponding response curves of the variables differed drastically, in some cases showing opposite trends for Landsat and MODIS. Results of the moving window approach suggest that the importance of the environmental variables varies notably depending on where on the QTP the analysis is conducted.

The scale effects observed for both spatial extent and spatial grain have a drastic influence on the results concerning which environmental parameters correlate with an increased area of negative vegetation trends. We particularly found that remote sensing-based analyses based on coarse grain data may lead to misleading interpretations concerning the causal relationships between grassland trends and environmental and anthropogenic variables. The results of our study call for remote sensing studies based on high-resolution datasets covering large spatial extents in combination with detailed local field studies allowing for a better understanding of the land-use decisions and environmental processes leading to negative vegetation trends.

The return of the fuzzy - ups and downs of remote sensing based mapping approaches for natural vegetation

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Natural vegetation forms fuzzy patterns of plant species composition. For more than a century, researchers aim to assess and map these patterns using Earth observation data for further analysis or monitoring purposes. In the body of literature on vegetation mapping, three general mapping approaches are frequently used: crisp classification, fuzzy classification, and gradient mapping. These approaches differ fundamentally in how species composition is described and presented in the resulting map.

Crisp classification meets the thinking of phytosociology. Each pixel is unambiguously assigned to a specific class that has been defined in a classification key. While this concept is in line with the human preference for pidgeonholing and easily enables area statistics, it has some limitations. First, ecotones are not well represented in the resulting maps since they often consist of transitions between the mapped classes. Second, for image pixels that contain a mixture of two or more classes, a certain loss of information in the map has to be accepted.

In contrast, gradient mapping builds on Gleason's continuum concept and aims to preserve all gradual transitions in species composition. Based on an ordination of vegetation records, each image pixel is assigned a position in the ordination space. This ordination-space position can be treated as proxy of species composition. Ecotones are well represented in the resulting map, there is no need for the definition of 'typical' classes and mixed pixels do not pose any problem. However, since the approach is data driven, an a priori definition of the mapped gradients is hardly feasible. This hampers the comparison of different areas. Further, area statistics are also not possible.

Fuzzy mapping aims to preserve the best of both worlds. The mapped units are defined as hard classes, but the resulting map shows the cover fractions per class and pixel. This enables area statistics and a spatially explicit accuracy assessment but preserves the fuzziness of the vegetation patterns in the map. It is, however, sometimes challenging to represent the distribution of all classes in a single map product. In this presentation, we attempt the - to our best knowledge - first fair and systematic comparison of the three mapping approaches. Using airborne hyperspectral data from a mosaic of raised bogs, poor fens, transitional mires and *Molinia* grasslands in the alpine foothills in Southern Germany as exemplary study area, we systematically discuss the advantages and disadvantages of the three approaches. This includes data requirements, the interpretability of maps and legends, as well as opportunities for monitoring and further analysis.

Talk Patterns, drivers, and conservation opportunities of grassland biodiversity

Hot and intense fire affects vegetation regeneration of the Cerrado herbaceous layer

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Cerrado is a fire-prone ecosystem which has evolved in the presence of fire in the last million years. Although fire influences vegetation structure and diversity, zero-fire policy still prevails in natural reserves in Brazil, leading to negative consequences such as changes in physiognomy, loss of savanna plant and animal species and finally, the periodic occurrence of wildfires. In 2017, wildfires occurred in different parts of the Cerrado, leading to hot and intense fires that might have negative impacts on vegetation. Therefore, the effects of more intense fires were tested by a manipulative experiment by changing the amount of fuel load (reducing by the half and increasing 2-fold) in order to measure these effects. Twenty four plots (2 m x 2 m) were established in open savannas areas: 12 of them had their biomass cut 5 cm above the surface. Biomass was weighed and 700 g m^{-2} was added in the other 12 plots. Therefore, we had plots with ca. 50 g m^{-2} of biomass (low intensity, LI) and plots with 1400 g m^{-2} of fuel load (high intensity, HI). Vegetation was sampled in all plots (% cover graminoids, forbs and shrubs) and thermocouples were established within each plot to measure fire temperatures. Fire was set in wind direction and temperatures were measured every 2 s. One year after fire, vegetation was sampled again, as well as biomass, which was grouped into live, graminoids and dead biomass. HI plots experienced the higher temperatures, showing that fire was more severe in these plots.

One year after fire, there was a decrease in forb and shrub cover in the high intensity plots and vegetation had not covered the entire plots, while low intensity fires recovered more than 80% of the plot area. On the other hand, high intensity fires had the highest amount of biomass accumulated in one year, mostly due to the higher amount of graminoids biomass, showing that this group was positively affected by hot and intense fires. In general, species diversity increased after fire equally in both treatments showing that fire alone increased species diversity. The results show hot and intense fires, caused mostly by fire exclusion and the accumulation of fuel load (mostly dead fuel) could lead to decreases in forb and shrubs cover, but would stimulate the production of grasses.

Talk Macroecological vegetation science: large grain patterns and processes of plant diversity

Geographical trends in functional traits in a temperate flora

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Recently available extensive datasets on plant distributions across the whole national floras and on functional traits of such floras and increasing availability of fine-scale information on the abiotic environment make it possible to explore the trends in plant traits across geographical space and explain them as a function of large-scale environmental factors.

Our aim is to define the main axes of variation in plant traits as surrogates for functional strategies and to test how functional trends vary with changing environmental factors at a large scale. We used the Pladias Database of the Czech Flora and Vegetation to extract plant composition in cells of 5 longitudinal minutes × 3 latitudinal minutes covering the whole country. We also extracted 79 species traits and calculated Principal Coordinate Analysis based on the Gower weighed distance among species, defined by their traits. We then used species composition of cells to calculate the average of scores for each of the first four ordination axes and mean trait dissimilarity within a cell as a measure of functional diversity. The functional trends (score averages and trait dissimilarity) were plotted on the country map to facilitate the interpretation of trends. We also related each of the functional trends to large-scale environmental factors such as precipitation, temperature, topographic wetness and bedrock using linear models.

The first four axes of the ordination represented approx. 30% of the total variation in traits. The first axis separated the annual herbs occurring mainly in warm lowlands *vs* perennial, clonal herbs or dwarf shrubs occurring mainly in cool and wet mountain areas, which are mostly formed of nutrient-poor rocks and have a larger representation of forest in the landscape. The second axis contrasted species with short-living shoots, large SLA, including hydrophytes, geophytes, in general R strategists and species more related to wetlands *vs* species with long-living shoots, large leaves with high dry matter content, usually C or S strategists with a higher presence in mesic/dry areas. The third axis reflected the difference between species with simple persistent-green leaves, prevailing dicyclic or polycyclic shoots in warm wetland areas, and those with compound summer-green leaves with monocyclic shoots in the areas with relatively high precipitation, poor soils and low temperatures. The fourth axis contrasted wind-pollinated species with fleshy fruits, often trees or shrubs, generally S strategists, related to the areas with acidic, nutrient-poor soils (submontane and montane landscapes on base-poor ancient rocks, also slightly cooler and precipitation richer) *vs* insect-pollinated species with dry fruits (lowland areas with Cretaceous and younger sediments, with more base-rich and nutrient-rich soils). Functional diversity within cells is higher in warm areas with low precipitation and outside wetlands.

Scale-dependency in the effects of long-term fertilization, haying and seed supplementation on grassland community structure

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It's widely recognized that processes controlling species diversity in communities can vary with spatial scale. Evaluation of these scale-dependencies is critical to better understand biodiversity patterns and to predict the responses of communities to natural and anthropogenic environmental changes. Further, because scale-dependencies are ubiquitous, a greater understanding of them is essential to the improvement of general theories of community organization. In this study we present results from a long-term field experiment established in Kansas, USA, in 2001 to investigate interactive effects of fertilization, annual haying and supplemental seeding on plant community structure and restoration of tallgrass prairie vegetation on abandoned agricultural land. Previous work documented plant community responses to these treatments at a single spatial scale. In this study we use data collected at scales ranging from 0.25 - 8 square meters, thirteen years after initiation of the experiment, to investigate potential scale-dependencies in these interactions. Significant scale dependent effects were reflected in the varied slopes of species accumulation curves and confirmed from two separate analyses. First, we analyzed the response of species richness using a linear model with fertilization, haying, seed supplementation and spatial scale as fixed factors. Second, we developed a three-way model evaluating the fitted z-values of species-accumulation curves as the response variable with fertilization, haying, and seed supplementation as fixed factors. We found a negative effect of fertilization on species richness that was much greater in magnitude in non-hayed than hayed plots, and a positive effect of haying on richness that manifest only in fertilized plots. The scale-dependence of the interaction between fertilization and haying manifested as: an increase in magnitude of the positive effect of haying on richness with scale in fertilized plots only; and a decrease in magnitude of the negative effect of fertilization on richness with scale in hayed plots only. In non-fertilized plots there was a positive effect of seed supplementation on richness that was invariant across scales, indicating strong seed limitation at all scales. However, in fertilized plots, this positive effect of seed addition was negligible at the smallest scales, but increased in magnitude with scale. Our findings indicate that the nature of interplay between multiple factors modulating species coexistence can be highly scale-dependent and that studies with observations taken at a single scale should be interpreted with care. We discuss how the explicit consideration of scale in experimental studies can improve our capacity to understand the impacts of multiple environmental perturbations on communities and aid in our ability to distinguish between alternative models of community organization as applicable to a given system under study.

Fracking impacts on the shortgrass steppe, Colorado, USA

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With new technological advances in slick horizontal fracturing, we are seeing an unprecedented increase in the frequency and magnitude of oil and natural gas (O&NG) production, causing a novel impact on native flora and fauna. The two major impacts of fracking include the accidental release (leaks) of volatile organic compounds (VOCs) and the physical changes to the site. However, few data are available on the amount of VOCs or the ability to restore well sites following plugging and abandonment. The objective of this study was to quantify volatile organic compounds adjacent to fracking and characterize proximate vegetation cover, diversity and functionality during well production and following abandonment. Study sites were randomly selected from Pawnee National Grassland (PNG) public lands in Northeastern Colorado, USA. Sites (N=20) were grouped according to status (PA or PR) and production date (spud date) to chronologically examine restoration success: PA = Plugged and abandoned in the 1980s (n=4), PR1 = Producing since 1980-1990 (n=6), PR2 = Producing since 2000-2005 (n=5), PR3 = Producing since 2006-2013 (n=5). There were significant differences between production groups for all VOCs. A majority of VOC concentrations were highest on sites with active (i.e., pumping) wells. Concentrations of VOCs were generally greater on sites with combined fugitive emissions, flaring, blowdown and venting operations (i.e., pumping sites). The mean concentration of benzene was 0.11 mg/m3 (0.03392 ppm) for all sites combined, which is nearly four times the EPA reference concentration (RFC) of 0.03 mg/m ^{3}. On pumping sites, toluene was, on average, above 3 ppm and MEK was nearly 2 ppm. In general, PA 100 m sites were vegetatively different from PR sites, including PR1 sites, which were reclaimed for > 30 yrs. Satisfactory reclamation was achieved on PR1 and PR2 sites as vegetation was at 80% total cover when compared to natural vegetation. PA sites were the highest in diversity indices E, H, D and FD, and PR3 sites were the lowest. Thus, it seems recovery over time is possible. We did not find high functional redundancy on O&NG sites; instead, we found high species diversity and high functional diversity on PA sites. The data suggest the potential hazards of VOC leaks near fracking sites, but also some ability to restore sites following abandonment.

Should I wait or should I act? Enriching plant diversity in agriculturally used grasslands via disturbance and seeding

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Diverse grasslands provide important ecosystem services and regulating functions. Biodiversity, however, has drastically declined due to agricultural intensification and the restoration of species-rich grasslands is thus a major target in nature conservation. Disturbing the vegetation sward and seeding diverse plant mixtures is a promising tool to increase diversity but has rarely been applied in agriculturally used grasslands. Whether land-use intensity affects the enrichment success and how increased diversity affects ecosystem functions in real-world grasslands therefore remains widely unknown.

We established a full-factorial disturbance and seeding experiment in 73 grasslands along a land-use intensity gradient in three regions in Germany. Topsoil disturbance and a diverse seed mixture were applied to test how effectively plant diversity could be increased. Vegetation, productivity and effects on soil nutrient availability were monitored over five years.

Our study shows that the combination of topsoil disturbance and seeding significantly increased diversity in most grasslands, while seeding alone is much less effective. After five years, plant species richness was 35% higher in the combined treatment compared to the control. Productivity and soil nutrient availability were only temporarily affected by disturbance and quickly recovered to original levels. We conclude that it is possible to increase plant diversity in most grasslands without long-term negative impacts on productivity or nutrient losses.

Poster Vegetation patterns and processes

Reestablishment and growth of the invasive alien species *Senecio madagascariensis* Poir. on abandoned paddy fields

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Senecio madagascariensis Pior. (fireweed) is an invasive alien plant, which originated in the tropical and subtropical grassland habitats in Madagascar and South Africa. This species has invaded Australia, Argentina, Brazil, Hawaii, and Japan. In Japan, it has spread on bare ground, road sides, abandoned paddy fields etc., from Kyushu to the southern part of the Tohoku district, especially in Awaji Island, Hyogo Prefecture, western Japan. At the regional and continental scales, climate may be a major driver of invasive species occurrence (Hellmann et al. 2007). The distribution of *S. madagascariensis* was affected by temperature in Japan (Thutsumi 2011). Conversely, at the local scale, distribution of alien species is likely affected by habitat conditions dependent on traits of the alien species. This species becomes dominant and reduces biodiversity in many regions. In many areas of Japan, this alien species has been controlled, but its seeds continue to rapidly invade areas where the plant has been removed. Controlling reestablishment of seedlings is important for preventing the expansion of this alien species. The objective of the present study was to clarify the pattern of establishment of its seedlings under different habitat conditions after control treatment. Field surveys and experiments were conducted on abandoned paddy fields in the southern part of Awaji Island. The mean annual temperature and precipitation of the meteorological station nearest to the study area were 15.2 °C and 1,634 mm, respectively. Control treatments (hand weeding and herbicide treatment) were applied to the field in November 2010. After removing the plants, the plot surface was covered with bamboo chips (hand weeding plus bamboo chip mulching) in November 2012. After treatments, the coverage and height of *S. madagascariensis* were measured, and the number of inflorescences was counted every 10 days. Peaks of inflorescences were found at the end of October (autumn) and the end of May (spring). Seed production peaked from November to January and May to June. In the hand-weeded plots, all shoots with fireweed roots were removed, but new seedlings were found in November (15 days after the treatment). In the plots with herbicide, all plant shoots had died, but dead shoots remained and covered the surface of plots. In these plots, new seedlings were found in February (150 days after treatment). In the hand-weeded plus bamboo chip plots, fireweed seedlings did not occur up to approximately 4 years after treatment. In abandoned paddy fields where water supply continued, *S. madagascariensis* did not occur. Surface condition of abandoned paddy fields was considered important for control of this alien species.

Potential natural vegetation and forest restoration: How species will come back? And Conclusions

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Comparisons of biodiversity can show many results: species counts, structural and functional aspects at different levels of biological organization. Biodiversity is also related to environmental factors including human impacts. Understanding these many aspects may help to restore vegetation types. Natural forests have been restored by plantation of native seedlings from temperate to tropical forests, based on phytosociological data. High alpha and gamma diversity are seen in Southeast Asia and low diversity at the northern limit of warm-temperate forests; secondary forests in Southeast Asia are low and northern warm-temperate forests are high under human management. Restoration of natural forests by the so-called Miyawaki method (plant seedling of indigenous species with high density and mix plantation) does not require maintenance except in the first three years. Fast growth is required in the first three years, then other species come back in after five to ten years. This depends on the plantation density, bird visits, and newcomer species. Re-colonization of tropical rainforests in Southeast Asia is more difficult than in subtropical evergreen forests. Most canopy tree species (*Dipterocarpaceae*) are distributed by wind. The canopies of subtropical forests are composed mainly of *Lauraceae*, *Rubiaceae*, *Myrtaceae*, etc., plus *Fagaceae* admixtures in Southeast Asia. Subtropical forests depend on bird dispersal. Comparison of growing speed, seedling mortality, and relation with newcomers are analyzed, and how to recover diversity is discussed.

Poster Vegetation patterns and processes

Phytoceonological studies in open sandy grasslands in the Hungarian Northern Great Plain (*Festuca* species and species composition of plant communities)

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During our survey the flora of sand grasslands along the Danube was studied. Coenological data were collected on the Hungarian Northern Great Plain on 5 locations (Vácrátót-Tece, Kisoroszi, Tahitótfalu, Szigetmonostor and Budapest Homoktövis Természetvédelmi Terület), in 12 well distinguishable vegetation patches in May, June and September 2018.

Dominant species were *Festuca vaginata* and *F. pseudovaginata*; the latter is an endemic species of the Carpathian Basin. Furthermore, we also found the hybrid taxon of these two species. We surveyed natural and degraded patches of both vegetation types; at Tahitótfalu strongly pastured grassland was also surveyed, where disturbance indicator *F. pseudovina* became dominant. Concerning species count and diversity *F. pseudovaginata* grasslands were more significant, particularly at Szigetmonostor, where this species can be found even in *Populus alba* patches. We also surveyed degraded versions of *F. pseudovaginata* grasslands, where weed and natural pioneer species became dominant in autumn. These populations form secondarily on disturbed or cut areas. *Festuca vaginata* grasslands were less diverse, but weeds did not occur during autumn data collecting.

According to nature conversation values *Festuca vaginata* vegetation types were of higher value, *F. pseudovaginata* patches showed both natural and degraded versions, but they composed individual vegetation types on a wider oecological spectrum and environment.

Our survey was supported by OTKA K-125423.

Local and regional changes in floristic diversity over the last 14000 years in NW Germany

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Pollen data offer the opportunity to analyse past changes in ecosystem parameters in response to changes in land use and climate. Thus, they provide baselines for evaluating current changes and scenarios for potential future responses to climate change. Based on a compilation of pollen diagrams from Europe we show that pollen type richness remained regionally stable or declined with postglacial climate warming, due to the expansion of forests. This dataset also demonstrates the regional increase in pollen type richness with manmade forest clearance and the expansion of agriculture. Here we want to examine, how these regional patterns compare to single sites and examine past changes in pollen diversity and ecosystem properties in more detail. Eversener See is a small lake situated 30 kilometres east of Bremen. The pollen in its sediments provide a continuous account of local vegetation change for the last 14,000 years. Pollen type richness at this site was high for the Lateglacial with open vegetation types. Richness declined during the Early Holocene with the closure of the forest and increased to highest values with the deforestation during the Late Holocene. The Early Holocene drop in pollen type richness could potentially be an artefact due to the high pollen production of trees compared to herbaceous plants and the proportion of tree pollen explains a large proportion of the pollen type richness in individual samples. However, this factor alone cannot explain the strong decrease in richness. The decline in richness was likely due to the replacement of rich open vegetation types by a species poor forest. Taxonomic turnover was highest after the onset of the Holocene at around 11,500 years ago together with the strongest rates in compositional change. Pollen type richness of pollen types found in Lateglacial samples declined until around 9,000 years ago. Thereafter the number of pollen taxa appearing over consecutive samples increased again. This general rise was punctuated by periods with higher settlement activity around the lake, causing peaks in richness. However, the strong general trend started before land use induced forest clearance suggesting a gradual increase in plant diversity within the forested landscape perhaps due to delays in the dispersal and establishment of plants. This early increase differs from the regional trends, which may be due to plants starting to spread in the landscape from localized pockets where establishment was successful after rare long distance events.

The origin of Alpine farming. Reconstruction of human induced vegetation changes in the subalpine and montane belt of the Bavarian Alps

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Alpine farming and pasturing at high altitudes in the Alps have created one of the most species rich and diverse landscapes in Europe. In order to fully understand, appreciate and protect these habitats it is essential to learn about their history and origin. With the discovery of remains from alpine dairy huts, archaeological studies showed that there is definite proof of alpine farming beginning in the Bronze Age in different parts of the central Alps. Palynological data as well as linguistic findings from different studies in central parts of the Alps support these findings. On the northern fringe of the Alps, however, little or no research was done in the context of prehistoric alpine farming. Our study therefore focuses on the reconstruction of the vegetation in the montane and subalpine belt of the Bavarian Alps in order to detect first human impact. Our results suggest strong human activities with fire clearings and subsequent alpine farming during the Iron Age. Increases in non-arboreal pollen and pasture indicators illustrate the transformation of naturally closed forests to open and herb-rich semi natural pastures on the subalpine and montane slopes. Preliminary pollen and charcoal data from our study indicate human impact on the mountain vegetation already in the late Neolithic period. These results underscore the value of these alpine and subalpine grasslands not only as biodiversity hotspots but also as biodiversity monuments.

Talk Vegetation patterns and processes

Colonisation resistance and establishment success in experimental plant communities under different functional and phylogenetic diversity regimes

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How colonizing species are able to enter resident communities remains a central question in ecology. While functional and phylogenetic diversity (FD and PD) of the resident community are expected to exert a role in community resistance, very few studies have assessed this experimentally or evaluated their interactive effects. We used a diversity experiment to disentangle the role of FD and PD by sowing monocultures and mixture of 6 species, drawn from a pool of 19 species naturally coexisting in Czech mesic meadows. The mixtures were designed to cover four independent combinations of high and low FD and PD. Species covers were estimated in spring and late summer over 3 seasons. We then assessed the resistance of the resident (sown) communities to natural colonizers, and characterized the success of colonizers in relation to their functional and phylogenetic distance from the resident communities.

Results generally indicated that FD decreased community resistance to natural colonisation. However, PD tempered this effect: with high PD, FD was not significant, suggesting overlapping information between these components of biodiversity. Decomposing the community structure into trait means and diversity, we were able to identify key features of dominant species promoting colonisation resistance. From the colonizers perspective, greater difference in functional traits from the resident community tended to improve colonisation success. However, the effect was subtle and significant only for a relatively small proportion of colonizers (14%). The phylogenetic distance had no detectable effect.

Our results confirm a certain interplay between FD and PD in their support of ecosystem functioning, namely resistance to colonizers, suggesting that they only partially overlap in their information about community structure. The widespread hypothesis that higher FD increases resistance by a more complete use of resources was challenged, suggesting rather that greater FD could provide an unsaturated functional trait space allowing functionally unique species to enter it.

The very first steps of primary succession in floodplains -Results from 4 years of vegetation and seed bank monitoring on a new sediment bar in the middle Loire River (France)

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Colonization of new habitats is a potentially complex process for plants. It implies vector-mediated transport from the parent plants to the new habitat mainly as seeds. Dispersal is then followed by germination, establishment and survival, after having passed series of environmental filters, and maybe after having responded to one or several specific stimuli. Where germination does not occur immediately, seeds may accumulate within sediments and form more or less perennial seedbanks that may allow germination and establishment later on.

Colonization in the context of fluvial pioneer habitats has a series of specific features: seeds may arrive by wind or animals as in other habitats types, but the dominant process is generally hydrochory, and colonization may involve either vegetative fragments or seeds. During floods, sediments can be re-mobilized or new sediments containing seeds can be deposited over older sediments, creating potentially a strong link between seed bank characteristics and site morphodynamics.

Our study took place on the middle reaches of the Loire River, close to the city of Orléans. The floodplain in this sector is characterized by an anabranching fluvial style. Pioneer habitats typically have sandy-gravely sediments and are frequently re-modeled by erosion and/or sediment deposition during high-water stages.

As a measure to reduce flood risk, an existing island had been removed in September 2012, and a new sediment bar is building up since then. Sediment characteristics and bar morphodynamics have been intensively monitored since 2013, and vegetation and seed banks were monitored yearly on a network of 46 regularly distributed plots over the upstream, down-stream and center zone of the island since 2015. This monitoring scheme allows to address the following questions: (i) What are the spatial and temporal dynamics of sediments and sediment characteristics? (ii) What are the spatial and temporal dynamics of vegetation, seed bank composition and seed bank densities in terms of species and plant traits?

We hypothesize that seed bank density will increase with time and will be positively correlated to temporal stability of the considered zone. A conceptual, spatially explicit model of the colonization process will be developed.

Retrieving early indicators of high impact of an invasive ecosystem engineer from remote sensing data

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High impact invaders, such as the N-fixing *Acacia longifolia*, are a major threat to ecosystems worldwide. They can build persistent and monospecific stands resulting in a clear decrease in native biodiversity. While the local impact of *A. longifolia* on ecosystem structure and functioning in biodiverse Mediterranean dune ecosystems is well understood, there is a lack of methods for early detection of its impact at larger scales. Thus, we aimed to assess impact from leaf to landscape scale using sensor-based techniques and focussing on three questions: Do leaf traits, e.g. N content, differ between *A. longifolia* and native species, and is it possible to map these traits? Can *A. longifolia*'s spatial impact on N cycling be tracked at stand level using functional tracers? Finally, how can *A. longifolia*'s modifications of ecosystem structure and functioning be detected and monitored at landscape scale?

First, we could show that the invader differs in its biochemical and biophysical traits from the native species of the same growth form, particularly regarding leaf N content. This dissimilarity may provide an indicator for invaders with a high impact on N cycling. It can be retrieved from hyperspectral data, which emphasizes potential for mapping.

Second, the impact of the invader on N cycling at the stand scale could be traced joining a functional tracer of N-fixation, the stable isotopic composition of nitrogen δ15N, with airborne laserscanning (LiDAR) data. Foliar δ15N of the non-fixing, native shrub *Corema album* increased in vicinity (5-8 m) of invader stands over and above the influence of environmental heterogeneity derived from LiDAR. Thus, the uptake of N previously fixed by the invader could be mapped, which gives mechanistic insights into the invasion process.

Third, *A. longifolia* could be mapped at landscape level by integrating airborne hyperspectral imagery and LiDAR data with a Sensitivity of 0.79, a Positive Predicted Value (PPV) of 0.81, and Cohen's Kappa of 0.77. Productivity in terms of Gross Primary Production (GPP) was calculated based on the recently developed Near-Infrared-Vegetation Index (NIRV). A clear increase of GPP after invasion was detected in this nutrient-poor dune ecosystem even at early stages of invasion when *A. longifolia* cover was below 10%. As an invasion by a resource-allocating tree that modifies ecosystem structure and functioning in areas with low resource abundance is a typical pattern or "Invasion Syndrome", we suggest that the NIRV-Index can be a model metric to track this invasion pattern in time and space using spaceborne data.

Thus, early indicators of high impact can be retrieved using remote sensing, which offers promising possibilities for monitoring invasions of ecosystem engineers in sensitive and biodiverse ecosystems.

The challenge of mapping tree species with low abundances using UAV images

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Biodiversity monitoring requires sound and objective methods and tools to detect changes in species abundances. Drones allow the precise mapping of tree species with very high resolution imagery. However, little is known about how species abundance itself, an important component of biodiversity, affects classification accuracy. We studied these effects in a thornbush savanna in central Namibia using RGB-NIR drone imagery and a canopy height model. We used a random forest algorithm to classify tree species using a variety of data and species subsets. Our results show that seven out of sixteen species could not be mapped sufficiently due to low abundances, i.e. less than 10 individuals per species. Some species occurred only once or twice in the image. This in turn led to too small training data sets affecting classification accuracy. We conclude that a future challenge will be the mapping of rare tree species with drone imagery in the context of biodiversity monitoring.

Scale-dependent biodiversity patterns of Mediterranean grasslands in Turkey

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Patterns of plant biodiversity across spatial scales in semi-natural grasslands may vary in terms of taxonomic and functional groups. Since more detailed studies are needed to better understand species-area relationships (SARs) and community structure, I started to conduct a standardised multi-scale diversity sampling scheme accordingly to Dengler et al. (2016) using seven grain sizes (0.0001-100 m^2) as methodological procedure. I collected 3 biodiversity plots and 11 normal plots in semi-natural grasslands in April-May 2018 in Buca, Izmir, Turkey. A Mediterranean climate with rainy winters and hot summers is typical for the study area. Mean annual temperature is 17.8 °C and mean annual precipitation is 697 mm in Izmir (long term data of the Turkish General Directorate of Meteorology, 1938-2017). Biodiversity plots were selected in quasi-homogenous stands in terms of floristic composition. Shoot cover estimates of all living terricolous vascular plants, bryophytes, and lichens were recorded. Site management of two of the biodiversity plots was abandoned, while one was heavily grazed over the past 20 years. Environmental and structural variables were collected for each of the biodiversity and normal plots. Data was stored in an excel file in the GrassPlot database. I found overall 122 species in the plots, 31 graminoids, 90 non-graminoid herbs and 1 bryophyte. The genus of *Trifolium*, *Bromus* and *Medicago* had the highest species numbers in the study sites. *Trifolium tomentosum*, *Medicago minima* var. *minima*, and *Avena barbata* were the most frequent species including the biodiversity and normal plots.

Taeniatherum caput-medusae and *Trifolium tomentosum* were the most dominant species in the study area. Mean species richness of the biodiversity plots was: 0.0001 cm^2 = 5.5; 0.001 cm^2 = 7.2; 0.01 cm^2 = 9.2; 0.1 cm^2 = 15,3; 1 m^2 = 25.5; 10 m^2 = 32; 100 m^2 =41.3, and normal plots: 10 m^2 = 34.7 (ranging from 23 to 42). I found remarkable species richness in the study sites. My study indicates the importance of the scale-dependent biodiversity patterns both for alpha and beta diversity by multiple taxonomic groups in Mediterranean grasslands in Turkey.

How disturbance levels affect plant species diversity in urban grasslands

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Urbanisation is rapidly growing with increasing human population worldwide. During the last few decades, maintaining of biodiversity and ecosystem functions in urban areas has became one of the largest challenges. To achieve this, there is a need to understand the patterns in urban green infrastructures. In this study, I investigated the grassland vegetation of three urban habitat types, namely peri-urban areas, urban roadsides and vacant lots in the city of Izmir (West-Turkey). I used 50 sampling plots for each habitat type resulting in 150 plots in total for the analysis. I tested whether (1) different disturbance levels affect species richness/diversity and composition and (2) biotic homogenisation strongly occurs in disturbed habitats or not. I found that species richness/diversity and composition was strongly affected by different disturbance levels in urbanised areas. Urban roadsides resulted in the lowest species richness and Shannon diversity, while vacant lots and peri-urban grasslands resulted in significantly higher species richness and diversity. Plant species in heavily disturbed urban areas was made up mainly by disturbance-tolerant species.

Alien species were more frequent in urban roadsides and vacant lots than in peri-urban grasslands. Cosmopolitan species were most frequent in urban roadsides and least common in peri-urban grasslands in terms of cover scores, but not species richness/diversity. Alien and cosmopolitan species both increased in the habitats of intensely disturbed city centers resulting in more homogenised habitats. Despite the lack of endemic species for conservation, urban gasslands still play an important role for urban biodiversity as well as urban ecosystem functioning. Since plant species host many animal species and substantially affect the distribution of animal species, high plant species diversity contributes indirectly to the general biodiversity in cities. Such biodiverse cities positively affect the society and human well-being. After all, natural greening projects in urban areas should be managed in most of the cities not only for conservation but also for adaptation to future global challenges.

Land-use change overrides climate change effects on the diversity and regeneration of Africa's woody vegetation

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Tree diversity and regeneration are interactively driven by biotic and abiotic factors. The relative importance of these drivers is still poorly understood, particularly within the context of global environmental change. This knowledge gap hampers the identification and design of sustainable management strategies. Our study uses a crossed space-for-time substitution for climate change and land-use change, taking advantage of steep natural gradients of climatic aridity and land-use intensity in West Africa. The study area comprises three ecozones with different climatic aridity, from the subhumid forest-savanna transition ecozone over the Guinea Savanna to the semi-arid Sudanian Savanna ecozone of Ghana. In each zone, local gradients of land-use intensity were sampled, including communal areas as well as protected areas with and without fire. A nested plot design was used: height and diameter of adult trees were recorded in 50 m x 20 m plots while juveniles were recorded in two subplots (5 m x 5 m). Land-use intensity (i.e., the frequency and intensity of human disturbance) was recorded as protection status, presence or absence of fire, and an expert assessment of grazing intensity. To quantify topsoil properties, a composite sample of five cores (0-5 cm) was collected per plot and analysed for chemical soil properties. Climatic variables were obtained from the WorldClim database.

Principal Component Analysis was done for climate and soil variables to select potential predictors. Using species richness, the Shannon-Wiener diversity index and number of seedlings as response variables, linear mixed-effect models and model selection procedures were applied to test the links between environmental conditions and woody vegetation characteristics. We found that anthropogenic disturbances and edaphic conditions were generally more important than climate variables for tree diversity and natural regeneration. In particular, grazing was the most important driver of species richness and diversity (>40% explained variance) as well as regeneration (12% explained variance). Soil base saturation was the most important edaphic factor for all response variables. For species richness and diversity, soil organic matter and magnesium were also important. Our results show that changing land-use pressure - in conjunction with a high spatial variability of edaphic conditions - may override the effects of climate change on tree diversity and natural regeneration in Africa's savanna vegetation. The observed importance of land-use and soil implies that well-conceived adaptation strategies could mitigate potential negative effects of climate change on woody vegetation. Given the importance of timber and non-timber forest products for rural livelihoods, these results have important consequences for management and conservation planning.

Keywords: Sudanian savanna; Guinea savanna; forest-savanna transition; diversity; biotic and abiotic factors; climate change; land-use change

Talk Vegetation patterns and processes

Spatial patterns of plant structural diversity across forested wetland landscapes in Atlantic Canada

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The diversity of plant structural elements or functional types is a useful measure for assessing vegetation complexity in any ecosytem regardless of species diversity or composition. Structural diversity is expected to be greater at edges and ecotones, which can contain elements of both adjoining plant communities. Forested wetlands, such as treed bogs and swamps, are also known for their complex vegetation structure, which provides habitat for species at risk such as birds and epiphytic lichens in Atlantic Canada. Our objective was to explore patterns of structural diversity across edges between plant communities in forested wetland landscapes. We hypothesized that structural diversity would be greater at edges or within forested wetlands, with abrupt changes occurring at these transitions along the wetland to upland gradient. Our 14 study sites were located in temperate (Acadian) forested wetland landscapes dominated by *Picea*, *Abies*, *Betula* and *Acer* in Nova Scotia, New Brunswick and Prince Edward Island in Atlantic Canada. We placed one 120-m long transect at each site. Most transects straddled 1-2 edges between forested wetland and upland, open wetland or a different type of forested wetland. We estimated the cover of trees, saplings, shrubs in three different height classes, *Sphagnum* spp., other bryophytes, lichens, graminonoids, ferns, forbs in contiguous 1 m x 1 m quadrats along each transect. We calculated structural diversity using the Shannon index with the different plant groups as pseudo-species. We used wavelet analysis with the Haar wavelet to identify locations of abrupt transitions. Bivariate wavelet analysis with the Mexican Hat wavelet was used to measure the correlation between structural diversity and *Sphagnum* cover at different scales. Site-specific results varied widely from no trend to an increase or decrease in structural diversity from wetland to upland. An abrupt change in structural diversity at or near the edge occurred at only a few sites, occasionally accompanied by an abrupt change in *Sphagnum* cover. Bivariate spatial analyses were not conclusive, but structural diversity was more often positively than negatively correlated with *Sphagnum* cover at a variety of scales. By combining data all we found structural diversity was highest where there was 5-75% *Sphagnum* cover, intermediate levels between upland and open bog. Structural diversity does not appear to be a reliable measure for distinguishing forested wetland from upland forest at a broad scale. Instead, fine-scale heterogeneity in *Sphagnum* cover does seem to be associated with greater plant structural diversity on forested wetland landscapes. Forested wetland landscapes in Atlantic Canada are complex with varying site-specific patterns of structural diversity at different scales.

Long-term changes of temperate forest vegetation due to slow-acting alterations of trophic conditions

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Alterations in trophic conditions are one of the main components of global change. Shifts in land use and airborne depositions belong to relatively slow and persistent drivers influencing the forest ecosystems worldwide. Combined with management-driven changes in tree overstory, they cause long-term shifts in temperate forest understories. Our aim was to analyze the combined effects of these three factors on diversity and compositional changes of the herbaceous layer in forests of the Czech Republic. The complex nature of causal pathways makes the predictions extremely difficult; however, a basic hypothesis suggests that higher levels of nutrients would lead to more intense changes, generally to more eutrophic plant communities. We used a dataset of 2,292 semi-permanent plots, resurveyed after five to six decades (1950s-2010s). The plots cover most forest types of the region, from lowlands to mountains and in various trophic conditions. Land use history was derived from digitized country-wide maps of the 19th and 20th centuries (1840, 1880, 1950, 1990, 2006), enabling to track the shifts between forest and non-forest vegetation, and changes in the proportion of forest cover in the plots' surroundings. Plot-level depositions of total nitrogen and sulphur were derived from models ranging from 1900 to 2012. Finally, the impact of changed tree composition was expressed indirectly as community weighted means for two indicator parameters: shade casting ability and litter quality.

Statistical models reveal the nature of the forest vegetation changes driven by the three groups of slow-acting factors contributing to alterations in trophic conditions.

Talk Vegetation patterns and processes

With Ellenberg indicator values towards the north: does the indicative power decrease with distance from Central Europe?

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Ellenberg indicator values (EIVs) are often used as proxies for environmental conditions in areas beyond their Central European origin, a use further enhanced by the growing scientific attention to global change issues. The performance of EIV outside their geographic origin and over extensive gradients has, however, hardly ever been tested. The objective of this study was thus to assess if the indicative power of EIVs alters over a large geographic gradient and to examine the potential causes of such changes. Based on data on forest understory vegetation and soils from >15,000 plots from the Swedish National Forest Inventory we modelled the relationship between community mean EIVs and measured environmental variables along an extensive latitudinal gradient (>15°). We applied Generalized Additive Mixed Models to account for the design of the inventory, and for modelling potential non-linearities in the relationship between the mean EIVs and the environmental variables. Moreover, Huisman-Olff-Fresco models were developed for the relationship between the occurrence probability and the environmental variables to analyze if the widths of species niches change along the geographic gradient. Our study shows that EIVs for N (nutrients), R (pH) and T (temperature) are valuable as far north as the Arctic Circle, while those for K (continentality) showed a much weaker relationship with estimated continentality. However, the indicative power of the EIVs for N and R step by step became weaker in the direction of the north alongside shifts toward larger environmental niche widths of the indicator species. In conclusion, EIVs are useful indicators of soil conditions in boreal forests situated far north of Central Europe. However, the decrease in indicative power in the northernmost areas due to increasing environmental niche widths should be taken into account, when applying EIVs along long geographic gradients, to avoid spatial bias.

Talk Long-term studies in vegetation science

Fire promotes shrub encroachment in arctic tundra

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Wildfires are a naturally rare phenomenon in sub-arctic tundra ecosystems. Future climate shifts, however, will lead to a significantly higher frequency and extent of fires in those regions. Fire has been shown to change ecosystem properties of the arctic tundra strongly. The loss of an insulating plant and litter cover, due to combustion, increases soil temperature during summer significantly. Higher soil temperatures lead to permafrost thaw and mobilize belowground resources, causing enhanced plant growth. However, long-term effects of fire on vegetation dynamics are still poorly understood and have been rarely in the focus of research so far.

Therefore we studied soil and vegetation patterns of three fire scars (>44, 28 and 12 years old), situated at the northern border of the forest tundra ecozone in Western Siberia within the Yamalo-Nenets Autonomous Okrug.

Negative long term fire effects were evident for lichen cover which dropped dramatically and positive effects were found for bryophyte and shrub cover. These effects were still apparent more than four decades after fire.

A clear winner of tundra fires was *Betula nana*, which showed enhanced growth of individual plants after burning: diameter and height of the shrubs as well as SLA of the leaves increased strongly with time since fire, indicating increased vitality and growth potential, due to modified ecosystem processes after fire. Fire led to higher soil temperatures and thus to a deeper active layer. While the active layer and soil temperatures returned to normal levels after a certain time, we found shrubs to grow further, which reveals a strong fire legacy effect with far reaching impacts on the whole ecosystem.

We could clearly show that fire enhances the recent process of shrub expansion that has been described from many regions across tundra biomes as a result of global warming.

Talk Vegetation patterns and processes

The effect of tree species mixtures with European beech at different spatial scales on biodiversity of vascular plants, bryophytes and lichens

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Stand-scale tree species mixtures positively affect the multifunctionality of forest stands. Beside an increased stability, mixed forest stands are also assumed to facilitate forest biodiversity conservation due to an increased habitat heterogeneity compared to respective monocultures. This is why conifer monocultures of Scots pine (*Pinus sylvestris*) and Norway spruce (*Picea abies*), widely promoted in Central Europe since the 18th and 19th century, are currently converted into mixed stands with naturally dominant European beech (*Fagus sylvatica*). In order to verify a positive effect of mixed stands on the biodiversity of vascular plants, bryophytes and lichens, we investigated the plot (alpha diversity) and landscape (gamma diversity) level diversity of these three taxonomic groups in pure and mixed stands of European beech and conifer species (Scots pine, Norway spruce) in four regions in Germany. We generated hypothetical forest type compositions by resampling plots of pure and mixed stands so that all compositional combinations were represented in steps of 10% with 1000 replications. We aimed to identify compositions of pure and mixed stands at the landscape scale that can maximize gamma diversity of the three taxonomic groups within regions.

Results show that gamma diversity of the investigated groups is highest when a landscape comprises different pure stands rather than tree species mixtures at the stand-scale. Species mainly associated with conifers rely on light regimes and available substrates that are only provided in pure conifer stands, whereas mixed stands of beech and conifers are more similar to beech stands. Thus, our results show that the habitat heterogeneity provided by different pure stands at the landscape scale is more effective for biodiversity than the heterogeneity by mixing beech and conifers at the stand-scale. Combining pure beech and pure conifer stands at the landscape scale can therefore increase landscape level biodiversity and conserve species assemblages of both stand types due to a complementarity in species assemblages, while landscapes solely composed of stand-scale tree species mixtures could lead to a biodiversity reduction of the investigated groups of up to 20%.

We will additionally show results on alpha and gamma diversity of pure and mixed stands of beech and oak (*Quercus petraea*/*robur*) for the study region Schorfheide-Chorin in eastern Germany. For the same region we will also present an optimized hypothetical forest landscape composition for biodiversity of vascular plants, bryophytes and lichens comprising beech, pine, oak as well as different mixed stand types.

Talk Remote sensing of vegetation for biodiversity research

Using both a function trait and spectranomics based approach to understand *Rosa rugosa* invasion impacts on community litter decomposition

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Invasive alien plant effects on ecosystem functions are often difficult to predict due to the context-dependent interactions between the invader and the recipient communities. Adopting a functional trait-based framework could provide more mechanistic predictions for invasive species' impacts. Recent advances in hyperspectral spectroscopy have furthermore shown that much functional leaf information can be obtained from species' (hyper)spectral properties. Using this 'spectranomics' approach thus allows a potential shortcut to obtain functional (leaf) trait information without the need for extensive,

time-consuming trait sampling. In this study, we contrast litter decomposition rates among coastal dune communities with and without the invasive plant *Rosa rugosa* along the Belgian seacoast. We collected both several functional leaf traits known to be related to litter decomposition (e.g. SLA, LDMC, leaf nutrients) and leaf level hyperspectral reflectances, for all abundant species, to assess whether hyperspectral information has the same potential as classical functional traits for predicting *R. rugosa* invasion impact on litter decomposition. Our results show that, while *R. rugosa* introduced recourse conservative leaf traits, and thus low litter quality, to the community, invasion simultaneously shifted the community trait composition toward more acquisitive leaf traits, and thus higher litter quality. These community trait changes furthermore explained a large proportion of the invasion induced increase in litter decomposition. Interestingly, hyperspectral information was equally suited in explaining invasion induced changes in litter decomposition, thus illustrating the potential of spectranomics in ecosystem functioning research.

Strategies of species coexistence and species interactions: how long-term data can provide unique information

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Long-term data collection provide an excellent tool to identify the role of plant-to-plant interactions within a community. Spatiotemporal process in the community necessarily bears a signature of interactions between individuals and species which can possibly be identified using careful data analysis. In our study, we aimed to identify such interactions, to determine the role of alternative plant strategies for coexistence, and tested several plant traits as proxies for these interactions. We used a long-term (30 years) data series to disentangle interactions between species, differences in plant strategies of coexisting species. We recorded spatially-explicit ramet counts of 20 coexisting species in a mountain meadow at a scale of 3 cm x 3 cm cells in a grid. We use dynamic models fitted on these data to determine natality, mortality, dispersal and density-dependence of these species. This analysis shows two main directions of species differentiation: (i) slow vs. fast continuum, which separates species according to instantaneous growth rate and strength of density dependence, and (ii) dispersal vs. local dynamics, which separates species that rely on dispersal (by seeds or vegetative) in their dynamics from species that tend to stay in the occupied spot. We used data from a manipulative removal experiment to show that these two axes of demographic differentiation with a community predict well species' response to reduced competition. These two demographic axes show relationship to a number of functional traits (seed mass, lateral spreading distance, specific leaf area) indicating that these traits can serve as proxies not only of species environmental niches as has been shown earlier, but also of within-community functional differentiation. Finally, we use the data set to generate hypotheses on species-specific pairwise interactions.

Poster Vegetation patterns and processes

Patterns of taxonomic, functional and phylogenetic beta diversity in south Atlantic European coastal dunes

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We use coastal dune systems to study the variability of community structure and how patterns of regional variation could be predicted from the relative importance of biotic interactions and abiotic filtering. Coastal dunes in the Cantabrian-Atlantic biogeographical subprovince provide an excellent study system. The near ocean environment presents relatively harsh conditions, driven by the lack of organic soils, relative soil/sand instability, low moisture retention, and higher salt content that demand specialized adaptations. This constellation of environmental factors suggests that abiotic filtering is the dominant assembly process. These conditions are gradually relaxed in more-stable dunes, providing greater opportunity for assembly from the regional species pool. This suggests the prediction that measures of alpha and beta diversity across regional variation should increase as abiotic filtering becomes less important, allowing greater opportunity for influence by regionally-varying species pools and stochastic priority effects during assembly. We test the prediction of a negative relationship between environmental harshness and inter-regional diversity by examining taxonomic, functional, and phylogenetic diversity in coastal dune communities.

We use plot data from 12 sites spanning 750 km along the southern Atlantic coast of Europe. We calculated beta diversity and its decomposition into richness and replacement (turnover). db-RDA analyses were performed to estimate the correlation of diversity components with the biogeographical distance along the coast. Local contributors of beta diversity (LCBD) were calculated to observe how each location changed in relation to beta diversity.

We observed a significant correlation between biogeographical distance and taxonomic diversity for embryo dune samples, while for mobile and fixed dunes distance correlated with difference in all 3 diversity components. The richness component of Beta diversity was relatively higher in embryo dunes while replacement was higher in fixed dunes. LCBD showed no clear patterns. Therefore, despite the variation in species richness in embryo dunes, functional and phylogenetic diversity showed no correlation with biogeographical distance. This could be due to environmental filtering, which could select some main species. In fixed dunes, changes in species composition were accompanied by changes in functional characters and phylogenetic relationships.

Environmental conditions in this habitat are likely less stressful and species composition may be affected by interspecific interactions to a greater degree than in embryo dunes. The constancy of many species of embryo dunes across biogeographic gradient would give more importance to species richness in beta diversity decomposition, while in fixed dunes, species replacement is the dominant component.

Summer precipitation determines the distribution of vegetation formations, even in regions with a warm-temperate humid climate

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An understanding of the factors controlling the distribution of vegetation formations is of major interest not only in vegetation science, but also for assessing the impacts of climate change. Globally, the distribution of vegetation formations is primarily determined by temperature and precipitation. In regions with a warm-temperate humid climate such as eastern Asia and the eastern United States, vegetation formations are believed to be determined mainly by temperature and not by precipitation; however, there are limited studies assessing the statistical validity of this assumption. In this study, high-resolution vegetation maps were developed and used, along with softmax regression (also known as multinomial logistic regression), to create a distribution model of six types of vegetation formations in Japan, including subalpine conifer forests (Sa-CFs), subalpine broadleaf forests (Sa-BFs), cool-temperate deciduous forests (CT-DFs), cool-temperate conifer forests (CT-CFs), warm-temperate evergreen broadleaf forests (WT-EBFs), and warm-temperate conifer forests (WT-CFs). Four climatic variables, warmth index (WI), mean minimum temperature in the coldest month (TMC), summer (May-September) precipitation (PRS), and winter (December-March) precipitation (PRW), and two non-climatic variables, slope inclination (INC) and topography (TOPO), were used as explanatory variables. Of these six variables, WI, TMC, and PRS had the most predictive power to explain the distribution of vegetation formations. The accuracy of predictions made using the four climatic variables was 62.55%, and including coarser, non-climatic variables only improved this accuracy by 0.55%. These results suggest that climatic factors are predominant in controlling the distribution of vegetation formations in Japan on a countrywide scale. Additionally, finer topographic factors (within 1 km) were able to explain up to about 40% of the distribution of vegetation formations. According to two-dimensional predictions by WI and TMC (i.e., when other factors were not taken into account), both CT-CFs and WT-CFs should not occur in the climatic space of Japan. This is consistent with the vegetation-climate classification system generally used in Japan. If only temperature is considered, CT-CFs and WT-CFs are not recognized as climatic zonal vegetation formations in Japan. However, the areas of CT-CFs and WT-CFs within the climate space of Japan gradually increased with increased summer precipitation. These results suggest that along with temperature, precipitation is essential in determining the distribution of vegetation formations in warm-temperate humid climates, and that both CT-CFs and WT-CFs can be climatic zonal vegetation formations along a PRS gradient.

Species diversity, biomass or productivity: Who is the main driver?

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Are there any principle drivers of ecosystem processes and properties? We assume that there is a general trend in the resource use by life on earth, which trends towards an optimal or most parsimonious pattern. In accordance with this concept, evolutionary and ecological processes promote the resource use of assemblies of organisms. Individuals, populations, species and ecosystem properties are always composed and rearranged along changing conditions to an as much as possible optimal use of resources.

Patterns in ecosystem function and their dependence on resources have already been identified in ecological studies. Yet, the sequence: resource existence, resource availability, resource exchange, resource use and optimization of the resource use, in an ecosystem represents increasing complexity with a simultaneous decrease in our quantity of empirical evidence and understanding. We here discuss the importance of the resource use of all organisms involved, including humans, in the framework of selected theories.

Species diversity, biomass and productivity are important properties of every ecosystem and changes in these properties reflect changes in the compartmentalisation and resource use of the ecosystem.

Under changing ecological conditions the ecosystem is adapting the resource use permanently by adjusting the combination of these features. Due to the reduced resource availability during dry or cold periodes most ecosystems have smaller productivity, biomass and species diversity than during rainy or warm seasons.

Limited resources can be depleted during a short time with the effect that they are no longer available. Or they can be used moderately for a longer period of time. The perspective of the short-term use is maximal recent profit, the perspective of the long-term use is survival and reproduction. This apparent contradiction can be disentangled by the assumption of an integral effect on the time axis. The resource use itself must be adjusted and optimized all the time along all changing conditions with respect to short-term profit and long-term survival.

The species diversity can increase by immigration and evolution and decrease by emigration and extinction. Productivity is an important driver of recent conditions and a precondition for biomass. Biomass means storage and is a precondition for productivity and survival. In highly dynamic environments such as rivers high values of biomass or species diversity cannot be realized. On the other hand, forest ecosystems with a very high amount of biomass will never be extremely productive or species-rich.

We assume that all these interrelationships including human influences are controlled by the resource availability. Thus, optimization of the resource use might be the main driver of ecosystem features such as diversity, productivity and biomass.

Talk Global biodiversity of plant species, plant forms and plant communities

Vascular plants as epiphytes in the temperate zones: An overlooked phenomenon

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Vascular epiphytes make up about 9% of all vascular plants globally. They are mainly associated with the tropics and thus are largely neglected by scientists in the temperate zones. Lower precipitation and lower temperatures are given as the main reason for the lower abundance of vascular epiphytes at higher latitudes. However, the accidental epiphytic occurrence of terrestrial species is common in the temperate zones and can provide important insights in the evolution of obligate epiphytes, as this phenomenon might reveal the first steps from terrestrial to epiphytic growth. In a Central European low mountain range we studied the abundance and species richness of accidental epiphytes, their temporal dynamics and intraspecific differences among terrestrial and epiphytic conspecifics. We also considered host tree suitability, occupied substrates and microsites and differences in microclimate between the terrestrial and epiphytic habitat.

We surveyed more than 1,200 trees for epiphytic individuals of vascular plants in two consecutive years with respect to host tree species and occupied microsites. Furthermore, we studied intraspecific differences in functional traits of 220 terrestrial and epiphytic individuals and related these results to microclimate conditions on the ground and in the canopy of host trees.

In the first year, about one quarter of the surveyed trees hosted epiphytic plants. We found 1,450 individuals of more than 100 species and 39 different families. The majority of epiphytic individuals in the second year newly emerged, whereas one third persisted and a small proportion even reproduced in the epiphytic habitat. Accidental epiphytes were mostly restricted to host tree species providing water-storing substrates such as extensive moss pads or arboreal soil accumulated in crotches. In these microhabitats, nutrient and water content were generally high, providing even better growth conditions than on the ground. This was underlined by a higher water content, higher specific leaf area (SLA), lower leaf dry matter content (LDMC), lower C/N ratio and higher P content in epiphytic than in terrestrial conspecifics.

For the majority of the observed species, epiphytism is indeed an accidental phenomenon, but the fact that numerous epiphytic individuals persisted and some even reproduced in the epiphytic habitat illustrates that abiotic conditions do not per se inhibit epiphytic occurrence of vascular plants in the temperate zones. Besides water shortage, the availability of suitable host trees is a decisive environmental factor that limits epiphytism of vascular plants in Central Europe. In humus-filled crotches, water and nutrient availability are no more the limiting factors for plant growth. Then, the epiphytic occurrence of a species seems to be primarily determined by its capability to disperse.

Talk Long-term studies in vegetation science

Re-survey of floodplain forest vegetation along the Upper Rhine after 32 years

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In the year 1977 the last impoundments at the upper River Rhine were built leaving this part of the river in a heavily modified hydrologic and morphologic status. The Federal Agency for Nature Conservation (BfN) had the task to monitor the effects of these changes on the floodplain vegetation. More than 100 relevés were established by 1982. 82 of these relevés could be re-located in 2012. However, the site conditions of 28 of these have been strongly changed in the meantime including complete deforestation by storm events or by the forestry. The site conditions of 54 relevés seemed to be little altered. Therefore, in 2013 these sites were re-surveyed by the Federal Institute of Hydrology (BfG). A comparative analysis of the corresponding relevé pairs revealed that there are changes in diversity, stand structure, and site conditions as indicated by changes in mean Ellenberg indicator values of the relevés. The overall gamma and alpha diversity (mean species number) as well as the dominance (Simpson) was higher in the old relevés of 1981/82 while beta diversity was slightly lower. The main structural changes were significant increases of the cover of the herb shrub and tree layers from 1981/82 to 2013. The mean Ellenberg indicator values of the relevés showed an overall significant increase in soil nutrients and a significant decrease of soil moisture and continentality. However, the variance in all values is fairly high, i.e., the above mentioned main trends were reversed in some relevés. It remains unclear how these findings can be interpreted most of all because there are no reliable hydrologic data. Further investigations of land use changes and groundwater measurements may clarify the interpretation of the results.

Poster Vegetation patterns and processes

The effects of vegetation management on plant functional diversity and composition in *Quercus serrata* secondary forests on the Musashino terrace, Japan

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Abandonment of coppicing in secondary forest is thought as one of the major causes of recent decrease in plant species diversity in man-made landscapes. Restart of traditional forest floor managements has been tried for conservation purpose elsewhere in Japan. But differences of effects among management treatments have not been clearly compared in previous studies. We examined the effect of management on plant diversity of the herb layer by comparing four management treatments: Mowing understory & Removing tree leaf litter (MR), Mowing understory (M), Cutting evergreen trees below shrub layer (C), Abandonment (A). Study sites were located in *Quercus serrata* secondary forests on the north of Musashino terrace, south-eastern Kanto district, Japan. We recorded plant species occurrence and coverage in 90 plots (8 m x 8 m), and compared species richness and the Shannon index of diversity. We classified into seven plant functional groups (PFGs) from the result of cluster analysis using nine plant functional traits of occurring plants in the herb layer. We compared functional diversity and compositions among the management types using CCA. Species richness, Shannon index of diversity and functional diversity of herb layer were highest in MR. Effect of management treatments is stronger on PFGs' composition than on species composition. Some PFGs showed biased appearances in specific management types. The species richness of four FTGs (PFG2 which include crowding grasses blooming in spring, pollinated by wind, fruiting in autumn and dispersed by gravity, PFG5 which include deciduous herbs fruiting in autumn and dispersed by wind, PFG6 which include herbs blooming in spring and pollinated by insects and PFG 7 which include deciduous herbs fruiting in autumn) were high in MR and M. Especially, species richness of PFG2 and PFG5 were the highest in MR. On the other hand, the species richness of PFG6 and PFG7 were high in the plots which have high ratio of canopy openness, and the species richness was almost the same in MR and M. More than 70% of species belonging in PFG 2 and PFG 5 whose seed weights are less than 1 mg are likely to occur in plots of MR. Because many threatened species are contained in PFG2 and PFG5, we concluded that it was important to conserve plant species of PFG2 and PFG5 by mowing and removing tree litter as vegetation management for preserving biodiversity in coppiced forests.

Poster Global biodiversity of plant species, plant forms and plant communities

Grassland stability: how can climate change affect productivity and the role of biodiversity

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Understanding how climate change can influence natural communities is a major concern in climate change research. Climatic control of vegetation phenology is evident from known relationships between precipitation, temperature and vegetation indexes, with expected effects on ecosystem stability. However, the effects of climatic anomalies can be mediated by biodiversity and thus it is expected that communities with greater functional redundancy will be more resistant and resilient. Here we demonstrate with data from south Brazilian native grasslands the effects of negative and positive precipitation anomalies on ecosystem productivity. We accessed ecosystem productivity for nine 250-m long grssland transects located in twelve 5 km x 5 km grids that were sampled for plant species composition. For each transect, we retrieved a monthly based 16-year time series of NDVI (Normalized Difference Vegetation Index), as a proxy for plant productivity, using MODIS data (250 m spatial resolution and 23 acquisitions/year). To define climate events from 2000 to 2015, we classified each month for each grid as extremely dry, moderately dry, normal, moderately wet, or extremely wet, using a drought index (SPEI) that quantified previous month-by-month variations in water balance on a 0.5-degree spatial resolution. Both extreme and moderate droughts caused a significant reduction on productivity compared to productivity during normal periods ($P < 0.0001$). We found an opposite effect of extremely and moderately wet events, when productivity increased ($P < 0.0001$). These results were consistent by considering only spring-summer growing seasons for a 12-month time window. For each 250-m transect, normal years will allow us to construct a baseline for normal conditions as the mean monthly NDVI observed. We will quantify resistance as the change of NDVI in relation to the baseline, and resilience as the rate of return to the baseline. These results will be evaluated in the light of species richness and, with compiled plant traits, functional diversity and functional redundancy of the plant communities.

Maintenance of diversity within endangered Themeda-dominated assemblages on coastal headlands within eastern Australia

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Themeda-dominated grasslands on coastal headlands are listed as endangered within eastern Australia. These grasslands occur on ecological-island like headlands along 200 km of coastline. At least seven formally described, and other yet to be described, threatened flora species are endemic to the grasslands. Listed threats to include native and exotic shrub encroachment, reduced fire frequency, residential development, agriculture, native and livestock grazing, mining, weed invasion, misguided plantings, vehicles and foot traffic. These headlands have been impacted by aboriginal people and more recently by European settlement. Some consider the grasslands are a disclimax stimulated by frequent aboriginal burning, others suggest clearing and grazing by Europeans greatly extended the grassland which is now returning to shrubland. Management organisations promote the implementation of regular burning, removal of native shrubs and control of overabundant native macropods. We placed 580 plots along the known extent with up to 200 plots revisited annually over five-years assessing the effects of fire, native macropod grazing, threatened species and the effect of management actions. Plots were 2 m x 2 m in size and divided into 16 50 cm x 50 cm subplots with three circular transects placed around each at 2 m, 4 m and 8 m to assess tall shrub identity and occurrence. Within plots percent cover of all vascular plant species and a frequency score out of 16 were recorded along with the three species contributing the most to biomass. Results showed patches of tall shrubs allowed protection from the harsh coastal environment and reduced the competitiveness but not the frequency of dominant taxa (direct and indirect facilitation) allowing more species to persist including ecotonal specialists. Intensive macropod grazing enhanced diversity without reducing frequency of dominant taxa. The life history of endemic taxa proved that fire must have been infrequent. Fire was also found to reduce the diversity of the typical native grassland species. Fire was found to promote non-grassland specialists from neighbouring communities, increase the frequency and diversity of weed species and the competitiveness of *Themeda* at the expense of most other species. Our results indicate that major changes in perspective and management is required in order to maintain the diversity and persistence of these grassland assemblages.

Plant diversity patterns of traditionally managed grasslands in the Carpathian Mountains (Central and Eastern Europe)

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Long-term extensively managed semi-natural grasslands of Central and Eastern Europe are among the world's richest, in terms of plant species and ecosystems especially at small spatial scales. Yet, it is not clear whether and how the biogeographical context affects the relative importance of environmental factors and management practices as drivers of diversity patterns (species richness, beta diversity and species pool) in these grasslands. In order to evaluate the biogeographical context, we selected 15 sites with long-term extensively managed grasslands in 6 countries within the Western and Eastern Carpathians. To maximize the variability in vegetation composition, we stratified each site (a circle of 25 km^2 in an extensively managed rural landscape) by slope inclination (flat, moderate, steep) and slope exposition (W-N-E *vs* E-S-W). In each combination of inclination and exposition we then placed randomly a series of 7 nested plots of increasing size (1 cm^2, 10 cm^2, 100 cm^2, 1000 cm^2, 1 m^2, 10 m^2, 100 m^2). In each nested plot series, we recorded all species of vascular plants, bryophytes and lichens. Detailed data on topography, soil parameters, management practices, and local agricultural history were either collected in the field, obtained from interviews with farmers, or extracted from maps and archives. We used regression trees (RT) to assess the relative importance of environmental variables, management practices, biogeographical context (site and region) for variation in alpha (number of all species per plot), beta and gamma diversity (the full species list for each site), built separately for different groups of taxa (vascular plants, bryophytes and total richness, including lichens).

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Standardised protocols for phenological monitoring of herbaceous species. Recommendations from the PhenObs network

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Changes in plant phenology, e.g., the timing of flowering, fruiting, leaf emergence and senescence are happening across the globe and are linked to rising temperatures. Climate-driven changes in phenology, which vary substantially among species and locations, are altering ecological relationships, carbon, nutrient, and water cycling, species competition, composition, and interactions, and the ability of species and populations to persist. Research is rapidly advancing our understanding of the drivers, mechanisms, and consequences of changes in the phenology of trees and shrubs. In contrast, our understanding of the phenology of herbaceous plant species is relatively poor. Furthermore, the limited work that does exist on the phenology of herbaceous species has focussed on flowering times, neglected the later stages of reproductive phenology, i.e. fruiting, and largely ignored vegetative stages such as leaf out and senescence. With herbaceous species representing over half of the plant diversity on Earth it is important that we fill in the gaps in our knowledge. A globally co-ordinated research effort across many geographic locations and taxa is needed in order to better understand the drivers, mechanisms and implications of phenological shifts and to develop management strategies in response. Botanical gardens present an exciting opportunity to both monitor phenology and measure functional traits, which have the potential to predict phenological patterns and shifts, across large numbers of taxa and across broad spatial gradients. Research efforts that are co-ordinated across many sites, taxa and recorders (many of whom may be citizen scientists) require clear and standardised protocols if results are to be comparable. Herbaceous species differ substantially both developmentally and in growth form in comparison to trees and shrubs and therefore protocols designed for the study of woody taxa cannot be directly applied across herbaceous species. In order to facilitate co-ordinated monitoring efforts, the PhenObs network of botanical gardens present protocols for monitoring phenology on herbaceous species that can easily be applied by both citizen scientists and those with more formal training. The recommendations include the minimum number of stages to monitor and methods that can be applied across a broad range of taxa, which will improve our understanding of phenological patterns and our ability to predict the consequences of phenological shifts for herbaceous plant species.

The diversity of European alpine vegetation: a new assessment based on the integration of plot databases

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Understanding large-scale diversity patterns of alpine vegetation is essential for biodiversity and conservation. Despite a long tradition of surveying alpine communities in Europe, the data effectively available for analytical research are limited and regionally biased. We used an ecoinformatics approach for collecting, integrating and analyzing vegetation plot data sampled in high-mountain grasslands of the European Mountain System (the Alps, the Carpathians, and the mountains of the Iberian, Italian and Balkan Peninsulas). We used the European Vegetation Archive and TURBOVEG software for storing and updating national and regional databases, for integrating taxonomic standards and for extracting functional traits from the Plant Trait Database. Overall, we integrated > 20,000 vegetation plots sampled in high-mountain grasslands above the treeline, representing the largest continental dataset on alpine plant communities currently available for biodiversity research. The data was then analyzed via R and GIS under a macroecological view. We present a summary of the patterns of species richness in this vegetation at both regional and plot levels, and the relative influence of major drivers such as regional alpine area and climate, considering the implications of soil bedrock in the observed patterns. We also evaluate the effect of sampling bias and plot size as major sources of uncertainty in the analysis of legacy vegetation data. Finally, we discuss the potential of these data for revealing patterns and processes in alpine community ecology and for assessing biodiversity hotspots in European mountains.

Impact of the pastoral plantation of *Atriplex canescens* on vegetation dynamics: case of Sebgag (Laghouat Algeria)

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The steppe ecosystem has been severely disturbed in arid and semi-arid zones, this disturbance affects all the living components of this ecosystem, but vegetation takes the first place because its destruction is often irreversible. Therefore, we are moving towards a transformation of steppe areas into desert areas. To combat desertification, the High Commission for Steppic Development (HCDS) has embarked on a program to rehabilitate degraded rangelands, including the setting aside and planting of fodder shrubs.

Our work consists of a study based on the comparison between planted and unplanted stations, in order to determine the qualitative and quantitative changes of the natural environment, thus to try to evaluate the floristic diversity and the balance of a plantation based on *Atriplex canescens*, carried out in the region of Laghouat at a place called Sebgag (southern Algeria).

The adopted methodology is based on the realization of phytoecological surveys on the one hand, and on the other hand the application of numerical treatments (Correspondence factorial analysis, ascending hierarchical classification) as well as the application of diversity indices in ecology. The results obtained show that the impact of the *Atriplex canescens* plantation has a positive effect on the degraded natural environment, by allowing a good recovery of the vegetation and an appreciable floristic richness.

The analysis of the floristic composition reveals that the study area has great richness, 53 species have been identified belonging to 21 families with a predominance of some families (*Amaranthaceae*, *Chenopodiaceae*) and a high rate of Mediterranean species. In addition, the percentage of vegetation cover is estimated at 79% within the plantation and only 36% outside the plantation. The Shannon diversity index is 2.30 in the plantation against 1.67 outside the plantation.

Correspondence factor analysis (FCA) and ascending hierarchical classification (AHC) have identified three floristic groups as well as ecological factors that govern the distribution of vegetation. On the phytogeographic level, the highest rates are those of Mediterranean and endemic elements, the latter decreasing outside the plantation leaving room for the saharo-arabic element. Soil improvement and good pastoral production have also been noted in the plantation.

The results obtained show that plantations in highly degraded environments are to be encouraged and must be integrated into the pastoral rotation model.

Key words: *Atriplex canescens*, steppe management, Laghouat, Algeria.

Functional traits interactions and habitat context control tree demography changes in tropical forests

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Trait-based ecology is largely based on the assumption that species functional traits determine species fitness. Clear trait-demographic relationships, however, have been limited in the literature, possibly due to both overriding environmental effects on fitness and trait interactions causing alternative designs with similar fitness. We analyzed demographic data (relative growth rate, RGT, and mortality rate, MR) of 16,000 individuals from 129 species surveyed in 13 1 ha permanent plots, distributed along an elevational gradient covering four broad habitat types in the Brazilian Atlantic Rainforest. By using both linear mixed effects and mixed-effects random forest models, we evaluated the relationship between population demography, functional traits (maximum height, woody density, seed mass, specific leaf area, nitrogen and phosphorous leaf content), elevation, and their interactions. We found that, as the crowding neighborhood increased with elevation, for several species, RGR decreased and MR increased with elevation. The importance of functional traits and elevation was, however, different on RGR and MR with interactions among traits, and between traits and elevation. For example, the changes in demography were best explained by wood density. Nevertheless, its relative influence was two times greater on RGR than MR and its effect changed across habitats. To sum up, interactions among functional traits shape fitness and life history strategies, but such interactions can be different in different environmental conditions and for different fitness components. We thus suggest the trait-based studies should consider the habitat suitability gradients to understand the changes in tropical tree performance and fully incorporate the concept of multiple trait-fitness optima resulting from trait interactions in different habitats.

Poster Vegetation patterns and processes

Comparison of factors affecting tree regeneration of *Tsuga diversifolia* forest in Mt. Kumotori, eastern Japan

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It is reported that deer browsing has negative effects on the vegetation in many parts of Japan. Similarly, in our research area, the population of *Cervus nippon* increased rapidly in the late 1990s and a decrease in plant species diversity had been reported. In our research forest, germination of seedlings and growth of saplings tend to be limited to old fallen logs or stumps where dwarf bamboo dominate in the forest floor. Therefore, if tree regeneration is prevented by deer browsing on seedlings and saplings, there is danger that the forest changes into grassland irreversibly. Actually, it is reported that *Picea jezoensis* var. *hondoensis* forests have changed into dwarf bamboo grassland in Mt. Ohdaigahara, western Japan. Our objective is to find out the most influential factors on tree regeneration by comparing various environmental factors simultaneously and through that to estimate a protection effect of fencing.

We investigated sites of four types, unfenced-control and dwarf bamboo (*Sasa hayatae*) dominating site, deer-excluded and dwarf bamboo dominating site, unfenced-control and dwarf bamboo absence site and deer-excluded and dwarf bamboo absence site. We investigated five 10 m x 10 m plots per site. In each plot we investigated the number of deer fecal mass, LAI, height and density of dwarf bamboo. In addition, for each fallen log in the plots, we recorded length, diameter, decay stage, surrounding vegetation and coverage of moss. For each tree seedling and saplings on fallen logs we recorded species name and height. In the data analysis, we constructed a model that reveals which environmental factor has the most influential effect on the number of seedlings. In the model we set the number of seedlings and saplings on each fallen log as dependent variable and set various standardized data of environmental factors as explanatory variables. We carried out the modeling analysis in six data sets. We set seedlings and saplings whose height was 10 cm and below 10 cm as U10 in all species, coniferous species and broadleaf species. In the same way we set seedlings whose height was over 10 cm as O10 in all species, coniferous species and broadleaf species.

Due to the model result, coverage of moss has the most positive effect on the number of seedlings in U10 seedlings of all species, coniferous species and broadleaf species. For all species and coniferous species, presence of fence and coverage of moss have strong positive effects on the number of O10. For broadleaf species, dominance of bamboo has the highest positive effect on the number of O10 and coverage of moss has the second hightest positive effect on that. We made it clear that coverage of moss always has a big positive effect and presence of fence has a strong positive effect on the number of coniferous O10. The reason that dominance of bamboo has a strong positive effect on number of broadleaf O10 can be thought to be the presence of broadleaf mother trees or protection from deer browsing by surrounding dwarf bamboo.

Clonal plants shape the vegetation structure of meadows under different degrees of abandonment

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Meadows underlie serious changes in Central Europe. Intensification or abandonment are the main processes that have enormous influence on species composition and diversity in meadows. Cessation of mowing leads to serious species losses depending on the nutritional status of the systems. Nearby Vienna, we tested how meadows from different nutritional status change during different degrees of abandonment over 15 years.

Nutrient rich and wet meadows showed species losses by more than 50% within few years under full abandonment, whereas semidry nutrient poor meadows lost only 25% of species in the same time period. Woody invaders played only a role in plots nearby forests. The most impressive qualitative changes were driven by few non-clonal tall growing herbs but mostly by clonal perennial herbs. Former species tend to dominate the early successional stages, the latter in the later stages.

Partial abandonment was tested by plots cut every second year. Species diversity was quickly reduced in nutrient rich and wet systems but slowly in semiarid nutrient poor meadows. After 15 years of partial abandonment, the nutrient rich meadows stabilize at a diversity level of 50% of the initial species number, the wet meadows reach about 40% (still decreasing), and the semiarid nutrient poor systems stabilize at about 70%.

Non-clonal meadow species depend very much on the spatial and temporal availability of gaps for reproduction by seeds. Meadows at low productivity levels provide more and longer lasting gaps compared to nutrient rich meadows that quickly close the canopy after cut. Thus vegetative (clonal) regeneration turned out to be most successful in nutrient rich meadows. Clonality per se was not enough to succeed - growing tall and bearing many or big leaves along the stems is an essential additional trait to outcompete other species. Additionally, summergreen clonals that produce annually much dead and slowly decomposing biomass impeded any seedling establishment. Clonal regrowth turned out to be the only way to persist.

The maintenance of mowing and biomass removal should be the main goal in conserving the biodiversity in any meadow.

Combining Convolutional Neural Networks and high resolution UAV imagery - a powerful tool for vegetation mapping

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UAV evolved as a valuable remote sensing tool for mapping and monitoring vegetation characteristics. However, the 'traditional' pixel-based remote sensing approaches are not fully compatible with the high spatial resolution of UAV imagery. The high spatial detail comes in line with a higher spectral variance making it more challenging to assign a pixel-based observation to a class (e.g. species) or to fit it on a regression line. Yet, the higher spatial detail reveals spatial patterns (e.g. branching characteristics or canopy structure) that can be of high value to discriminate vegetation characteristics. Thus, in order to adequately harness the spatial detail of high resolution imagery one has to incorporate the spatial context of multiple pixels. In line with current developments in the image analysis, we propose the use of Convolutional Neural Networks (CNN) for vegetation characteristics. The principles of CNN were inspired by the functioning of the animal cortex, where neurons are sensitive to visual stimuli in different and partly overlapping regions of the visual space, also known as receptive fields. CNN resemble and automatically learn the relevant filters. However, a transfer to CNN to UAV imagery for continuous vegetation mapping remains scarce. We assume that this is due to 1) the requirements of the data dimensionality of common CNN approaches, which requires equally spaced tensors, 2) the complexity of natural vegetation canopies, frequently featuring smooth transitions rather than discrete boundaries, and 3) the need for extensive reference data for training and validating CNN-based models. Accordingly, we test the potential of a CNN-based regression models trained with large numbers of reference data derived from visual delineations in the orthoimagery and equally spaced image tiles (2-5m). The approach is tested within three case studies, i.e. mapping invasive species (Central Chile), mapping tree species in a dense primary forest (Waitutu, New Zealand) and mapping a periglacial succession (Müller Glacier, New Zealand). Our results show that CNN-based regression models allow for very accurate predictions. The accuracy of the predictions depends on the tile size, whereas larger scales are more accurate as they include more spatial context. The fact that we obtained high predictive accuracies using low cost RGB data highlights that the presented approach is applicable by a wide range of users. We thus conclude that CNN regression models are a powerful tool to harness high resolution data acquired from UAV to predict vegetation patterns and have a great potential to revolutionize UAV-based remote sensing of natural canopies.

Talk Vegetation patterns and processes

Fine-scale variation in microclimate and understory vegetation associated with different management intensities in beech forests

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Forest microclimate is strongly affected by management and is of high ecological relevance due to its profound impacts on diversity and composition of understory plant communities. The present work introduces observed patterns of spatio-temporal variation in microclimate and a short-term response of vegetation to forest management, derived from forestry experiments conducted in managed fir-beech forests in the Dinaric karst (Slovenia), characterized by rugged terrain with numerous sinkholes (dolines). The stand level treatments, performed in 2012, represent a range in intensity of overstory removal: uncut controls (low management intensity - LMI), 50% cut of stand growing stock (medium management intensity - MMI) and 100% cut (high management intensity - HMI). Fine-scale variation in topographic factors (slope exposition and inclination) and its effects on microclimate and vegetation was assessed by comparing different within-sinkhole positions: in the centre, on the northern and on the southern side of each of the selected bowl-shaped karst sinkholes (27 in total). We measured microclimatic variables (air temperature - T, relative humidity - RH) 1 m above ground over three consecutive post-treatment growing seasons (2012, 2013, 2014). Vapour pressure deficit (VPD) was calculated based on T and RH. Vegetation was sampled in 2014 in three circular plots (r = 2 m) per sinkhole (corresponding to three positions), 81 plots in total. Treatment means of different microclimatic variables showed a monotonic increase (T and VPD) or decrease (RH) with the intensity of management. Results confirmed a general buffering effect of below-canopy microclimate. Daily Tmax and VPDmax in HMI plots were up to 5.9 °C (overall average: 3.5 °C) and up to 1.4 kPa (0.6 kPa) higher than in LMI plots, respectively; whereas daily RHmin was up to 22.7% (12.9%) lower.

Microclimatic differences between the treatments were even greater during the summer and evidently depended on general weather situation. Along the cutting intensity gradient, the differences between positions within the same treatment increased. South-facing plots in HMI treatment exhibited the most extreme conditions (highest T and lowest RH). Plot-level understory species richness (shrub and herb layer) was on average highest in the southern HMI plots (34.0) and lowest in the control centres (17.2). Species composition differed significantly between treatments, but with only minor variations among positions within each treatment. Using redundancy analysis and linear modelling, we found that among the considered microclimatic variables, diurnal temperature range and daily Tmean showed most significant effect on understory species composition and diversity. However, other environmental factors (e.g. light availability, depth of organic soil layer) explained a substantial proportion of compositional variability. The results of this study can be supportive for both forest management and biodiversity conservation planning.

New opportunities for semi-natural grassland conservation in urban areas

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In Central Europe, semi-natural dry grasslands of cultural landscapes are among the most threatened ecosystem types. Nutrient-poor sandy dry grasslands of Northwestern Germany particularly suffer from habitat loss due to agriculture and urbanisation as well as from degradation by land use intensification and eutrophication. Nevertheless, remnants of ancient dry grasslands can still be found even in urban and sub-urban areas. Their conservation and restoration should be a priority nature-conservation target, but they are usually small and not well managed. In cities, these remnants are often functionally linked to urban and post-industrial brownfields, which can offer valuable secondary habitats for populations of dry grassland species including red-list species, but are mostly neglected in nature conservation.

While dry grasslands on brownfields in shrinking cities are often lost over time due to ongoing succession, it is also a challenge to conserve and develop them in growing cities with increasing competition for space needed for housing and grey infrastructure. Therefore, new approaches are needed to support dry grassland development in urban green infrastructure and to create urban habitat networks for grassland target plant and animal species (especially insects). Based on a habitat template approach we use regionally occurring plant species from Northwestern dry sandy grasslands for extensive roof greening (EGR). By seeding seed mixtures of regional provenance and application of raked plant material from ancient dry grasslands on experimental miniature roofs we showed that native dry grassland species are indeed suitable for EGR. Vegetation surveys over four years revealed that especially the application of raked plant material is a fruitful approach for roof greening with dry grassland species. Several plant species including lichens, mosses and rare vascular plants not available on the German native seed market could be introduced. Species establishment and persistence depended on substrate quality and weather conditions. Based on these results and an extensive screening of potentially suitable species, several experiments on real green roofs were started in 2018 to test additional more species-rich seed mixtures as well as different EGR designs and substrates.

Poster Using plant traits for the recovery of ecosystem functions and services: Trait-based ecosystem engineering?

Effect of the canopy tree species on the structure, biodiversity and dynamics of tree seedlings communities beneath their crowns

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In forest communities, canopy trees modify the environmental conditions and resources available under its crowns, which may affect plant species presence, abundance and development in the understory (filter effect). However, this filter effect needs to be confirmed in different communities and species, as well as the possible mechanisms involved in it. Although the filter effect should involve many processes, the litterfall has been pointed out as one of the most important mechanisms in promoting this effect. Our aims are to investigate the existence of canopy trees' selective effect on species that regenerate under their crowns and verify if litterfall is involved in this process. In a tropical forest in Campinas, SP, Brazil, we selected 25 individuals of five canopy tree species, *Aspidosperma polyneuron* Müll. Arg, *Astronium graveolens* Jacq, *Croton piptocalyx* Müll. Arg, *Diatenopteryx sorbifolia* Radlk. and *Pachystroma longifolium* (Nees) I.M.John. Below each tree crown, we introduced four plots containing six seedlings of *Gallesia integrifolia* (Spreng.) Harms, one of *Ceiba speciosa* (A.St.-Hil.) Ravenna, four of *Hymenaea courbaril* L. and four of *Piptadenia gonoacantha* (Mart.) JFMacbr. After one year, we counted dead plants and measured the variation of height of the survivors. Next to the plots we had installed litter collectors, whose contents we collected during the same one year. We expected that the variation of height and number of dead individuals, after a year, for each seedling species would be different under each canopy species, which would characterize the filter effect. Besides, we expected that the number of dead plants per plot was related to the mass of litterfall in the respective plots. We evaluated the existence of the possible filter effect and litter role through mixed and generalized linear models of mortality and growth of each species' seedlings planted under the crowns among different canopy species. We found that all species of seedlings presented different growth or mortality, or both, below different canopy species. *H. courbaril* and *P. gonoacantha* showed different growth, and *H. courbaril* and *G. integrifolia* had different mortality under different canopy species. *G. integrifolia* showed an effect of litterfall on mortality too. Mortality of *C. speciosa* was influenced by an interaction between canopy species and litterfall. These results mean an evidence of filter effect and litterfall has a possible role in this filter. The way of responding to the effect of canopy varied among seedling species in any degree and way. Possibly, the type of response to the filter effect depends on species traits that had different survival and growth strategies in response to this effect. We conclude that there is a filter effect and a role of litterfall in this effect, but how the species respond to the effect depends on the species. The forest canopy, through the filter effect, is a key factor in the characterization of biodiversity in the tropical forests.

Talk Vegetation patterns and processes

Myrmecochorous plants and their ecological preferences across Czech flora and vegetation

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Myrmecochory is a plant-ant mutualism for which plants are adapted by a nutrient-rich appendage, the elaiosome. The reward for myrmecochorous plants is dispersal. However, a complete and reliable list of species that use this strategy is not available. Myrmecochorous status for 1,776 angiosperm herb species of the Czech flora was established based on our own observations of the elaiosome presence in seeds, or on the known myrmecochorous status of the closest relatives. We defined categories based on the appendage:seed size ratio and fleshiness, and found 238 myrmecochorous species (fleshy, high appendage:seed ratio), 170 probably myrmecochorous (fleshy, very low appendage:seed ratio), and 241 probably non-myrmecochrous (not fleshy, low appendage:seed ratio). Therefore, under the most conservative scenario, myrmecochorous plants would comprise 13.0%, while under the most inclusive scenario, they would comprise 36.5% of species, belonging to 35 (23.4%) out of a total of 154 families of the Czech flora.

We combined our checklist of myrmecochorous species with the Czech National Phytosociological Database and searched for patterns in ecological preferences of myrmecochorous plants in vegetation plots. In each plot, we counted the number of myrmecochorous species, their total cover and proportional number. Then, we characterized their response to temperature, precipitation and mean Ellenberg values, and also their affinities to habitat types.

Of the basic vegetation categories, the shrublands followed by forests had the highest representation of myrmecochorous species. Among the forest alliances, *Carpinion betuli* had the highest cover and number of myrmecochorous plants. For *Carpinion*, it is typical that many plants flower and produce seeds very early. High representation of myrmecochorous plants there supports the hypothesis that the elaiosomes are efficient in early spring, when ants' typical prey, other insects, are in short supply.

Among grasslands, the semi-dry alliance *Bromion erecti* had the highest representation of myrmecochorous plants, followed by mesic *Arrhenatherion elatioris* and wet *Calthion palustris*. There was no trend along the moisture gradient, however, the representation of myrmecochorous plants was slightly increasing with Ellenberg moisture value and annual precipitation.

Generalized linear models revealed that the representation of myrmecochorous species in forests increases with annual temperature and decreases with precipitation and Ellenberg values for moisture, whereas an opposite trend was found in grasslands. Across vegetation types, the representation of myrmecochorous species increases with the mean Ellenberg value for reaction (pH) and decreases with the value for nutrients, supporting the hypothesis of higher benefit from myrmecochory by directed dispersal in nutrient poor conditions.

Our results support the hypothesis of temperate deciduous forests being a myrmecochory hotspot, at least within temperate vegetation types.

Disturbance history impact on plant diversity in primary spruce (*Picea abies*) forests in the Western Carpathians

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Mountain Norway spruce forests are increasingly affected by various harmful events triggered by environmental changes resulting into large-scale disturbances across their entire distributional range. However, disturbances naturally play a key role in their long-term dynamics. Therefore, understanding how disturbance legacies shape current forest structure from stand to landscape level is essential to interpret ongoing biological processes during the era of global change. Recent dendrochronological research in primeval forests revealed many new insights into long-term dynamics of mountain spruce forests, however, very little is known whether there is any ecological memory written in the forest understories reflecting disturbance history and development of spruce forest ecosystems.

To address this question we investigated relationships between vascular plant diversity and various stand structural and disturbance parameters using 140 plots from 11 localities in primary spruce forest on silicate bedrock in the West Carpathians established under the REMOTE project (www.remoteforests.org). Linear multilevel models within Bayesian approach with uninformative priors were used to fit and evaluate corresponding statistical models. Random effect of locality was included, and variation in both intercept and slope among localities was enabled.

Most of the disturbance events had rather low severity and occurred over the entire recorded time gradient reaching to 1750. Within this time span we identified two peaks of disturbance activity in 1860-1880 and 1930-1950 when disturbances were also more severe. These events, particularly those from the second half of the 19th century, considerably affected development of mountain spruce forests and shape current stand structures and also understorey plant diversity. We found that new tree cohorts occurring after disturbance suppress understory cover, but do not induce decrease in species richness due to the spatial heterogeneity of the stand structure. Further tree-layer development without any serious disturbance lead into stands with homogenous age and spatial structure with limited understorey diversity in rather old stands. Evenness and cover of herb layer species increase immediately after recent disturbances accompanied by canopy-tree dieback. Our findings suggest that periodically repeated small disturbances keep more diverse understories of spruce forests while large-scale severe events which are currently ongoing may develop into species poorer forests. As a conclusion for the forest management, we can suggest maintaining heterogeneous stand structures to promote higher plant diversity and limit its temporal and spatial variability.

Restoration of native grasslands at urban-industrial sites - a great opportunity for biodiversity conservation

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The restoration of native vegetation on unused urban-industrial areas has largely been neglected despite their great potential for nature conservation purposes. We present the results of the restoration of sandy grassland by different seed introduction methods at an urban-industrial area, Nyíregyháza, NE Hungary. Our aims were to investigate the effect of seed quality and different seed introduction methods on in situ establishment in sandy grassland restoration. First, germination capability and second year field establishment of sown and hay transferred native species were studied and compared. Second, the grasslands resulting from the three seed introduction methods applied (sowing of commercial seed mixture; sowing of seeds of a single dominant species and hay transfer) were compared to reference grasslands: open and closed primary (semi-natural) and secondary (old-field) reference sites.

In the first study, the field establishment of sown native species was positively correlated with germination under laboratory condition with and without cold-stratification. Transferred hay provided low amounts of seeds of target species, and field establishment was not linked to transferred seed density. We conclude that laboratory germination tests prior sowing seeds of native species have high predictive value for restoration planning opposite to transferred hay. In the second study, the two types of seeding (commercial seed mixture and seeds of a single dominant species) resulted in similar cover, whereas seeding of commercial seed mixture and hay transfer resulted in similar species richness to reference grasslands. The cover of natural constituents also reached that of reference grasslands in case of both seeding methods, while hay transfer resulted in lower cover and higher number of natural constituents than seeding. We have prepared a guideline for helping to choose the best method for certain restoration situation. Based on our results, three years of vegetation development induced by seed introduction worth 30 years of secondary succession in urban-industrial grassland restoration. We conclude that investing in the restoration of native grasslands at unused urban-industrial sites can be a great opportunity to enhance biodiversity and to improve ecosystem services in a short period of time and can contribute to the development of the European green infrastructure network.

Talk Vegetation patterns and processes

Contribution of non-native plants as a seasonal pollen source to native honeybees in a suburban landscape of Japan

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Current urban and suburban ecosystems contain various non-native plant species, including crop plants, garden plants and weeds. Non-native plants may help to maintain biodiversity in these ecosystems by providing a source of forage for pollinators. However, the contribution of non-native plants to ecosystem services has often been underestimated in biodiversity assessments. In this study, we investigated the pollen sources of native honeybees (*Apis cerana*) in an arboretum containing native trees and various non-native plants located in a suburban landscape of Japan.

From June to October, we surveyed the flowering tree species planted inside the arboretum, which were potential pollen sources. We also collected *A. cerana* pollen balls every month and identified plant species of pollen in the collected pollen balls using DNA barcoding.

The number of potential pollen-source species of native trees peaked in June and July and decreased after August. We identified a total of 29 plant species from *A. cerana* pollen balls. The probability of *A. cerana* using pollen from non-native plants was higher in July and August than in June. *A. cerana* collected pollen forages from native tree species (>50%), but also gathered pollen from crop plants, garden trees and native and non-native weeds. Particularly, the pollen sources in September and October largely depended on the garden tree Ulmus parvifolia and the non-native weed *Solidago altissima*.

The results suggest that native honeybees used plants from a variety of habitats including non-native plants to compensate for apparent seasonal shortages of native tree sources in suburban ecosystems. We highlight the importance of assessments of both positive and negative roles of non-native plants in urbanized ecosystems to improve biodiversity conservation.

Long-term monitoring of abandoned and afforested calcareous grassland sites after restoration by clearcutting - changes in taxonomic and functional diversity during the first 25 years

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Semi-natural calcareous grasslands are one of the most species-rich plant communities in Central Europe. The first evidence of their existence reaches back until the Neolithic period. Nowadays, these grasslands are highly endangered. One reason is their abandonment or afforestation, mainly in the period between the 1960s and 1980s when on the one hand sheep number, as a result of cheap wool imports from overseas, declined and on the other hand, marginal agricultural lands have become fallow due to the intensification of agricultural practices.

Therefrom, since the beginning of 1990s, efforts were undertaken not only to support shepherds by paying subsidies for conservation and landscape management but also to restore abandoned or afforested grasslands by clearcutting and reintroducing grazing management.

In Southwest-Germany, we therefore selected in 1992 and 1993 ten calcareous grassland sites which were abandoned or afforested mainly in the 1960s. Before the clearcutting we established permanent plots and since then followed the vegetation development. Taxonomic and functional diversity were recorded not only at the restoration sites but also on the nearby species-rich grasslands where grazing management was continuously maintained (reference sites). We will show how species and functional assembly changed during the period of 25 years and at which moment the vegetation of the restored sites was taxonomically and functionally convergent to the vegetation of the reference sites.

Multi-method approach to capture aboveground biomass stocks at the tundra-taiga transition zone in East Siberia, Russia

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Ecosystem changes driven by climate changes and disturbances can dramatically alter ecosystem services. Of particular interest is the tundra-taiga ecotone covering vast Siberian permafrost landscapes that is currently experiencing a strong warming. It is unknown whether this leads to an increase of carbon sequestration or to a release if additionally human-caused disturbances destabilize natural boreal forest trajectories. To assess the consequences, field data for such remote regions is rare and often focusses on one aspect (e.g. trees or surface layer) rather than the complete ecosystem.

We aim to forecast how global warming is affecting the tundra-taiga transition zone.

Therefore, we visited and sampled vegetation plots (N=64) along a large bioclimatic gradients and disturbance regimes. The transect starts in the tundra in northeastern Chukotka, includes northern summergreen taiga forests, and ends in evergreen boreal forests of central Yakutia.

For each plot, we will analyse the complete carbon stocks based on samples taken following classical biomass sampling procedures and soil samples. This is complemented by vegetation surveys and forest inventories at the plot level. However, to acquire detailed spatial variability we use very high-resolution near UAV-based imagery to build 3D-point clouds. With these, we can detect and analyse single trees and shrub individuals as well as the surface vegetation cover, and, in addition, we can train statistical-models for upscaling the retrieved data to a larger region.

With our time-for-space sampling location design, we can evaluate biomass changes that we have to expect for these ecosystems in a changing environment. In addition, the results will be used to parameterize the individual-based spatially explicit vegetation model LAVESI developed for Siberian larch forest dynamics. Finally, when forcing this model with future climate scenarios, it can help to estimate carbon stock development and to highlight regions of high sensitivity, destabilized by recent changes or disturbance regime shifts.

Talk Long-term studies in vegetation science

Trait composition in glacier forefield succession

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Due to climate warming, glaciers retreated during the past 150 years in many parts of the Alps and gave way to some of the few opportunities of genuine, natural primary succession. I initiated long-term relevés in four glacier forefields of the Northern Limestone Alps (Dachsteingebirge 2016, Berchtesgadener Alpen 2018), covering a chronosequence of areas were the glaciers retreated approx. 10 years, 40 years, 70 years and >100 years ago, respectively, with 52 relevés all together in an almost balanced design. Using the frequency method, I surveyed the vegetation analysed data of the initial sampling period, namely species richness, vegetation cover and the composition of several traits, based on the TRY database, across the chronosequence. I used linear mixed effects models and multinomial, vector generalized linear models. While it is obvious that cover as well as species richness increased with successional time, traits revealed more pronounced patterns. There is, e.g., an increase in community weighted mean seed mass, the proportion of insect pollinated species and a decrease in those able to do selfing. Similarly, there is a decrease in the proportion of facultative mycorriza over time and in increase in non-mycorrhiza. Using Grime's Strategy, the proportion of ruderal strategists is low, as expected, and decreases further while the proportions of both competitors and especially stress strategists are higher and even increase during successional stages.

Summarizing, the chronosequence revealed changes in the composition of traits from those adapted to colonisation without being dependent on other organisms to compositions that allow for more species interactions.

A synthesis of long-term disturbance dynamics of central-European mountain spruce forests

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Disturbances such as fire, grazing, windthrows or pathogens play an important role in long-term ecosystem dynamics. Mountain ecosystems of central Europe, such as spruce-dominant forests, experience a variety of disturbances that are threatening their survival. Therefore, long-term observations of ecosystem disturbance dynamics may provide a better understanding of natural *vs* anthropogenic disturbance ecology within spruce forests, which may be crucial for their future conservation.

We developed a new method of quantifying overall disturbance by linking well dated pollen records with plant indicator values for disturbance. Here we use several pollen, macrofossil and charcoal records from the Bohemian Forest region along the Czech-German-Austrian borderland. Our new disturbance index was calculated by assigning each pollen type to a plant taxon with a disturbance index derived from central-European flora. Reconstructed levels of disturbance frequency were then compared to fire activity (frequency) inferred from contiguous macrocharcoal analysis, and to other disturbance proxies such as non-pollen palynomorphs, geochemistry (XRF data), beetle remains, and plant macrofossils. Surrounding vegetation was moreover interpreted quantitatively by the Landscape Reconstruction Algorithm.

Our results reflect similar trends in all records showing continuously increasing disturbance frequency over the entire Holocene. Distinct disturbance events in the early Holocene are associated with increased fire frequency, however, we find asynchronicity between nearby sites in response to particular disturbance events. The local vegetation during the early Holocene was mostly dominated by pine, but with increasing spruce after 8000 cal. BP. For this period, we interpret fire as the main disturbance agent probably fueled by drier and warmer-than-present climate. The period between 6500 and 3500 cal. BP is marked by quite low disturbance frequency, but often accompanied by findings of bark beetles. This period is also marked by the lowest fire frequency. A profound increase in disturbance frequency between 3000 and 2000 cal. BP is not accompanied by increased fire suggesting human impact or other disturbance factors playing the crucial role. The last millennium experienced the highest disturbance frequency accompanied by increased fire activity. This regime is most probably triggered by increasing human occupancy in the study area.

Our methods introduce another dimension in disturbance regime reconstructions by quantifying disturbances other than fire. We also suggest that disturbances were an inherent part of spruce forests development in the past.

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Talk Macroecological vegetation science: large grain patterns and processes of plant diversity

Mapping potential diversity of woody plants using diversity estimation approach with a global occurrence data

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Mapping large-scale biodiversity patterns relevant to species pool properties is a fundamental step for better understanding the mechanism of local-scale community assembly and conservation planning. In this decade, tons of plant species occurrence records including botanical specimens and vegetation surveys became publicly available, allowing us to draw a global plant diversity map at given spatial resolution. Observed species occurrences include spatial bias in relation to sampling effort. Therefore, it is essential to standardize the dataset to fairly compare diversity among sites. In this view, the theory of biodiversity estimation based on Hill number provides an analytical framework for modulating sampling incompleteness that informs a detailed picture of well-sampled sites (or poorly sampled sites). To delineate reliable biogeographical distribution of woody plant species with the best knowledge at present, we compiled a large-scale dataset of species occurrence from the existent databases and published literature. Using the biodiversity estimation method, we firstly detected cold-spots of occurrence information and then estimated potential (asymptotic) diversity for data-rich sites (i.e. high sampling completeness) and finally identified environmental drivers (climatic, edaphic and topographic factors) of woody plant diversity. These analyses were conducted at different taxonomic (species and species-rich family) levels and also investigated at different spatial scale (global and biogeographical realm). We found contrasting patterns in the sampling completeness and the observed/potential diversities among regions and families. Based on these results, we discuss the current status of occurrence information of global woody plant species and infer mechanisms shaping plant diversity patterns.

Mesic grassland habitats of Ukraine - differentiation, management, and environmental value

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During preparation of the National Habitat Catalogue of Ukraine, as a part of the implementation of the European environmental legislation in Ukraine in accordance with the EU-Ukraine Association Agreement, a comprehensive analysis of mesic grassland habitats was carried out. Eight habitat types were distinguished within this group; the main factors of their differentiation are management and edaphic peculiarities. In conditions of combined use on elevated relief elements in floodplains of large rivers are formed Xero-mesic alluvial grasslands (type T2.1); in conditions of grazing on rich soils Low and medium altitude pastures (T2.2.1), Mountain pastures of Carpathians (T2.2.2) and Mountain pastures of Crimea (T2.2.3), and on poor soils Lowland heath grasslands (T2.4.1) and Mountain heath grasslands (T.2.4.2) with two subtypes; in conditions of hay mowing are formed Low and medium altitude hay meadows (T2.3.1) and Mountain hay meadows (T2.3.2). All types of hay meadows and heath grasslands are of European importance, as included in the Resolution 4 of the Bern Convention (E2.2, E2.3, E1.71 types). Both types of hay meadows as well as mountain heath grasslands are included in Annex I of the Habitat Directive 92/43/EEC (6510, 6520 and 6230*types). The highest conservation value have Low and medium altitude hay meadows (includes 24 species from the Red Data Book of Ukraine), Mountain heath grasslands (22 species) and Mountain hay meadows (16 species). The plant species listed in the Resolution 6 of the Bern Convention and Annexes II and IV of the Habitat Directive (*Angelica palustris*, *Campanula serrata*, *Narcissus poeticus* subsp. *radiiflorus*) are present in the same habitat types. The main threat for all types of mesic grasslands of Ukraine is the cessation of traditional management, with various negative consequences for their composition and structure. For pastures only, the threat in some regions can be overgrazing, and for hay meadows - change of land purpose, primarily the transfer of meadow to pasture or their plowing. Hydraulic engineering is a threat for many habitat types and for some types (heath grasslands) - the global climate change is a main threat. The compilation of a list of characteristic species, as well as their threshold values, allowed developing an expert system for habitat identification in phytosociological databases. Based of this system, a selection of relevés belonging to various habitat types from the Ukrainian Grasslands Database was made, their distribution in Ukraine was analyzed and areas with a lack of phytosociological data requiring further field surveys were identified. A phytoindicative assessment was performed with the Didukh ecological scale, and it confirmed the leading role of edaphic factors in the differentiation of the mesic grassland habitats.

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Poster Global biodiversity of plant species, plant forms and plant communities

Classification of the European annual weed vegetation

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The study of classification of vegetation of arable land and annual ruderal vegetation (often called 'weed vegetation' for short) has a long tradition in Europe. Hundreds of authors recorded tens of thousands of relevés in almost all European countries. In the last two decades, increased efforts lead to digitizing of vegetation data, primarily focused on compilations of national or regional depositories of different vegetation types. In order to classify the weed vegetation on a continental scale, a compilation of the data across the whole continent was required. The compilation sourced several vegetation databases (assisted by European Vegetation Archive) and was, in part, supplemented by own digitalization efforts, the latter forming the European Weed Vegetation Database. After implementation of nomenclatural corrections, collation of taxonomic concepts, and exclusion of cultivated species and non-vascular plants, we submitted the final data set to a hierarchical cluster analysis. Using Sørensen similarity index and beta-flexible -0.25 group linkage method, we identified some clearly defined clusters, corresponding to so far well-established syntaxa, such as the annual ruderal vegetation of the *Malvion neglectae* and the *Atriplicion*, Mediterranean segetal vegetation of the *Roemerion hybridae*, and segetal vegetation in precipitation-rich areas on nutrient-poor sandy soil (*Arnoseridion minimae* and *Scleranthion annui*). The emergence of some other clusters suggests a need for new syntaxon delimitations. For instance, the thermophilous segetal vegetation so far defined as the alliance *Caucalidion* appears to split into two syntaxonomic entities and the spring communities on arable land might deserve recognition as a syntaxon in its own right. A combination of several factors appears to underpin the classification at the high fusion levels of the clustering hierarchy. These divisions include main vegetation separation of the arable-land (segetal) or ruderal vegetation, geographical split between the Mediterranean and temperate Europe, and finally split based on the nature of the management practice associated with the crop type (hoed crops or cereals). In our poster, we will present (and discuss) the resulting clusters in terms of syntaxonomic alliances.

Living on the edge - changes of plant species persistence on range margins in the UK and Estonia during the 20th century

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Species are constantly in motion, their population dynamics changes throughout their range. These changes are caused by various abiotic and biotic natural factors including human activities. However, we have very fragmented knowledge about species range changes, as these processes are relatively slow and there is a lack of comprehensive and consistent large(r)-scale data for most organisms and places. The most significant and fundamental changes in species distributions take place on their range margins. The edges of geographical ranges are considered to be the focal zones where most crucial ecological acclimatizations and evolutionary adaptations take place, mainly due to transition of predominately intraspecific competition context to mainly interspecific competition context.

Populations living on distribution range margins are generally considered to be under higher stress due to less optimal conditions than in range centre, yet changing climates are expected to favour species living in certain parts of their ranges - e.g. plants living on the northern edge of their distribution range. How are these expectations balanced - is living on the edge of distribution always more stressful than in the centre, or does it depend on the location of the margin (N or S edge)?

This study tackles the question based on two generations of vegetation atlas data from the UK and Estonia, describing plant species' range changes during the 20th century. In both countries the presence of each studied species was recorded on maps in hectad grid cells (100 sq. km.). Persistence (% of grid cell presence changes) of plant species in United Kingdom and Estonia was studied for 1,418 plant species in the UK and 1,226 species in Estonia based on two major survey periods: 1st from 1930 to 1969, and 2nd from 1987 to 1999 in the UK; and from 1921 to 1970, and from 1971 to 2004 in Estonia. We distinguished species currently living in their range margins in the UK (406 species) and Estonia (452 species) and analyzed, whether there are significant persistence differences between the species living in range margin (separately for N and S edge) and range centre.

We found significant differences in plant species persistence between range center and range margin species for both the UK and Estonia. While the average persistence of range center species in the UK was 71% and 78% in Estonia, range margin species had on average 15% lower persistence, 57% and 64%, respectively. Thus, the gap of difference between range center and range margin persistence in both countries was similar (14%). Being on a range margin resulted in lower persistence in comparison with range center species, regardless of whether the species is in northern or southern edge. As the second generation vegetation atlases used in this study were compiled largely based on distribution data from the last century, when climate change effects were still relatively mild, this study is a good baseline for future comparisons.

Talk Using plant traits for the recovery of ecosystem functions and services: Trait-based ecosystem engineering?

Prioritizing plant species to deliver multiple ecosystem functions in ecological restoration

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It is worth thinking critically about which plant species are appropriate to use for restoration treatments and why. How can we restore targets for not only diversity, but also for supporting ecosystem services and function? Can we be more effective in selecting species for particular targets to maximize desired outcomes, and minimize inputs? Our study suggests we can. Here, for the first time, we applied decision support software in a non-spatially-explicit framework, to prioritize plant species by maximizing the provision of plant traits that enable ecosystem functions in order to compile an optimized selection of plant species. Using European alpine grasslands as a case study, we identified a target restoration species pool from which to select and prioritize plant species important for achieving restoration objectives to maximize multiple ecosystem functions. We compared the prioritized species selections to that of selecting plant species for biodiversity (systematically selecting one plant species of every taxonomic family or genera), for dominant species, and for selecting species completely randomly. Our results suggest that the functional identity of plant species matters more for ecosystem function than the number of species. This novel framework transcends that of a case study, and may be applicable to any initiative, in any habitat seeking to apply quantitative decision making to ecological restoration objectives so as to optimize the provision of desirable ecosystem functions or targets. This also has implications for the support of multi-trophic functions in conservation decision making. We present a simple proof of concept, but suggest approaches to practical situations.

Talk Macroecological vegetation science: large grain patterns and processes of plant diversity

Leaf traits and isotope composition in zonal plant communities from a 2000 km latitudinal gradient in Northern Eurasia

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In order to follow their climatic niche in a changing climate, many species migrate along latitude and may face environmental challenges on this track. Our knowledge about the relative importance of environmental factors along with potential migration routes is still poor. A useful insight can be gained from foliar element isotope discrimination of plant communities that provide an integrated signal of plant responses to such differences. Plants preferably use the lighter carbon and nitrogen isotopes but include heavier isotopes if they must. In addition, functional leaf traits, such as leaf mass per area (LMA), adaptively track the environmental differences adding information about the associated plant community response. Here we present results from a comprehensive survey of leaf isotopes and leaf traits of more than 400 plant samples (grasses and herbs) from 21 sites of zonal plant communities across a 2,000 km latitudinal transect east of the Ural Mountains in Russia and northern Kazakhstan. This transect is characterized by flat topography, with precipitation increasing and temperatures decreasing with higher latitude. While LMA decreased moderately with higher latitude, leaf δ13C and δ15N showed strong declines. However, when the habitat, steppe or forest, is taken into account LMA and δ13C decreased only in the forest and showed no latitudinal cline in steppe plants. Conversely, δ15N showed a steep decline in steppe plants but remained unchanged along the gradient in forest understory plants. Together, these results indicate that global leaf trait pattern may be strongly influenced by the habitat from which the plants originate. Furthermore, in different habitats plants may face contrasting challenges along the same latitudinal gradient when migrating to track their climatic niche.

Silhouette width using generalized mean – a flexible method for assessing clustering efficiency

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Cluster analysis plays a vital role in pattern recognition in several fields of science. Silhouette width is a widely used measure for assessing the fit of individual objects in the classification, as well as the quality of clusters and the entire classification. This index uses two clustering criteria, compactness (average within-cluster distances) and separation (average between-cluster distances), which implies that spherical cluster shapes are preferred over others – a property that can be seen as a disadvantage in the presence of clusters with high internal heterogeneity, which is common in real situations.

We suggest a generalization of the silhouette width using the generalized mean. By changing the p parameter of the generalized mean between −Inf and +Inf, several specific summary statistics, including the minimum, maximum, the arithmetic, harmonic, and geometric means, can be reproduced. Implementing the generalized mean in the calculation of silhouette width allows for changing the sensitivity of the index to compactness *vs* connectedness. With higher sensitivity to connectedness instead of compactness the preference of silhouette width towards spherical clusters is expected to reduce. We test the performance of the generalized silhouette width on artificial data sets. We examine how classifications with different numbers of clusters prepared by single linkage, group average, and complete linkage algorithms are evaluated, if p is set to different values.

When p was negative, well separated clusters achieved high silhouette widths despite their elongated or circular shapes. Positive values of p increased the importance of compactness, hence the preference towards spherical clusters became even more evident. With low p, single linkage clustering was deemed the most efficient clustering method, while with higher parameter values the performance of group average and complete linkage seemed better.

The generalized silhouette width is a promising tool for assessing clustering quality. It allows for adjusting the contribution of compactness and connectedness criteria to the index value, thus avoiding underestimation of clustering efficiency in the presence of clusters with high internal heterogeneity.

Talk Vegetation patterns and processes

Defense of analyses of Community Weighted Means of functional traits

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Recently, several papers criticized the analyses of community weighted means (CWM) of traits in studies of trait - environment relationships, claiming that this approach leads to very high Type I error rates. The problem can be illustrated by the fact that if dandelions prevail in fertilized plots, we will get positive response of CWM for yellow flowers to fertilization, although color has no adaptive significance here. I argue that the Type I error rate has a meaning only in connection with a specific null hypothesis, which should be determined by our specific ecological question.

There is no single trait-environment relationship. Either the community trait composition changes along environmental gradients or the responses of individual species to environment are determined by species traits. Although these two relationships are not independent, their correspondence is not straightforward. Within each of them, plethora of meaningful ecological questions exist, each needing specific null models.

The community trait composition is usually characterized by CWM of trait values, or by functional diversity (FD, a measure of variability of traits within the community, prone in analyses to similar problems as CWM). Originally, CWM was used by Garnier to test the Grime's mass ratio hypothesis; the leaf traits weighted by the proportion of biomass of individual species varied in systematic way during succession and predicted well the ecosystem properties (e.g. productivity). The traits were considered to be the effect traits and the results did not imply their adaptive significance. In such cases, I do not see any problem with classical CWM analyses.

The situations where a very limited number of (dominant) species responding to a gradient change the functioning of the whole ecosystem are not rare. Often, the CWM is a good predictor of functioning, and reflects the change of functioning along the environmental gradient. Tree lines in mountains are often formed by very limited numbers of tree species. Around the tree lines, the (biomass weighted) CWM for height or for woodiness decreases strongly with elevation, but height is not a good predictor of species optimum on this elevation gradient. This has a clear reason - the climatic gradient (determined by elevation) is limiting for the ability of dominants to form a tall woody stem, but the majority of (mostly herbaceous) species respond on elevation to gradient of shade, imposed by the woody dominant. In consequence, CWM for height (determined mainly by dominants) decreases with elevation (repeatedly in various geographical regions), but the height is not sufficient to predict a species' elevational optimum. In conclusion, the statistical null models against which we test our data must be determined by our ecological questions. There is no simple way to decide which of the statistical relationships imply adaptive significance of traits, but amending statistical results by ecological commonsense often helps.

Talk Vegetation patterns and processes

The phytosociology study of winter monsoon evergreen broad-leaved forest in Taiwan

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The winter monsoon evergreen broad-leaved forest is a refuge for the relic species in Taiwan. These species include tree ferns, *Cyathea lepifera*; the conifers, *Amentotaxus formosana* and *Keteleeria davidiana* v. *formosana*; and the broad-leaved species, *Bretschneidera sinensis* and *Euscaphis japonica*. The characteristic features of winter monsoon evergreen broad-leaved forest are: it is short and dense compared to the other forests in Taiwan. The character species of the forest are *Ilex maximowicziana*, *Ilex uraiensis*, *Itea oldhamii*, *Machilus thunbergii*, *Myrsine seguinii*, *Nageia nagi*, *Pyrenaria shinkoensis*, and many others. Before I want to understand why this type of habitat provides a refuge for many relic species, I would like to figure out how many vegetation types there are in this forest and what the main factors are related to the change of floristic composition.

I used the data of 939 relevés, which have been classified into winter monsoon evergreen broad-leaved forest from the National Vegetation Database of Taiwan to answer the questions. Two main vegetation types can be recognized as subtropical and tropical vegetation types. Then, they can be further divided into ten associations related to elevation, soil properties, the successional stages, and the topography. All the relic species present in these vegetation types of early successional stage, rocky habitats and topography are heavily influenced by the strong wind in winter. I suppose that these are the stressors for evergreen broad-leaved species to grow and they make many species to co-exist in the habitats.

Ecosystem service quality of small forests in rural landscapes - the effect of the past and present

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Land-use intensification and land-cover transformation have led to the degradation of ecosystem services provided by semi-natural habitats. Forest islands in rural agriculture dominated landscape are expected to provide high quality services.

However, this may depend on the history and spatial context of these forests. The estimation of service provision quality also depends on indicator variable, e.g. species richness is widely used, but probably not the best proxy. We will present a three-component indicator system, consisting of functional Diversity, functional Intensity and functional Stability, in short the DIS-system; and use the herb layer survey data from small forests of temperate Europe in combination with flower traits, We hypothesised that the quality of floral ecosystem service provision by mid-field forest fragments depend on forest history and present status. We also will consider the perception of various direct flower service users, e.g. humans and pollinators. Beyond some region-specific patterns, ecosystem service quality provided by small forest fragments does depend on forest properties. Fragments ranked quite similarly from both human and pollinator perspective, but looks that the human perspective overstates the service quality. We will interpret indentified ecological patterns and provide suggestions for future planning for efficient landscape greening.

Diversity pattern of woody species along elevation in Taiwan: does the sample standardisation matter?

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The unimodal pattern of diversity along elevation is one of the classical yet peculiar diversity patterns, frequently reported for different organisms and from different parts of the World. Elevation can be seen as a 'natural experiment', since several environmental features change along it, and one reason to study diversity-elevation pattern is to understand the ecological processes behind. Several theories explaining the unimodal pattern were proposed (area hypothesis, productivity hypothesis, mid-domain effect), yet their relative importance remains to be verified. Most of previous plant diversity-elevation studies were based on vegetation plots of the fixed area or on floristic surveys done in grid cells of fixed size. However, even if the sampling is standardised to fixed areas, the numbers of individuals and completeness may differ among them, which could make the resulting diversities not comparable.

In this study, we focus on describing the diversity pattern of woody species along elevation in Taiwan and testing how different standardisation methods influence the shape of the diversity-elevation pattern. Taiwan, an island located in Eastern Asia, represents a great study site to explore the diversity-elevation pattern, due to a wide elevation range (0-3952 m a.s.l) and rich subtropical flora. We used the dataset of 9,822 plots from the National Vegetation Database of Taiwan and analysed the elevation pattern of woody species diversity on two scales: local (plot level) and regional (elevation zone). On both scales, we applied different methods of sampling standardisation. For the local scale, we used abundance-based data and standardised diversity to the fixed area (400 m^2), the number of individuals (taller than 2 m) and completeness (proportion of observed species in the community). For the regional scale, we used incidence-based data and standardised diversity to the fixed number of samples and completeness. Standardisation was based on relevant abundance- or incidence-based rarefaction method with extrapolation.

The results show that both local and regional diversity patterns are unimodal with maxima at lower middle elevation (750-1360 m a.s.l.), and the standardisation methods have a relatively small effect on the shape and maxima of the diversity patterns. When separating data into latitudinal zones, the peak of diversity is highest in the central part of Taiwan, probably as a result of *Massenerhebung* effect caused by the presence of large-mass mountain ranges. The resulting unimodal pattern is in agreement with studies published from other regions. The fact that the shape and the position of diversity maxima are not considerably influenced by standardisation method is good news, indicating that previous studies based on plots standardised fixed area can be considered robust and reliable.

Poster Plant phenology and plant traits

Changes of community-level leaf morphological traits of terrestrial and epiphytic ferns along elevation gradient in northeastern Taiwan

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Leaf morphological traits of angiosperm species are often related to different environmental factors, revealing distinct strategies how plants adapt to their habitats. Some traits are known to have important functional meaning; for example, leaf dry matter content (LDMC) and carbon content per mass (Cmass) are related to the investment strategy of leaf development. Ferns, as an evolutionary old clade, have distinct body form and life history compared to angiosperms. However, few studies have focused on how ferns growing strategies and leaf morphological traits change along environment.

Taiwan has strong elevation gradients, driving the change of many environmental factors and creating diverse habitats. We established 60 10 m x10 m plots at elevation zones between 850 and 2100 m a.s.l., recorded topographical, soil and biotic environmental factors, recorded all terrestrial and epiphytic fern species, and measured a set of leaf traits for most of them. Response of community-level traits along environmental variables was analyzed using the fourth corner with Pmax test. Our results show that in the case of terrestrial ferns, LDMC and Cmass increase with elevation and soil acidity, while in the case of epiphytic ferns, delta13C content decreases with elevation. Species composition of woody species, recorded in the plots with high C/N ratio soils, is related to lower leaf area (LA) for terrestrial ferns and higher LDMC and Cmass for epiphytic ferns. Additionally, epiphytic ferns in northeast facing slopes often have lower leaf area. At higher elevation, lower mean temperature and slower decomposition rate limits the nutrient cycle, supporting slow growing terrestrial ferns with long living leaves. High elevation zones also have more frequent fog, and this stable water source is related to lower delta13C content in epiphytic ferns, indicating poor photosynthetic water use efficiency. The occurrence of *Chamaecyparis* and *Rhododendron* dominant forest growing on soils with high C/N ratio limits the distribution of most epiphytic species; only *Hymenophyllum*, the shade tolerant, moisture dependent, and slow growing ferns are dominant there. In the same habitat, soil is nitrogen limited and terrestrial ferns growing there produce smaller leaves. For epiphytic ferns growing on northeast-facing slopes, smaller leaves are likely adaptation to reduce the mechanical stress caused by winter monsoon.

Overall, terrestrial ferns are sensitive to the availability of soil nutrients, while epiphytic ferns are sensitive to host tree identities, water availability and wind intensity. In the future, we will use results of this study to select specialist fern species with specific combination of leaf traits as indicators of changes in key environmental conditions.

Accumulating species in time and space: Does high temporal variability matter?

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The species-area relationship (SAR) is a well-studied phenomenon in ecology. Recent advances in statistics and theory, in combination with "big data" approaches, have led to significant insights on the nature of SAR. In contrast, the species-time relationship (STR) has received much less attention. It appears that in many ecosystems, the relative rate of species accumulation in space versus in time greatly depends on scale. While at small spatial scales, species accumulation in time is faster than in space, on larger spatial scales species accumulation in time is slowed down. In consequence, in any system there should be a point where these two accumulation rates are equivalent. By identifying this point of time-space equivalence, we could gain insight into species turnover processes in time and space, in particular at which point time gives way to space as the dominant determinant of species turnover. Hence, SAR and STR are not independent relationships, but two components of a species-time-area relationship (STAR).

In my talk, I will link the STAR discussion to the conceptual framework of the Intermediate Disturbance Hypothesis (IDH) which predicts a high diversity along a disturbance gradient (e.g., a gradient of land-use intensity). I will present the STAR of vascular plants from an eleven-year study in a semi-arid savanna in north-western Namibia, which is characerized by a high temporal variability of plant resources. Here, a STAR monitoring site of 50 km² was established in 1996, which includes a steep gradient of land-use intensity from protected to highly overgrazed. Twelve fully nested Whittaker Plots with a maximum size of 20 m x 50 m were established and monitored annually. In each observation year, the spatial scale considered on the plot level ranged from 1 m² to 1000 m², and doubled between individual steps.

Results indicate that species accumulation rates z (i.e. slopes of SAR) and initial accumulation rates c varied with resource availability. Specifically, I found slow species accumulation in years with bad and good resource availability, respectively. In contrast, fast species accumulation and high species numbers were found in years with average resource availability. In good years with above-average precipitation, species accumulation seems to be restricted by a high dominance of productive species, while in bad years with below-average precipitation, microhabitats below trees (subcanopy habitats) serve as refugia for species with high water requirements. At the same time, species accumulation rates peaked at intermediate levels of human disturbances. My results support the IDH, and imply a general STAR pattern. I will discuss implications for biodiversity assessments and for conservation practices in African savannas and beyond.

Talk Vegetation patterns and processes

Where does the forest come back from? Soil and litter seed banks and juvenile bank as sources of vegetation resilience in the face of land-use change in a semiarid Neotropical forest

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The existence of reservoirs from which dominant species could recruit after disturbance is considered a key factor in ecosystem resilience. The literature on the role of soil seed banks in community regeneration is vast for sub-humid Holarctic systems, but much scarcer for semiarid Neotropical ones. Additionally, litter seed banks and juvenile plant banks have been scarcely studied worldwide. In this study, we aimed to analyze the different reservoirs from where dominant woody species regenerate from in the semiarid Neotropical Chaco forest of Córdoba, Argentina, and, whether the soil and litter seed banks, and the juvenile bank are effective sources of resilience of these forests in the face of different land use regimes. We selected four ecosystem types subjected to increasing long-term land-use intensity: primary forest (with no land use in the last 50 yr), secondary forest (with low land use intensity), closed species-rich shrubland (with moderate land use intensity), and open shrubland (with high land use intensity). We monitored four sites per ecosystem type. At each site we recorded the % cover of adults and the number of juveniles (saplings and seedlings) of all woody species. Additionally, we collected litter and soil samples that were then processed in the lab for taxonomic identification and germinability of seeds. We compared the species composition of the soil, litter and juvenile banks ("reservoirs") with that of the established vegetation within each ecosystem type. We also compared the reservoirs from different ecosystem types with the established vegetation of the primary forest, considered as the reference ecosystem. Woody species were absent from the soil seed bank, but were very well represented in the litter seed bank and juvenile bank from different ecosystem types. These two reservoirs showed high similarity with the established vegetation within each ecosystem type. However, increasing land use intensity decreased similarity between the reservoirs from each of the three ecosystem types subjected to land use and the established vegetation of the primary forest. Litter seed and juvenile banks, but not the soil seed bank are the main reservoirs of dominant woody species in the Chaco forest. However, the ability of these reservoirs to act as sources of resilience decreases as land use intensifies.

Talk Vegetation patterns and processes

Do functional traits and their distance from community-weighted mean determine species success?

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Understanding why some plant species are more successful at some places than others has been in the scientific focus for many years. Species and environmental characteristics play an important role in determining whether a plant will be successful in establishment and long-term survival in a community or not. However, not many studies have explored the relationship between a species abundance gradient and their characteristics while controlling for differences in environmental conditions.

To identify how the success (characterized by abundance) of six selected, widespread and in their abundance variable species is affected by their traits, we measured vegetative height (VH), specific leaf area (SLA), and leaf dry-matter content (LDMC), and estimated the cover of these species on 16 calcareous dry alvar grasslands in western Estonia. We also included trait information from LEDA traitbase about the remaining species in sampled communities to see how the species perform depending on the distance from community-weighted mean CWM. Abiotic characteristics (soil depth, aboveground biomass, nutrient soil content) were used to filter out the effect of environmental conditions on species.

Environmental conditions significantly affect the composition and characteristics of species in studied communities. However, on top of that, our results highlight high importance of intraspecific variability in selected species traits for their success, when environmental conditions are filtered out of the models. Response to the environment varies substantially between species, while the effect of plant characteristics is rather consistent - species with higher stature and LDMC are more likely to become abundant, while SLA exhibits the opposite pattern. Although not consistently, the distance of the species from CWM was also a strong determinant for species success, showing either negative, neutral, or positive associations.

Our results point out to the importance of species' functional differences to quantify individual plant species success in a given community and discriminate this biotic effect from the effect of abiotic conditions. The existing strong relationship between functional traits and species abundance emphasize non-random processes in species rarity or commonness patterns, which is even more highlighted by the changing species performance as their mean trait values are moving further from CWM.

Historical or present-day conditions - which variables affect the forest specialist diversity in hedgerows?

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Hedgerows are very important for maintaining the biodiversity in cleared and agriculturally intensified landscapes. Especially for specialist species such as herbaceous forest plants they can provide important refuge habitats. This study quantified the loss in hedgerow density between 1877 and today in Schleswig-Holstein, northern Germany. Based on this information, we examined whether there is an extinction debt of forest specialists in hedgerows.

There was a considerable loss in hedgerow density over the studied period of 130 years of, on average, about half of the former hedgerows. Regions that were particularly hedgerow-rich in historical times suffered the greatest losses both in absolute numbers and proportionally.

We found no effect of the historical hedgerow density on the diversity of forest plants in hedgerows, i.e. no extinction debt, but instead a negative influence of a dense present-day network. This counterintuitive finding can be linked to the fact that hedgerows were found to be narrower in areas with a higher density, presumably due to land-saving measures by farmers. Hedgerow width is a main factor for the quality of the habitat for forest specialists.

We conclude that the quality of the hedgerow habitat is more important for forest plants than the former or current landscape configuration. This does not imply that the remaining hedgerows do not need further protection but, instead, that an even stronger focus needs to be put on the habitat quality and especially the width of the hedgerows.

Spatial and temporal patterns in seedling emergence in salt marsh communities

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Community dynamics are determined by dispersal processes, abiotic and biotic interactions. We aimed to understand how these processes determine the salt marsh plant community establishment and development under different connectivity conditions by analysing the spatial and temporal patterns of seedling emergence along the environmental gradient.

We established an experiment along the salt marsh elevation gradient with bare sediment open for spontaneous colonisation on the natural salt marsh and on the experimental salt marsh islands built on the tidal mud flats of Spiekeroog approximately 300 m from the back-barrier salt marsh for low connectivity. We identified the seedling emergence from georeferenced photos at least monthly during one growing season. Low connectivity plots showed limited colonisation by annual halophytes that produce large number of small seeds. Number of seedlings on the high connectivity plots on the other hand was significantly larger with most individuals in the middle of the elevation gradient. Timing of seedling emergence was however similar for all elevation zones.

Species richness increased along the elevation gradient, indicating that zonation in the salt marsh vegetation is not due to the seed dispersal limitation within the salt marsh. The effect of dispersal and establishment success of salt marsh plant species plays a crucial role in highly dynamic ecosystems subjected to high level of disturbances by tidal activities, storm surges and in the long term also changes in the sea level. Spatial and temporal patterns of seedling emergence along the environmental gradient confirm that interaction between seed availability and environmental conditions determine the initial community on the salt marshes. Initial species composition is driven by stochastic colonization events and its functional composition reflects successful dispersal rather than resource use efficiency.

Vegetation diversity patterns along the temperate-desertic gradient in Southwest Europe - Northwest Africa

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The southwestern tip of Europe, the Iberian Peninsula, and the northwestern extreme of Africa have had an intense relationship based in a common history since the mid Tertiary, when both areas approached due to the plate tectonics moved Africa northwards. The uplift of the mountain ranges during the Alpine orogenic cycle, the several periods in which Iberia was connected or came very close to North Africa, such as the Messinian episode at the end of the Miocene, and the glacial periods in which the sea level was substantially lower than now, together with the appearance of the Mediterranean climate and the aridity belts, shaped the composition and distribution of the flora and vegetation units in that area. Currently, there is a strong north-south gradient from the humid areas of the Cantabrian region and Pyrenees to the Sahara Desert, crossing a number of Mediterranean ecosystems and a set of mountain ranges of high elevation, mostly disposed east-west, increasing the regional and the local climatic variability by the effects of temperatures diversity, orographic rains, rain shadow and geologic diversity. The landscape units we have distinguished in this gradient are: 1 Lowlands and midlands of the Atlantic areas with deciduous beech and oak forests, heathlands and hay meadows; 2 Submediterranean areas of the central-north Iberian Peninsula, with forests of marcescent species such as *Quercus faginea* and *Q. pyrenaica*, scrub and dry grasslands; 3 Mediterranean areas of central and southern Iberia and northern Morocco, with sclerophylle forests of *Q. ilex*, *Q. rotundifolia*, *Q. suber*, *Q. coccifera*, *Olea europaea*, *Juniperus thurifera*, etc., with dry scrub; 4 humid Mediterranean areas of southern Iberia and Northern Morocco with fir, cedar and *Q. canariensis* forests; 5 Arid Mediterranean areas of southern Spain and Morocco, with *Periploca laevigata*, *Tetraclinis articulata* and *Argania spinosa*; 6 Desert. Those units can be recognized as belts disposed north-south determined by the climatic conditions and adapted to the topography. In addition to that, the mountain ranges show also a gradient in their altitudinal zonation and in their latutudinal position, showing the history of speciation and migrations that have taken place following the connections and disconnections happened among them along the time, driven by the glacial cycles of the Pleistocene. The groups are: I Pyrenees-Cantabrian Range; II Central Iberian ranges; III Southern Iberian ranges (Betic, Sierra Nevada), Northern and central Moroccan ranges (Rif and Middle Atlas); IV southern Moroccan ranges (High Atlas). In general, a decrease of humidity towards the south, especially affecting summer-drought, is clearly observed.

Poster Global biodiversity of plant species, plant forms and plant communities

Vascular epiphytes in the Neotropical Region: a phytogeographical meta-analysis

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The Neotropical Region (NR) holds a large portion of the global vascular plants, as well as the vascular epiphyte species (VE). Despite this diversity, the knowledge about its distribution considering the whole NR still is not investigated. We compiled a dataset of VE species occurrence in the NR to access the floristic relationships in this region. We used data from 119 qualitative/quantitative studies (articles, chapters and theses), from 173 localities in 14 countries. By means of cluster analysis, using the Jaccard index, we assessed the local species similarity in the NR. We found 14,689 identified records and 3,935 species. More than the half (2,117) of the species were recorded in only one area. Our results showed three groups and 13 subgroups.

Group 1 was formed by: sites of Southern and Southeastern Brazil, with four subgroups: only the Southern Brazilian Atlantic Forest (a); ecotonal and restinga areas of the São Paulo State and Southern Brazil (b); montane areas of the Atlantic Forest (altitudinal average of 1245 m) (c); and pluvial forests of Santa Catarina State (altitudinal average of 560 m) (d). This first group was congruent with a distribution in mild climate areas: at low altitudes in high latitudinal ranges, and in lower latitudinal places in higher altitudes. The group 2 was the most heterogeneous, grouping sites from every region included in the analyses, clustering Amazon sites and three lowland Panama forests (e); an outlier group (areas with lowest species richness) (f); areas of the north coast of São Paulo, east Minas Gerais, Espírito Santo, Rio de Janeiro, and south Bahia States (g); Andes areas (altitudinal average of 2235 m) (h); Caribbean areas, plus Central America, northern Colombia and southern Mexico (i); and areas of Mexico (j). Also the Panama lowland grouping with the Amazon areas show that the putative northern Andes barrier may not be so effective when it comes to the rain forests. Finally, the group 3 included seasonal areas of the Southeastern and Southern Brazil (k), areas of Paraná, São Paulo and Mato Grosso do Sul States; the cold Pampean region (l), and the Araucarian Forests in Southern Brazil (m). In general, we could demonstrate some congruent distributions in the NR, even in accord with the Morrones bioregionalization, with better resolution in regions with more studies. Besides, this compilation sheds light on the great lack of knowledge, with countries with no recorded studies at all, like Peru. This approach will help to elucidate the distribution, floristic relationships and the lack of the knowledge about VE in the NR.

Linking aboveground vegetation attributes and belowground carbon stock with remote sensing data

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Peatlands are key reservoirs of belowground carbon (C) and their monitoring is important to assess the rapid changes in the C cycle caused by climate change and direct anthropogenic impacts. Remote sensing provides a rapid and economical approach to estimate belowground C stock, supplementing traditional direct methods such as coring and probing. Frequently, in-situ measurements to estimate peatland C stock include peat thickness, dry bulk density and carbon concentration, which has to be obtained by laboratory analysis. Meanwhile, remote sensing products often include peatland area and vegetation types.

These variables are then used to predict belowground C stock by applying allometric functions to the obtained vegetation classes. Despite the accuracy of such approaches, there is still the need to find mappable proxies that enhance predictions with remote sensing data by reducing field and laboratory efforts. The use of direct approaches using reflectance data to predict peatland belowground C stock usually depicts low agreements because the links between aboveground (i.e., what is measure by remote sensing sensors) and belowground properties often presents non-linear or complex interdependencies. Therefore, we assessed the use of aboveground vegetation attributes as proxies to predict peatland belowground C stock.

To link the aboveground vegetation attributes with belowground C stock by means of reflectance data, we coupled two different type of empirical models: structural equation models (SEMs) and random forest regressions. First, the causal associations between aboveground vegetation attributes (i.e. vegetation height, aboveground biomass, species richness and floristic composition of vascular plants) and belowground C stock were obtained using SEM. The structural model was formulated using expert knowledge and trained and validated using plot-based information. Second, the SEM latent vectors were spatially mapped using random forest regressions with UAV-based hyperspectral and canopy 3D structural information. Finally, this enabled us to map belowground C stock using the SEM functions parameterized with the random forest derived maps.

The coupling of SEM and random forest resulted in higher accuracies than a direct application of the purely data-driven random forest approach with UAV data. The coupled model increased r^2s from 0.39 to 0.54, normalized RMSEs from 31.33% to 20.24% and biases from -0.73 to 0.05. Our case study showed that: (1) vegetation height, species richness and aboveground biomass can be good proxies to estimate peatland belowground C stock, as they can be estimated using remote sensing data and hold strong relationships with the belowground C gradient; and (2) SEM is useful to include theoretical knowledge in empirical modeling approaches.

Talk Macroecological vegetation science: large grain patterns and processes of plant diversity

Phylogenetic and functional diversity patterns: New insights from European grasslands

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In cooperation with EVA data contributors and TRY data contributors

The patterns of phylogenetic (PD) and functional (FD) diversity of plants in grassland communities across Europe remain insufficiently known. We used a multi-scale framework to ask if grasslands exhibit patterns of phylogenetic and functional disconnection (decoupling) within six habitat types, namely alpine, dry, mesic, wet, saline and sandy grasslands. The aim of this work is to identify which of these habitats and which regions in Europe are characterized by decoupled PD and FD and to propose possible explanations of such patterns. Our results are based on an extensive dataset of 122,724 vegetation plots provided from the European Vegetation Archive, which was filtered to meet our criteria on plot size, date of recording and geographical distribution. PD was estimated based on the largest available dated phylogenetic tree and FD was estimated using ecologically relevant traits obtained from the TRY database. We explore how spatial patterns in phylogenetic diversity coincide with the distribution of plant species richness, and how they vary among grassland types and along macroclimatic gradients.

Talk Plant phenology and plant traits

Post-fire flowering increases in the Cerrado

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In several fire-prone ecosystems fire affects reproductive phenology of plants mainly by enhancing flowering and fruiting. Sometimes, fire can also accelerate those processes. Therefore, we evaluated fire effects on the number and profusion of flowering of Cerrado's species. We established 6 plots (30 m x30 m) in open savannas in Central Brazil, with the following treatments: fire exclusion (E, excluded from fire for 6 years) and burned (FB, recent and frequently burned). In all treatments, the number of species flowering, and fruiting was counted every 15 days for 3 months and then at 6, 9 and 12 months after fire. We also counted the number of reproductive and vegetative shoots in 30 subplots (1 m x 1 m) in each area. Our results showed that fire enhanced flowering in general. Already in the first 30 days up to 3 months after fire there was up to 2-fold more species flowering in the FB than E areas. After 12 months there was still a higher percentage of species flowering in the burned area (E=26%, FB=39%). At the community level, there was significant increase in the ratio of reproductive shoots at 3 months post-fire, showing that that mass response of flowering happened in the first 3 months after fire. Both areas shared less than 50% of common species flowering at each time post-fire. We also classified species according their responses to fire in: sensitive, dependent, affected and independent and we found 47 species to be fire-dependent, since 40% of species flowered only in the burned area. Therefore, although the mechanism of flowering in post-fire environments is not known our results showed that fire changes the reproductive phenology of many species thus altering the dynamics of the plant community in the Cerrado.

Resilience of Mediterranean and boreal riparian woody vegetation to flow regulation

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Regulated rivers due to their unnatural water-level regimes can promote filtering effect on riparian vegetation, leading to functional diversity loss and consequently affecting ecosystem resilience. We tested the riparian woody vegetation resilience to river regulation in Sweden and Portugal by evaluating the functional diversity changes between free-flowing and regulated sites.

The research was undertaken in the north and central mainland of Portugal and in the boreal coniferous zone from northern Sweden. We selected: in Portugal, 30 minimum impaired river reaches and 22 sites on river stretches downstream from dams and in Sweden, 32 sites in the free-flowing rivers and 25 sites in the regulated rivers. We used 9 functional traits and two functional diversity indices - Functional Richness (FRic) and Functional Redundancy (FRed) to characterize the effect of altered stream-flows on functional diversity in riparian woody vegetation. We used 29 ecologically relevant flow attributes and identified the most important using linear regression.

We found that FRic and FRed were negatively affected by regulation in both countries, but effects were only significant in Sweden. Similarly, in Sweden, we observed significant changes between free-flowing and regulated sites in most analyzed traits (except for seed buoyancy and reproduction by seeds) and shifts towards reduced plant size, smaller leaves, more herbaceous plants, shallower roots with regulation unlike in Portugal, where the same traits persisted. Since, linear models for FRic and FRed with hydrological variables were not significant for Portugal, we could only identify the key hydrological attributes in Sweden - magnitude of monthly water conditions, magnitude and duration of annual extreme waters, frequencies of high/low pulses and rate of water condition changes.

We concluded that flow regulation may decrease the resilience of riparian woody vegetation through its effects on functional diversity, but that the extent of these effects may vary depending on the legacy of previous local stream-flow disturbances on the species. Namely, long-standing water stress and sudden events which characterize the Mediterranean biome have become an advantage when facing flow regulation. Further, in the Mediterranean biome, over evolutionary time, the filtering effect has already removed or favored certain traits and shaped the present communities to face and cope with water stress.

Our study provides insights on functional diversity patterns of riparian woody vegetation as affected by flow regulation in contrasting biomes and encourages further studies on quantifying the thresholds for riparian functional richness and redundancy for maintenance of ecosystem resilience.

Talk Plant phenology and plant traits

Resource acquisition strategy affects grassland species' phenological responses to climate change

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Grasslands are one of Earth's major ecosystems and provide essential ecosystem services such as forage. Forage quality and quantity is, among other factors, linked to plant phenology. However, it is not yet fully understood how climate change, i.e., rising temperature, increased precipitation during spring and fall, and decreased precipitation during summer, will affect plant phenology. Both delay and advancement are observed in experimental studies. Species with different functional strategies also appear to differ in their direction and magnitude of phenological response. The Global Change Experimental Facility (GCEF) in Bad Lauchstädt (Germany) offers an opportunity to assess long-term changes in plant phenology and their link to functional plant traits.

In our talk, we will present results from the first four years of climate manipulation in the GCEF (2015-2018). At eight occasions (May and August cuts), we assessed plant phenology and sampled functional traits of abundant plant species on extensive meadows. Species represented different plant functional types, i.e. the strategy of resource acquisition (fast, intermediate, slow), growth form (herbs, legumes and grasses), and pollination type (wind or insect pollinated). Plant phenology was captured on a modified BBCH scale. Sampled functional traits include specific leaf area (SLA), chlorophyll content, vegetative and generative height, and individual biomass. Shifting phenology was captured by calculating difference values between future and ambient climate conditions. Generalized linear mixed models were used to investigate the effects of season, plant functional type (resource acquisition strategy, growth form, or pollination type) on shifting phenology. We also used measured trait values as linear predictors to analyse which functional traits are related to shifting phenology.

Results indicate that phenological responses varied considerably among species and functional types, but also across years and seasons. Phenology in summer was delayed, possibly due to a stronger water limitation of plant growth under future climate conditions. During spring, wind- and insect-pollinated species responded differently to future climate conditions. Moreover, plants with a slow resource acquisition strategy displayed an advanced phenology, while plants with an intermediate strategy were delayed and plants with a fast strategy were not affected. We also observed strong relationships between intraspecific trait variation and phenological shifts. Future years will show if this connection between plants' functional strategies and shifting phenologies will become more pronounced over time.

Talk Long-term studies in vegetation science

Buffering climate change impacts in forests: it is not (only) about temperature

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Changes in forest understory lag behind the warming climate. As a possible explanation, it was suggested that increasing canopy cover may have buffered the impacts of climate change. However, the mechanism of this buffering remained unclear: in-situ microclimate measurements show weak effects of canopy on understory mean temperatures and opposing effects on minimum and maximum temperatures. Besides temperatures, the potentially important yet neglected microclimatic variable is the Vapour Pressure Deficit (VPD), which integrates temperature and relative humidity regime. Using networks of temperature and moisture sensors in a landscape-scale study, we explored spatial variability in forest microclimate and quantified the buffering capacity of the canopy. We also linked different climatic drivers to spatial dynamics of understory vegetation. Interestingly, we found that VPD explained more variance in species composition than any temperature index. We than quantified long-term changes (50 years) in forest vegetation from a resurvey study conducted in the same region and linked these changes to combined effects of macro- and microclimate trends, using weather station records corrected for local, site-specific topographic and canopy effects.

UAV-based monitoring of eco-morphological processes in Mediterranean coastal dunes

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Although highly endangered, coastal dunes deliver a wide range of ecosystem services resulting from a complex interaction of eco-morphological processes. Following EU Directives, monitoring schemes are urgently needed to quantify spatial changes in these functions alongside the severe degradation exerted by human pressure. In these ecosystems, vegetation distribution and biomass together with topographic features have been widely recognized as key spatial variables to quantify the ecomorphological pattern along the sea-inland gradient. However, field monitoring approaches are labor intense and often fails to capture the coastal such patterns.

In this regard, in situ sensing from small Unmanned Aerial Vehicles (UAV) carrying lightweight cameras, besides collecting multispectral images able to capture vegetation patterns, represents an emerging low-cost alternative to traditional photogrammetry or active sensor technologies (i.e. LIDAR) to generate high resolution topographic reconstruction from large sets of multi-angle images using structure-form motion (SfM) and multi view-stereo analysis algorithms.

We analyzed the eco-morphological spatial pattern along the sea-inland gradient in two coastal dune sites in Central Italy characterized by low (site 1) and high (site 2) human pressure, respectively. Specifically, by the processing of UAV images, we derived NDVI and topographic variables at very fine scale (0.5 m) for a 250 m wide strip starting from the coastline toward inland. To map the heterogeneity of such gradient, the Rao Q' index was applied to NDVI and topographic variables (elevation, slope and curvature). In particular, thanks to the multidimensional meaning of the Rao Q' index, the variability of the three topographical variables was synthetized into a single layer. We then inspected how the NDVI and topographic Rao Q' index values change as a function of the distance from the sea within the two coastal sites. Site 1 featured a varying trend of heterogeneity values along the sea-inland gradient. The maximum level of eco-morphological heterogeneity occurred at intermediate distances from the sea and the lowest at the end of the gradient where the extreme physical stress exerted by the sea is weaker and dunes are more stable and vegetation homogenously distributed. On the contrary, site 2 featured constant values of heterogeneity along the gradient, highlighting a possibly disrupted eco-morphological gradient due to the high human pressure.
We demonstrate that monitoring and quantification of the eco-morphological gradient of coastal dunes at a very fine scale can be made over management-relevant extents through UAVs. Moreover, Rao Q' index applied to sensing imagery successfully captured the differences in the eco-morphological heterogeneity for the two sites. Our approach supports frequent surveys and can deliver data for spatial monitoring of key coastal functions and services.

Poster Long-term studies in vegetation science

Effects of shrub advancement on boreal treeline ecotone communities under varying magnitude of disturbance during 30 years

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Climate warming increases the productivity of northern ecosystems and drives the advancement of southern and low elevational species and communities towards north and higher elevations. However, these shifts are not constant. Thus, more knowledge is needed on the combined effects of climate and local drivers, such as land use changes, on northern plant communities in order to understand the varying long-term dynamics of vegetation. Here, we use observational resurvey data to study the effects of direct human disturbance on vegetation in one of the southernmost elevational treeline ecotones in Finland. The original survey took place over 30 years ago and at that time the vegetation along the elevational gradient (245-426 m a.s.l.) was characterized by boreal coniferous forest, treeline ecotone and a treeless heath-like top of a small extent. Right after the original survey, the studied sites on the top and half of the sites on the slopes were subjected to continuous and heavy disturbance, connected to construction of a skiing center and related infrastructure. The other half of the sites on the slopes remained further away or nearly untouched from direct disturbances. During the study period, annual thermal sums increased while precipitation remained constant. Our aim was to explore whether the abundance of northern boreal forest species had advanced along the elevational gradient and if previously treeless heath-like features of the top had diminished during three decades. Moreover, we tested if the magnitude of direct human disturbance had promoted or buffered against vegetation changes.

We found that communities on the top lost treeless heath-like characteristics over time. Throughout the elevational gradient, temporal turnover of communities was expectedly higher in heavily disturbed sites. However, alpha diversity increased in both heavily and slightly disturbed sites. In general, a major increase in shrubs (e.g. *Juniperus communis*, *Betula pubescens*, *Salix* sp.) and dwarf shrubs (e.g. *Vaccinium myrtillus*, *Vaccinium uliginosum*) took place across the studied sites but the pattern of this shrubification along elevational gradient was different between heavily and slightly disturbed sites. In slightly disturbed sites, shrub expansion was stronger closer to the top while the increase of dwarf shrubs was greater at lower elevations. In heavily disturbed sites, the increase of both shrubs and dwarf shrubs was even throughout the gradient. Previously extensive bryophyte cover decreased significantly across the studied sites, decrease being strongest at lower elevations and this pattern was similar under both heavily and slightly disturbed sites. Along with a strong evidence of a major shrubification from the southern border of the Finnish fell area, our results indicate that the magnitude of direct human disturbance affects the patterns of shrub and dwarf shrub advancement, which in turn leads to pronounced decrease of ground layer species in any case.

No effect of productivity on the slope of species-area-curves in a grassland dataset with clear humped-back productivity-species richness relationship

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Variation in spatial scale might influence the productivity-species richness-relationship. According to the 'no-interaction model' of Oksanen (1996) at least at small spatial scales the typical humped-back relationship might just arise as a sampling artefact due to changes in the density of plant individuals along the productivity gradient. In the discussions following the proposal of Oksanen, it has been suggested to use species-area curves as a scale independent indicator of how species richness is influenced by site productivity at different spatial scales.

In order to investigate the relationship between productivity and several measures of biodiversity we sampled vascular plant diversity in 79 nested plots in grasslands around Greifswald (Northeast-Germany) with 6 spatial scales ranging from 0.001 m² to 100 m². All selected grasslands are managed with low intensity without fertilization and a mowing regime of one cut per year. We measured dry standing biomass together with several soil parameters and further estimated total cover and average height of the herb layer as proxies for plant density and plant size.

Productivity of the stands ranges from about 20 g/m² to more than 1600 g/m² and basically follows a moisture gradient from very dry and highly acidic sandy sites over mesic sites with or without groundwater influence to nutrient-rich peatlands. Along the productivity gradient, total vegetation cover follows a saturation function, reaching crowding at productivity levels between 200-300 g/m², while average vegetation height shows a linear increase with productivity. As predicted by the 'no-interaction-model' species richness first rises with increasing cover, peaks shortly after crowding starts and shows a declining trend with steadily increasing average vegetation height. This humped-back productivity-richness relationship is consistent at all six spatial scales.

While the constant c of the power function as well as the Shannon-Weiner and the inverse Simpson indices also show a quadratic relationship to productivity (because all are somewhat related to species richness), the slope z of the power function and the Simpson eveness index are independent of standing biomass. This pattern is consistent with the first model of Scheiner et al. (2000), expecting a relationship between productivity and species richness that is invariant to spatial scale.

Formal classification of the *Lygeum spartum* vegetation of the Mediterranean Region

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Lygeum spartum L. is a robust rhizomatous grass, widely distributed in the Mediterranean Region. It occurs from the sea level up to 2260 m of elevation, mainly in the Western Mediterranean (Iberian Peninsula, NW Africa), with some scattered, isolated populations in Southern Italy, Sardinia, Sicily, Malta, SE Crete, Cyrenaica and northern Egypt. In the EuroVegChecklist (EVC), the grasslands dominated by *Lygeum spartum* are assigned either to the phytosociological order *Lygeo-Stipetalia tenacissimae* (class *Lygeo sparti-Stipetea tenacissimae*), comprising the circum-Mediterranean edaphic pseudo-steppes on deep clayey soils, or to the *Limonietalia* and *Limoniastretalia guyoniani* (class *Salicornietea fruticosae*), comprising the Western and Central Mediterranean vegetation of inland salt pans and rarely flooded coastal depressions. A data-driven classification of the communities dominated by *Lygeum spartum* was still missing and therefore we set off to: (1) test the robustness of the classification of *Lygeum spartum* grasslands proposed in the EVC, involving also the extra-European regions of the distribution; (2) propose the formal definitions of phytosociological alliances characterized by the dominance of *Lygeum spartum*; (3) delineate the distribution areas of each alliance; and (4) explore the relationships of these alliances with relevant climatic gradients. We compiled a database of 1838 relevés, which were resampled to reduce unbalanced sampling effort. The resampled relevés were classified using modified TWINSPAN, and the resulting clusters were interpreted and used to develop the formal definition of each alliance. We defined 11 alliances of *Lygeum spartum* dominated communities, including the newly described *Launaeo laniferae-Lygeion sparti* from Morocco. The floristic relationships among the alliances, as well as the environmental gradients underpinning the classification, were examined and visualised by means of a distance-based redundancy analysis. Biogeography was the main factor underlying the floristic differentiation of alliances, with a sharp separation between the West Mediterranean (Iberian Peninsula and Maghreb) and the central-east Mediterranean Basin. The best environmental driver was the isothermality, defined as the ratio between the daily temperature range and the summer-to-winter temperature range.

Tree diversity, tree height and environmental harshness in eastern and western North America

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Does variation in environmental harshness explain local and regional species diversity gradients? We hypothesize that for a given life form like trees, greater harshness leads to a smaller range of traits that are viable and thereby also to lower species diversity. Based on a strong dependence of maximum tree height on site productivity and other measures of site quality, we propose maximum tree height as an inverse measure of environmental harshness for trees. Our results show that tree species richness is strongly positively correlated with maximum tree height across multiple spatial scales in forests of both eastern and western North America. Maximum tree height co-varied with species richness along gradients from benign to harsh environmental conditions, which supports the hypothesis that harshness may be a general mechanism limiting local diversity and explaining diversity gradients within a biogeographic region.

Talk Long-term studies in vegetation science

Dynamics of non-native shrub species abundance in Lithuanian forests in the periods of 1998-2018

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Many woody plant species are cultivated outside their natural range as a cultivation of productive or decorative plants which may lead to economic benefits. These species can cause serious issues in forest ecosystems. This is a matter of considerable concern in the forestry sector. It is important to ensure that such species do not influence native ecosystems. The aim of the study was to assess changes and trends in the abundance of non-native deciduous shrub species over the past 20 years in the forests of Lithuania. The most widespread non-native shrub species *Sambucus* sp. L., *Amelanchier spicata* (Lam.) K. Koch and *Sarothamnus scoparius* (L.) Wimmer in the Lithuanian forests were analysed. Data on an abundance of non-native shrub species were collected from the Lithuanian national forest inventory database which includes four inventory cycles: 1998-2002, 2003-2007, 2008-2012, and 2013-2018. In order to assess the abundance of non-native shrub species the number of stems per hectare was calculated in different height categories: 0-0.5 m, 0.6-1.5 m, 1.6-3.0 m and >3.0 m. The biomass was calculated using allometric equations. Over the past 20 years, the biomass of non-native deciduous shrub species in old forest stands increased from 0.2% to 1.10%. In birch stands biomass of non-native deciduous shrub species increased from 0.2% to 0.7%; in black alder stands - from 0.2% to 0.7%; in spruce stands - decreased from 2.9% to 1.4%. Over 20 years the abundance of *Sambucus* sp. increased in younger forest stands, while the abundance of *Amelanchier spicata* increased in all forest stands. Over 20 years abundance of *Sambucus* sp. increased in spruce, oak and birch dominated stands; the abundance of *Amelanchier spicata* increased in spruce, birch, and grey, but decreased in oak-dominated stands. Although forests are considered to be relatively stable ecosystems resistant to invasion, the abundance of non-native shrub was increasing in Lithuanian forests, thaw show increasing impact of alien species to forest ecosystems.

Variation of germination and seed morphometric traits between twelve *Alnus glutinosa* populations

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Alnus glutinosa (L.) Gaertn. is a riparian tree species with a wide natural latitudinal distribution, from northern Scandinavia to northern Africa. Climate change may have a substantial impact on its geographical distribution due to the specific local ecological requirements of this tree which make it more susceptible to habitat loss. Recruitment of populations is intimately related with the tree species' germination capacity. Thus, a first step for improving maintenance of alders would require quantifying variation among individuals and populations. Several studies have already suggested the existence of phenotypic and genetic variations throughout the geographic range of *A. glutinosa*. A better understanding of the intraspecific variations in germination traits could help selecting populations with higher recruitment capacity. This study aimed to relate germination and seed morphometric traits of *A. glutinosa* populations with environmental conditions of the sites of origin.

Twelve populations of *A. glutinosa* ranging the latitudinal extremes of its distribution (Sweden, France, Czech Republic, Austria, Serbia, Greece, Morocco, Spain - two populations -, and Portugal - three populations -), were sampled in 10-15 mother trees. Seeds were collected and germinated in a substrate mixture of 2 peat to 1 sand in growing trays with 40 cells, inside a temperature controlled greenhouse with an automatic watering system. Germination observations were done periodically. Seed morphometric features such as projected area, curved length and seed weight were assessed by population and by mother tree. A preliminary correlation analysis and a PCA were performed to detect multicollinearity among environmental variables. Analyses of variance was performed to test the effect of population on germination traits and seed morphometric features, followed by a Tukey's test to investigate which pairs of populations showed significant differences. Linear regressions were applied to the data, to explain germination response variables by seed morphometric variables.

Seed projected area values between Iberian and Czech Republic populations were similar. These populations also showed closer distribution in the PCA's ordination space. The Serbian population was the most significantly different from all the populations concerning germination and morphometric seed features. Two morphometric variables (projected area and curved length) and one environmental variable (annual precipitation from the seed source locality) related well with germination. Considering environmental variables and seed morphometric features, it was possible to group populations with similar geographical distribution.

A deeper study of the germination intraspecific variation within *A. glutinosa* populations in future climate change conditions could help understand the future geographical distribution of this species.

Talk Long-term studies in Vegetation Science

Spatiotemporal dynamics and species turnover during primary succession on tropical coastal dunes

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Primary succession on coastal dunes offers a good opportunity to explore community assembly processes, because: a) species richness is naturally low, especially on mobile dunes; b) environmental conditions differ drastically between early and late states, and c) changes in community structure and composition take place at a relatively fast rate, especially during the initial colonization period. Early successional stages on coastal dunes are characterized by extreme conditions: intense sand movement, highly contrasting temperatures, drought and low nutrient supply. Thus, the initial process of dune colonization is restricted to a few highly specialized plant species known as psammophytes, which are tolerant to burial by sand. As plant cover increases, extreme environmental conditions become ameliorated and the establishment of less tolerant species is facilitated, typically resulting in an increased species richness and diversity. For 25 years (from 1991 to 2016), species turnover was monitored in 150 permanent plots (4 m x 4 m) placed on an originally mobile dune system located on the coast of the Gulf of Mexico. We found that successional rate, species richness and diversity increased in a humped-back manner with the highest values occurring between 1995 and 2000. This coincided with the period when the growth season had a higher precipitation and highest temperatures than in the preceding and following years. Species turn-over showed how early colonizers (psammophytes) were replaced by late successional species. Finally, we calculated Moran´s Index for the most abundant and frequent species which included psammophytes (*Chamaecrista chamaecristoides*, *Palafoxia lindenii* and *Croton punctatus*) and late colonizer species (*Schizachyrium scoparium*, *Trachypogon plumosus*, *Opuntia stricta*) to look for spatial auto-correlations. Moran´s correlograms showed that positive autocorrelations increased with successional time. The spatiotemporal dynamics observed during primary succession taking place on tropical coastal dunes were consistent with the facilitation-nucleation model where colonization occurs in micro-scale safe sites, covered by early pioneer species *Chamaecrista chamaecristoides*. As late colonizers grow, and their plant cover expands, early colonizers are replaced and become locally extinct. The spatial patterns revealed that ecological succession does not occur evenly on the dunes. On the contrary, a spatial differentiation of vegetation is associated with the facilitation process and the relevance of microtopography which provides different environmental conditions.

Talk Plant phenology and plant traits

Can forest legume species survive to fire?

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Fire is an environmental driver that shapes many types of ecosystems since millions of years. As an ecological and evolutionary agent is responsible for maintaining biodiversity in flammable ecosystems. Most Brazilian forest formations are not adapted to fire. However, we know that there are some species which may occur in transition areas between savannah and forest. Therefore, regeneration strategies can vary according to the ecology of fire and characteristics of the vegetation. We hypothesised that forest species would have lower capacity or absence of post-fire regrowth because of the absence of resprouting underground structures. The aim of the study was to evaluate the sprouting ability of tree species that occur in forest and transition areas between forest and Brazilian Savannah post fire. For this purpose, we selected 10 legume species, since *Fabaceae* is one of the richest families in Neotropical forests, and it is distributed in both forest and Cerrado habitats: *Albizia hassleri*, *Inga laurina*, *Pterogyne nitens*, *Lonchocarpus cultratus*, *Poecilanthe parviflora* for forest areas, and *Anadenanthera colubrina*, *Enterolobium contortisiliquum*, *Peltophorum dubium*, *Senegalia polyphylla*, *Erythrina crista-galli* for transition between forest and savannah. In the field, three experimental plots (17 m x 17m) were used for fire experiment. Six individuals of each species with 18 and 6 months of age with 1 m space between the plants were used in the field. After the fire, the plants were taken from the field and maintained in the greenhouse for 6 months. We measured the number of plants with shoots, shoot position, number and height, and plant mortality rate. All the species showed resprout already in the first month after fire, excepting *P. dubium* (18 months) and *P. parviflora* (6-months old). Species that sprouted with the greatest vigor were *E. crista-galli* (100%) and *A. hassleri* (88%) 18-months old plants. After six months of the experiment, the species with the greatest number of sprouts were *A. hassleri* (62%). The highest mortality was observed in *E. crista-galli* at 6 months (72%) age. For species with 18 months, the highest number of shoots was observed in *E. contortisiliquum* (9.3 shoots) as early as the first month. Concerning the species with 6 months olds, the highest number of shoots was observed for *A. hassleri* (4.3 shoots) in the first month, *I. laurina* (6.1 shoots) in the third month and sixth month (2.8 shoots). All species showed regrowth at the stem base. No sprouting was observed from aerial branches. Some species also showed sprouting from underground organs. Regarding the height of the shoots in the 18 months old plants *E. contortisiliquum* reached 1.67 meters. However, forest legume species showed resprout and, therefore, resilience to fire, contradicting our initial hypothesis. In addition, species that sprouts originated mainly from the stem base had their aerial biomass fully recovered after six months of experiment.

Patterns of phylogenetic diversity across forest community types in Greece: what can be inferred about the ecological or historical processes that have affected community assembly?

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Phylogenetic diversity has been increasingly considered as an important facet of biological diversity, which helps understand ecological processes that underlie the observed community assembly patterns. Environmental filtering and competitive exclusion are considered as the main processes that affect community assembly at a local level while historical processes have been shown to affect regional species diversity. Thus community-level investigation of phylogenetic diversity has been used for understanding the main ecological processes that shape species assemblages as well as for identifying areas that have possibly acted as microrefugia in a regional or a local level. Having such an aim, we studied the patterns of phylogenetic diversity and structure at the community level for the main types of forests prevailing in northern and central Greece, a region that has been suggested as one of the main putative Pleistocene refugia of temperate forest biota in Europe. For this purpose, a database of vegetation plots from deciduous and mountain coniferous forests of northern and central Greece was developed. The plots were classified into floristically and ecologically interpretable community types. Phylogenetic diversity patterns of each community type were investigated by means of Faith's phylogenetic diversity, mean phylogenetic distance and mean nearest taxon distance, as well as their standardized equivalents. The analyses were conducted both for all the vascular plant taxa and for angiosperm taxa only. In addition, main ecological factors were estimated for each community type using the Ellenberg indicator values and related to the measures of phylogenetic diversity and structure. Twenty-five community types were identified and differences in their phylogenetic diversity and structure were revealed. When old evolutionary lineages, namely gymnosperms and ferns, were included in the analyses, more community types with high levels of phylogenetic diversity and overdispersed phylogenetic structure were observed, indicating the significant effect of the above-mentioned taxonomic groups on the observed patterns of phylogenetic diversity. Overall, a random or overdispersed phylogenetic structure was observed for most of the community types, and only two oak-dominated community types were phylogenetically clustered. Two mesic ravine forest community types had high phylogenetic diversity and a notably high proportion of plots with overdispersed phylogenetic structure. Phylogenetic metrics were found to be correlated with the ecological conditions, and phylogenetic overdispersion was more common in shaded, cooler and moister forests. The high phylogenetic diversity and overdispersed structure of the two ravine community types can be considered as a supportive argument for the putative refugial role of these forest habitats.

Building EpIG 1.0, the epiphyte inventory group database

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We present EpIG, a global initiative that brings together vascular epiphyte inventory data from across the world and makes it available to the research community.

Data comprise complete samples of vascular epiphyte species composition and abundance recorded in a well-defined area (a tree within a plot), thus following the general procedure of community sampling, but here restricted to a single (hyper-diverse) plant community. Data are standardized using TurboVeg database manager and a protocol adapted to this particular life form. Nomenclature is revised through a comprehensive epiphyte worldwide list of > 30,000 species defined by the EpIG consortia and then standardized to global checklists using the package Taxonstand.

This first version has 70 datasets from nine countries and 20 regions of Central and South America (from the sea level till 3,000 m a.s.l.); and 2,342 species distributed in 12,716 trees (ca. 8% of total epiphyte list) with over 400,000 individuals (within 500 plots). We plan to further increase the number of datasets and expand the geographical distribution worldwide. We use this database to assess large-scale variation and drivers of alpha diversity of epiphytes in the Neotropics.

Vascular epiphytes are amongst the least studied components of diversity in the tropics despite their very high diversity, as reflected in a large number of datasets throughout the Neotropics. With this initiative, we want to move from idiosyncratic local studies to “thinking big” in epiphyte ecology.

When are traits "functional"? A demographic perspective

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Functional-trait approaches have gained great interest for their mechanistic and predictive capacities in solving major ecological challenges, such as quantifying plant community dynamics under global environmental change. Yet, empirical studies have shown mixed results in terms of their explanatory and predictive power. This issue has likely arisen from the decoupling of "functionality" in functional traits, i.e. how traits influence demography, or more specifically, an individual's vital rates (survival, growth, and reproduction).

To better understand the predictive power of functional traits for fitness components, we undertook a literature review of papers working at the interface of functional traits and population ecology. We analysed 186 peer-reviewed articles to determine the level of integration between functional traits and demography. Data on 50 functional traits, and 7 demographic parameters were extracted from the articles. Measured traits fell into three broad categories: leaf economics spectrum (e.g. leaf mass area), below-ground resource acquisition (e.g. root density) and reproductive traits (e.g. seed mass). We explored functional trait-demographic linkages at different biological scales and studied evidence for upscaling. Specifically, we evaluated which traits gain functionality (i.e., have a fitness consequence) over which vital rates as a function of biome and growth form.

Our results suggest that researchers need to carefully revisit the term "functional" before the noun "trait", for not all traits that we reviewed had consistent impacts on vital rates. We provide a conceptual framework for moving forward in the integration of trait-based ecological research from a demographic perspective.

Talk Long-term studies in vegetation science

Effects of climate change on the alpine and subalpine vegetation of the Mt. Field National Park, Australia

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Climate change is predicted to impact mountain vegetation, causing upward shifts in the elevational distributions of plant species and vegetation communities. Population declines may occur in species that are unable to disperse rapidly enough to keep up with climate change or which face barriers to establishment (e.g. competition) at higher elevation sites. Species that currently occur only at the highest elevations are particularly at risk of local extinction. Though the effects of climate change have been studied on mountains in Europe and North America, there has been little research in the southern hemisphere. This project examines changes in the vegetation of the Mt. Field Plateau, Tasmania, Australia, an ideal location for this study because it is protected within a National Park and there have been no changes in land use, no major invasive plant species, minimal impacts of air pollution, and no wildfires or other major disturbance events within the study region over the past 40 years. A network of 241 vegetation plots (100 m²) that were initially surveyed in the summers of 1980-1982 were re-sampled in February-April 2019. The data will be analyzed to test for changes in abundances and elevational distributions of species and communities. Though data collection was still in progress at the time of writing, preliminary impressions are that upward shifts will be detected, particularly in herbaceous species, and that some species will display reductions in range of occurrence and abundance due to lower summer rainfall.

Talk Vegetation patterns and processes

Antibiotic-induced effects on plant traits

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Antibiotics are used to treat infections in humans and animals by either directly killing bacteria or inhibiting their growth. They have become integral to livestock industry, with sales' figures reporting almost 8,500 t of veterinary antibiotics used in the EU/EEA in 2011. Antibiotics in the environment have been recognized as a serious threat to non-target organisms as well as entire ecosystems, and have been grouped, together with other pharmaceuticals and personal-care products, in a new group of chemicals termed "contaminants of emerging concern". Whereas possible detrimental effects of antibiotics taken up by crop plants on human health have been intensively investigated, the effect of antibiotics on plants themselves, particularly on non-crop species, has received much less attention.

Here, we evaluate the effects of three major antibiotics, penicillin, sulfadiazine and tetracycline, on the germination rates and post-germinative traits (incl. element contents) of four plant species during ontogenesis and at the time of full development. Plant species included *Brassica napus* and *Capsella bursa-pastoris* (herb species) and *Triticum aestivum* and *Apera spica-venti* (grass species), and represent two crop-species and two non-crop species commonly found in field margins, respectively. Antibiotic concentrations were chosen as to reflect in vivo situations, i.e. concentrations similar to those detected in soils. Germination tests were performed in climate chambers and effects on the remaining plant traits were determined in greenhouse experiments.

Results show that antibiotics, even in small concentrations, significantly affect plant traits. These effects include delayed germination and post-germinative development. Effects on element contents were strongest in roots compared to stems and leaves. Effects were species and functional group dependent, with herbs being more sensitive to antibiotics then grasses. Effects were generally stronger for penicillin and sulfadiazine than for tetracycline.

Our study showed that plant species can respond to concentrations of antibiotics as typically found in agricultural soils with for example delayed germination or reduced biomass. Our study also implies that different antibiotics could potentially affect the species composition of natural communities in field margins due to species-specific responses which may affect their competitive abilities.

Managing ecosystem functions and services in the face of drought: A plant functional trait perspective

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The savanna biome is the largest biome in Africa, occupying almost 50% of the land area. For the rural population, ecosystem services (ESs) provided by savannas are of major importance, especially using them as rangeland for their livestock. Global change scenarios project increasing livestock numbers as well as more frequent and severe droughts, which have the potential to negatively impact ecosystem functioning and ES supply from savanna vegetation.

In the presented research, two main questions are addressed: (1) What determines the stability of rangeland vegetation in the face of drought? (2) What are suitable management interventions to avoid degradation during and after a drought event?

The study started in the growing season 2014/2015 as a large-scale field experiment (DroughtAct). It is located in a semi-arid thornbush savanna of South Africa's Limpopo province. Passive rain-out shelters and grazing exclosure fences were set up to simulate a severe drought (two-thirds reduction) in combination with differing resting schemes of the rangeland. The eight resulting treatments compare realistic scenarios of rangeland management in face of centennial scale drought. We assessed treatment effects on the two ESs 'forage quantity' (aboveground net primary production) and 'forage quality' (in vitro digestibility). We linked ES responses to shifts in the functional composition of the grass layer. To this end, we recorded plant population dynamics and intraspecific variation in plant functional traits. Leaf traits (leaf area, specific leaf area, and leaf dry matter content) were used to assess plant populations' shifting CSR ecological strategies, making use of the novel CSR analysis tool 'StrateFy' developed by Simon Pierce and colleagues (Pierce et al. 2017). Generalized linear mixed models were used to investigate interactive effects of drought and grazing treatment on forage quantity and quality. Community-weighted means of functional traits and CSR strategies were included as linear predictors to analyse their role for ES supply.

Results from five treatment years indicate a decreased functionality and ES delivery under drought and continued grazing, and suggest that grazing management may mitigate drought effects. While too early grazing can damage the layer of productive perennial grasses and favour their replacement by stress-tolerant and ruderal species, a too long resting period may reduce aboveground net primary production due to an accumulation of dead biomass. In both cases, a trajectory in the CSR space was observable. Our results stress the importance of a flexible rangeland management adapted to climatic variability and to prevailing CSR strategies. More generally, our experimental approach helps to predict functional responses to changing climate and land-use.

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Identifying tropical forest responses to climate change using paleoecological records from northern Madagascar

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The tropical forest in Madagascar is well known as a biological hotspot with a unique flora and fauna regarded as one of the Earth's biologically richest. Assessing its future development under climate change and increasing land use pressure, requires a profound understanding of its natural dynamics on millennial timescales. Using long-ecological records from northern Madagascar, our aim is to identify environmental triggers for ecosystem state shifts. Preliminary results from the investigation of several lacustrine sediment records, continuously covering the past 25,000 years before present, reveal distinct vegetation responses to different climate forcings. The onset of the African Humid Period in Madagascar, starting at *ca* 15,000 years before present, is well evidenced in our record by a remarkable increase in sediment accumulation rate, increased minerogenic input and coarser particles together with enhanced organic carbon content. Contemporaneously, montane rain forest occurrence and reduced fire activity suggest forest expansion from mountain to lowland environments and are consistent with moister conditions. Moist conditions were intensified during the Early Holocene until ca. 5000 years before present. Thereafter, distinctly increased fire activity and vegetation dynamic occur under drier conditions in northern Madagascar. Further, our records clearly indicate human impact on the vegetation during the past *ca* 1000 years through a tremendous increase of fire activity. Our studies in northern Madagascar will increase the understanding of past vegetation dynamics and stability in tropical regions, which may also help to distinguish between climatic and anthropogenic drivers for ecosystem changes in this highly vulnerable region.

Poster Vegetation patterns and processes

The vegetation in two archaeological complexes of the center (Huánuco) and north (Amazonas) of Peru: a phytosociological comparison between the jalca and the puna

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A vegetation study was carried out in two archaeological sites in Peru, in the department of Amazonas and department of Huánuco. The climate is humid temperate exclusive of the western part of the Central Andes. Following the edaphoclimatic and ecological characteristics according to the Braun-Blanquet methodology, the vegetation of these territories was studied. Two subassociations, 2 associations, 2 alliances, 2 orders and 2 phytosociological classes are described. As a result, we analyse the association *Gynoxyo cerrateanae-Baccharidetum latifoliae* (archaeological walls with abundant shrub-tree vegetation) that occurs in Amazonas within the alliance *Gynoxyo cerrateanae-Baccharіion latifoliae* belonging to the order *Mutisio acuminatae-Baccharidetalia latifoliae* and class *Clematido peruvianae-Baccharitetea latifolia*. Likewise, the association *Dendrophorbio chopinii-Paspaletum bonplandianum* (scattered archaeological remains with open vegetation of high abundance of grasses) included in the alliance *Agrostio tolucensis-Paspalion bonplandiani*, order *Agrostio tolucensis-Paspaletalia bonplandiani* and class *Calamagrostietea vicunarum* is analysed. In the centre of Peru, the association *Calceolario weberbauerianae-Calamagrostietum rigidae* (walls and archaeological remains with open vegetation and composed mostly of grasses) is described within the *Calamagrostio rigidae-Muehlenbeckiion volcanicae* alliance, order *Calamagrostio rigidae-Muehlenbeckietalia volcanicae* and class *Calamagrostietea vicunarum*. Likewise, a floristic scheme on the levels of endemism is presented and briefly mentioned the conservation problem.

Key words: Phytosociology, vegetation, jalca, Puna, Andes, Huánuco, Amazonas

Talk Vegetation patterns and processes

Floristic diversity, plant communities and conservation proposals of the riparian forest in the Chili River (Arequipa, Peru)

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The floristic diversity of the riparian forest of the Chili River along the riverbed that crosses the city of Arequipa (province and department of Arequipa) in the districts of Alto Selva Alegre, Cayma, Yanahuara, Cercado, Sachaca, Tiabaya and Uchumayo was studied. Forty-five sampling areas were selected where 245 species of flora (Magnoliophyta and Pteridophyta), divided into 177 genera and 66 families, were identified. An alliance and two associations are described as new syntaxonomic units according to the Braun-Blanquet phytosociological school and classified using the TWINSPAN software. The diversity of endemic species occurs in areas of rocky outcrops where the valley is narrower or encased, while the diversity of native species occurs along the entire riverbed. However, the presence of introduced species is higher in the middle part of the portion of the river that crosses the city. The correlation between environmental variables and floristic species with respect to the sampling locations was evaluated using the Canoco 5.0 software. Likewise, a trend assessment in case of flood due to increase in river flow has been carried and how it could affect the riparian forest, as happened in 1989, 1999 and 2012. In reference to conservation, it is suggested to preserve the fluvial and terrestrial ecosystems coexisting in the urban section and to lead to a sustainable development to improve the quality of life of the inhabitants. The different planning and management processes within the Chili river basin require an autonomous authority that could indicate the lines of action, continuous evaluation, monitoring and that include in the programs the active participation of citizens, and conduct and enhance the management and conservation plans of the riparian forest in the medium and long term period.

Keywords: riparian forest, phytosociology, floristics, conservation, Arequipa Province, Peru
Floristic diversity, plant communities and conservation proposals of the riparian forest in the Chili River (Arequipa, Peru).

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Holocene vegetation and disturbance dynamics in the Araucaria forest, northern Patagonia

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Disturbance through fire and volcanic eruptions play an important role in the vegetation dynamics of the *Araucaria* forest in northern Patagonia. *Araucaria* does not depend on disturbances to persist, but it is well adapted to resist low to medium intensity disturbances. Human activity, through land-use change and modification of the fire regime is thought to threaten the persistence of the *Araucaria* forest. Little is known about the Holocene history of *Araucaria* forest, its natural variability and response to past disturbances and a long-term perspective can provide information for conservation management. Here we present a case study, from a small lake in northern Patagonia, documenting the vegetation history, the past fire and volcanic disturbances in an open *Araucaria* forest at the forest-steppe ecotone. The 9000-year-old sediment core recovered from lake Relem (<1ha surface) was analysed for pollen and macro charcoal. Results show a gradual expansion of the forest into the steppe documented by a shift from *Poaceae* towards *Nothofagus dombeyi*-type pollen. This general trend has been disrupted by fire and volcanic events. Tephra from volcanic eruptions frequently buried the vegetation around the studied lake, with generally little impact on the vegetation composition. However, one large eruption about 3000 years ago led to the deposition of approximately 2m tephra, which initiated a vegetation succession on the new surface. The return to pre-eruption vegetation composition lasted for 500 years. Fires were rather infrequent between 9-6ka, frequency and magnitude increased between 6-3kaBP. Fire events were not followed by lasting shifts in vegetation composition suggesting small severity. Fires during Euro-American colonisation were comparatively smaller and more infrequent. Major changes in vegetation composition did not occur until recent pine plantations developed during the 1980es. Pollen accumulation rate and percentage from *Araucaria* show high values between 8 and 6.2ka; neither fire nor tephra fall seems to be responsible for the sudden fall. From 6.2ka to the present, *Araucaria* pollen abundance suggests a low variability, disregard of disturbance, and also does not show a strong decrease because of land-use change. The vegetation composition shows sensitivity, but a strong resilience to past disturbance. Palaeoecological studies are powerful tools to understand present vegetation patterns, and thus contribute to develop conservation strategies of the *Araucaria* forest.

Comparative analyses of the flora, vegetation and soil of fallows of different age in the Askania-Nova Biosphere Reserve (Southern Ukraine)

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Steppes are one of the most transformed ecosystems in Europe, mainly as a result of ploughing. Little is known about the natural regeneration capabilities of formerly ploughed steppe, the speed of regeneration process and its direction. That knowledge could be very helpful in restoration practice, which in case of natural ecosystems should mimic or even speed-up natural successional changes.
The study was performed in the Askania-Nova Nature Reserve and its close proximity (Kherson Region, Southern Ukraine). We applied an approach of substituting time for space, in order to check how the vegetation and soil characteristics vary in fallows of different time since abandonment, and how much they both differ from the reference community of a virgin steppe. We studied a chronosequence of fields abandoned in: 1920, 1967, 1996, 2002, and 2011 located in the Askania-Nova Nature Reserve, and a reference area represented by the plots located within the never ploughed part of the reserve.

In May 2017 we collected vegetation data and soil samples from a total of 72 sampling plots (10 m^2) at six locations (the abovementioned 5 recovery phases after abandonment and a reference). Vegetation data were used to characterise their species and functional composition and richness patterns. Soil was analysed for pH, and total C and N content and its texture classes were determined.

Total plant species richness and coverage increased significantly during secondary succession. There were noted 139 species of vascular plants and 37 species of bryophytes and lichens on 72 surfaces. The number of species is the largest on reference steppe plots (97) and decreases with the age of fallows (1920 - 80 species, 2011 - 61 species). The within-plot species richness (density) of vascular plants was highest in virgin steppe (mean 43.17), while the lowest in the fallows from years 1996, 2002 and 2011 (means 23.17-25.33, respectively). The share of habitat specialists in an area abandoned nearly 100 years ago is very close to the reference community. The share of aliens and native synanthropic species, commonly present in the recent fallows, declined gradually towards virgin steppe. We observed an increasing role of hemicryptophytes and chamaephytes in late successional stages. However, some weeds remaining after the cultivation are still present. The soil pH was slightly lower in the virgin steppe and the oldest fallows than in the most recent ones, the nitrogen and carbon contents were significantly higher in the virgin steppe and the fallow from 1920, while the fraction of clay was higher in the most recent fallows (2011 and 2002).

We assume that 100 years is enough to fully recover steppe vegetation and soil parameters. However, within our study area virgin steppe was still present, and could facilitate this process as source of diaspores of steppe species.

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Where have all the flowers gone? Land-use change depletes the grassland diversity of South Africa

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South African grasslands are ancient and highly biodiverse. Habitat transformation through land-use change is threatening these grassland ecosystems. The loss of plant species per unit area cannot be quantified for transformed grasslands, as the richness of untransformed grasslands has not been determined accurately. The aim of this study was to determine and compare the species richness of grasslands in South Africa along a soil disturbance gradient. Floristic data were gathered from 144 plots of 10 m x 10 m at 18 sites representing different land-use changes, namely, overgrazed pastures, mine tailings, abandoned crop fields, plantations, urban open spaces, home gardens, maize fields, soya fields and riverbanks. Floristic diversity of four plots were sampled within each of the 18 transformed grassland sites, accompanied by four plots in an adjacent untransformed benchmark site. All plots were surveyed in late spring and repeated in mid-summer and late summer. The results outline the species loss due to land-use change, with special attention given to endemic and threatened species, and those with special traits such as geophytes. Endemic species have evolved in open grassy habitats and contribute considerably to the phylogenetic and functional diversity of these ecosystems, but are most at risk of being displaced by alien invasive trees in disturbed habitat.

Talk Long-term studies in vegetation science

Spatio-temporal heterogeneity in vegetation - Could we understand it better using UAS?

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Spatial/temporal variability of vegetation represents a crucial key to understand ecosystem functioning since natural ecosystems exhibit continuous change driven by biotic and abiotic forces at both spatial and temporal scales, affecting biodiversity, communities, vegetation distribution and physiological status in a complex multi-level network. UASs open new opportunities to assess dynamic changes in the ecosystems, such as phenology, plant physiological status (biotic or abiotic stress), or dramatic processes as wildfires and post-fire recovery dynamics. There is a lot of important information on ecosystem functioning hidden in its intrinsic variability that should not be overlooked, and UAS can be very helpful for this purpose, still many challenges remain in UAS data interpretation, understanding the local (micro)variability, and scaling up from field to remote observations. UASs are capable to fill the gap between field measurements and higher scales obtained by manned aircraft and satellites; however with increasing resolution of unmanned aircraft, some of the challenges, unseen before using either satellite imagery or field sampling, became apparent. Local variability visible from remote sensing imagery is often called “noise” but actually consists of two major components, very difficult to separate - measurement errors (‘real noise’) and variability due to ecosystem processes, which may be highly relevant for understanding the system’s functioning. One of the challenges in studying heterogeneous ecosystems is thus to identify the appropriate scale representing a trade-off between maximizing captured heterogeneity and minimizing the errors of measurements. The optimal spatial resolution depends on several factors such as objective of the study, the measured trait / pattern / process (its characteristics as well as magnitude) and the sensor adopted; there may also be strong dependence on the spatial characteristics of the considered ecosystem. We assume that there is a dependency between optimal pixel resolution and spatial heterogeneity with a need to increase spatial resolution with increasing spatial heterogeneity of the system. Still, since at different spatial scales, different components of spatial heterogeneity reveal, it is probable that no universally correct scale exists, and combination of techniques is needed to capture the whole range of heterogeneity.

Keywords: heterogeneity, change detection, inner variability, ecosystem, noise, scale and resolution, spatial and temporal patterns, unmanned aircraft, upscaling

Poster Vegetation patterns and processes

Vegetation structure does affect nesting preference of Maleo Bird (Macrocephalon maleo) in Panua Nature Reserve, Sulawesi, Indonesia

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Sulawesi is the largest island in the Wallacea region and being home for some of the most unique and endemic floras and faunas. According to the IUCN Redlist, one of the endangered species is *Macrocephalon maleo* that is an endemic bird species that can only be found on Sulawesi, Indonesia. Unfortunately, *M. maleo* faces various threats on its nesting grounds and its forest habitat. Unlike other birds, *M. maleo* lays its eggs on the ground by utilizing sun heat or geothermal energy. Research on bird nesting mostly focuses on nest characteristics, vegetation comparison, and predator control, while how vegetation affects the nesting ground preference, in this case in *M. maleo*, has received less researcher's attention. Moreover, there is only one nesting site remaining for *M. maleo* in the Panua Nature Reserve. Therefore, managing the vegetation structure might be useful for better improving nesting areas and supporting Maleo's conservation. We assessed the vegetation structure in the nesting ground area, measured the environmental factors under different plant cover and in the nesting site, and set up camera traps to observe the Maleo activity at the nesting ground. This study has been conducted in Panua Nature Reserve, Pohuwato Regency, Gorontalo, Indonesia. This reveals that by comparing nesting ground by its number of gullies or ground that has been used as a nesting ground, vegetation structure influences the nesting preference of *M. maleo*. Trees provide shade for *M. maleo* during egg laying and places to hide. However, grasses negatively affect *M. maleo* to lay its eggs. All grasses, *Spinifex littoreus*, *Cyperus pedunculatus*, and *Ischaemum muticum*, have sharp leaf-tips iand are disliked by *M. maleo*. Temperature and humidity under shrub and grass are different compared to those in the natural nesting ground, meaning that vegetation alters the microclimate that might be necessary to hatch eggs. To sum up, managing nesting ground to have sufficient vegetation would help *M. maleo* to have an ideal nesting ground.

Poster Plant phenology and plant traits

Effect of light and support on the growth of herbaceous vine *Aristolochia contorta*

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Aristolochia contorta Bunge (northern pipevine, *Aristolochiaceae*) is a perennial herbaceous vine which mainly inhabits at forest edges in Northeast Asia and Russia. It is the only host species of the vulnerable butterfly *Sericinus montela* (dragon swallowtail). Despite its value in the conservation of endangered species, the optimal habitat and environment of *A. contorta* have been poorly understood. Through a field study, light and physical support are considered as a essential factors that affect the growth of vine species. We conducted a mesocosm experiment on the growth of *A. contorta* under different light (100% RLI and 50% RLI) and support (with-support and without-support) conditions. 4 year-old *A. contorta* individuals were used for the experiment and 50% RLI condition was created using a shading net. The number of branches, leaves, roots and the dry weight of root were significantly higher under 100% RLI than 50% RLI. On the contrary, stem length, dry weight and single leaf area were significantly higher under 50% RLI compared to 100% RLI. Under with-support conditions, shoot length and single leaf area showed higher values than without-support conditions. The number of branches, additional shoot and root buds were significantly larger under without-support conditions than with-support conditions. Flowering was observed only under the combination of 50% RLI and with-support condition. Overall, *A. contorta* showed vigorous growth of stem length and leaf size under the shade (50% RLI) and this growth was more facilitated with physical support. They also showed escape response by emergence of shoot, branch and root buds under 100% RLI or without-support conditions. It suggests that proper shade and physical condition should be provided for conservation and growth of *A. contorta* populations. This research was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea Government (MSIT) (NRF2018R1A2B2002267).

Long-term vegetation studies on active European volcanos - examples from the Azores and other European volcanoes

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Volcanoes and historic volcanic eruptions provide the opportunity to observe pioneer vegetation process in situ. The most notable example is the analysis of the vegetation recovery after the Mount St. Helen eruption in the 1980. The results of this long term ecological research were recently published in book edited by Crisafulli & Dale (2018) called "Ecological Responses at Mount St. Helens: Revisited 35 years after the 1980 Eruption".

In Europe we have no long term research on vegetation dynamics on active volcanoes which have the dimension of the Mount St. Helen studies, except the Surtsey long term study done by several scientists from Island observing the pioneer vegetation dynamics from the birth of this volcanic islands in the North Atlantic 1963 (Overview in Neff 2018/19, Magnússon et al. 2014, Fridriksson 2005). Nonetheless there are still some interesting long term studies that have been done on European volcanoes but which remain often unknown to a large scientific community, partly because some of the studies have been published in Italian, German, French and Portuguese etc.

The talk presents an overview of different studies done by different authors on several volcanoes (Etna, Stromboli, Santorin, and the Azores etc.) including own long term vegetation studies on the Capelinhos volcano (Faial/Azores) which have begun in 1999 - and are still ongoing (Neff 2017, 2018/19). The author tries to compare the result of his own work on the Azores with the studies from the other European volcanoes and provides a first descriptive categorization of vegetation dynamics on these volcanoes. He also stressed the importance of avifauna for the North Atlantic volcanic islands pioneer vegetation (Island, Azores). Analogies and differences between the Capelinhos (Faial-Azores) and Surtsey (Island) in the process of vegetation establishment in both volcanic islands are shown. More than 60 years after the Capelinhos emerged from the Sea - there have been no trees or bushes observed on the Volcano (Neff 2018/19).

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Talk Vegetation patterns and processes

Plant association and vegetation dynamics in the Valdivian coastal landscape in Chile

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In the past decades, the Valdivian coastal landscape has undergone intensive degradation due to strong anthropogenic influence. This is particularly critical as the region hosts the relict Olivillo forest and is part of the Chilean Winter Rainfall - Valdivian forest, one of the world's biological hotspots. To support the development and implementation of suitable intervention measures for the protection and restoration of the highly fragmented potential natural vegetation, an investigation of the current plant communities and vegetation dynamics was conducted. The work consisted of a phytosociological analysis based on a multivariate statistical approach. The data collection was carried out between the Bonifacio and Hueicolla sectors (de Los Ríos Region) and up to an altitude of 300 m a.s.l. A total of 169 phytosociological relevés between 100 and 400 m² was used to survey the vegetation. The analysis led to the identification of twelve plant communities. These belong to two classes (*Molinio-Arrhenatheretea* and *Wintero-Nothofagetea*), three orders and six alliances. One alliance and two associations are newly described: the *Libertion chilensis* and *Agrostio capillariae-Eryngietum paniculatae* in *Molinio-Arrhenatheretea*, and *Rubo constricto-Greigietum sphacelatae* in *Wintero-Nothofagetea*. The communities include 137 species, which are distributed over five classes, 62 families and 117 genera. The results indicate that: i) the identified units show serial relationships of anthropogenic origin; ii) human activity favours the development of native and non-native permanent communities in the research area; iii) soil management is one of the degradation's driving factors.

Bush encroachment and forest succession: the role of seed and fruit traits

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Seed and fruit characteristics affect seed dispersal and seedling establishment, both part of important ecological processes. The aim of the study was to investigate the role of seed and fruit traits (i.e. diaspore traits) in forest succession in a system in which savannas are being encroached by forest species. Diaspores were measured for 18 diaspore traits of savanna, forest pioneer and forest climax species. Ordinations and general linear models were used to test for differences in diaspore traits between savanna, forest pioneer and forest climax species. To identify differences in trait-pair trade-offs between these three vegetation groups, standard major axis regression was used. Diaspore traits were not able to separate out the vegetation groups in ordinations; however, pioneer species had lower investment in accessory dispersal structures and total seed mass than climax species, whilst savanna species did not differ from either group. For 38 of 45 bivariate trait relationships, there were differences in either trait trade-offs, or parental plant investment in diaspores, between at least two vegetation groups. In most trait-pairs, climax and savanna species showed no difference in trait patterns; however, pioneer trait patterns differed from those of both savanna and climax species. Results suggest that forest pioneer species invest more in number of diaspores at the expense of individual diaspore resources, while climax species invest more in accessory dispersal structures and seed size. Savanna species display an intermediate strategy. Diaspore traits are therefore important to consider, as they form the first step in community composition changes.

Mapping extensively used grassland types at a regional scale using multispectral remote sensing

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Semi-natural, extensively managed grasslands have a high nature conservation value and provide key habitats for biodiversity in European agricultural landscapes. However, the European Habitats Directive only covers a subset of these grasslands according to pre-defined habitat types, namely those of high conservation priority. Many species-rich, extensively managed types of grasslands are therefore not assessed even though their value for biodiversity is also high, and they are similarly affected by agricultural intensification and farmland abandonment, climate change and invasive species.

Remote sensing can play an essential role in assessing and monitoring these semi-natural grasslands by providing a synoptic view of the area of interest and by reducing the need for costly vegetation surveys. The increased availability of remote sensing data from different sensors, with higher spatial, spectral and temporal resolution, requires a systematic assessment of the choice of the sensor and to which extent these data can differentiate semi-natural grassland types.

Here, we combine multispectral remote sensing data with vegetation surveys in order to assess the performance of several multispectral sensors to differentiate semi-natural grassland types in the low mountain area of the Thuringian forest, central Germany, at elevations of 250-830 m a.s.l. The landscape is characterized by a complex terrain and a fine-scale mosaic of different grassland types whose persistence is totally or partially dependent on the maintenance of specific low-intensity farming practices.

Within the study area, a total of 1,045 managed grassland sites with a mean field size of 2.4 ha were surveyed using a line transect approach on field level. The grasslands were classified into 10 different types, ranging from wet, nutrient-rich grasslands such as wet meadows to dry types such as *Meo-Festucetum rubrae* and *Dauco carotae-Arrhenatheretum elatioris*.

Remote sensing data include the two multispectral sensors Sentinel-2 and RapidEye, but also additional data derived from LiDAR and topographic information. For the optical sensors, images of the vegetation period 2017 with cloud cover below a maximum threshold of 20% were used in order to capture the phenological development of the grassland types, and they provide a high spectral (Sentinel-2) and spatial (RapidEye) resolution. LiDAR data from the Thuringian Geodata Initiative add information on vegetation structure and surface roughness.

First results indicate that the remote sensing data capture the phenological development of different grassland types, but that additional data on topography are necessary to improve classification accuracy. These results aid in understanding the potential of multispectral remote sensing in designing cost-effective monitoring schemes in order to facilitate the spatial targeting of conservation measures to maintain species-rich grasslands.

Riparian landscape dynamics and ecosystem services in a mediterranean river of western Greece

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Riparian landscapes are among the most threatened landscapes in the world, mainly due to human activities and land cover changes. Mediterranean landscapes and especially riparian corridors have been experiencing more rapid changes in land cover/ uses that affect ecological landscape functions and processes. Rivers provide direct benefits to human wellbeing by supporting a number of ecosystem services (ES). However, human activities have altered river ecological integrity, mainly through land cover / land use (LCLU) changes. Thus, understanding and predicting the response of rivers to LCLU changes is critical for managing aquatic resources. Remote Sensing and Geographic Information System applications constitute valuable research tools which can map, quantify, and describe spatiotemporal changes in riparian zones. An integrative approach for assessing the impact of human intervention to the Acheron landscape was conducted. During recent decades, Acheron has been degraded throughout the catchment's area.

The impacts of land use change and intensification in a spatial grid of 5 km × 5 km were assessed through the model of weighed 'Land Use Dynamic Degree'. The ES 'matrix' approach was used to assess the riparian areas' capacity to supply ES. The results showed that the pattern and intensity of LCLU changed due to intense human activities, especially at the lowlands where natural land cover types decreased and arable land and artificial surfaces increased. Land use disturbances in the catchment's area decreased habitat integrity, with maximum habitat integrity recorded in the springs of the river. Human interventions have changed the river beds, increased landscape fragmentation, and led to the degradation and loss of wetland habitats. The driving forces of land use change were the socio-economic development of the country, urbanisation and agriculture. It was proven that natural LCLU types are important suppliers of various ES in the region. The current research provided a methodological reference to map ES, by applying remote sensing techniques, and assessment the impact of land use change and intensification on the spatial patterns of the riparian landscape. The results of the current approach could be a valuable tool to improve conservation management of the riparian zones and to develop area-specific policies that minimize human influences.

Poster Vegetation patterns and processes

Macrophyte functional groups and environmental conditions in freshwater mediterranean lakes: A trait-based approach

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Aquatic macrophytes constitute a key component of lake ecosystems with significant implications for several ecological processes. Additionally, macrophytes are one of the Biological Quality Elements in the Water Framework Directive 2000/60/EE [WFD] for which status assessments must be defined. However, human activities and eutrophication have resulted in macrophyte loss in many lakes throughout Europe.

In this research, the relationships between functional characteristics of aquatic macrophytes and environmental gradients were explored using an extensive data set from freshwater lakes of the mainland Greece. We applied RLQ and Fourth-corner method to investigate the trait-environment associations. This novel trait-based analysis, which links the macrophyet traits to the variation of community composition along environmental gradients, contributes to the understanding of the impacts of eutrophication on macrophyte assemblages.

The preliminary results of this study showed a differentiation of several macrophyte species according to environmental conditions and water quality. Charophytes were confirmed to show a preference for clear and nutrient poor waters while floating leaved macrophytes were mostly associated with more eutrophic sites. Submerged species generally prefer clear water, appeared to present a wide range of occurrence from oligotrophic to meso- and eutrophic conditions which may be attributed to specific plant traits and underlying factors that affect the distribution of these taxa in the studied lakes. Also the results revealed that conductivity, orthophosphates, and nitrate nitrogen were the main environmental variables that were associated with the macrophyte traits and assemblages reflecting a major effect of eutrophication on the taxa distribution. Decline of aquatic macrophytes from shallow waters and prevention of re-growth are also discussed.

Overall, the findings will give information about the impact of eutrophication on macrophytes community functioning and as a reference for future improve freshwater biodiversity management in east Mediterranean lakes.

Impact of wild ungulate browsing on the vegetation of restored mountain hay meadows

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Grasslands of middle-mountain regions are among the most diverse habitats of the Carpathian Basin. However, they are endangered by several factors, such as spontaneous succession. The task of nature conservation management is to decrease shrub cover or to form new habitat patches through shrub cutting. Our study was carried out between April and August 2016 in 3 different grasslands of the Mátra Mountains. In the Parádóhuta and Fallóskút areas shrub control was performed 5 years before our research, while the Sombokor area is a natural rocky grassland without previous interventions. The composition of woody vegetation and ungulate browsing impact were studied. Browsing impact was measured within circles of radius 1.13 m (4 m^2) using the ratio of browsed saplings of the tree and shrub species. Simultaneously, we carried out coenological surveys in the same sampling units. During data analyses we calculated diversity indexes and performed PCA and CCA ordinations.

Our present survey affirms that wild ungulate communities can maintain dynamic spatial grassland-shrub complexes as ecosystem engineers. The results also indicate which shrub or tree species are responsible for afforesting. These species are less browsed or significantly non-preferred (*Crataegus* spp., *Rubus* spp., *Rosa* spp.), so they play a large role in encroachment of other woody species as facilitators, therefore additional management is needed to remove them. Other woody species can be driven back by wild large herbivores.

Poster Plant phenology and plant traits

Relationship between growth characteristics, environmental factors, and secondary metabolites content of *Aristolochia contorta*

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Aristolochia contorta Bunge, one of the perennial vine plants, has various types of secondary metabolites including aristolochic acids and aristolactams. Various plant secondary metabolites have played important roles in plant-herbivore interactions. However, geographical variations and effects of environmental factors on the biosynthesis of aristolochic acids and aristolactams are largely unknown. To understand the effects of abiotic and biotic factors on the biosynthesis of secondary metabolites and growth in *A. contorta*, firstly we measured physiochemical traits of soils from four native habitats of *A. contorta* in South Korea. We also collected the leaf samples from each habitat and measured secondary metabolites using an ultra HPLC (UHPLC)-quadrupole TOFMS (qTOFMS) method. Stem length, single leaf area, and the number of leaves have been measured as growth-related parameters of *A. contorta*. Among the secondary metabolites, two alkaloids (magnoflorine, magnocurarine), six aristolactams, and two aristolochic acids were identified. The levels of magnoflorine and aristolactam-1a-β-glucopyranoside were significantly higher in damaged leaves than in the undamaged leaves ($p < 0.05$). Aristolactam-1a-β-glucopyranoside were positively correlation with stem length in undamaged group ($r^2 = 0.329$, $p = 0.049$). Aristolactam-1-β-glucopyranoside and aristolactam-2-β-glucopyranoside showed strong positive correlation with nitrate contents in soil ($r^2 = 0.355$, $p = 0.001$; $r^2 = 0.295$, $p = 0.001$, respectively). Since aristolactams and aristolochic acids could act as resistant compounds against herbivores, herbivore damages might induce the biosynthesis of magnoflorine and aristolactam-1a-β-glucopyranoside. However, aristolochic acid 1 and 2, which are the most abundant compounds in seed and root had been barely detected in leaves of *A. contorta*. It would be necessary to test why those compounds have not been detected in leaves. Moreover, productions of plant secondary metabolite are often constrained by the plant growth under a resource-limited environment, so the growth of *A. contorta* or soil nutrients also could affect the synthesis of aristolactams and aristolochic acids. These results indicate that both biotic and abiotic factors can in a complex way affect the synthesis of defensive metabolites in *A. contorta*. It seems to be necessary to figure out the effect of each environmental factor on the biosynthesis of secondary metabolites in *A. contorta* and the following effect on herbivore in detail. This research was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (MSIT) (No. 2018R1A2B2002267).

Macroecological vegetation science: call to explore large-grain plant assemblages

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Vegetation is the sum of all the plants inhabiting an area, regardless of the spatial scale. Vegetation science, however, has traditionally studied small and large spatial scales separately. Plant community ecology focuses on taxonomic or functional composition in relatively small sampling plots, from square centimeters up to a few hundred square meters. Large-scale vegetation science, on the other hand, mostly deals with predefined vegetation types for mapping and modelling at the biogeo-graphical scale. Recently, large-grain plant data has become gradually available as digital collections of local floras, plant atlases with grid cells (e.g. 10 x 10 km ^{2}), or georeferenced observations (e.g. GBIF, sPlot, EVA). Macroecological vegetation science can use this data to explore large-grain plant assemblages, widening our knowledge of both community ecology and biogeography. All vegetation topics we explore at local scales can also be studied at broad scales: biodiversity, functional traits, phylogeny, biomass, community dynamics etc. Underlying processes, however, are likely different. I argue that macroecological vegetation science might reveal many novel vegetation patterns and demonstrate the effects of large-scale processes which are not evident from small-scale sample plots or large-scale vegetation maps alone. In particular, historical migration, diffuse anthropogenic influences, global climate and land-use changes, alien species invasions, and centuries-long time delays might only be evident at large grain sizes. In addition, comparison of small- and large-grain results can reveal scale-dependence of various ecological phenomena. This is vital to understand and sustainably manage vegetation at different spatial scales. Although many approaches from community ecology and biogeography can be applied to large-grain vegetation studies, there are also novel issues and challenges. Large areas might vary a lot in abiotic conditions, but this should not be seen just as a problem but also as a natural aspect associated with such scales. Currently, it is still a challenge to obtain reliable species abundance data for large grains but rare and common species evidently have different roles. It is important to carefully evaluate data quality, since sampling intensity can vary a lot between large-grain sampled areas and integrated databases often contain errors. In addition, data at broad scales have usually accumulated over a long time period and might reflect more the past than the present situation. All such aspects should be carefully considered in the analyses. Nevertheless, macroecological vegetation science is a promising research field which can address several novel and urgent questions. The time is ready to develop both theoretical and methodological frameworks for large-grain plant assemblage studies.

Between land and sea - a classification of saline and brackish grasslands of the Baltic Sea coast

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Aims: Baltic Sea coastal grasslands are influenced by saline or brackish sea water, a narrow tidal range and non-intensive land use. At least since they have been listed as Natura 2000 habitat types (EU Habitats Directive), they have become an important conservation issue at European scale. So far, only little supra-regional research has been conducted on their floristic and ecological diversity, syntaxonomy and geographic variation. We aim to survey the geographical distribution and syntaxonomical variation of saline and brackish grasslands on a transnational perspective, to highlight large-scale gradients in species composition and underlying climatic and other abiotic factors. We discuss the resulting vegetation types in the light of a wider north-west European perspective and review conservation aspects.

Study area: Baltic Sea coast

Methods: We compiled an overall plot-based vegetation dataset for the Baltic Sea coast and subsequently selected relevés by species composition and plot size. We classified 3,732 relevés, using modified TWINSPAN, identified differential species and syntaxa, and performed a DCA with post-hoc fitted intrinsic and climatic variables. We tested main differences in relevant factors for significance.

Results: The classification resulted in 33 vegetation types widely differing in distribution range and area size and belonging to the classes *Juncetea maritimi* (21), *Molinio-Arrhenatheretea* (16), *Phragmito-Magnocaricetea* (6), *Cakiletea maritimae* (2), *Saginetea maritimae* (2), *Scheuchzerio palustris-Caricetea fuscae* (2) and *Koelerio-Corynephoretea canescentis* (1). Baltic Sea coastal grasslands vary in soil salinity and moisture and to a lesser extent in nutrient availability and base content.

Conclusions: Variation in plant communities generally reflects regional phytogeographical patterns. Communities most similar to north-west European coastal grassland types are characterized by euhaline to alpha-mesohaline site conditions. Designations of the Natura 2000 habitat types H1330 and H1630 require revision.

Effect of conservation management practices on sandy grassland vegetation in Budapest

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Újpest Homoktövis Természetvédelmi Terület (in Budapest) was selected as the research site, where conservation management has been taking place since 2006 to preserve the grassland fragments in a long term. In order to follow the effects of conservation management we made coenological relevés in 10 permanent quadrats of 1 m × 1 m on 7 sites from 2012 to 2018. We evaluated the coenological records using natural conservation values and lifeform type systems. Detrended correspondence analysis (DCA) was also used for data analysis. Changes of the vegetation in the examined area were clearly observable during a 12 year long period, species of the sandy grassland have become dominant and this was favourable regarding the aims of nature conservation. In the stands where conservation management has been carried out for 12 years, a natural or semi-natural vegetation had developed, invasive species and weeds had disappeared.

On open sandy grassland vegetation developed in place of forests, *Festuca pseudovaginata* became dominant instead of *F. vaginata*. The latter, which is typical on natural sandy grasslands, was only dominant on patches which had been grasslands for a longer period. This is also supported by comparing older and newer aerial photographs.

The survey was supported by OTKA-125423.

Scaling up biodiversity patterns: the case of México

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This contribution documents the strategy to develop a nested hierarchical classification scheme aimed at conducting sound vegetation mapping. Joint approximations were used to merge phytosociological (vegetation inventories) and geographic (land cover data bases) approaches. The research method included bioclimatic regionalization, georeferenced fieldwork, over 30 years of vegetation outcomes and expert knowledge, which enabled us to develop a novel method for vegetation mapping. At a national macroregional level, we were able to depict Gamma vegetation diversity. At a state regional level, we were able to delineate Beta vegetation diversity. At a mesoscale scale level were able to portrait Alpha vegetation diversity. This was challenging since Mexico is regarded as a country of high ecological-geographical complexity, where temperate-tropical conditions intermingle creating a large ecological mosaic, depicted by harboring over 12 per cent of the plant diversity worldwide. The contribution discusses the (dis)similarities of each approach reviewing concepts and analytical instruments. It further gives emphasis on the advantages of the joint approximation and contrasts the output with experiences of other countries such as Canada, Bolivia and Colombia. In addition, there is a final highlight on the value of a rigorous vegetation maps for the purposes of constructing public environmental policies, such as land use planning, establishment of protected areas, allocation of incentives for sustainable environmental services and long-term conservation practices.

Predicting extinction in the Atlantic forest (Brazil) based on plant dispersal attributes

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The degradation of tropical forests such as the Atlantic Forest (AF) of Brazil is driving the decline and extinction of native biotas, including large-bodied animals that provide several ecosystems services such as seed dispersal. Seed dispersal is a fundamental process in the life cycle of plants, to reach new locations and thus influence the structure of communities. Here, we hypothesize that dispersal mode and plant attributes related to dispersal are important determinants of range size and thus extinction risk in the AF flora. To test this, we built a comprehensive database for >900 AF angiosperms species, including their dispersal syndrome, dispersal traits, IUCN threat categories, range size and origin. We use linear models to understand how plant traits (dispersal unit length, seed weight, seed length, plant height), dispersal mode and origin (exotic, native or endemic) influence range size and extinction risk. Our results suggest that animal-dispersed plants with large fruits (> 4 cm dispersal unit length) have smaller range sizes than animal-dispersed plants with small fruits (< 4 cm). However, range sizes of animal-dispersed plants with large fruits are generally similar to plants dispersed abiotically (i.e. by wind or water). Besides interestingly, exotic species show a different result: species with abiotic dispersal have larger range sizes than animal-dispersed species with large fruits, whereas we do not find this difference for the native or endemic AF floras. Last, threatened species have fewer, and often larger, seeds per fruit than non-threatened species, suggesting that plants with slow reproductive strategies (i.e. 'K-strategy') are vulnerable to extinction. Our results show that dispersal by animals facilitates range size expansion, but not (anymore) for plants with large fruits, possibly because of recent defaunation especially of large-bodied frugivores (e.g. by habitat fragmentation and hunting). Furthermore, fragmentation may also facilitate the spread and establishment of exotic plants with abiotic dispersal (e.g. invasive grasses). Understanding which species or functional groups are more susceptive to go extinct is necessary to predict the cascading effects of biodiversity loss on ecosystem functions.

Talk Long-term studies in vegetation science

Intraspecific interactions in post-disturbance communities in a changing climate: insights from a long-term seedling mortality dataset

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Climate change is creating more extreme climatic conditions and interacting with historical disturbance regimes to severely alter environmental conditions. Understanding how these amplified environmental conditions affect the outcome of species interactions will allow for a better understanding of future community composition and structure. The stress gradient hypothesis postulates that abiotic conditions mediate the dominant interspecific interaction. While having been tested in multiple environments and for a host of different species, less is known about how the stress gradient hypothesis operates for fine-scale, intraspecific interactions following high severity, large-scale disturbances. The focus of our study is to understand how climate influences intraspecific interactions to subsequently affect mortality in post-disturbance environments. Our research questions are as follows: 1) how do intraspecific interactions vary with elevation, 2) how does the seasonality of an abiotic stressor influence the dominant intraspecific interaction, and 3) how does gradual canopy removal following a high severity disturbance interact with climatic variability to influence intraspecific interactions? We have been continuously monitoring annual seedling mortality of 11,446 Norway spruce (*Picea abies*) seedlings since 2008 after an epidemic spruce beetle outbreak (*Ips typographus*) resulted in greater than 95% mortality of canopy spruce. Our dataset is unique in that it allows for a fine resolution analysis on how intraspecific interactions operate and fluctuate with climatic variability in a post-disturbance environment. To address our research questions, we use generalized linear mixed effects models to predict seedling mortality across a range in elevation (1090 - 1350 m asl), neighborhood density, canopy openness, and annual climatic conditions. With 60% of spruce seedlings succumbing to mortality over the course of the study period, the results of our study represent a unique test case of the stress gradient hypothesis under climate change where we can better characterize how climate influences species interactions following climate-mediated disturbances.

Distribution and composition changes in super-páramo plant communities by the end of the century

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Questions: Predicting the behaviour of biodiversity facing climate change is one of today's scientific challenges, and it takes greater importance in the tropics where ecological impacts are accelerated, and studies remain scarce. Here, we predicted the future of the super-páramo plant communities in terms of species richness and composition and estimated local vulnerability to climate change. Specifically, we 1. calculated species' dispersal capacity, 2. modelled their distributions at present (2010) up to 2100, and 3. obtained species assemblages for each mountain range and assessed local vulnerability based on richness and composition changes in time.

Location: super-páramo (4200-5000 m) in Ecuador

Methods: The SESAM framework was used to predict plant communities. Using trait data and a kernel algorithm, the mean dispersal capacity of 605 species was calculated. Species distribution models (SDM) were conducted to obtain each species' 2010 realized distribution followed by its decadal potential distribution up to 2100. Dispersal and SDM results were combined to refine future predictions. To compare 2010 and 2100, all SDMs were stacked and thresholded at the potential local richness by summing probabilistic occurrences and finally, the probability ranking rule was applied to obtain the final assemblages.

Results: Dispersal capacity ranged between 0.07-835 m/yr. Species usually reduced their potential distribution by 2100 and 10% went extinct, mostly endemics. Regarding future changes, the north-western páramos suffered more drastic composition (60% reconversion) and richness (- 60 species) changes by 2100 whereas the central-eastern páramos were less affected.

Conclusions: Dispersal is key in constraining SDMs in tropical mountains. Super-páramo species are particularly vulnerable to climate change and ex-situ conservation priorities should be considered for endemics. The most threatened super-páramos are humid and little disturbed today, so stronger in-situ conservation strategies should be envisaged. Finally, the upheaval of low elevation species, often tied to land-use, is becoming a pressing issue.

Talk Using plant traits for the recovery of ecosystem functions and services: Trait-based ecosystem engineering?

Discriminating resident and invasive functional community responses to invasion and invasive removal

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Invasion effects on the functional structure of communities depend on the abundance and traits of both invasive and resident species. However, no consensus exists whether invasive species should be included or excluded in the computation of community responses. We offer a simple partitioning method to discriminate resident and invasive community components of the functional structure, which we apply to evaluate *Eragrostis plana* invasion and the recovery of grassland communities after its removal. Partitioning was based on 0 or 1 weights attributed to invasive and resident community species in the formulae of Rao functional diversity and community weighted means (CWMs). We used data of a four-year invasive removal, randomized experiment comparing invaded, non-invaded and invasive species removal communities in southern Brazilian native grassland.

Permanent plots located in an invaded grassland were subjected to invasive species removal treatments: clipping, herbicide, hand-pulling and no-removal. Plots located in an adjacent non-invaded area were also monitored. Annual vegetation surveys before and during four years of removals assessed temporal changes in community's functional structure, which we partitioned into resident and invasive components. We calculated fuzzy-weighted composition, functional diversity and CWMs. *E. plana* invasion turned communities less functionally diverse, by affecting resident species composition (resident component) and by adding new trait values (invasive component). *E. plana* was associated to higher values of dry mass per area and leaf dry-matter content. Encouraging, removals turned communities functionally similar to non-invaded references, and different from invaded communities, which was particularly noticeable for hand-pulling removal that enhanced resident component contribution. In manipulative experiments, the invasive species is commonly excluded from the computation of community responses to avoid circularity, as the experiment may involve a direct manipulation of the invasive species. However, resident communities after invasion may not correspond to non-invaded communities, as invasive species could already have shifted the identity and abundance of resident species, by modifying its functional trait diversity and composition. Thus, considering that the invasive species is part of the community in some treatments, it is essential to consider invaded communities as the result of both resident and invasive additive components. The additive partitioning of functional structure descriptors into resident and invasive species components can help disentangling the relative contribution of each component to community response to invasion.

Poster Plant phenology and plant traits

Relationships between flowering phenology and flower traits in herbaceous species

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Climate change determines seasonal dynamics and thus affects plant phenology and, eventually, ecosystem functions. Several studies already showed that the phenology of plants as well as animals is shifted by changing climate in a highly species specific way. This can affect important ecosystem services like pollination if for example pollination mismatches occur. We know that functional traits can explain the flowering phenology of plants. However, flower traits are so far understudied in this field and rarely measured for a broader species set. Knowledge on flower traits is crucial to understand the consequences of climate change on plant fitness and reproduction. Furthermore, flower traits such as pollen and nectar amount serve as important resources for pollinators. Against the background of insect decline, shifts in resource availability can have drastic impacts on pollinating insects. To address these issues we want to link data on flowering phenology with data on flower traits. With this we want to elucidate possible relationships that help understanding the fluctuation of resource availability for pollinators over the year. Furthermore flower traits are related to plant fitness and attraction of pollinators and are thus strongly connected to the plants reproductive success.

In this contribution we will present data that was deduced as part of "PhenObs - Botanical Gardens as a Global Phenological Observation Network". More specifically, we observed the phenology of ~ 100 herbaceous species in four botanical gardens in Germany (namely Halle, Leipzig, Jena and Berlin) and recorded flower traits related to morphology, productivity and resource-provision for the observed plants in all four gardens. For a subset of 60 species pollen and nectar samples are analyzed in terms of quality and quantity. More precisely nectar sugar concentration and composition, nectar amino acid concentration and composition as well as pollen amount, size and nutrient content will be analyzed. Results will be discussed with respect to consequences on plants reproductive success and ecosystem services in the light of climate change.

Talk Vegetation patterns and processes

Changes in plant interaction intensity and frequency of positive interactions with environmental stress

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Intensity and frequency are metrics of plant interactions that may respond differently to environmental stress. In an attempt at understanding productivity gradients, most research on facilitation has focused on interaction intensity, and whether predictions of the stress gradient hypothesis (SGH) hold at gradient extremes. Here we addressed how facilitation intensity and frequency respond to environmental severity in high-elevation communities in the fringes of the Atacama Desert. Following the SGH, we expected a monotonic increase in both metrics with increasing stress, as well as a whole range of pairwise interactions, from very negative to very positive. We found that facilitation intensity decreased with decreasing productivity, whereas frequency remained almost constant. Indeed the scarcity of species and individuals was reflected in low community weighted mean values showing that, overall, plant interactions contributed little to community structure. Although climatic conditions act as drivers of plant community structure in high-elevation environments, we found soil nitrogen to be a key driver as well. Plant interaction intensity did not parallel frequency of positive interactions, and both responded differently to environmental stress. In this part of the Atacama Desert, both parameters point to an environmental threshold above which positive interactions become important drivers of plant community structure.

Unified vegetation classification system of zonal boreal forests in Northern Europe

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We will present the first version of the unified vegetation classification system of forests in the boreal and hemiboreal zone in Northern Europe following the phytosociological approach. Until now, no unified classification system of this vegetation has been established in Europe. Instead, Northern European countries use their own systems with varying approaches to classification. Moreover, a sufficiently comprehensive vegetation-plot dataset which would enable European-scale analysis has not been brought together so far.

We will base the classification analysis on forest vegetation-plot data from numerous databases of the European Vegetation Archive (EVA), including the European Boreal Forest Vegetation Database (GIVD ID: EU-00-027) which was specifically collected for the purposes of this study. The analysis will be complemented with the data of the Finnish and Swedish National Forest Inventories. These data sources combined sum up to over 60 000 vegetation plots from Scotland, Norway, Germany, Denmark, Sweden, Poland, Finland, Estonia, Latvia, Lithuania, Belarus and European Russia. The resulting classification units will be compared with the previously described phytosociological syntaxa, and the system will be made compatible with the EuroVegChecklist classification developed by the European Vegetation Survey.

In the near future, our aim is to further develop the classification system by establishing formal definitions of the syntaxa and an expert system for automatic assignment of new vegetation records into the system. Furthermore, we aim to cover the remaining data gaps, i.e. Iceland, by continuing the search for collaborators to join the project and the digitization of existing vegetation-plot records.

Boreal cities are resilient of invasive species

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In Finland there is a long tradition of local floristic surveys. Nowadays many urban floras have been studied. For this study we selected four large cities in Finland, Helsinki, Vantaa, Tampere and Oulu. These cities comprise a 600 km long gradient from south to north. The aim of the study is to explore the invasive alien species (IAS) accorfing to the National strategy of alien species of Finland. The strategy includes a list of 54 IAS.

We noticed that IAS richness was very low in the studied cities. From over 500 000 plant observations, only 3.25% were IAS, 16 252 observations.

According to our hypothesis, the boreal forests resist IAS quite well. Generally, Nordic cities consist of considerable amounts of natural vegetation like coniferous forests, wetlands, lakes and rocky areas, which are resistant to IAS. Same pattern was observed in all our studied cities: some IAS in grid cells near the central business districts, but fewer in the suburbs and none at the outskirts of the city.

A very significant positive correlation was detected between the IAS and population density, reed density and the amount of impervious surfaces, but a very significant negative correlation between IAS and the percentage of forest cover in a grid cell. The more forest is included in a grid cell, the less IAS are present. When the forest percentage in a grid cell approaches 50%, there are usually no IAS present.

Only 3-4 IAS form a dominant pool of all IAS in a city. Most of the IAS have frequencies less than 1% or in some cases even 0%. The urban IAS show similar frequencies as in the National Plant atlas. The studied Finnish cities have about half of the number of alien species when compared with Central European cities. We conclude that presence of natural vegetation, mostly forest, resists the establishment of IAS in the boreal cities in Finland. Habitat codes reveal which kind of habitats are more susceptible to IAS. The habitats most prone to IAS invasion are land traffic corridors, gardens and parks.

The city of Tampere consists of urban parts (city proper) and rural parts (annexed former rural municipality of Teisko). In Teisko there are 147 IAS free grid cells (27.8%), but in the urban Tampere there are only 27 grid cells free of IAS (4.5%). Teisko is covered by IAS resistant boreal forests.

Talk Vegetation patterns and processes

What can be learnt from biomassing a forest?

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The construction of a public cycleway through a patch of native bush (a mixture of a restoration planting and natural regeneration) affected a belt 200 m long and 6-10 m wide. It also gave the opportunity to biomass some of the 400 trees which were being cut down. About 60 trees were selected for biomassing under two differing criteria. For the more common species, a random selection was made in size categories across the available range of sizes, but focussing on single- and/or multi-stemmed plants. For other species, particularly large or valuable trees were selected, randomly where possible. For some trees entire shoots were weighed directly, but biomassing generally involved random subsampling based on branch diameters. For a few trees, root boles were also extracted for natural cleaning and drying.

The forest was dominated by early successional trees, especially in the unrestored section, though demographics were more varied there. Trees varied in diameter, biomass, wood density, leaf traits, and lamina/support tissue ratios. Biomasses were small, a consequence of the relatively young ages of most trees. Laminae were smaller closer to the canopy than lower down, suggesting plasticity to light levels. Many trees had relatively small allocations to foliage and to foliage support tissues, suggesting competitive exclusion is developing. Some species appeared very susceptible to foliage herbivory.

Conclusions were that biomassing is not tricky given modern technology and random sub-sampling, and that interesting explorations can be made in the areas of carbon sequestration, allometry, tree longevity and tree death, though at some cost.

Hydrochorous seed transport in small rivers as trait-dependent filter of plant dispersal

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Hydrochorous seed transport is an important dispersal vector for many plant species of riparian landscapes. Plant propagules transported via running water contribute significantly to re-vegetation of river banks after disturbance, both natural and in course of nature conservation management. It is supposed to support the establishment of autochthonous species of riparian plant communities, but it is also known to be an important path for invaders. At the same time, hydrochory functions as an ecological filter and the ability to pass through it differs strongly between species and species groups.

The present contribution is going to sum up the results of two long-time studies to hydrochorous seed dispersal in European rivers (Eider, N-Germany, 2001-02; Traisen, Lower Austria, 2014 and 2017) with reference to some further exemplarily sampled rivers (Pärnu, Estonia, 2002; Elbe, E-Germany, 2003; Voss, W-Norway, 2005).

In the main studies, river water was sampled weekly by fine mesh nets for transported plant propagules at two sides per study area (Eider, n= 52 weeks; Traisen, n=5+5 weeks). At the Traisen river, reconstruction of the riverbed took place in the study area between the first (2014) and the second (2017) sampling period. Samples were treated in two different ways: one half was dried and seeds were counted manually, the other half was exposed on sterilized soil for germination. In this way a direct comparison between total transport and propagules viable after drift was possible.

We analysed the probability of species to successful water dispersal considering functional traits (e.g. seed morphology, adaptations to different dispersal vectors, life forms and strategies, Ellenberg-values) as factors responsible for the survival of propagules. Additionally, we calculated community weighted means (CWMs) of functional traits for seeds (total transport), seedlings (survivers of transport) and local species pool of the river valley.

About half of the species and about 1/10 of the seeds were able to survive the transport. This relationship was true for both analysed river systems. CWMs of functional traits appeared to be only weak predictors for success of hydrochorous dispersal at community level. Nevertheless, the majority of functional traits clearly reflect the differences between seeds and seedlings.

Especially small seed size, ruderal life strategy and high light preference correlate positively with the survival, while large-seeded species adapted to endozoochory tend to lose viability during the drift. This observation explains, among others, the success of various invasive species.

Effects of the extent and habitat diversity of sand forest steppe habitats on their landscape scale plant biodiversity

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The transitional forest-steppe biom harbours worldwide an exceptional biodiversity. To keep it, nature conservation should be planned at the landscape scale. We examined how extent and habitat diversity of the Pannonian sand forest-steppe landscapes affect plant biodiversity on landscape scale.

We sampled sixteen 5 km × 5 km study sites, representing the landscape heterogeneity of the largest dry, calcareous sandy area of Hungary, the Kiskunság region. Altogether 602 of 20 m x 20 m vegetation plots were surveyed in a stratified random design using habitats as strata. The total species richness and the richness of the forest steppe specialists of the study sites were regressed against the cumulative area and diversity (measured by Rao-index) of the natural forest steppe habitats in the landscape. Beyond their relative area, Rao diversity includes differences among habitats measured by dissimilarity of their species pool.

In the case of the richness of forest-steppe specialists we found that the area and Rao diversity of natural forest-steppe habitats together explained significant parts of the variance. The relationship among the species richness and both measured aspects of landscape heterogeneity proved to be non-linear. It shows that below 10 ha area of forest-steppe habitats in a study site species richness increases intensively and then saturates. The effect of habitat diversity is strongest on the mid of the scale, where the area and diversity of the woody habitats is the determining factor. Contrary to the case of habitat specialist species, the landscape pattern does not have a significant effect on the total species richness.

Poster Long-term studies in vegetation science

Long-term effect of mowing on the restoration success of Pannonic sand steppe at clear-cut *Robinia pseudoacacia* plantation

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Biological invasion is considered one of the major drivers leading to biodiversity loss and also threatening the self-rehabilitation of natural vegetation. Therefore, ecologists seek the best methods to eliminate invasive species to restore natural habitats. By now, almost fifty percent of 18th century open sand grasslands have been replaced by tree plantations, mainly black locust (*Robinia pseudoacacia*) stands, in the Pannonian region. This species was introduced to Hungary in 1750s to control soil erosion from North America, and currently is widely used for forestry despite being invasive. Several factors can hinder the self-rehabilitation of clear-cut black locust forest sites: the re-sprouting after clear cut, the nitrogen accumulation in the soil due to *Robinia* and the lack of propagule dispersion. This supports the need to accelerate the rehabilitation process towards the natural vegetation by appropriate management activities. We studied the long-term effect of mowing on the recovery of Pannonian sand steppe after elimination of black locust. Three stands of ~1 ha were selected in the area of Kiskunság, Hungary. The stands were clear-cut in the winter of 1994-1995 followed by chemical (GARLON 4E) application on tree trunks. The three stands were allocated in different landscape types; closed forest (Bugac), grassland-forest mosaic (Fülöpháza) and predominantly open grassland area (Izsák). Mowing with hay removal was done as management to lower soil nitrogen and control weeds, and thus helps the establishment of grassland species twice a year (June, September) in 1995-2001 in six 10 m by 10 m parcels and its success was compared to unmown control and semi-natural reference. Vegetation was sampled in June and August yearly in 1995-1999 in the three sites and re-sampled six times until 2017 in Izsák and Fülöpháza. In all sites the treatment's trajectory is moving in the same direction and its closer to reference than the control's trajectory according to PCoA analysis. In Izsák, treatment is almost reaching the reference's trajectory. Mowing resulted in a significant higher cover of target species compared to control from ~2003 on in Izsák and Fülöpháza, but it is still different from the reference. We couldn't see a significant increase in target species cover in Bugac due to limited dispersal. A dense shrub cover was developed in unmown areas significantly different from the mown parcels since 1998 in all sites. Fülöpháza has the highest shrub encroachment in control plots since the begging of the experiment, achieving 60.6% cover by 2017, 30% of which is hawthorn (*Crataegus monogyna*). Mown plots were not resistant to invasion principally in sites with lower propagule availability (Fülöpháza and Bugac), achieving ~30% of invasive species by 2017 in Fülöpháza. The long-term monitoring revealed that mowing assisted the restoration of Pannonian sand steppe, but the recovery process is still slow calling for further interventions (e.g. seeding).

Taxonomic and functional diversity of pollen and plants across northern Europe

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Pollen data is often used to characterize past vegetation composition and diversity. To improve the interpretation of sedimentary pollen data, it is important to understand the relationship between modern pollen and plant richness. We present preliminary results from a regional-scale comparison of pollen and plant functional diversity from northern Europe. We use a pollen dataset of 511 lake-surface pollen samples ranging through temperate, boreal, and tundra biomes. To characterize plant diversity, we use a dataset formulated from the two largest plant atlases available in Europe. We compare functional diversity estimates based on plant and pollen data. In addition, we test the potential of pollen data to reconstruct environmental gradients based on Ellenberg indicator values.

Pollen richness is significantly positively correlated with plant richness (r=0.53). The highest correlation is found between pollen and plant richness of trees and shrubs (r=0.83) suggesting that these are the best measures of broad-scale plant richness over several thousands of square kilometres. Data of trees and shrubs is therefore used to test how well pollen data can reflect functional diversity. Community weighted mean values of fifteen traits (seed weight, leaf area, proportions of different mycorrhizal types etc.) are all significantly ($p<0.05$) positively correlated in pollen and plant data. The highest correlations are found for proportion of ectoendomycorrhizal taxa (r=0.78) and seed number (r=0.63). Pollen-based and plant-based mean Ellenberg indicator values are all significantly positively correlated with correlation coefficients above 0.5.

In an example pollen dataset from eastern Baltic covering the entire post-glacial time, we show that most of the traits and Ellenberg indicators have contrasting values for Late Glacial and mid-Holocene periods. For example, the proportion of taxa with arbuscular mycorrhizal symbionts was the highest between 8000 and 6000 years ago while it is was considerably lower during Late Glacial and during the last 4000 years.

Our results indicate that pollen data can provide insights into past plant functional diversity changes. Reconstructions of mean trait values and functional diversity of chosen traits allow to investigate trends in functional vegetation diversity over several millennia.

The spectral species concept at wide geographical scales: estimating ecosystem alpha- and beta-diversity by remote sensing

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There is an increasing need to rapidly assess the biodiversity of ecosystems, due to the widely acknowledged trend towards biodiversity loss. Nevertheless, estimation of biodiversity using ecological field data can be difficult for several reasons. In particular, if an investigation area is large, it is challenging to collect data providing reliable information. Observer bias, restrictions in accessibility, funding and workload limitations, missing expert knowledge, dynamics in emergence and phenology are just some examples that limit the collection of representative in-situ information in Earth observation. Some of these restrictions in Earth observation can be avoided through using remote sensing approaches. Remote sensing is efficient and cost-effective.

Modern sensors allow the identification of biodiversity patterns in vegetation over large areas and provide sensitive information on the dynamics of their biodiversity. Obviously, shortcomings are also present such as sub-canopy diversity, limited representation of very steep slope surfaces, very different sizes (diameter) of plant species, similar spectral traits between species, or ecosystems that are constantly covered by clouds (e.g. laurel forest). Different works have estimated biodiversity on the basis of the Spectral Variation Hypothesis; according to this hypothesis, spectral heterogeneity over the different pixels reflects a higher niche heterogeneity, allowing more organisms to coexist. From this assumption, the concept of spectral species has been derived, following the consideration that the spectral heterogeneity at a landscape scale corresponds to a combination of subspaces sharing a similar spectral signature. At a local scale, with the use of high resolution remote sensing data, the different subspaces can be identified as different 'spectral species'. This has been done using an unsupervised method based on the clustering of the different subsets. From the distribution of these spectral species (and the derivation of alpha- and beta-diversity) is then possible to approximate the diversity of the species living in an area. Our approach derives from this concept and extends it at a wide spatial extent. We have been able to apply this method to MODIS imagery data, producing a map of the distribution of the spectral species over all Europe and an estimate of the European alpha- and beta-diversity. In this case, the diversity is not evaluated at species level, but at community level, introducing the concept of spectral community. We propose to apply the method on a stack of images of the months of the year, in order to cluster niches taking also into account their response to different seasons, and therefore to elaborate multi-temporal and multi-dimensional data.

Medieval records and present-day forest composition: welcome and unwanted intruders among lowland English biodiversity

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Medieval court records of legal and criminal land use and decorative church stone carvings provide site-specific data on woodland plants at two localities in the English lowlands over 600 years ago. With a phytosociological eye, such data give us glimpses of two recognisable forest types on contrasting geology and soils. Alongside other contemporary data, such sources can provide valuable information about forest character and use in the wider landscapes of the time. They also prompt particular questions about current forest biodiversity, notably how non-native trees have found a place - or not - within existing canopy types; and what values are given to the presence of such trees then and now.

Peri-Carpathian forest-steppe: soil charcoal elucidates the role of humans in the development of landscape of extreme biodiversity

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Forest-steppe has a substantial extent in Eastern Europe, where it forms a belt stretching between the Carpathians and Ural Mts. In Central Europe, analogous landscapes with climate suitable for tree growth and a mosaic of dry grassland and woodland vegetation are often considered a part of temperate forest biome. We suggest that for the understanding of forest-steppe distribution and species composition, historical perspective is crucial, as the steppe component has ancient, relict origin from a major part. We reconstructed the history of an extremely species-rich forest-steppe-like landscape in the White Carpathians (Czech Republic, Slovakia) using an interdisciplinary approach. While biogeographical analysis, pollen, macroremains, fossil molluscs and archaeological data brought some information relevant for our study, soil charcoal analysis provided so far the most complete picture of the regional landscape development. We identified a clear pattern in the taxonomic composition of woody soil charcoal and anthracomass along a gradient of elevation and history of human settlement. Charcoal assemblages of chernozem-like soils in the promontories of the mountain range had a low anthracomass and were dominated by heliophilous and semi-shade species, suggesting continuity of an open to semi-open landscape. Soils of the middle elevations had a high anthracomass and often showed pronounced differences in charcoal composition at different soil depths, suggesting deforestation between the Neolithic and Early Middle Ages. Soils of the summit areas showed a medium anthracomass and charcoal assemblages dominated by shade-tolerant trees, in agreement with historical data on High Medieval colonization of higher elevations of the mountain range. Local steppe meadows with extremely high biodiversity thus appear to be a continuation of an Early Holocene forest-steppe, with local history driven mainly by human activities. Synthesis of published and original data suggests that similar systems are scattered around the Carpathians Mts. and we coin the term relict peri-Carpathian forest-steppe to summarize their species composition, structure and genesis.

Talk Long-term studies in vegetation science

Regeneration succession in former wet grassland communities after abandonment

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In order to re-cover biodiversity after 30 years of abandonment a mowing regime (two cuts/year) was re-established in previous *Calthion* and *Caricion fuscae* communities which had been abandoned in the Oste valley (NW Germany) already in the 1950s. Starting with extremely species poor tall forbs and tall grass communities (*Filipendulion* / *Magnocaricion*) we found a significant reduction of the standing crop with re-mowing and a threefold increase of the species numbers on permanent plots already during the first years. Small growing vascular plants such as *Lychnis flos-cuculi* became dominant which significantly changed vegetation structure and flowering aspects. The new established plant species partly represented the species pool of former *Calthion* and *Caricion fuscae* communities which had been recorded on these stands in 1952 prior to the abandonment.

They established from the soil seed bank which apparently survived the fallow period. Seed bank typology had a high predictive value for predicting regeneration succession. On the other hand, many wet grassland target species such as *Carex nigra*, *Bromus racemosus* and *Senecio aquaticus* failed in re-colonizing even though an appropriate mowing regime had been re-installed. Our experiments show that wet fallow communities are capable of storing seeds and therefore "memorizing" previous biodiversity conditions for decades. However, the complete species assemblage of original plant communities was not possible to be re-established due to limited seed persistence and reduced invasion from the surrounding landscape.

Limited dispersal reduces restoration success in wet grasslands

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Restoration projects in previously intensively used wet grassland areas in Europe showed that the re-establishment of target plant species can be strongly limited by propagule dispersal. In a large wet grassland area in Northwest Germany it was tested whether the re-establishment of grassland species during restoration succession depends on population density in the established vegetation, the ability to survive in the soil seed bank, or on long-distance dispersal through winter inundations.

Recruitment was mainly controlled by population density in the established vegetation. Long distance dispersal by means of winter floods and a long seed bank persistence contributed less (but still significantly) to the recruitment rates. Propagation by means of stolons and adaptations to hydrochory had a positive effect on recruitment rates. High recruitment rates of target species in the test area, compared with other grassland areas of a more intensive land use history, emphasise the importance of a big species pool and the spatial interconnection of species-rich (source-) and species-deficient (sink-) habitats. Many target species of wet grasslands, however, exhibited low recruitment rates because their ability to disperse in time and space is low.

Restoration management for wet grasslands should, therefore, focus on large areas with a short intensification history and remnants of target species populations, which are connected with sink habitats by inundations.

Using sPlot - the global vegetation plot database - to explore global patterns of plot-specific plant species pools

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Focusing on species pools, i.e. all species present in a region that can both disperse to and potentially persist in a focal locality, is a promising approach for exploring global patterns of biodiversity. It allows controlling for stochastic variation due to site-specific idiosyncrasies and sampling artefacts, and for the effect of sampling grain. We use the data contained in the 'sPlot' database, a vegetation-plot database incorporating more than 1.1 million plots worldwide, to produce the first standardized global maps of species richness density and site-specific species pool size.

For each plot, we first defined a probabilistic set of species that may co-occur with the species of the target community based on Beals' index of sociological favourability. We then extracted all plot records that fulfilled a minimum similarity criterion within a given geographical distance to build empirical species area relationships and estimate the size of the target plot's species pool, as well as species richness density at different spatial grains. Finally, we modelled how species richness density and pool size varied along the main macroecological (climatic, soil) gradients using boosted regression trees, based on 99 resamplings of original data to control for spatial autocorrelation, and estimate uncertainty.

The global pattern in species richness density differs markedly from the pattern in species pool size. Macroecological gradients were important predictors of both metrics, but the relative importance of different variables changed across scales. The size of the species pool decreased with increasing latitude, but when considering species richness density of local communities (100 m^2) this effect disappeared, while edaphic gradients became dominant.

We conclude that the relative importance of macroecological vs. local environmental conditions in shaping plant diversity patterns varies across regions and with scale. Thus, comparing biodiversity patterns at multiple spatial grains is necessary to understand diversity patterns.

A geobotanical overview on *Arthrocaulon* (*Arthrocnemum*) *macrostachyum* plant communities in the Iberian Peninsula and Balearic and Canary Islands (Spain and Portugal)

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Almost three hundred phytosociological relevés from the Iberian and Macaronesian Vegetation Information System (SIVIM) [Font & al., 2010 (SIVIM: an online database of Iberian and Macaronesian vegetation. Waldökologie, Landschaftsforschung und Naturschutz 9: 15-22), and 2012 (The Iberian and Macaronesian Vegetation Information System (SIVIM, www.sivim.info), five years of online vegetation's data publishing. Plant Sociology 49: 89-95)], other bibliographical sources, and unpublished own data were used to analyze the diversity of halophytic vegetation structured by *Arthrocaulon* (*Arthrocnemum*) *macrostachyum* (*Chenopodiaceae* / *Amaranthaceae*) on the Iberian Peninsula and Canary and Balearic Islands. The selected data were appropiately managed to be analyzed by the K-means method using the Hellinger Distance as dissimilarity measure, the Ward's hierarchical clustering method and a minimum number of groups of 2 and maximum of 7. A synthetic table has been created with the generated groups and rearranged based on the percentage presence and faithful species contributed by the K-means analysis.

The recognized units (including their biogeographical, floristic, ecological and dynamic features) are framed within the following syntaxonomical scheme:

SALICORNIETEA FRUTICOSAE Br-.Bl. & Tüxen ex A. Bolòs 1950
+ *Arthrocnemo macrostachyi-Suaedetalia braun-blanquetii* Rufo, de la Fuente & Sánchez-Mata 2016
. *Arthrocnemion glauci* (Rivas-Martínez in Rivas-Martínez & al. 1980) Rivas-Martínez & Costa 1984
. *Suaedion braun-blanquetii* Br.- Bl. & O. Bolòs 1958 corr. Rivas- Martínez, Báscones, T.E. Díaz, Fernández-González & Loidi 1991

Living Archives: Safeguarding regional and national floras – the example of the Netherlands

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In the Netherlands, like in most European countries, many plant species are under threat, and despite extensive restoration programmes, it proves to be extremely difficult to turn the tide. More than one third of the 1,500 indigenous plant species in this small country are on the Red List of Vascular Plants, of which about 70 are so critically endangered that they easily may get extinct on the national level. Eutrophication, acidification and desiccation are major problems, but even when we succeed in re-establishing the former environmental conditions, the species often do not return, due to fragmentation, limited dispersal capacity and/or lack of proper dispersal vectors. Inspired by the Svalbard Global Seed Vault, a world-wide seed storage facility to safeguard the genetic diversity of crops and crop wild relatives, a broadly supported national initiative was founded to rescue the genetic diversity of endangered wild flowers in the Netherlands, called the Living Archive. Within this platform, programmes will be set up for both genetic rescuing and reintroduction of a wide range of priority species, a National Seed Bank will be established, and for each target species a tailored plan will be set up. The Living Archive operates with a stepwise approach, including: (1) analysing habitat characteristics of still-existing populations across the Netherlands, (2) assessing viability of these populations, (3) identifying new suitable sites by comparing them to habitat characteristics of viable populations, (4) collecting seeds from suitable source populations, (5) multiplying plant material through an ex situ breeding program, (6) using viable off-spring for reinforcing existing impoverished populations and/or reintroducing the species at former sites where the site conditions have been improved, and (7) monitoring the reintroduction success. The Living Archive also encourages the establishment of protocolled seed gardens, private and public, throughout the country, for harvesting local seeds to supplement the National Seed Bank.

Talk Long-term studies in vegetation science

Relating plant cover to climatic drivers and nutrient deposition over space and time in Europe

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Changes in species abundances and composition are a natural part of ecosystem dynamics. However, human influence on climate, soil conditions, and other factors relevant to plant survival may alter these dynamics in a deterministic manner. While climate and land use change may be the strongest drivers of vegetation change on a global level, this may not be the case in regions with an early onset of industrialization. Particularly in Europe, the main drivers of vegetation change may be deposited acidifying and eutrophicating compounds as NH_3, NO_x and SO_2. Using the combination of vegetation surveys and environmental data with exceptional temporal and spatial resolution in Europe compiled by the forestREplot research network, we aimed at testing this hypothesis by including climatic as well as deposition data in a joint model to explain vegetation changes over the last decades.

Potential drivers were related to plant cover on a per species-basis on temporal and spatial scales for the most abundant plant species, i.e. regarding time series of individual plots as well as inter plot-differences. Therefore, relationships obtained could be used to cross-validate each other. Additionally, Ellenberg values and plant functional traits were used to gain an understanding of the causal mechanisms behind vegetation change. Combining the investigation of vegetation change in the light of N- and S-deposition with functional trait research using a large dataset, this study presents a robust approach to estimate the relevance of drivers of environmental change in Europe as well as a way to predict future changes.

A top-down perspective on forest canopy traits in a soil chrono-sequence

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A large project striving for understanding the relationship between soil weathering and vegetation has been conducted in the Waitutu forest (Fjordland National Park, New Zealand) with sequences of different-aged terraces and soils (soil chrono-sequences). As in other projects addressing soil-vegetation relationships, most investigations in the Waitutu area have been exclusively plot-based. These investigations yielded a wealth of valuable results but plot-based studies can also miss information because broad-scale differences in canopy traits and species along the gradients can be covered by small-scale heterogeneity. We suggest increasing the observational base for such comparisons by using remote sensing methods. The presented study followed a multi-scale approach involving the collection of soil samples and leaves in the field, the use of an unmanned aerial system with a hyperspectral sensor and the analysis of multispectral satellite data with high spatial resolution. While complex topography or human interference make it difficult to interpret links between soils and canopy reflectance in most parts of the world, the chosen area features near-to-primeval forests on relatively flat terrain. In this setting, remote sensing allowed the identification of site-induced differences that would otherwise have remained hidden.

Talk Long-term studies in vegetation science

Long-term trends in plant species composition and diversity in response to seasonal weather conditions and herbivore density in the South African Kalahari

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In global comparison, southern Africa is one of the regions that is most threatened by climate change. The projections assume a sharp rise in temperature and a shift in seasonal precipitation. At the same time, as the population grows, the demand for land for agricultural cultivation and for farming with domestic or wild animals (game farming/tourism) will further increase. In order to assess the impact of the increasing land use pressure and climate change on the natural environment, SASSCAL ObservationNet (www.sasscalobservationnet.org) monitors the biodiversity in standardised biodiversity observatories in different biomes of southern Africa. Species composition, diversity and coverage of natural vegetation are annually assessed.

The talk will present results on the vegetation response to monthly and quarterly weather conditions and the annual density of small vs. large antelopes on a game farm in the South African Kalahari, where one of the biodiversity observatories is situated. The results are based on a 17-year time series. More humid conditions and moderate temperatures (expressed as a high Standardized Precipitation Evaporation Index, SPEI) in late summer, towards the end of the rainy season, had a strong positive impact on species richness and abundance-based plant diversity indices. The frequency of individuals per species in response to seasonal climatic conditions depended on the species and their life form type: annual species responded mainly positively to a high SPEI index during the growing season, while perennial grasses and shrubs responded more strongly to a high SPEI index during the early or late winter months.

Small and large antelopes, respectively, had opposite effects on the plant species. This can be explained by their foraging strategies. The smaller springbok (*Antidorcas marsupialis*), which are mainly browsers, predominantly affect the shrub species whereas the large antelopes such as the Oryx (*Oryx gazelle*), hartebeest (*Alcelaphus buselaphus*), and gnu (*Connochaetes tarinus*) are mainly grazers and had a stronger effect on the species of the herbaceous layer.

Increasing temperature and shifting seasonal rainfall will change the seasonal climatic conditions. The current results suggest that climate change and an increase of herbivore pressure may have a strong negative impact on the vegetation and biodiversity in the region. This will also have dire consequences for people's livelihood.

Talk Plant phenology and plant traits

Bud preformation influences growth phenology of temperate herbaceous perennials

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Plant phenology, the timing of developmental processes, has recently gained a lot of attention mainly because of its relation to global environmental changes. As temperate perennial plants have to cope with seasonal climate, the precise timing of bud sprouting, growth rate and set of flowering determine their success in the habitats and species coexistence. The perennials have developed several strategies to successfully deal with the short season. First, they store resources produced during the previous vegetative season. Second, they form renewal buds on different overwintering organs that are responsible for renewing of the whole shoot. Interestingly, the renewal buds may differ a lot in the stage of development before sprouting. This phenomenon is called bud preformation and means that vegetative or generative organs (or both) are (pre)formed in the bud before sprouting. Even though bud preformation is known for quite a long time especially from arid and alpine climates, we have only a limited knowledge of its distribution across the temperate flora and its relation to plant phenology is rather scarce.

We collected data on the growth phenology of a large set of phylogenetically and ecologically representative temperate perennial herbs (328 species). The renewal buds of these species were sampled before winter and were used for the study of organ preformation. We were especially interested in the stage of inflorescence development. These data were then correlated to plant phenology data, genome size and plant ecological parameters.

Bud preformation affected mainly dates of flowering and maturity. Preformed species flowered significantly earlier (about 36 days) than the nonperforming species and even before their peak growth. Interestingly, no correlation with relative or absolute growth rate was found. Inflorescence preformation was observed in 30% of the studied species and showed a strong phylogenetic signal. It was found in many different genera (e.g. *Geranium*, *Viola*, *Polygonatum*, *Convallaria*, *Carex*, *Pulmonaria*, *Primula*). Its frequency was much higher in plants with large genomes (e.g. spring geophytes). Inflorescence preformation was found more often in undisturbed and shaded habitats.
The study clearly demonstrates that bud preformation is an important plant strategy enabling early flowering and maturing of plants in order to take advantage of favourable conditions. Due to its relatively high frequency in the temperate flora, it is a key plant trait and certainly should not be neglected when studying plant phenology.

Talk Using plant traits for the recovery of ecosystem functions and services: Trait-based ecosystem engineering?

Functional variability of Common Sagebrush associated species and implications for ecological restoration

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Sagebrush ecosystems are among the most widespread and imperiled in the United States. They provide essential ecosystem services and habitat for over 400 sagebrush obligate taxa. Ecological restoration is a process that can be utilized to repair damaged sagebrush ecosystems. However, this process can be expensive, and therefore it is important to utilize restoration protocols that have a high chance of restoring functional ecosystems. Local adaptation and phenotypic plasticity are two factors that affect the successful establishment of plants in restoration, and both have been linked to plant functional traits. Understanding the degree of these factors in plant species commonly used in restoration is vital for informing seed sourcing protocol and planning for anthropogenic climate change. We aim to quantify the plasticity of functional leaf traits of six species commonly used in sagebrush restoration on a small scale.

We chose three north-facing, south-facing, ridge, and valley plots on Bureau of Land Management land near Kremmling, Colorado. At each site we measured photosynthetic rate, intercellular CO_2, stomatal conductance, water use efficiency, specific leaf area, leaf water content, and leaf dry matter content for ten replicates of each species. A two-way MANOVA using data collected from one species (*Artemisia tridentata*) resulted in a significant effect of slope position ($P=2.2e^{-16}$) and plot ($P=2.2e^{-16}$). However, there were no significant interactions, indicating that our representative plots were more similar within groups than among groups. Follow up ANOVAS and Tukey's post hoc test revealed that carbon assimilation rate, intercellular CO_2, and stomatal conductance were meaningfully higher in north facing and valley sites compared to ridge and south facing sites. Water use efficiency was highest in ridge sites, with all other sites having significantly lower values. We performed an NMS ordination with a follow up MRPP analysis using photosynthetic data to test our four slope-position groupings. This resulted in significant differences among our groups ($p<0.0000001$). Based on these analyses, it appears that harsher environments (south facing and ridge sites) take up a smaller trait space in our ordination (with average ordination distances of .28 and .39, respectively); Less stressful slope positions (North-Facing and Valley sites) take up larger trait spaces (with average intraspecific distances of 0.52 and 0.53, respectively). We plan to continue this analysis with five other species to assess the degree of interspecific and intraspecific variability on a small scale and better understand the degree of plasticity these species express. These data in conjunction with genetic data can be used to develop seed transfer zones and prioritize seed collection and development for restoration in sagebrush habitat.

Talk Vegetation patterns and processes

Indirect effects of saltwater intrusion, via alterations of microbial symbionts, intensify invasion of *Phragmites australis* in a freshwater wetland

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Although global change clearly influences species invasion, the exact mechanisms by which global change either intensifies or limits invasive spread remain elusive. Global change can affect invasion directly by altering abiotic conditions, as well as indirectly by altering the abundance and composition of interacting species. Here we examine the relative impacts of direct and indirect effects of saltwater intrusion on the expansion of a model invasive plant species, *Phragmites australis*, in freshwater marshes of coastal Louisiana. Using experimental mesocosms, we test two hypotheses: (1) saltwater intrusion facilitates invasion of *P. australis* in freshwater marshes and (2) this process relies primarily on an indirect mechanism, alterations in composition of microbial symbionts. To tease apart the relative impacts of salinity and microbial communities on invasion, we experimentally manipulate these factors in three community contexts: *P. australis* monoculture, a native community, and a mixed *P. australis* and native community. We predict that the indirect effects of salinity will be stronger than the direct effects of salinity on invasion across all community types.

We find that overall salinity strongly increases invasion, but the direction and magnitude of direct and indirect effects are context dependent. Indirect effects of salinity (via alterations in soil microbial composition) increase invasive performance in monoculture and decrease native performance in native communities. However, in mixed communities, direct effects of salinity are stronger than indirect effects. When *P. australis* and natives are grown together, salinity increases invasion regardless of changes in microbial composition. Results suggest that indirect effects of saltwater intrusion will promote *P. australis* expansion and hinder native productivity in freshwater wetlands. However, the relative strength of direct and indirect effects of salinity on invasion will be contingent on community context. More broadly, these results underscore the importance of considering microbially-mediated indirect effects of global change in investigating the long-term outcomes of plant species interactions.

Poster Vegetation patterns and processes

Response of *Geum urbanum* and *Milium effusum* to an experimental soil pH gradient - the roles of physiological limits and competition

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Plant species are confined to certain parts of the environment, their ecological niches, and these niches can be described by response curves of the species to environmental gradients such as soil pH or nutrient availability. The response limits determine where in nature the species can be found and are particularly interesting when the sites of the species are affected by environmental changes. However, when examining response curves of species, for example by means of Huisman-Olff-Fresco models, the limits of species can be due to physiological constraints, but also competition, and we need experiments to determine the underlying causes for these limits.

In our study we examine the responses of two herbaceous forest species (*Geum urbanum* and *Milium effusum*) to gradients of important soil variables, focusing on pH. Based on data of the species' occurrences on soils of varying soil chemistry in the region of Bremen, Germany, we collected large amounts of soil from forests varying in soil pH between 2.8 and 6.7. After having analysed the soils with respect also to other variables (C, N, P, Ca, Mg, K) the soils we put in pots in the greenhouse of the Botanical garden. Young specimen of *Geum* and *Milium* raised from seeds were weighed and then planted in pots from 26 different forest sites with five replicates for each site. During the course of the experiment we regularly measured the height of the plants as well as the number of leaves and leaf size. At the end we will determine the weight and the growth rate of the single plants. While the experiments are still in progress, preliminary results already show an optimum curve of some of the growth parameters for *Geum* along the pH gradient. We will relate the response curves of the two species to the soil variables as observed in the greenhouse to the responses of the species at their natural growing sites to disentangle the roles of physiology constraints and competition.

Poster Macroecological vegetation science: large grain patterns and processes of plant diversity

100 years of botanical mapping in Estonia - what can we learn from the data?

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Growing human pressure and climate change are expected to have a major impact on biodiversity at a global scale. Historical recordings can be valuable tools to study distribution trends and loss of biodiversity. Unfortunately, large-scale distribution datasets of vascular plants are rare in Europe. Estonia has a remarkably long history of floristic mapping covering the whole national territory (in 9 km x 11 km grid cells). Distribution datasets of Estonian vascular plants include recordings from three different time periods (1921-1970, 1971-2005 and 2006-2019). Plant data covering almost a 100-year period provide an excellent opportunity to analyse what kind of changes have taken place in the Estonian flora under the conditions of growing human impact and climate change.

Preliminary analysis of the latest floristic survey (2006-2019) has demonstrated a widespread distribution loss of some native species (e.g. *Polygonum viviparum*, *Saxifraga hirculus*, *Nardus stricta*), while some alien species (e.g. *Conyza canadensis*, *Chaenorhinum minus*, *Veronica persica*) have expanded their distribution areas remarkably over the last 50 years.

Large-scale atlas datasets often include potential biases caused by methodological differences, such as spatial and temporal recording variability and the use of different taxonomic concepts. We demonstrate that distribution changes of some common species (e.g. *Anemone ranunculoides*, *Ranunculus ficaria*, *Lathraea squamaria*) can be attributed to differences in recording methods. Therefore, potential biases must be taken into account when interpreting large-scale plant datasets. It is important not to confuse changes caused by differences in recording methods with distribution changes caused by human impact and climate change.

Poster Vegetation patterns and processes

Host size preferences of vascular epiphytes may be reflected in spatial distribution patterns: case study in a mature broadleaf evergreen forest of Kochi, Japan

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Epiphytes are one of the most diverse plant functions and considerably contribute to the forest diversity around the world. Understanding of the influential factors for the diversity distributions of epiphytes are fundamental for conservation and restoration of forest plant species diversity. Several studies revealed that host tree size is the fundamental factor for epiphyte occurrence; however, there are contrasting results for spatial diversity distributions (patchy or random). In this study, we examined the relationships between host tree size preferences and distribution patterns for eight epiphyte species in a mature broadleaf evergreen forest of Kochi, southern Japan, and revealed that the host size preference of epiphytes differed among the target species: Two fern species, *Lemmaphyllum microphyllum* C. Presl and *Lepisorus onoei* (Franch. et Sav.) Ching, showed lower host size preferences, but five orchids and *Ribes ambiguum* often growing on large trees had higher host size preferences. The spatial distributions of *L. microphyllum* showed an aggregative pattern, while *Eria japonica* Maxim. (*Orchidaceae*), which had higher host size preference, occurred randomly. The differences in spatial distribution pattern may be caused by differences in their host size preferences and species interaction. *L. microphyllum* will expand by spore dispersal, and lower host size preference may facilitate establishment on any tree around adhered trees. On the other hand, occurrence of epiphytes with higher host size preference may depend on the specific conditions of a large host tree. Large and old trees not only provide longer invasion opportunity for epiphytes, but also have suitable habitat conditions such as development of water-rich and/or rough barks, and light-rich branches beneath the canopy layer. In addition, orchids strongly depend on coexistence with symbiotic bacteria. Therefore, even if the diaspores of *E. japonica* are dispersed for trees around the adhered tree, it cannot establish on trees without symbiotic bacteria. Invasion opportunity for symbiotic bacteria is expected to be longer for large and old trees, as well as epiphytes. These results suggest that the spectrum distributions of the host size preferences among the epiphytic flora may be affected by differences in diversity distribution patterns (i.e., patchy or random) in forests.

Shrubification and tree infilling in the north-eastern Siberia between 2001 and 2016 derived from Landsat land cover classification

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Vegetation is sensitive to recent climate change which is particularly strong in northern high latitudes. For these remote regions the quantification of vegetation changes is a very challenging task since only few field data is available. Satellite remote sensing provides valuable information on the spatial distribution of vegetation and reflects changes as well. However, interpretation of inferred changes is difficult. The aim of the study is to classify and map vegetation types and quantify changes between derived classes within over North-Eastern Siberia (68° N, 163° E to 65°N, 169° E), a region of observed intense greening in MODIS NDVI time series.

Hence, we explored four specific locations along the gradient of vegetation ecotypes and ecotones of the study area (northern taiga, tundra-taiga transition zone, treeless mountain tundra) during the Expedition "Keperveem 2016". Foliage projective cover (percentage cover) of different plant taxa was described at 58 sites.

We used Landsat satellite data to map the vegetation and its change that took place within the study area. We took the best available cloud-free satellite data from Landsat Enhanced Thematic Mapper (ETM+) in 2001 and from Operational Land Imager (OLI) in 2016. We selected peak-summer (mid-July to mid-August) acquisitions to calculate spectral vegetation indices (Normalised Difference Vegetation Index (NDVI), Normalised Difference Moisture Index (NDMI), Normalised Difference Water Index (NDWI)) and acquisitions from March using the green reflectance as albedo equivalent. To make comparison between Landsat EMT+ and OLI spectral bands possible we developed a transformation algorithm.

For classification, we built a model based on constrained ordination where percentage cover represents predictant and Landsat spectral data represents predictors. Based on the model scores we ran fuzzy c-means classification to obtain probabilities for certain land cover classes. Only assignments to classes with a probability exceeding a threshold of 0.7 were taken into account. The best performing classification distinguishes 3 classes: (1) dense forest (predominantly characterised by high coverage of *Larix cajanderi*), (2) densely vegetated open tundra (including sparse forest, tussock *Eriophorum vaginatum*, grasslands, erect and dwarf shrub tundra with *Salix* sp. and *Betula nana* as well as *Pinus pumila* tall shrubs), (3) alpine herb tundra, sparsely vegetated *Dryas*-lichens communities and barren areas.

Preliminary results applying this method and comparing year 2001 with 2016 show strong changes. In detail, shrubification all over the region was indicated by the transition of sparsely vegetated areas to more densely vegetated open tundra. Significant forest expansion is restricted to those areas where already in 2001 a large part was covered by forest indicating tree infilling rather than treeline extension.

Software tools for identification and habitat monitoring by satellite images

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Remote sensing tools help vegetation scientists and ecologists better understand diversity patterns and spatial distributions of target communities. Recently, software NaturaSat was developed for monitoring and identifying NATURA 2000 habitats by satellite images. The localization, classification and dynamic space-time segmentation and tracking were mainly based on processing and analyzing of Sentinel-2 multispectral imaging data by novel mathematical methods. The presented case study about the suitability of this approach was performed on riparian forests and alpine vegetation. In Central Europe, riparian forests are traditionally classified within the alliance *Salicion albae* which represents the Natura 2000 priority habitat 91E0, and the alliance *Fraxino-Quercion roboris* - Natura 2000 habitat 91F0. In lowland areas the floodplain forests were often replaced by non-native *Robinia pseudoacacia* or *Populus x canadedsis* plantations. These habitats grow usually connected one to another, but their classification into habitat types, their ecology and management needs are different. The distinction between them is a challenge, crucial for effective monitoring of selected Natura 2000 habitats and preventing them against the spread of alien tree species.

In high altitudes, bushes with *Pinus mugo* usually form large areas with diversified shape, discontinued by avalanche gullies, small mountain creeks or by glacially formed moraines. In the field they are connected with mountain spruce forests on one side and alpine meadows on the other, creating a heterogenous mosaic. The field mapping of habitat borders in high-altitude rugged terrain is very complicated and time-consuming, so using the satellite image segmentation methods seems to be very efficient way of monitoring these habitats.

For the purposes of classification based on satellite images data, we choose fragments of 91F0 and 91E0 habitats together with *Robinia pseudoacacia* and *Populus x canadensis* plantations for the first case study, and fragments of habitat 4070 Bushes with *Pinus mugo*, 4060 Alpine and boreal heaths, 6150 Siliceous alpine and boreal grasslands, 6170 Alpine and subalpine calcareous grasslands and 9410 Acidophilous *Picea* forests of the montane to alpine levels for the second case study.
A mean intensity color value and standard deviation of all Sentinel-2 bands for the interior area of each habitat fragments in every available date of the year 2018 were calculated using NaturaSat software. The composition of these values creates a characteristic for each habitat. The first results of PERMANOVA analyses show significant difference and subsequent feasibility to distinguish target habitats based on satellite data.

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Poster Using plant traits for the recovery of ecosystem functions and services: Trait-based ecosystem engineering?

Structural and functional changes of montane spruce forests after the disturbances

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Global climate change may elicit more radical weather anomalies, including more frequent and severe droughts and intense storms. Such weather disturbances are a natural component of ecosystems resulting in landscape heterogeneity. Plants have evolved various adaptations to these weather disturbances, but it remains unclear which plants are positively affected, especially when disturbances are large-scale. There is a growing need to understand how different plants respond if stewards want to predict ecosystem response and successfully manage public lands.

We examined plant functional response to disturbance in the Tatra Mountains at both the community and population levels. We collected 10 plots (10 m x 10 m) of data from four disturbance site types (DR = wind throw and not salvaged; DS = wind throw salvaged; NF = Forest without gap; NG = forest with canopy gap) in both Slovakia and Poland. Data included cover of all species, heterogeneity data and clonal connectedness data (through dye experiments on selected species). Based on the variance to mean ratio as a measure of heterogeneity, wind throw sites that were not salvaged had the greatest heterogeneity. We found distinct differences in community composition and structure among the four treatments, however, floristic differences do not copy only the studied treatments but other factors such as the species pool from spruce forests. This must be considered when explaining floristic variability and vegetation structure. Clonal integration was related to heterogeneity, but all growth forms did not behave equally. Temperatures on salvaged wind throw sites reached the highest values in comparison with the rest of the site types.

Similarly, temperature heterogeneity was the highest at managed sites as well. Considering recent negative climate change effect, it is obvious that some forest management practices can be unhelpful when trying to mitigate this phenomenon.

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Putting forbs onto the agenda: whereto in savanna ecological research?

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Ecological research in African savannas is largely focused upon the improved understanding of the co-dominance of trees and grasses - from disturbance response patterns to their role in providing essential ecosystem services and functions. In contrast, the ecology of forbs, a plant life form representing non-graminoid herbaceous or semi-woody vascular plants, is a comparatively uncommon research focus. Over the past decades, savanna research at the plant functional level has received increasing attention, attempting to disentangle the ecological roles of different functional components of herbaceous communities and their responses to disturbances. Although such studies often include forbs as a major life form, there still seem to be limited focus on understanding the ecology of forbs in African savannas. In this presentation, we will report on the extent to which studies implicitly or explicitly considered forbs as a discrete vegetation component in dry African savannas. Using a systematic review approach, our results revealed strong research biases towards (i) semi-arid systems, particularly in South Africa, (ii) local-scale rather than landscape scale analyses, (iii) forbs being analysed at the plant functional group level in attempts to understand vegetation responses or resource potential, and (iv) a focus on tree-grass life-form interactions with very little emphasis on forb-grass and/or forb-tree interactions. It became evident that the understanding of African savanna community responses to drivers of global environmental change requires knowledge beyond tree-grass interactions only, and beyond the plant functional group level. Despite evidence of our current understanding of forbs in dry savannas, there appears to be knowledge gaps, specifically in linking drivers of environmental change to forb community responses. Recent research projects from semi-arid savannas in South Africa have been established in an attempt to link drivers, such as fire, herbivory and climate change, to responses of forbs at the species and functional group level. Our results revealed that forb diversity losses are highest under herbivore loss and fire exclusion. Furthermore, forb communities were able to maintain their function during an extreme drought in an African savanna, despite the negative effects of dry, hot conditions on forb richness and diversity. Compared to grasses, forbs also contribute significantly more to the functional diversity of herbaceous communities. More highlights will be presented to emphasise the value of considering forbs as an additional ecologically important plant life form in the conventional tree-grass paradigm of African savannas.

Talk Using plant traits for the recovery of ecosystem functions and services: Trait-based ecosystem engineering?

Ecosystem resilience of nutrient-rich sodic savannas: herbivore effects on forb and grass species - and functional diversity during a drought

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In semi-arid and arid grassy savannas, abiotic stress (e.g. drought) and consumer stress (e.g. herbivory) interact, resulting in complex responses of herbaceous plant community structure and function. Herbaceous layers of savanna ecosystems are functionally important and characterised by forb-grass mixtures, of which the grass component functions as the main source of forage, not only to the high diversity of African grazers, but also domestic livestock. Although acknowledged that forbs contribute significantly to the richness and diversity of savanna and grassland systems, their functional contribution and how they respond to common savanna drivers remain elusive. Given projected increased global changes, understanding herbaceous vegetation response to these environmental drivers may aid in predicting effects of future changes in savanna ecosystems.

Effective conservation of species diversity is widely accepted to promote ecosystem insurance against unfavourable environmental fluctuations. However, species diversity has been reported as a slow respondent to herbivory in dry ecosystems with a long evolutionary history of this stressor. Furthermore, relations between savanna disturbances, species diversity and functional diversity of higher plant communities remain unexplored, specifically when considering herbaceous life forms as separate functional entities. We evaluated herbivore utilisation effects on species- and functional diversity of forbs and grasses during an episodic drought in a semi-arid nutrient-rich sodic savanna using data collected from a long-term herbivore exclusion experiment in the Kruger National Park, South Africa. Species and functional trait richness were the only measures where herbaceous life forms responded similarly, where the loss of all herbivores lead to significantly lower richness of species and traits. Although we expected that combined effects of drought and intense utilisation would have strong negative effects on species and functional diversity, lowest diversity and richness of forbs and grasses were recorded in the absence of herbivory during the drought. This suggests that long-term herbivore loss from this disturbance-maintained savanna ecosystem seems to outweigh the negative effects of disturbances such as herbivory and drought on the herbaceous community. As expected, forbs contributed significantly to species richness and diversity during drought, irrespective of herbivory. However, our results revealed that forbs contributed significantly to trait richness during the drought. Since functional diversity plays an important role in the conservation and management of ecosystems by being closely linked to ecosystem functioning, forbs are considered fundamental to the functioning of this semi-arid sodic savanna herbaceous plant community during episodes of drought.

Talk Patterns, drivers, and conservation opportunities of grassland biodiversity

Determinants of bryophyte species composition in traditionally managed grasslands of the Carpathian Mts (Central and Eastern Europe)

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In agricultural landscapes of Europe, especially in the Carpathian Mts, semi-natural grasslands belong to the most valuable habitats as they contain a very high diversity of various plants. However, there is a lack of detailed studies on the effects of traditional grassland management on plant species (both vascular and non-vascular) composition and diversity. In particular, bryophytes have rarely been used in such studies. In this paper we evaluated the relationship between 45 environmental variables (classified as biotic, topographic, edaphic and management factors) and bryophyte species composition in long-term extensively managed grasslands in the Western and Eastern Carpathians (including Austria, Hungary, Poland, Romania, Slovakia and Ukraine). The analysis was based on a dataset of 77 bryophyte taxa recorded in 90 plots (10 m^2) from 15 sites along broad environmental gradients (elevation range of roughly 1200 meters, various geological bedrock and land-use history). The plot selection within each site was stratified by slope inclination (flat, moderate, steep) and slope aspect (W-N-E *vs* E-S-W). The results of a forward selection applied to a CCA analysis of all plots showed that a total of 8 variables (cover of stones and rocks, solar radiation, moisture, cover of herb layer, cover of bare soil, maximum microrelief, soil depth and slope) were statistically significant; together they accounted for 23.6% of compositional variation. Neither factors related to managment practices (such as mowing, grazing, burning, ploughing or abandonment) or their intensity (e.g. number of management elements applied, grazing intensity, type of grazing animals, ploughing in the past), nor edaphic factors related to soil nutrients (such as N, P, K, Ca, Mg, C/N) or humus contents had a significant influence on the speices composition of bryophytes. Our results thus indicate that in mesic semi-natural grasslands mostly topographic and soil-structural factors play a key role in bryophyte species composition. All these variables, as well as the cover of herb layer, substantially influence availability and moisture of the particular microhabitats, the main requirements for bryophyte occurrence.

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Developing a large vegetation database to improve conservation of threatened *Banksia* woodlands in the global biodiversity hotspot of south-western Australia.

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Creating and managing a large biodiversity database can be challenging. Firstly, existing data sources may be held in a variety of formats, data may have been acquired using different methods and field survey data can be of variable quality.

Secondly, in Australia, high species diversity combined with large areas often means that available data are sparse, or unevenly available. My PhD research aims to improve the understanding of *Banksia* woodlands of the Swan Coastal Plain of Western Australia, through developing a meta-dataset of recent and historic vegetation plots. In Western Australia, no managed vegetation database is currently available for use by the public or researchers. This research project compiled vegetation data into a custom built database in Microsoft Access. Data were sourced from Western Australian government agencies, non-government organisations, researchers, environmental consultants and individuals. This project was developed to aid in the conservation and threat assessment of *Banksia* woodlands. *Banksia* woodlands of the Swan Coastal Plain are nationally listed in Australia as a Threatened Ecological Community (TEC), and several sub-communities are also classified as TECs in Western Australia (WA). This project assessed approximately 1800 flora plots, almost 100,000 plant species presence records and >2000 species over the 1.53 million hectares extent of the Swan Coastal Plain region in south-western Australia. The study area is a coastal sandplain with a Mediterranean-type climate stretching north and south of the rapidly urbanising city of Perth, Western Australia. High rates of species richness exist, with around 65 plant species or more present within 10 m x 10 m survey plots in undisturbed *Banksia* woodland. This high species richness at both local and regional levels is a challenge for field surveys and data management.

Nomenclature changes relating to revised taxonomy required extensive updates to be made to old datasets. Nomenclature of the dataset was standardised based on current taxonomy (2018). Analysis was conducted using Primer7, starting with nMDS ordination of a similarity matrix of presence / absence data to identify outliers. Outlier plots were removed for *Banksia* woodland classification. Cluster analysis was conducted using Bray-Curtis Similarity and Group Average. There were 117 plots identified as forming a *Banksia* woodland group at 46% similarity for the eastern Swan Coastal Plain, with the presence of additional unique sub-groups within the eastern *Banksia* woodlands. This suggests the WA *Banksia* woodland TECs are under greater threat due to restricted range, than previously thought. It is clear that the use of big data is helping to refine our understanding of conservation risk in this biodiversity hotspot.

The way bioclimatic variables are calculated has impact on predictive distribution models

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Predictive Vegetation Models (PVMs) are means of formalized prediction of vegetation patterns in space and time. The newly arising vegetation and plant distribution databases provide a growing potential to use these models both for understanding and predicting vegetation patterns either by modelling vegetation types or individual species. Explanatory variables required by the models are also widely available in databases today, especially regarding climate. To help ecologists to summarize the explanatory potential in climate variables, bioclimatic variables (BCVs) combining basic climatic parameters were defined. These are routinely used in predictive distribution models including PVMs, typically without considering the logically arising calculation options in detail. We aimed at studying the impact of decisions on the calculation of bioclimatic variables. BCVs often rely on specific months/quarters of the year, e.g. wettest quarter, these are particularly exposed to calculation decisions. In our study we examine the effect of selection options of the specific months/quarters of BCVs reflecting two dilemmas: (1) whether to preserve spatial coherence or select the months/quarters for BCV calculation pointwise and (2) whether these months/quarters shall be reselected under future condition in case of extrapolation in time.

Our study relies on potential natural vegetation models of Hungary, encompassing 38 habitat types and the whole territory of the country. Correlation structure of the explanatory variables were specifically taken into account and thus different starting variable sets have been tested. The resulting models were applied to the reference and one future time period (with data from two regional climate models) and effects of the BCV calculation approaches were tested by linear mixed-effects models and model goodness-of-fit measures in a comprehensive framework of 570 predictions. Area Under the ROC Curve (AUC) and True Positive Rate (TPR) curves were used to evaluate models. Our results show that both of the studied decisions in BCV calculation had a distinctive and strong effect on model structure as well as on predictions. Furthermore, the widely applied calculation approaches of BCVs were observed to add uncertainty to predictions and no evidence supporting their superiority were found. On the other hand, we found examples of prediction artefacts when applying these widespread ways of calculation. We conclude that more attention and more transparent communication is needed when BCVs are used as predictors in PVMs; and not only ecophysiology but also the way predictors are calculated should be considered when preselecting predictors for predictive distribution models.

Species-specific effects of litter accumulation and seed burial depth drive the establishment of invasives

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Invasive species are considered among the biggest threats to biodiversity worldwide and can also seriously hamper restoration projects. To assess the risks posed by them and to plan management and restoration accordingly, information on their germination requirements is essential. Here we analyse how invasive species' germination and establishment is affected by seed burial depths in combination with different litter layers. We selected 11 herbaceous invasive species and tested their germination and establishment from under four different seed burial depths and four different amounts of grass litter in a full factorial greenhouse experiment. We analysed the effects of burial depth, litter cover, species identity and their interactions on germination, seedling length and fresh and dry weight across species, and the effects of burial depth and litter cover on the species level. We also tested whether effect sizes correlate with the species' seed weight. Both litter cover, burial depth, species identity and their interactions had a significant effect on the germination and establishment when analysed across species, but most of the variance was explained by species identity. When analysed at the species level, we observed a general trend of species with bigger seeds being not or less seriously affected by burial depth and litter cover than species with smaller seeds.

Correlations between seed mass and effect sizes also confirmed this general trend, but some species conspicuously deviated from it. Our results confirmed that seed size is a major driver of species' response to litter cover and seed burial, but we found that some species' response considerably differed from the general trend. Thus, specific information on species' response to conditions such as litter accumulation and seed burial is crucial when planning management or restoration in areas subjected to plant invasions.

Poster Long-term studies in vegetation science

Multi-temporal analysis of coastal dune ecosystems in Central Italy: experiences from a resurveying study

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Global changes and anthropogenic pressures are severely transforming both composition and diversity of ecosystems worldwide. Quantifying such alteration and identifying main trends are therefore crucial tasks in the protection and management of natural systems. In this context, resurveying studies proved to be effective tools to track temporal changes in a variety of ecosystems. Being dynamic ecotones located at the boundary between land and sea, coastal dunes are unique habitats characterized by constraining environmental conditions and high habitat heterogeneity. However, in spite of a prominent ecological value and a wide range of socio-economic services provided, coastal dunes appear among the most threatened ecosystems on earth. For this reason, monitoring their status through time should be considered as top priority for promoting their conservation.

We hereby present results from a resurveying study performed on coastal dune ecosystems of Central Italy. A set of 334 georeferenced random plots, originally sampled between 2002 and 2007 and belonging to the first portion of the coastal vegetation zonation (from upper beach communities to coastal stable dune grasslands), was resurveyed during two sampling seasons (2017-2018). To investigate community changes in composition and abundance, Species Exchange Ratio (SER) metrics based on both presence/absence and abundance data were computed for each pair of old vs new plots. Each of these metrics was tested for significant differences among vegetation communities using non-parametric tests. Furthermore, changes in occurrence frequency and cover were analyzed for a set of diagnostic species in each reference community by using McNemar's tests for paired data and Wilcoxon signed-rank tests. Results suggest how, during the investigated time-span, coastal dune communities of Central Italy experienced considerable changes affecting both species composition and dominance structure. Although all investigated communities were somehow affected, upper beach communities, embryonic and shifting dunes experienced the most important transformations, as also confirmed by the analysis of diagnostic species. Specifically, the loss in both occurrence frequency and cover of *Ammophila arenaria* subsp. *australis* appears to be particularly alarming, given the key functional role played by this perennial rhizomatous grass in the dune-building process. Overall, our results suggest that the last 10-15 years brought considerable deterioration in the conditions of coastal dunes, probably induced by the combined action of multiple natural and anthropogenic drivers, and urgently call for specific conservation efforts.

Talk Macroecological vegetation science: large grain patterns and processes of plant diversity

Assessing abundance-suitability and -centrality relationships in vascular plant species in geographic and climatic space

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In biogeography and macroecology, the abundant-centre hypothesis (ACH) describes the widely held assumption that species abundance is highest in the centre of its geographical and environmental space and should decline towards the edges. Studies on ACH and related abundance-suitability relationships have been examined previously, with some studies finding strong support and others failing to detect an effect. While species occurrence information is mostly available, availability of abundance data is often limited. We here make use of vegetation-plot data for which plant abundance has been measured as plant cover, the relative projected area covered by a species which is an important characteristic of the composition of herbal plant communities. We test the abundant-centre hypotheses for 517 vascular plant species across their whole European ranges.

Range maps from the Chorological Database Halle were used as background reference data to capture species' geographic ranges and to derive species' climatic niches. Species abundance cover values were retrieved for 808,794 vegetation plots from the European Vegetation Archive. Distance to range centre was calculated per species for each plot location via Haversine and Mahalanobis distance in geographic and climatic space, respectively. We applied species distribution models to test for the relationship between species plot cover abundance and predicted climatic suitability. We used Spearman rank correlation to test for general relationships between centrality and climatic suitability and plot cover abundance. Quantile regressions were applied to examine relationships of centrality and climatic suitability for the upper limits of plot cover abundance.

For several species, the Spearman's correlation coefficients were significantly positive, but these cases were not more frequent than cases in which the correlations were significantly negative. Similarly, quantile regressions for climatic suitability and distance and cover abundance were similarly often significantly positive as well as negative. On average, slopes of quantile regressions ranged from -0.05 to 0.06 for half of the studied species (25th and 75th percentile) and were significantly positive in only 12.3% of the species. Multiple R-squared values from linear models were used as measure of explained variance in cover abundance values by centrality and climatic suitability respectively, and revealed that for half of the studied species, explained variance was between 0.0% and 1.0%.

Our results do not provide support for a global validity of the abundant-centre hypothesis, although it may apply to single species with certain characteristics. Across all species, we conclude that environmental factors influencing cover abundance may differ from those limiting distribution. Furthermore, other unmeasured abiotic factors or constraints such as biotic interactions or dispersal limitation may affect cover abundance in addition to climatic environment.

Poster Vegetation patterns and processes

Invasive red oak (*Quercus rubra* L.) induced changes in chemical and microbiological soil properties

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Quercus rubra L. is a northern American species that was introduced into European forests in the 17th century. However, rapid acclimatization, high productivity and a wide range of tolerance of *Q. rubra* to environmental conditions make its introduction to forest cultivation controversial. In the Polish flora, *Q. rubra* has the status of an invasive plant species since it causes serious changes in ecosystems by decreasing biodiversity. The aim of this study was to assess the effect of *Q. rubra* on chemical and microbial parameters of two soil horizons. Nineteen study sites were established in semi-natural forests in southern Poland. Each site consisted of two plots - one dominated by *Q. rubra* and one overgrown only by native species (control). At each plot, soil samples from organic and organo-mineral soil horizons were collected and examined for organic C, total N, P, Ca, Mg and K contents, as well as total microbial, bacterial and fungal biomass (phospholipid fatty acid analysis). The organic horizon was characterized by higher element content and microbial biomass than the organo-mineral horizon. The soil samples from both horizons from sites overgrown by *Q. rubra* were characterized by significantly ($p < 0.05$) lower C, N, P, K and Mg contents and microbial biomass in comparison to sites with native vegetation. Moreover, *Q. rubra* changed microbial community structure by increasing the fungi:bacteria ratio, which was a consequence of the decrease in bacterial biomass ($p < 0.001$). *Q. rubra* did not affect the fungal biomass. The observed changes in soil properties may lead to alterations in the ecosystem functioning. The changes might have resulted from a high production of *Q. rubra* litter containing specific chemical compounds, e.g., phenolics. This problem requires further investigation.

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Poster Vegetation patterns and processes

Soil microbial community structure rather than its function responded to *Reynoutria japonica* invasion

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The aims of this study were to assess the influence of *Reynoutria japonica* Houtt. (*Polygonaceae*) - one of the most successful plant invaders in Europe - on soil microbial properties and to relate potential changes in these properties to the quality of plant biomass. Twenty five study sites were established in fallow/riparian habitats. Each site consisted of two plots - one located in a near-monospecific patch of *R. japonica* and one in a neighboring patch of native plants. At each plot, samples of soil and senescing aboveground and belowground biomass were collected - leaves, stems and roots/rhizomes of *R. japonica* and shoots and roots/rhizomes in the case of native plants. The biomass was characterized in terms of C, N, P, total phenolics, and condensed tannin concentrations. Soil was characterized in terms of B-glucosidase, acid and alkaline phosphatases, phenoloxidase and peroxidase activity, as well as total microbial, bacterial and fungal biomass (phospholipid fatty acid analysis). The quality of plant biomass differed significantly ($p < 0.05$) between *R. japonica* and native species; it also depended on biomass type (aboveground vs. belowground). *R. japonica* had higher C, phenolics and condensed tannins concentrations, higher C/N and C/P ratios, as well as lower N and P concentrations than native species. Total microbial, bacterial and fungal biomass were reduced due to *R. japonica* invasion. The decrease in microbial biomass under *R. japonica* might have been related to the low quality of its litter or root exudates. However, changes in microbial biomass did not lead to disturbance in microbial functioning. The activity of soil enzymes did not generally respond to invasion ($p > 0.05$) and only peroxidase activity was higher under *R. japonica* than under native plants. It cannot be excluded, however, that the response of soil functions to *R. japonica* invasion is site- or season-specific. This problem requires further investigation.

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Phylogenetic structure of grassland communities in Southern Brazil

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Analyzing phylogenetic patterns across a metacommunity allows the understanding of the regional (e.g. landscape isolation, dispersal limitation) and local (e.g. habitat heterogeneity, niche differentiation) processes which determine species distribution. Little is known about phylogenetic patterns of grassland vegetation along climatic gradients, and whether groups of phylogenetically and functionally closely related species tend to respond in a similar way to the same environmental factors.

We studied the variation of phylogenetic structure and diversity of grassland communities along latitudinal and climatic gradients. We compiled community data of grassland vegetation in 9 different sites in Southern Brazil. A hypothesized phylogenetic tree for the plant species occurring in the sampled area was constructed using the Phylomatic tree version R20120829 software. Branch lengths were assigned using the function BLADJ of the Phylocom software. Phylogenetic structure was calculated using the Net Related Index (NRI), while phylogenetic diversity was inferred from Faith's Phylogenetic Diversity (Faith's PD), with the package picante in R.

NRI was related to the latitudinal gradient, with phylogenetic nestedness prevailing in the Northern portion ($R^2 = 0.189$; $P < 0.05$). This can be explained by the higher species turnover in the Southern direction of the gradient, due to the shift from subtropical to temperate climate. However, NRI did not show association with temperature and rainfall seasonality. Considering Faith's PD, we found the opposite trend - correlation with latitude was not important, whereas it was related to climatic variables. Faith's PD was higher in communities with: low temperature seasonality ($R^2 = 0.2471$, $P < 0.05$) and high rainfall seasonality ($R^2 = 0.1702$, $P < 0.05$).

Even though we found patterns of phylogenetic structure along the gradients, they seem blurred and it was not possible to clearly infer the ecological processes involved in community assembly rules. We are including data from grassland communities from more temperate climate to expand our gradients. By this, we expect to clarify the assembly patterns of grassland vegetation in South America.

Talk Long-term studies in vegetation science

Long-term monitoring of shrub dynamics in the Thornbush Savanna in central Namibia

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Bush encroachment has been reported to be a problem in the extensive grazing systems in the savannas of Namibia since the 1970's. However, little data is available in the Namibian context on the degree and spread of bush encroachment other than anecdotal evidence. The find of old photographs from the 1950's by Prof Volk, associated with some relevé data from that time, triggered this research into the long-term dynamics of the Thornbush Savanna of Central Namibia.

A number of approaches were followed: In addition to resurveying the old data of the 1950's, we also made comparisons of the old photographs with the present situation. A long-term biodiversity observatory was established in 2001, and this is resurveyed annually. This ground-based survey of floristic biodiversity is since 2016 supplemented by high-resolution aerial surveys of the observatory using drones.

We found that all approaches have their advantages and disadvantages. Comparing the historic data with present day situation gives a good impression of change (especially using old photographs), but locating the historic sites is difficult, especially if based only on route descriptions and odometer readings. Comparing old photographs with present-day photographs yields good qualitative data, but little quantitative data. Comparing long-term data series is marred by observer bias. Although aerial photographs have the drawback that species recognition is difficult, we obtained the best results by comparing the drone imagery with historic aerial photographs. Here we were able to show an increase in woody plant density over the past 60 years in the central Thornbush Savanna. At the same time we also picked up a disturbing tendency that many older trees (standing for over 60 years) are removed by farmers in an attempt to combat bush encroachment, rather than the younger (and problematic) shrubs.

Poster Long-term studies in vegetation science

The species diversity patterns of *Quercus* in China and their responses to climate change

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The species diversity pattern is an important spatial characteristic of species. It is the result of the long-term interaction between species and the environment. Future climate change could lead to the loss of species diversity, thereby changing the species diversity pattern. At present, species distribution models (SDMs) are considered as the prime method to study the effect of climate change on species diversity pattern. The genus *Quercus* is the main forest species and dominant species in China. It is suitable for studying the species diversity pattern because of its large number of species and continuous distribution. In this paper, based on the distribution data of fifty-one oak species and nineteen climate factors, the geographical distribution pattern and characteristics of species diversity of *Quercus* in China were analyzed with ArcGIS software. The main climate factors which affected the species diversity pattern of *Quercus* were also identified utilizing principal component analysis. Meanwhile, using Maxent model, the species diversity patterns of *Quercus* in three future greenhouse gas emission scenarios were predicted based on future climate data. The loss area of species diversity was found. The future main migration area and conservation area of oak species were ascertained.

In terms of species diversity protection, the results predicted the spatial variation of species diversity pattern due to climate change. It has a theoretical and realistic significance for the protection of species diversity and maintaining the ecosystem function. At the same time, the effect of climate change on the species diversity and distribution of *Quercus* plays an important role in Chinese forest ecosystems. Simulating the potential impact of climate change also has an important significance for the rational use and management of oak forest.

Keywords: *Quercus*, species diversity pattern, climate change, species distribution model

Talk Vegetation patterns and processes

Experimental assessment of biotic interactions driving species co-occurrence in community composition

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Species occurrence in a site can be limited by both the abiotic environment and the biotic interactions, especially by competition. These two factors operate in concert, but their relative importance is often unknown. Beals index is employed to estimate habitat suitability for a species from the community composition and is based on species coexistence patterns in large vegetation databases. The set of species for which the habitat is suitable are often considered to be a species pool. However, we can also assess a species pool experimentally by seed introduction or transplanting experiments. In the sowing/transplanting experiments, the plant can be introduced into artificial competition-free gaps or to the intact vegetation to disentangle the biotic and abiotic effect on plant establishment.

We conducted a seed sowing and transplanting experiment in three meadows on a moisture gradient (from moist to wet). Species were introduced as either seeds or pre-grown transplants into competition-free gaps and into the intact vegetation.

Subsequently, we compared their performance with their respective Beals index values. The investigated species included 12 species resident in the locality and 18 species typical for different habitats and not expected in the species pool. The experiment was established in 2013 and gaps were kept competition free by regular weeding two times a year up to spring 2016. In 2017 and 2018, gaps were vegetatively overgrown from surrounding and we observed the competitive exclusion of our focal plants there. Many of the species with habitat preferences very different from our localities were able to establish from seeds and grow in the focal habitat if competition was removed. They included species typical for very dry conditions (*Hypericum hirsutum*, *Nardus stricta*, *Origanum vulgare*, *Sanguisorba minor*, *Thymus pulegioides*, *Trifolium montanum*). None of these species survived in the intact community. These species are thus not limited by the abiotic conditions but by competition. Pre-grown transplants were not so sensitive to competition as seeds germinating in a field. Beals index was a statistically significant predictor of both species success in gaps and also for the ability to withstand the competition. Survival in a community is thus conditioned by adaptation to both the abiotic environment and the biotic interactions. Correlation coefficients between survival of seedlings and Beals index were higher for the intact vegetation than for gaps suggesting the importance of biotic interactions as determinant of community composition.

Many species traditionally excluded from species pool by comparative methods (e.g. Beals index) are able to grow in a habitat in the absence of competition. It is thus vitally important to distinguish between species pool as a set of species able to grow in a given community (determined by Beals index) and a set of species for which the abiotic conditions are suitable.

Changing of biomass variability in open sandy grasslands dominated by *Festuca vaginata* and *F. pseudovaginata* in Hungary

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In our study we compared biomass production of two different types of open sandy grasslands in Little Hungarian Plain (Gönyü, Györszentiván) and Great Hungarian Plain (Vácrátót, Szigetszentmiklós, Szigetmonostor, Újpest, Tahitótfalu, Tatárszentgyörgy, Kunpeszér, Kunadacs, Kéléshalom, Tázlár, Bugac, Imrehegy). One of the two types is dominated by Festuca vaginata, the determinative species of sandy grasslands, the other is characterised by the dominance of a newly described taxon, F. pseudovaginata. We sampled the biomass in eight 50 x 50 cm quadrats in every site. In a sandy horse pasture near Kisújszállás exclusion experiment was carried out with 2x2 m fenced areas. We took biomass samples from four 0.5x0.5 m quadrats within the fenced plots, biomass samples were also taken from the pasture. Biomass sampling was also done in Tahitótfalu, Imrehegy and Tázlár, in sheep pastures.
During grassland management studies, ratio and quantity of medicinal herbs, forage value and grassland management categories were analyzed. Forage values of significant species occurring in the grassland were determined according to the 10-stage scale of Klapp et al. (1953), which gives value 8 for species with high forage value, 0 for those with the least value or not grazed by animals and -1 for poisonous species.
Values and notations of grassland management categories were used following Tasi (2007). Groups 1 (Poaceae species) and 2 (Fabaceae species) contain plants that are the most important for grassland management. Species of groups 3 (other Poaceae, Carex and monocotyledonous species neutral for grassland management) and 4 (other dicotyledonous species) do not influence grassland management below a total cover of 20-30% while species belonging to groups 5 (poisonous plants) and 6 (stingy plants) are harmful. Species carrying medicinal effect were recorded separately as well.
We found the following groups in our samples: Poaceae species important for grassland management (Festuca species, which occurred in the highest amounts, were separated), other Poaceae, Carex and monocotyledonous species (Carex liparicarpos was dominant in this group), dicotyledonous species, Fabaceae species and litter. On the whole, biomass production is appropriate only for grazing, it was the five times lower than it needed for a hay meadow (Tasi 2010). Mean Klapp's forage value was about 3 thanks to the high amount of Festuca species. Differences between Festuca vaginata and F. pseudovaginata grasslands were decreased in intensively grazed pastures. In Tahitótfalu plots, F. pseudovina, which tolerates disturbance better, became the dominant species.
Despite of the low amount of biomass, composition is approprite because of the domince of grass species (50-70%) and the occurance of legumes (2-4%). Based on our results these grasslands can be utilized sustainably with moderate sheep grazing.

Talk Macroecological vegetation science: large grain patterns and processes of plant diversity

Global distribution of nitrogen-fixing plants

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In many terrestrial ecosystems, symbiotic interactions between plants and nitrogen-fixing bacteria have an important role in dealing with nitrogen (N) limitation. In addition, plants hosting symbiotic N-fixing microbes (hereafter N-fixers) are often major ecosystem drivers, enriching soil with N and shaping other biotic interactions above- and belowground. However, the current empirical information about the large-scale distribution of N-fixing plant species and the factors influencing their distribution patterns is fragmentary. Most of the published case studies concern trees or woody species in specific regions. With the growing availability of global plant trait databases and plant species distribution data, we are able to address the global distribution of

N-fixing plant species at large spatial grains. We estimated the extrapolated Shannon diversity index and relative richness of N-fixing vascular plant species for ~7800 km ^{2} equal-area grid cells (spatial scale resembling 1 degree x 1 degree latitude x longitude grid cells) using the recently published NodDB database about root-symbiotic N-fixing plant genera and the GBIF database for vascular plant distribution. In addition to the global distribution of all N-fixers, we explored separately the ratio of N-fixers associated with *Rhizobia*, *Frankia* or *Nostocaceae*. We also used information about environmental (altitude, climate and soil) and biogeographical (biome and realm) conditions in linear models to explain N-fixer distribution. While both N-fixer diversity and relative richness showed a unimodal relationship with absolute latitude, the global distribution of these variables varied owing to different responses to environmental and biogeographical factors. Diversity of N-fixers was highest in warm and wet regions with low soil pH, but the relative richness was highest in warm and dry regions with high soil pH. When environmental effects were taken into account, N-fixer diversity was highest in dry biomes and Australasia, whereas the relative richness of N-fixers was highest in tropical and temperate grasslands and in Eurasia (Indomalaya and Palearctic realms). The importance of different types of N-fixers changed geographically - plants associated with *Nostocaceae* were better represented near the equator, the relative richness of *Rhizobia*-associated plants was highest at the edge of the tropics (absolute latitude ~20 degrees), and *Frankia* was more prevalent in higher latitudes (especially in boreal forests). Our large-grain species diversity results show that the distribution of N-fixing plant species is not globally uniform but exhibits regional hotspots and coldspots. It is important that this patchy distribution is accounted for when predicting vegetation dynamics or estimating biogeochemical cycles in the changing world.

This research was done in co-authorship with the EcolChange Centre of Excellence.

Talk Using plant traits for the recovery of ecosystem functions and services: Trait-based ecosystem engineering?

Post-fire resprouting in New Zealand woody vegetation: implications for restoration

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Resprouting is an important trait that allows plants to persist after fire events, and is considered a key functional trait in woody plants. While resprouting is well-documented in fire-prone plant communities, information is scarce on resprouting in non-fire prone ecosystems, such as New Zealand (NZ) forests. The objective of this study is to investigate the post-fire resprouting trait in a NZ regenerating forest by first identifying the species resprout capability, then, understanding the influence of species' abundance on the resprouting rates within the local plant community. Considering that fire frequency is likely to increase in NZ as a consequence of climate change, this investigation is of strategic importance in planning future restoration actions.

This study was undertaken on the Port Hills, Christchurch. The region was affected by a 1700 ha wildfire in 2017, and the burnt woody vegetation was sampled 10 months afterwards using ten 10 m x 10 m plots. All the plants >5 cm diameter were identified, and their resprouts counted and classified according to whether their position was basal or epicormic. The species were classified as strong- (≥ 70% individuals resprouting), intermediate- (30-70%) and non-resprouters (≤ 30%). The influence of species composition and abundance on the resprouting rates of the plots was analysed using non-metric multidimensional scaling (NMDS) and PERMANOVA.

A total of 453 individuals were assessed, of which 38% resprouted. From the total of 24 species identified, 20 were native and 4 exotic. The 13 most common native species (N ≥ 9) represented 78% of the sample, and were classified as strong resprouters (2 species), intermediate (4) and non-resprouters (7). Most of the native species sampled appeared incapable of resprouting after the fire, which can be explained by their evolution in an environment with a naturally low fire frequency.
The resprouting rate in the plots varied from 7% to 74%. Species composition and abundance were important predictors of resprouting patterns among plots, with similar communities resulting in similar resprouting responses (stress = 0.09, $p<0.01$, $R^2=0.58$). Among the plots with greater resprouting rates, *Melicytus ramiflorus* was the most abundant species. This species has low flammability and, when not severely burned, it resprouted abundantly including with both basal and epicormic resprouts. In contrast, the most abundant species in the plots with lower resprouting rates was *Kunzea robusta*. This pioneer and high-flammable species was incapable of resprouting after the fire.

In summary, by planting high proportions of the strong and intermediate resprouters identified in this study, it is possible to engineer more fire resilient restoration plantings. The incorporation of the resprout trait in restoration plans is likely to be relevant not just in New Zealand, but also in other non-fire prone regions that face an increase in fire frequency as a consequence of climate change.

Poster Using plant traits for the recovery of ecosystem functions and services: Trait-based ecosystem engineering?

Resprouting after fire: a functional response trait for a tropical montane rainforest

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Frequency and intensity of fires have increased especially in tropical forests in the last decades. Mechanistically linking changes in species composition to changes in community performance in response to fire will help conservation and restoration efforts. Vegetative resprouting, a functional trait for persistence after fire, indicates recovery and persistence after a fire. We aimed to test the importance of vegetation sprouting as a functional trait for tropical rainforest after fire, by examining the ability of forest species to resprout in burned and unburned areas in montane Atlantic rainforest (Serra do Valentim, Iúna, Espírito Santo, Brazil), originally burned in 2014. We counted and classified (root, base and stem sprout) all individuals with dead aerial parts in two reference ecosystems and a burnt area (10 plots x 3 areas, each plot 5 m x 10 m). We selected the species representing 80% of the community dominance and measured their functional traits related to persistence, establishment and dispersal. The PCoA analyses with a community weighed means (CWM) matrix explained 82% of the variation in species trait composition. We found that resprouting traits, as basal sprout and root sprout, are more correlated with plants from burned areas. Specifically, CWM of resprouting traits were more correlated among trees, shrubs and understory species in burned areas compared to unburned. On the other hand, dispersal traits and stem sprout, rather than basal and root sprout, are more correlated with unburned areas.

Resprouting is an important trait contributing to the resilience of montane rainforests after fire being strategic for restoration of community dynamics.

Poster Using plant traits for the recovery of ecosystem functions and services: Trait-based ecosystem engineering?

Linking plant traits to multiple soil functions in semi-arid ecosystems

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Keywords: Caatinga, evidence-based restoration, mass-ratio hypothesis, multifunctionality, trait-based approach.

Considering the role of plant species for ecosystem functioning is particularly relevant for restoration programs conducted in semi-arid areas, where land-use intensification combined with critical droughts have resulted in widespread desertification. Here, we evaluate the importance of 15 species of native trees for restoring degraded areas in the Brazilian semi-arid region on the basis of the suitability of their functional traits to ecosystem multifunctionality. To do so, we performed a greenhouse experiment to estimate the importance of above- and below-ground traits in modulating soil and water quality. Above-ground traits yielded stronger effects on soil and water quality than below-ground traits. Above-ground biomass held the strongest positive effect on ecosystem multifunctionality, being the most beneficial attribute for the soil functions assessed. Thus, plants holding high biomass production should be preferentially selected as candidates for restoration in arid and semi-arid regions.

Some approaches into the understanding of the history of *Megasporaceae* (lichenized Ascomycota) in the Quaternary

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The establishment of a history of dispersal routes of particular lichen families in the past is currently hardly possible due to deficiency of data on fossils, subfossils, and propagules in ice and peat. Using phylogenetic relationships between taxa, understanding of their plesiomorphic and apomorphic characters combined with modern distribution of species it can be feasible to establish the origin of families and their migrations.

Species of the lichen family *Megasporaceae* are common representatives of saxicolous and terricolous communities in mountainous and arid regions. In the Northern Hemisphere, the distribution of *Megasporaceae* is restricted to the Holarctic region. The family encompasses according to different approaches from 200 to 400 taxa in 7 to 11 genera.

Megasporaceae are a member of the order *Pertusariales* and a closest relative to *Ochrolechiaceae* (genera *Lepra*, *Ochrolechia*, and *Varicellaria*). The characters shared by these taxa and some *Megasporaceae* may be considered as plesiomorphic and the presence of them in both *Ochrolechiaceae* and *Megasporaceae* is a symplesiomorphy. In our view, these characters are large spores and to some extent the presence of some secondary metabolites such as norstictic and stictic acids as well as aliphatic acids. Smaller spores in *Aspicilia*, *Lobothallia*, and *Sagedia* along with a lack of xanthones and lecanoric acid in *Megasporaceae* are apomorphies which appear in this family later. According to this assumption, the genera which share the plesiomorphies with *Ochrolechiaceae* are *Megaspora* and *Circinaria*.

These two genera are widespread in the Holarctic, however, the most species-rich territories are hot-arid and cold-arid regions of Eurasia and North America. We suppose that the origin of *Megasporaceae* can be connected with the territories alike stretching from the Mediterranean, including the Caspian region and continuing to Altai. According to estimations of evolutionary rates in other genera, this process could have started in the early Miocene. The following evolution of the family might correlate with its migration northwards and eastwards primarily by taxa which were adapted to cold conditions with subsequent formation of new species.

Quaternary glaciations after their receding left a vast territory suitable for colonization by saxicolous species of *Megasporaceae*. This brought about an appearance of some species currently known from the Northern Europe and Novaya Zemlya only, which can be considered as the 'youngest' species of the group. The high rate of endemism in *Megasporaceae* is known for Korea and Japan, where the representatives populate primarily elevated localities.

The study was supported by RFBR (projects 18-04-00414 and 19-54-50010).

Poster Using plant traits for the recovery of ecosystem functions and services: Trait-based ecosystem engineering?

Traits in root morphology and anatomy in some *Caryophyllaceae* in conditions of different levels of moisture

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Due to the extension of arid areas there is an urgent need to figure out mechanisms of adaptation of plants to moisture deficiency. The adaptation of plants to the lack of moisture is achieved by a complex of characters both in aboveground and underground parts. The purpose of this work is to study the structural parameters of root systems and absorbing roots of species of *Caryophyllaceae* in habitats with moisture deficiency.

We found that annual species, *Spergula arvensis* and *Arenaria serpyllifolia*, are adapted to absorb water from surface soil horizons, which is indicated by features of an intensive root system: small root index, shallow rooting depth, massive root branching; they absorb the moisture coming from the rains and dew. However, water use strategies are different for these two species. Roots of *S. arvensis* are thick, with a massive stele and cortex with large cells and a high specific root length, which performs a water-saving function, belonging to the succulent type, as well as the leaves. *A. serpyllifolia* has leaves of a xeromesophytic type and the thinnest absorbing roots with small close-packed cells of the cortex parenchyma and long root hairs, which efficiently absorb moisture from the upper soil horizons. The small diameter of the root and long root hairs allow them to increase the absorbing surface, as well as the radial conductivity and the ability to penetrate the dense drying volumes of the soil.

The root system of perennial species have well-developed primary roots and abundant horizontal well branched lateral roots, which make it possible to collect moisture from the upper and deep soil horizons. *Silene baschkirorum* and *Dianthus acicularis* differ in the characteristics of the absorbing roots. *D. acicularis* has well branched lateral roots, relatively long root hairs and the presence of mycorrhiza, which allows it to grow on shallow rocky soils, whereas *S. baschkirorum* has deep roots. The thin roots of *G. altissima* differentiate high specific root length, which is characteristic of fast-growing roots, with many root branching orders, which allows the plant to actively explore the soil in search of moisture. The main strategy of *Dianthus versicolor* was to increase the absorbing surface due to the length of the root hairs.

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Impact of edaphic factors on structure and species composition in plant communities on rocky substrates in the Urals, Russia

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Edaphic factors have a strong influence on the species composition of plant communities and determine the vegetation patterns and distribution of species in mountainous regions. The complexity of the edaphic factors is caused by a set of interacting parameters of soils and rocks and, in turn, determines the high floristic diversity and variability of plant communities.

We attempted to investigate how edaphic and topographic factors influence plant diversity and which of them have the greatest influence on the composition of plant communities. In the territory of the South Urals, we conducted extensive studies of plant communities on 100 cm^2 plots on various types of rocky outcrops such as limestone, serpentinite, basalt, dunite, and granite. The outcrops had southern and close to southern expositions. The vegetation was represented by petrophytic-steppe communities. On each plot the diversity of lichens, mosses and vascular plants was recorded and the species abundance was defined using the seven-degree Braun-Blanquet cover-abundance scale. For each plot environmental characteristics were determined, in particular various edaphic and topographic parameters were evaluated in the field (rock type, soil depth, elevation, slope inclination), or measured in the laboratory (pH, rockiness of soil, type of soil).

Canonical correspondence analysis (CCA) was used for estimation of the influence of environmental factors on species composition and species richness in the studied plots. Species composition and the cover of lichens were influenced by the edaphic factors, whereas higher plants and mosses did not show such a relationship. Vascular plants did not reveal strong confinement to a particular rock type. This may be caused by high values of precipitation and a washing regime of the habitats.

The influence of rock type is only pronounced under conditions of high or low pH values, which cause a formation of unique species communities on a level of associations and subassociations, which are endemic to the region. The depth of soil is an important parameter that affects species cover, and, depending on rock type, defines the proportion of lichens, mosses and vascular plants in the plots. The species composition rather depends on slope inclination and soil depth than on the type of rock.

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Temporal patterns of floodplain grassland succession - Ecological restoration in a dyke relocation area along the Elbe River, Germany

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Riverine vegetation is considered to be one of the most threatened ecosystems in Europe. In the past, many human-induced alterations to rivers (like regulation, flood protection or settlement) have profoundly disrupted connectivity between rivers and their floodplains. Thus, the largest rivers in central Europe, e.g. the Danube, the Rhine and the Elbe, have lost up to 90% of their natural floodplain area, principally as a result of dykes. The remaining inactive floodplain has been transformed into intensively used pastures and arable land. Floodplain forests almost completely disappeared. Only recently, nature conservation requirements but also the need for water retention areas for flood protection resulted in the implementation of large-scale restoration projects, like dyke relocations, to increase the amount of active floodplains together with the corresponding ecosystems. However, long-term studies regarding both assessment of the success of such measures and their effects on flora, fauna and vegetation and detailed analyses of the controlling factors are still scarce.

In 2009, an area of 420 ha of former floodplain on the Middle Elbe River near the city of Lenzen / Germany was reconnected to the river dynamics and thus hydrologically rehabilitated by the construction of a 6.1 km long new dyke, up to 1.3 km inland from the river, while the old dyke was opened by slotting. This created a new retention area with a diverse floodplain, including mainly alluvial grasslands and reeds but also some rests of floodplain forests, half-open pasture landscapes, flood channels, temporary lakes and other typical habitats of lowland floodplains. By the cutting of the old dyke, the vegetation inside the dyke relocation area became fallow and was left for natural succession. With the purpose of monitoring and documenting the vegetation changes due to the restored hydrological conditions, since 2011, a total of 216 vegetation relevés were conducted once a year, exclusively at permanent plots of open grassland sites within the active floodplain and by using the Braun-Blanquet method. For comparison, the sampling took place both within the dyke relocation area and the neighbouring forelands that were never separated from the river in the past. In addition, several environmental variables (regarding hydrology, soil, climate or disturbance) were recorded or derived for the entire period.

Using temporal diversity indices and NMDS ordination, temporal patterns of vegetation change were analysed and visualized. The influence of environmental parameters was estimated.

Talk Using plant traits for the recovery of ecosystem functions and services: Trait-based ecosystem engineering?

To trait or not to trait?

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Using plant functional traits in nature conservation and restoration or more generally in decision- and policy-making requires that we understand their links with ecosystem properties and processes. These links are currently approached by the framework of functional ecology, which may be called "the functional trait paradigm". This framework operates with community-aggregated functional trait values, namely the community-weighted mean and functional diversity. It is a universal and elegant theory which allows vegetation patterns to be related with ecosystem properties and functions.

The functional trait paradigm relies on the assumptions that i. trait function is universal, i.e. indicates species reaction to environment or its contribution to ecosystem process in a predictive manner and this is independent of other trait or community context ii. The contribution of species to ecosystem processes is proportional to their abundance. Such assumptions have not really been subjected to a critical evaluation. Here, I present a series of ideas and empirical evidence to shed light on the issue. Two principal examples are presented - one for response and one for effect traits.

Evergreenness in woody species is a functional response trait with a straightforward effect on plant resource acquisition and growth strategy. Despite this, evergreen species do occur in very contrasting environments like the Mediterranean scrub and subarctic tundra. Conversely, evergreen and deciduous species do coexist in many communities. Evergreenness is also related with the evolutionary history and the macro-evolutionary patterns in vascular plants.

A case study relating plant functional traits and insect herbivory in a species-rich meadow represents an example of the link between an ecosystem process and effect traits. Species-specific herbivory was strongly density dependent there, which means that trait values of a given species may have different effects when the species is common or rare. Herbivory showed a pronounced phylogenetic pattern, which was furthermore interactive with trait effects. As a result, a trait value affected herbivory differently in grasses and forbs. Finally, the herbivory pattern was also affected by presence of a single keystone species.

These findings indicate violations of the functional trait paradigm assumptions. Trait functions seem not to be universal but rather context dependent. This context dependency includes trait-trait interactive effects, community effects and inconsistent relations with the environment in different parts of environmental gradients. Further issues may be related with presence of keystone species or unique trait syndromes. The functional trait paradigm should thus be reconsidered quite thoroughly before its introduction to nature conservation. Rather, good naturalist experience with species and local ecological processes seems absolutely crucial for appropriate decisions in ecological applications.

Global patterns of the alpine biome

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Alpine areas have a global distribution, yet their comprehensive characterization is currently lacking. This knowledge gap arises from the absence of a common definition of alpine vegetation, but also from the lack of widely distributed empirical data. Here, we assess the distribution, bioclimatic and productivity patterns of high-mountain areas above the climatic treeline, which is the only universally measurable boundary of the alpine life zone. We analyzed freely available, high-resolution data using the Google Earth Engine computing platform for modeling treeline elevation in global mountain ranges outside the Arctic. Our definition of alpine fits with previously observed latitudinal and altitudinal patterns providing the first characterization of the global extent of alpine areas based on forestry and climatic data. We found that alpine areas across the globe show high climatic convergence in Whittaker's representation of biomes and strong separation from warmer environments regardless of latitude. A multivariate analysis highlighted that bioclimatic variability between alpine areas is relatively independent of geographic patterns, with major climatic groups showing similar patterns of primary productivity, estimated through the Normalized Difference Vegetation Index. Our findings support the existence of a unique, climatically packed, global alpine biome, despite regional differences in species composition.

Talk Plant phenology and plant traits

Leaf phenology patterns of sea cliff plants in a humid subtropical climate area of Japan

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Due to strong wind pressure, salt spray, and other environmental stress, plant communities established on sea cliffs differ from inland vegetation. The coastal area in Japan's humid subtropical climate (Cfa) zone is exposed to excessive temperature, dryness, and strong disturbance by typhoons during summer and early autumn. Also, the winter temperature is sufficient for the growth of evergreen and wintergreen plants. Thus, the leaf phenology of the plants which grow on sea cliffs is considered to adapt to such environmental conditions. This study was carried out to clarify the leaf phenology characters and their adaptive acceptations of sea cliff plants for coastal environmental conditions in the Cfa zone of Japan.

Seventyone survey plots were selected on the Miura Peninsula, Kanagawa Prefecture, eastern Japan. In each plot, leaf coverage % of occurring species and vegetation height were recorded in spring (late April to mid-May), summer (late July to mid-August), autumn (late September to mid-October), and winter (mid-February to early March). Additionally, functional trait data of each species were collected from previous studies.

In the study area, we identified four herbaceous vegetation types: a *Miscanthus condensatus* community, a *Zoysia japonica* community, a *Fimbristylis sieboldii* community, and a *Phragmites australis* community. The aboveground biomass of all communities was lowest in winter and highest in summer and autumn. In total 171 species were recorded in the plots, and the leaf phenology pattern of 1/3 of the species was divided broadly into three types according to the timing and duration of the peak of the leaf coverage. The spring-summer type included geophytes and many inland grassland species (e.g. *Lilium maculatum* and *Sanguisorba officinalis*). The summer type characteristically contained vine plants (e.g. *Lonicera japonica* and *Lespedeza cuneata* var. *serpens*). The summer-autumn type mainly consisted of *Poaceae* and *Cyperaceae* species (e.g. *Miscanthus condensatus* and *Zoysia japonica*) and all C4 plants within this type. The three phenology types are considered to have different photosynthetic strategies for the coastal habitat conditions. The spring-summer type has an advantage in photosynthesis in the few aboveground biomass seasons. The spring-summer type and the summer type would be suitable to avoid the harsh weather season. Many species of the summer-autumn type are considered to be adapted to grow under high temperature and dry conditions from their photosynthetic features. These results also suggest that differences in leaf phenology patterns among species lead to seasonal niche separation of the component species of sea cliff vegetation.

When old foes turn into new allies: Drainage canal banks concentrate grassland species in irreversibly desiccated lands

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Wet grasslands and marshes have been drained for cultivation worldwide for centuries, greatly contributing to the global biodiversity loss. In the lowlands of Hungary, nearly 5,000 kilometres of canals were constructed, contributing to the desiccation of the region. There have recently been steps toward removing some canals, but canals are only one of the several reasons of aridification (e.g. afforestation, climate change and communal water use). Thus, it is unlikely that the removal of the entire canal network could sufficiently restore original hydrological conditions, rendering desiccation irreversible in the region. At the same time, canal banks provide secondary habitats for a variety of plants; therefore, in this profoundly degraded region, notable conservation value may be assigned to canals. In this study we aimed to prioritize among different canal types regarding their carrying capacity of the indigenous grassland flora. We selected sixty 200 m-long canal sections differing in the embedding landscape matrix (cropland or grassland), substrate type (fen, sandy or saline) and size (small or large). In each canal section we recorded species richness in eight 1-m^2 plots for alpha-diversity, compiled full species lists for gamma-diversity and inventoried invasive species. We also surveyed thirty 200-m-long reference grassland transects parallel to grassland canals. Only non-ruderal species were considered in diversity analyses to avoid pseudo-diversity. We found that the alpha-diversity of canals embedded in grassland matrix was higher than in the surrounding reference grasslands, irrespective of substrate type or size class. In cropland matrix, all canals had lower alpha-diversity than references and small canals had lower scores than large canals. Gamma-diversity was higher in both grassland and cropland canals than in reference grasslands. In cropland matrix, saline canals had the highest species concentrating capacity among the three substrate types, and large canals outperformed small ones. Invasive species were more abundant in cropland canals than in grassland canals. Small canals had a lower prevalence of invasive infestation than large ones and canals on saline substrate were scarcer in invasive species than on other substrates. We conclude that all canals of the region increase landscape-level botanical value, although plant populations are smaller and more fragmented in cropland matrix. Complete removal of canals, especially on saline substrate, should be avoided; only their draining capacity should be minimized by densely spaced floodgates and partial fillings. Boosting population sizes of grassland species and removing invasive species should be promoted in cropland canals to make them more complete green corridors.

Talk Using plant traits for the recovery of ecosystem functions and services: Trait-based ecosystem engineering?

Both trait-neutrality and filtering effects drive early grassland succession

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Neutral theory of species assembly means that species assembly is driven by stochastic dispersal processes and fluctuations in established populations. An alternative explanation suggests that species assembly is strongly influenced by functional trait filtering governed by abiotic and biotic filtering selecting species from the local species pool. Changes in species composition are frequently studied in secondary succession, but functional analyses focusing on the temporal changes of plant trait composition and functional diversity are rather scarce. We analyzed vegetation changes in the first 12 years of succession after heavy goose grazing on acidic sand. With trait-based analyses using permanent plots we addressed the following hypotheses: (i) High fluctuations in the trait values are typical in the first years; later a temporally divergent change in the trait patterns of sites with different vertical position becomes characteristic. (ii) In the functional diversity of regenerative and vegetative traits we expected different temporal patterns. Altogether 15 functional plant traits were considered in the analyses: seven traits related to growth, vegetative spread and competitive ability (leaf area, leaf dry weight, leaf dry matter content, specific leaf area, plant height, life form and clonal spreading ability) and eight traits related to generative reproduction, spatial dispersal and persistence (flowering start, flowering period, the rate of wind pollination, insect pollination and self-pollination, seed weight, terminal velocity and seed bank type). We calculated community-weighted means (CWMs) and single trait variance for each trait, and multi-trait functional richness, functional evenness, and functional divergence using all traits except pollination. We also calculated the multi-trait indices separately for the vegetative and regenerative traits. We found that in the first few years most traits displayed high fluctuations; but we found a marked increase in the CWMs of clonal spreading, life span, and leaf dry matter contents during the succession. In parallel, we found a trend of decrease in the CWMs of plant height and SLA. While there were distinct patterns detected in the functional richness of traits, functional divergence and evenness displayed no clear distinctive patterns. We can conclude that both trait neutrality and filtering effects can be tracked in the vegetation changes during the first period of secondary grassland succession. High fluctuations in some trait values, however, were typical during the whole study period, which underlines that the effects of stochastic processes were especially important in later stages of vegetation development as well.

Forest biodiversity estimated from optical and LiDAR data: testing the Spectral Variation Hypothesis and the Height Variation Hypothesis through the Rao's Q index

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Forests cover about 30 percent of the earth surface, they are among the most biodiverse terrestrial ecosystems and they are at the base of many ecological processes and services. The loss of forest biodiversity makes in risk the benefits that the humans derived from them. The assessment of biodiversity is therefore an important and essential goal to achieve, that, however, can be difficult, time consuming and expensive if estimated through field data. Earth observation can be a unique source for consistent and standardized data to support these mapping efforts.

One of the methods to estimate species diversity from optical remote sensing data is applying the Spectral Variation Hypothesis (SVH), which states that, the higher the spectral variation of an image, the higher the environmental heterogeneity and the species diversity of that area. The SVH has been tested using different indices and measures; recently in literature, the Rao's Q index, applied to remote sensing data has been tested as a new and innovative spectral variation measure.

In the first part of this this study, we tested the SVH, evaluating the performance of the Rao's Q, comparing it with another index, the Coefficient of Variation (used as a benchmark). We validate them against values of Shannon's H (used as species diversity index) derived from in-situ collected data. Twenty forest plots (1 ha each), mainly covered by conifer, located in South Tyrol (North of Italy) have been used for this purpose. The SVH has been tested using an NDVI data-set derived from Sentinel-2 and Landsat 8 for the year 2016 and 2017. This has been done to test the effect of the spatial grain of different sensors and to understand the seasonality of the SVH.

The second part of this research is focused on the use of the LiDAR data to understand the relation between the height variation of the forest trees and their species diversity. A new concept called Height Variation Hypothesis (HVH) has been devised and developed, stating that, the higher the variation of the height of the trees (Canopy Height Model -CHM-) derived from LiDAR data is, the more complex is the overall structure of the forest and the higher is the species diversity of that area. In this case, the concept of HVH has been tested with LiDAR data at different CHM resolutions, through the Rao's Q index and correlated with data of tree species diversity (through Shannon's H) collected in the mentioned 20 forest plots and in other 100 plots in a temperate forest in Traunstein (S of Germany).

The results showed that the SVH is season- and sensor-dependent. For both years and satellites, the relation between Rao's Q and field data reached the highest R^2 for the Sentinel-2 satellite, between June and July decreasing towards winter and spring similarly to the NDVI time-series.
The HVH showed also good results in both the considered forests: the correlation with field data reached excellent values of R^2, especially when the CHM resolution was of 2.5 m.

Talk Using plant traits for the recovery of ecosystem functions and services: Trait-based ecosystem engineering?

Trait-based analyses support biodiversity conservation: importance of grassland type and grazing intensity in grassland biodiversity in four grassland types

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One of the main drivers of biodiversity loss in grasslands is the spread of high intensity grazing systems across the European continent. Consequently, the selection of the appropriate grazing intensity for sustainable grassland conservation and grazing management is of high importance. While the selection of livestock type can mask the effects of grazing intensity, grassland type is also a crucial factor which, sadly, is rarely analysed alongside grazing intensity. Our aim was to analyse vegetation patterns in four widespread grassland types (dry loess steppes, dry alkali short-grass steppes, alkali wet and non-alkali wet grasslands) along an intensity gradient of beef cattle grazing (Hungarian grey cattle). We selected 73 sites of the four grassland types in Hungary, and we set three study hypotheses: 1) The effect of grazing intensity on species and functional diversity is strongly dependent on grassland type. 2) The magnitude of diet selectivity of grazers decreases with increasing grazing intensity. 3) Increasing grazing intensity increases evenness and functional evenness of the subjected grasslands. We analysed species richness, Shannon diversity and evenness scores and the changes of four quantitative leaf traits (LDW, LDMC, LA, and SLA). We calculated community-weighted means (CWM) for each trait, multi-trait functional richness, functional evenness, and divergence for all leaf traits. Almost all species and functional diversity metrics were significantly affected by the grassland type, except LDMC. The effect of interaction between grazing intensity and grassland type was also significant for almost all functional features, CWM of LA, and species richness and evenness scores. An increasing trend of SLA was detected in all grasslands and the change was also grassland type dependent. We found that, with increasing intensity, the selectivity of grazers is decreasing. The detected changes suggest that evenness was affected but functional evenness was not affected by grazing intensity. Functional evenness scores were more related to the grassland type than to changes in grazing intensity. Our results clearly suggest that the effects of grazing intensity are strongly grassland dependent, and loess grasslands are the most vulnerable among the studied grassland types. Their species richness and functional diversity rapidly decrease with increasing grazing intensity; thus, a very careful management and conservation planning is necessary in loess grasslands.

Talk Using plant traits for the recovery of ecosystem functions and services: Trait-based ecosystem engineering?

High resistance of grassland biodiversity to moderate native woody encroachment in loess steppe fragments

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Woody encroachment affects many open habitats from semi-deserts to wetlands and grasslands. Management of species-rich loess steppe grassland fragments in the Western-Palaearctic has declined in its capacity to provide viable livelihoods, leading to the abandonment of grasslands and subsequent woody encroachment. We aimed to analyse the effect of native woody encroachment on grassland plant biodiversity in loess steppe fragments by analysing the vegetation composition of grasslands subjected to different levels of encroachment. We studied both primary and secondary grasslands with the following research hypotheses: (i) the increase of woody cover decreases total diversity, and the cover and species richness of grassland species; (ii) both grassland continuity and woody cover affect grassland biodiversity in the studied grasslands. Altogether 54 loess grassland fragments (31 ancient and 23 recovered grasslands) were selected for the study. Percentage cover of trees, shrubs and herbaceous vegetation were recorded in 400 m^2-sized plots. Effects of woody encroachment and grassland continuity on diversity, total cover and richness, and richness and cover of grassland species were analysed. We found that woody encroachment decreased the total herb cover as well as the cover and species richness of grassland species, but none of the studied variable measures were affected by grassland continuity. Both species composition and richness displayed a high resistance to moderate woody encroachment; a significant change was detected only at high levels of increased woody cover. We can conclude that low to moderate woody encroachment cannot be simplistically regarded as degradation. These results may suggest that moderately encroached loess grasslands can be easily restored by the suppression of woody species, as their species pool still contains many grassland species targeted for restoration.

Poster Long-term studies in vegetation science

Succession of native woody species within an early-successional forest following the removal of domestic livestock grazing

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Removing degrading factors such as grazing animals is widely used for forest restoration especially in temperate regions where pastoral farming is extensive. However, the success of this approach for native woody species recovery in remnant woody vegetation is not always guaranteed because of the prevalence of competitive exclusion by dominant species in many early-successional communities. In this study, quantitative data on species composition and growth, mortality, and recruitment rates over 11 years in a regenerating kanuka (*Kunzea robusta*, *Myrtaceae*) stand are presented to understand the regeneration of native woody species in an early-successional vegetation that has established as a result of grazing exclusion. We found that succession of native woody species in the kanuka stand is characterised by lack of diversity in species composition, high mortality rates and low recruitment rates, and the strong dominance of a single species mahoe (*Melicytus ramiflorus*, *Violaceae*), which may represent a state of arrested or delayed succession. These results could be related to the unfavourable light condition or high competition for light under the dense kanuka canopy. While there was a slight compositional change in canopy tree species abundance, this was mainly due to gains in mahoe abundance in the overstorey suggesting the possible transition in dominance from kanuka to mahoe. This transition is highly likely given the dominance of mahoe in the understorey and the height growth of this species over time was about twice higher than any other regenerating woody species in the area. The dominance of kanuka and mahoe is likely to last for many years unless a major disturbance occurs, or canopy intervention is undertaken to control the density of these species and introduce new species.

Talk Vegetation patterns and processes

Response of understorey native woody regeneration to artificial canopy gaps in an early-successional angiosperm canopy

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Gap creation may reduce the intensity of competition and provide opportunities for less tolerant species to persist or coexist with more tolerant or predominant counterparts. This study examined the potential of artificial gaps to facilitate the natural regeneration and establishment of woody species in dense regenerating stands of kanuka (*Kunzea robusta*, *Myrtaceae*) that have developed following the removal of degrading factors, especially grazing. Artificial gaps were created through selective felling of kanuka canopy trees and the species composition, density, growth, and survival of regenerating native woody species under the canopy gaps and intact kanuka canopy were monitored for 28 months. Gap creation resulted in a significant increase in the number of species and density of woody regeneration including both shade-tolerant and intolerant native woody species.

There was no significant effect detected with respect to the interaction of time and gap creation on species recruitment. Survival and growth of woody regeneration were significantly greater in canopy gaps than beneath the intact canopy despite the higher proportions of ground vegetation and browsing incidence by ungulates in gap treatments. The tendency of woody seedlings to grow better in canopy gaps may have provided them the competitive ability and browsing tolerance to offset the effects of browsing. The duration of the study was too short to capture fully the potential of canopy intervention, but woody regeneration within the artificial gaps are likely to accelerate as the regeneration proceeds and the results presented here provide useful insight into the early stages of this process.

Talk Plant phenology and plant traits

Invertebrate decline affects plant species abundance and phenology

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Land-use and climate change lead to phenological changes in both plants and insects. Previous findings revealed that some plant species advance or prolong their flowering period, whereas other species do not respond. In some studies, it has even been shown that insects are more responsive to changes in temperature than plants. This, in combination with the massive decline of insect biomass within the last decades, might result in mismatches of plant-insect interactions, with consequent losses of ecosystem functions, such as flower availability. The aim of this study was to identify the potential links between invertebrate density, plant phenology, and resultant effects on ecosystem functions.

Using the 24 experimental units of the iDiv Ecotron, we assessed the effects of invertebrate decline on an artificial grassland community formed by 12 herbaceous species. More specifically, invertebrates from a meadow close to Halle, Germany, were caught using Malaise traps and sweep nets with different catching efficacies corresponding to two different densities: 100% (no invertebrate decline) and 25% (invertebrate decline of 75%). Invertebrates were transferred into eight units, respectively. Another eight units received no additional fauna and served as a control. Plant species abundance and flowering phenology were observed weekly over a period of 18 weeks.

Our results showed that invertebrate densities affected the abundance and phenology of plant species. We observed a distinct species abundance, with respect to the invertebrate treatment - especially a reduction of the dominant species when invertebrates were present. Additionally, we showed that the species shifted their flowering phenology as a response to the different invertebrate densities. The peak flowering was more dispersed in time when invertebrates were present.

We could demonstrate that, besides commonly studied abiotic drivers, there are also biotic components that drive phenological changes in plant communities. Strikingly, a 75% loss of invertebrates resulted in effects which were similar to a complete loss of invertebrates. This study clearly suggests that invertebrate decline may contribute to already observed mismatches between plants and animals, with potential corresponding negative consequences for ecosystem services like fodder provision and pollination success. This deterioration of ecosystem functions could enhance the loss of insects and plant biodiversity.

Mid- and late Holocene environmental changes inferred from multi-proxy-studies of lacustrine sediments from the Dayan Nuur region in the Altai Mountains, Mongolia

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The 'Altai Tavan Bogd' National Park, located between 2,000 m and 4,000 m a.s.l. in the north-western part of the Mongolian Altai, is a forest-steppe ecosystem in Central Asia which occurs under extreme continental and high-altitude conditions. The vegetation is very sensitive to environmental changes and impact by nomadic people. To reconstruct the dynamics of this forest-steppe ecosystem, multi-proxy analyses, including the analysis of pollen, spores, non-pollen palynomorphs, charcoal and diatoms, as well as XRF scanning of a lacustrine sediment core of a small and shallow lake located south of Dayan Nuur were performed. Five radiocarbon dates indicate a record spanning back to the last 4,375 years.

Between 4,310 and 1,040 cal BP, the vegetation was characterized by a mixture of alpine meadow and moist true steppe communities as well as forested areas with *Larix sibirica*, *Pinus sibirica* and *Picea obovata* stands. Starting around 2,350 cal BP, a substantially greater and/or denser forest occurrence can be inferred. A marked forest decline after 1,040 cal BP and the loss of *Pinus sibirica* and *Picea obovata* near the study area proceeded in accordance with a significantly higher abundance of large herbivores and a strong indication of nomadic people in the area as inferred from coprophilous fungi. One period of markedly increased fire activity is found from 640-550 cal BP. For the latest Holocene period, the records of non-pollen palynomorphs and diatoms suggest a rise of the lake water level. These contrasting trends of forest decline despite of higher water availability may reflect the considerable human impact of the nomadic population and their cattle on the ecosystem in the 'Altai Tavan Bogd' National Park and Central Asia in general.

Multiple anthropogenic stressors have altered northern forest understory communities over the last half century

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Boreal and temperate forests of the northern hemisphere create the biggest forested area globally. These forests are under growing anthropogenic pressure from forestry, nitrogen deposition and climate change, which may have substantial impact on their ecosystem functions and services. Swedish forests cover a wide climatic gradient, receive highly variable rates of nitrogen deposition, and have a long history of forest use. Unique nation-wide long-term data on understory vegetation from the National Forest Inventory make Sweden an ideal area to study how species composition and function of more pristine boreal forests might change under increased anthropogenic pressure, and which is the relative contribution of different drivers to these changes. We used these data to quantify changes in 13 vegetation types in Sweden between two periods, 1953-1962 and 2003-2012.

Our results show evidence of large-scale changes of the understory vegetation of Swedish forests over the last 50 years. A majority of the vegetation types changed significantly in areal extent over time, with a general decrease of types characterized by high nutrient conservatism and light demand, e.g. low specific leaf area, and an increase in types characterized by high nutrient acquisition and shade adaptation, e.g. high specific leaf area. Additionally, the mean cover of the functionally important, ericaceous dwarf-shrubs decreased dramatically. These effects were most pronounced in areas with the highest anthropogenic impact, suggesting a link to anthropogenic drivers such as nitrogen deposition and land-use changes. We ask, which are the relative contributions of these drivers? Are there interactions between large-scale and local drivers? Are edaphic conditions (e.g. pH) restricting the transition between vegetation types? We answer these questions by an integrative spatio-temporal modelling framework and link our results to ecosystem functioning and processes.

Functional characteristics of soil seed bank after 26 years of restoration management in wet grasslands

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Soil seed banks of stable, semi-natural grasslands act as insurance compartments for regeneration after severe disturbance events, like fire, drought or flooding. These regeneration trajectories are thus strongly influenced by the taxonomic and functional composition of the seed bank. However, little is known about how the grassland management regime filters not only the aboveground vegetation, but also the corresponding seed bank communities.

To investigate these effects, we used seed bank data from a long-term management experiment in wet meadows in Northwestern Germany: Treatments include mowing once (early and late), mowing twice and leaving fallow with removal of woody plants. To gain insights into the assembly processes and strategies of soil seed bank and aboveground vegetation, we calculated functional composition (CWMs) and diversity (Rao's Q) for selected plant functional traits.

Compared to the aboveground vegetation, seed bank communities displayed much smaller, more numerous and persistent seeds, a lower specific leaf area and harbored more commonly non-perennials. Differences in functional diversity were found in an array of traits. Seed bank was generally more diverse regarding clonal traits, while seed mass and seed longevity did not show differences. Management intensity strongly shaped the aboveground vegetation and consequently the seed bank composition.

Seed bank communities of wet meadows do not display fast growing characteristics compared to their aboveground vegetation, but are less adapted to mowing. Most remarkably, seed bank communities display some adaption towards trampling and grazing defense. Despite environmental filtering in the soil only occurring on a diaspore level, traits related to that life stage are not less diverse than adult plant traits.

Effects of fire, grazing and water availability on Mediterranean pseudo-steppe communities and their dominant species *Brachypodium retusum*

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Brachypodium retusum is the dominant species of highly diverse Mediterranean pseudo-steppe communities (Natura 2000 habitat 6220) endangered by abandonment of traditional grazing and/or agricultural intensification. Once the species disappeared by human interventions involving soil disturbance, spontaneous reestablishment is very low even if source populations are close. Plant community restoration remains incomplete if the dominant species of the reference system is lacking. In the present study, we are testing the major environmental factors that may influence reestablishment of the dominant species and the surrounding plant community. We hypothesize that fire and grazing reduce competition and favor *B. retusum* due to its high resprouting capacity but also typical annual species of the pseudo-steppe community increasing species richness. We further hypothesize that initial watering increases seedling recruitment although long-term watering favors competitive ruderal species. The experiments were started in 2016 using the "La Crau" nature reserve (South-Eastern France). Experiments were run on a former arable field and in the pristine pseudo-steppe. Fire largely reduced plant cover in the beginning. However, stands recovered quickly in the second season and *B. retusum* inflorescence production was even higher than in controls without fire.
Fire also increased community species richness and diversity. Although *B. retusum* is well adapted to drought, initial watering had a positive effect on seedling recruitment and survival, in particular in grazed plots. Grazing reduced performance of *B. retusum* seedlings but short-term grazing exclosure had only a weak influence on adult plants and community composition. In conclusion, prescribed burning may be used to maintain or restore pseudo-steppe communities, in particular at undergrazed or abandoned sites. Moderate initial watering improves the success of *B. retusum* reintroduction by sowing or planting.

Half a century of vegetation change in the forests of the White Carpathians, Czech Republic

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The White Carpathians Protected Landscape Area, located by the border of Czechia and Slovakia, is famous for its extremely rich meadows. Forests in this area deserved much less attention so far in spite of their rich management history and high diversity. In 2014-2016, we resampled 216 quasi-permanent plots first recorded in 1953-1964. Our aim was to describe the patterns in long-term vegetation change and to understand the underlying drivers. We found no overall change in species richness but species composition changed significantly. The lack of change in any of the Ellenberg indicator values (calculated as plot averages) suggests that there was no consistent shift in environmental conditions across the area. At the species level, we identified several winners and losers which clearly differed in their ecological requirements. Losers were mostly light-demanding and less competitive species and winners were nutrient demanding species, often considered ruderal species. Correlation of species richness of loser species and various environmental factors revealed that the highest number of losers was concentrated to types of formerly light forests with nutrient-poor soils, occurring at low to middle altitudes. We conclude that these forests were under more intensive human impact in the past which was abandoned in the past decades, while the forests of the higher altitudes have not undergone similar changes.

Nameless no more: bedrock meadows - natural biodiversity hotspots in the moist temperate forest zone of western North America

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Naturally open habitat types provide important ecosystem services, including provision of habitat for endangered plants and animals and maintenance of hydrological regimes. In the last decades much progress has been made to describe open habitat types and understand their biodiversity and ecological functions. However, there are still habitats that have never been named, inventoried or mapped and hence overlooked in research and in environmental decision making in conservation.

It is little known that the Inland Northwest of North America - a region globally renowned for its forests - is also home to natural meadows ("bedrock meadows") that occur interspersed in its mid-elevational zone. In contrast to their globally renowned forest counterpart, these meadows have never been studied, mapped and inventoried by scientists and hence do not exist in the public eye; their ecological functions have not been studied either. As a consequence, we have no knowledge about the conservation value of this habitat type and its importance for wildlife and pollinators. Their small size could make bedrock meadows disproportionately vulnerable to the pressures of land-use change, including resource exploitation, a warming climate and invasive species. We additionally lack an understanding what keeps this habitat open amid a forest matrix.

In our research we aim to increase our understanding of biodiversity in this overlooked habitat type by conducting a plot-based vegetation survey in the Salish and Cabinet Mountains in Montana and Idaho.

Our data show that this habitat type occurs on shallow and periodically seepy soils over dense bedrock (argillite) and is rich in annual plants (e.g. *Idahoa scapigera*, *Mimulus breweri*) and perennials with underground storage organs (*Claytonia lanceolata*, *Lomatium ambiguum*). Invasive non-native plants are rare, although we detected cheatgrass (*Bromus tectorum*), common St. John's-wort (*Hypericum perforatum*) and knapweed (*Centaurea stoebe*) in some plots. Future studies need to explore the importance of bedrock meadows for wildlife and the ecological processes that restrict tree growth in this open habitat type.

Patterns of functional rarity of mesophilic grassland species

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In terms of biodiversity and ecosystem functioning research, the importance of rare species has long been neglected. Yet, there is growing evidence that rare species can significantly affect ecosystem processes. This idea is taken up by the concept of functional rarity, which combines species rarity with functional traits, and thus defines species as functionally rare when they are a) rare and b) exhibit distinct trait attributes. Due to their distinct trait attributes these species are expected to strongly influence ecosystem processes. However, a generally accepted measure of functional rarity is still missing.

Here we propose a continuous and dimensionless measure of functional rarity (Rfun) that is based on different measures already existing in the literature. Rfun combines species trait dissimilarities with species rarity on a local and regional scale and eventually returns a single value for the functional rarity of a species. We exemplarily test its applicability on a set of mesophilic grassland species by combining vegetation data with functional trait data. The proposed measure provides a suitable tool to be applied in further studies to better understand how rare species affect ecosystem processes and can thus be conducive to maintain ecosystem functioning in the long run.

Talk Vegetation patterns and processes

Estimation of changes in soil pH and calcium content from 1960 till 2010

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Soil acidity and calcium content of the soil in nature have been affected by air pollution for over a century, first by sulphur deposition and later by nitrogen deposition. To assess the acidification process, nationwide information about soil pH and calcium content on the site level is called for. Field measurements may be used, however, they are not sufficiently available to map on a nationwide level. Instead we developed a soil pH and calcium content map based on vegetation data combined with actual field measurements.

Geo referenced vegetation plots were used to estimate average soil pH and calcium content per plot applying plant species indicator values for pH H_20 and calcium content. These indicator values are based on field measurements and not, as often, on expert knowledge. In addition to the estimates, soil measurements were used except for a small selection that were used for validation. By spatial interpolation between the estimated and measured values, with soil type, groundwater table and vegetation management type as ancillary explanatory variables, we estimated a soil pH and a calcium content map for 25 m * 25 m raster cells. We performed this procedure to create maps for the periods 1960-1969, 1980-1989 and 2000-2010. The maps were compared and differences were calculated for all nature areas in the Netherlands with a focus on the Veluwe in the middle of the Netherlands.

The Veluwe area is a dry sandy area mostly forested, but also with heathlands, free blown sand and more wet sites. The soil pH was always relatively low as were calcium contents. However, our maps show that on the Veluwe soil pH has dropped from the period 1960-1969 to 2000-2010 with on average more than half a pH unit, with many sites that dropped more than one pH unit. This is in line with the changes in calcium content that often dropped more than a factor of ten. On the Veluwe, since some years now, eggs of birds are suffering from calcium shortage as are the bones of the young birds resulting in ruptures. There are now also areas where no or almost no snails are found due to lack of calcium for their external shell. Our maps offer an explanation for these findings.

Poster Using plant traits for the recovery of ecosystem functions and services: Trait-based ecosystem engineering?

Effects of defoliation position on plant growth, leaf traits and carbohydrate allocation in two *Leguminosae* woody species

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Defoliation because of human disturbances, insects and grazing animal feeding is an important factor affecting plant growth and vegetation dynamics. Leguminose woody species recover quickly after leaf damage, which is an important reason for their colonization in the new areas. In this study, we selected *Robinia pseudoacacia* L. and *Amorpha fruticosa* L. to study the effects of different defoliation positions on individual plant growth, leaf traits and carbohydrate allocation. A greenhouse experiment in which the *A. fruticosa* and *R. pseudoacacia* seedlings were grown under three different defoliation treatments was conducted, i.e. removal of leaf areas from the upper fifty percent of the crown (DU), removal of leaf areas from the lower fifty percent of the crown (DL), and without leaf removal (Control). Seedlings were harvested after defoliation for one day, three days, fourteen days, thirty days, and sixty days, respectively. Plant physiological and growth traits including plant height, basal diameter, total biomass, total chlorophyll content, leaf thickness, specific leaf area, net photosynthetic rate, soluble sugar/starch ratio and nonstructural carbohydrates (NSC) content were determined in the study. Our results demonstrated that different defoliation positions had significant effects on leaf traits including gas exchange, but no significant effects on plant growth were found. Moreover, *R. pseudoacacia* adopted more obviously compensatory effects than did *A. fruticosa* after defoliation, including alteration in leaf traits, up-regulation of photosynthetic rates in remaining leaves and changing the carbohydrate allocation pattern to increase ratio of leaf NSC mass increment. In *A. fruticosa*, the seedlings didn't increase the photosynthetic capacity of the remaining leaves after defoliation, and the compensation mechanism is increasing the carbon allocation to the aboveground. According to our results, *R. pseudoacacia* is shown to be more resistant to defoliation damage than the sympatric species *A. fruticosa*. The two species have different carbohydrate management strategies, which may be related to their different ecological niche in the warm temperate zone. In conclusion, *A. fruticosa* and *R. pseudoacacia* have strong abilities to deal with leaf damage and can recover in a short time, but the *R. pseudoacacia* seedlings are more suitable for vegetation restoration than the *A. fruticosa* seedlings when considering the recovery ability after leaf damage.

Keywords: defoliation; nonstructural carbohydrate mass; plant growth; leaf traits; soluble sugar/starch ratio

Environmental and socio-economic effects on species-area relationships of sixteen plant and animal taxa

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The increase in species richness with area is one of the most ubiquitous patterns in ecology and is apparent across a broad range of taxa, biomes, and spatial scales. However, the rate of increase and the number of species per unit area, i.e. slope and intercept, of species-area relationships (SARs) vary between island and continental systems and among taxa. Identification of the factors that generate system- and taxon-specific differences in SARs is crucial to understand the mechanisms driving spatial patterns of diversity and can provide key insights into taxon-dependent sensitivity to habitat change. Yet, studies evaluating the impact of environment and socio-economy on global-scale SARs in a broad range of taxa and study systems are scarce.

Here we present a global analysis of the impact of environmental variation on SARs of 16 animal and plant taxa. Using 104 island and 164 continental datasets, we calculated island-only, continental-only, and combined SARs for each taxon to identify system- and taxon-specific variation in slope and intercept of non-linear power models. We quantified the effects of 14 variables representing variation in climate, soils, habitat heterogeneity, biogeographic history, isolation, and socio-economy on SAR residuals.

Within taxa, island SARs had higher slopes and lower intercepts than continental SARs. A strong negative effect of distance to the nearest continent on species richness in all higher plant and animal taxa further highlights the impact of isolation on SARs. Taxa differed in their SAR parameters and SARs of good-dispersing taxa had lower slopes and higher intercepts than those of poor-dispersing ones. Differences between island and continental SARs were more pronounced in poor-dispersing taxa, suggesting an interaction of isolation and dispersal. Environmental factors explained a large proportion of SAR residuals. Temperature and precipitation had the strongest positive, and soil pH and carbon-to-nitrogen ratio had the strongest negative effects. Gross domestic product per area (GDP) had the overall most important and positive effect on observed species richness in all taxa.

Variables often impacted SARs in a consistent direction across taxa. Yet, distinct ecological preferences resulted in deviations of individual taxa from general patterns.

In conclusion, climate and location impact SARs more strongly than previously acknowledged. Our data suggest that taxa differ strongly in their sensitivity to habitat loss and climatic change. The strong impact of GDP highlights that differences in financial investment into science can mask environmental effects on patterns of species richness and hamper the reliable documentation of SARs. Ecologists should be aware of sampling bias and taxon-specific variation in SARs and try to control for it by including socio-economic factors, carefully selecting taxonomic scale and considering the ecology of species when using SAR models to predict responses to habitat change.

Poster Vegetation patterns and processes

Fungal-mediated plant-soil-feedbacks affect secondary succession of tropical rainforests

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Secondary forests are increasingly prominent features of tropical landscapes, with their area now exceeding that of primary forests. The often slow recovery and unpredictability of species composition through succession limits the potential for restoration of ecosystem services. Improved understanding of the mechanisms that drive tropical forest dynamics after severe disturbance is urgently needed to promote the recovery of ecosystem functionality and inform restoration policies.

Plant-soil feedbacks (PSF), by which soil-borne fungi and their plant hosts reciprocally affect each other's presence and performance, have been shown to drive the generation and maintenance of tropical tree diversity. However, the impact of PSF on the rate and direction of species turnover during secondary succession remains unclear.

In a shade-house study in Panama we tested the interacting effects of fungi, light availability and successional soil age on seedling emergence and performance of ten woody plant species. The species differed in their life-history strategy and association with early-successional to old-growth-forest. They were sown in sterile (fungal growth suppressed by steam-sterilization plus fungicide) and live soils from four successional forest ages (2-yrs, 15-yrs, 25-yrs and 115-yrs after agricultural abandonment). Seedling emergence, growth and survival were monitored for three months under two different light levels (10% vs 40%).

Seedling emergence varied greatly with soil age and fungal suppression, indicating that seedling establishment is affected by the interaction of plant life-history strategy and the soil fungal community present at specific successional ages. Moreover, light conditions influenced seedling growth and development, suggesting that PSF and abiotic conditions together affect trajectories of secondary succession in neotropical rainforests.

In conclusion, plant-fungal interactions play a larger role in tree community dynamics than previously acknowledged, and may be key to a full understanding of species turnover during secondary succession of tropical rainforests.

Land cover drives large scale productivity-diversity relationships in Irish vascular plants

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The impact of productivity on species diversity is often studied at small spatial scales and without taking additional environmental factors into account. Focusing on small spatial scales removes important regional scale effects, such as the role of land cover heterogeneity. Here, we use a regional spatial scale (10 km square) to establish the relationship between productivity and vascular plant species richness across the island of Ireland that takes into account variation in land cover. We used generalised additive mixed effects models to relate species richness, estimated from biological records, to plant productivity, quantified by the satellite-derived enhanced vegetation index (EVI). The productivity-diversity relationship was fitted for three land cover types: pasture-dominated (i.e. improved agricultural grassland), heterogeneous and non-pasture-dominated landscapes. We find that species richness decreases with increasing productivity, especially at higher productivity levels. This decreasing relationship appears to be driven by pasture-dominated areas. Additionally, the relationship between both spatial and temporal heterogeneity in productivity, and species richness, varies with land cover. Our results suggest that the impact of pasture on species richness extends beyond field level. The effect of human modified landscapes, therefore, is important to consider when investigating classical ecological relationships, particularly at the wider landscape scale.

Evaluating the predictive power of ordination methods in ecological context

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When striving for the ordination methods best predicting independently measured site factors, the following questions arise: does the optimum choice depend on the kind of biological community analysed? Are there different ordination methods needed to address different site factors? Simultaneously I explore alternative similarity approaches of entire ordinations as well as the role of the scale used in measuring species performance. The combination of methods and data transformations result in 96 alternative solutions for anyone data set. These are compared by a graphical display, that is, an ordination of ordinations.

Goodness of fit of independently measured site factors is assessed by two alternative methods. The resulting 96 performance values serve as independent variables in trend surfaces overlaid to the ordination of ordinations. The results from two real-world data sets indicate that some ordination methods strongly vary with data transformation. Scores close to a binary scale perform best in almost all ordination methods. Methods that intrinsically constrain the range of species scores, such as principal components analysis based on correlation, correspondence analysis including its detrended version, nonmetric multidimensional scaling as well as principal coordinates analysis based on the Bray-Curtis distance always figure among the most successful methods irrespective of data used.

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Poster Vegetation patterns and processes

Species diversity and compositional variability of the EU habitat types 91H0 and 91I0 in Austria (Central Europe)

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Themophilous oak forests on base-rich soils are an important component of the Pannonian lowlands in Eastern Central Europe. However, the area covered by these forests is rather limited, and forest patches surrounded by cultural landscapes are often heavily influenced by forestry and other human activities. In the Habitats Directive of the European Union, these forests are included as priority habitats 91H0 ("Pannonian woods with *Quercus pubescens*") and 91I0 ("Euro-Siberian steppic woods with *Quercus* spp."). On behalf of the Austrian Environmental Agency, we conducted a survey of these two habitat types in 2018. We did 130 relevés according to a stratified random sampling design. We recorded all vascular plant species on 20 m x 20 m plots and estimated their cover according to a modified Braun-Blanquet scale. In total, 464 vascular plant species were recorded. Average species number per plot was 44 for habitat type 91H0 and 28 for habitat type 91I0. We present a detailed analysis of the alpha and beta diversity of the two types as well as a comparison with species numbers of previously published relevés of these forest communities from Austria. Moreover, we present a phytosociological classification of the relevés and discuss problems in the definition and delimitation of the two habitat types.

Talk Vegetation patterns and processes

Macroclimate mediates the distribution of plant functional types across topographic gradients: the case of New Zealand's divaricate plants

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The abundance of the divaricate growth form in New Zealand has been interpreted as either (a) the response of an isolated flora to cool, dry, Plio-Pleistocene climates; or (b) a defence against large browsing birds (moa) that were hunted to extinction shortly after human arrival during the last millennium. We used patterns of divaricate plant abundance across present-day landscapes to test a novel synthetic hypothesis: that the divaricate form (and other putative physical defences against browsers) are of most value to plants on fertile sites that attract herbivores, and where climatic constraints prevent plants from quickly growing out of the browse zone. This hypothesis predicts that divaricate species should be most abundant on terraces (fertile, frost-prone) in dry regions, especially towards the colder south of the country. To address our hypothesis, we extracted a dataset of 236 surveys comprising 11,222 relevé plots from the NZ National Vegetation Survey databank. We calculated the % of arborescent species with a divaricate growth form and the % cover of divaricates on each plot and fitted linear mixed-effect models predicting these response variables as functions of topographic position and climatic variables. Survey identity and lithological class were included as random effects. There was only partial support for our hypothesis. Overall, topographic position and climate variables explained much less variation than the random effects. As predicted, divaricates were scarce on warm wet sites, and were best represented on sites with short frost-free periods and/or water deficits. However, there was a strong 3-way interaction between frost-free period, water deficit and topographic position. Throughout most of the country divaricates were least prominent on ridges, as predicted. However, this pattern was dramatically inverted in the cold and dry climates of the eastern South Island, where divaricates accounted for a large proportion of both arborescent species and cover on ridges. Divaricates therefore made their largest contributions to arborescent species richness and cover on those sites likely to be subject to the most climatic stress. This equates to terraces throughout most of the country, where frosts are common only on this landform. However, in cold and dry regions where frosts occur frequently on all topographic positions, the high representation of divaricates on ridges may reflect reduction of broadleaved completion by drought. The contemporary distribution of the divaricate form across New Zealand landscapes is thus better accounted for by climatic stressors, than by the hypothesized interaction of climate and fertility-mediated browsing.

Poster Vegetation patterns and processes

Factors of the variation in vegetation invaded by *Reynoutria japonica* Houtt.

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Reynoutria japonica Houtt. (*Polygonaceae*) is a perennial geophyte from eastern Asia that invades riparian and fallow habitats in Europe and reduces diversity of native plant communities. It completely eliminates other plant species or reduces their number to a few; however, there is a group of species capable of growing and reproducing in dense patches of *R. japonica*. The aim of this study was to assess changes caused by *R. japonica* invasion in plant communities and to test factors affecting the composition and diversity of vegetation occurring in patches of *R. japonica*. The study was performed at 25 paired plots with the invader and native plants in western Malopolska and eastern Silesia (S Poland). Vegetation was characterized in terms of plant coverage, species richness and composition, and plant traits. Soil physicochemical properties were also measured.

R. japonica changed plant community structure through decreasing the number of native plant species, forbs, grasses, representatives of *Artemisietea vulgaris* and *Molinio-Arrhenatheretea* classes, species of ruderal-competitive (CR) and competitive (C) Grime's strategies, while increasing the number of alien species, plants of *Carpino-Fagetea* and *Galio-Urticenea* classes, vernal geophytes and species dispersed by ants and water. Within the *R. japonica* plots, organic C, P-PO4 concentration, C/N ratio, the thickness of organic soil horizon were main factors negatively affecting species richness and composition, whereas total Ca, K and Mg in soil had the most positive effect on these parameters. The species richness was affected by habitat properties to a much lesser extent than the species composition.

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Talk Long-term studies in vegetation science

Rare disturbances structure tree populations and drive diversity and biomass dynamics in old-growth temperate forests: insights from a case study of multi-decade permanent-plots

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I use long-term studies of permanent plots in two old-growth forests of northern Michigan, USA, to assess the consequences of rare disturbance events for tree population dynamics, community diversity, and biomass dynamics. Analyses are based on 8-10 remeasurements of ca. 150 plots (total area ~12 ha) over 57-84 years (remeasurement interval of 5 yr since 1989), in mesic northern hardwood and hardwood-hemlock stands. A major wind-disturbance event in 2002 allows close analysis of disturbance effects as a function of previous stand history and as a driver of subsequent change at decadal scales, allowing inferences about past disturbance events through comparison of observed dynamics. Results show that 'background' diffuse tree mortality assumed by conventional 'gap-phase' models is inadequate to explain dynamics at the scale of individual plots and local stands (100s of m^2 to 10s of ha); study forests do not exhibit implied 'quasi-equilibrium' at multi-decade time-scales. Analyses imply, rather, that, in intervals between major disturbance, most tree populations become increasingly dominated by very large stems, diversity declines, and canopy structure becomes more complex. While some studies suggest old-growth forests are long-term carbon sinks with positive net ecosystem productivity, this long-term perspective suggests that observed multi-decade increases in biomass are likely responses to earlier major disturbances, and likely to be maintained for only a few decades. Tree diversity and demographic patterns in tree populations also appear to echo effects of past disturbances, with disturbance signatures persisting for a century or more; the case study incorporates direct measurement of the 2002 event, equivalent to ca. 25 years of 'background' mortality, and allows inference of at least two less severe events over the previous 60-70 years.

Observed effects suggest that rarer, more severe events with return times of 1-2 centuries (still within the life-expectancy of dominant canopy trees) would leave larger, more long-lasting signatures on community and ecosystem properties. These findings have important implications regarding the potential effects of climate change; changes in the frequency and intensity of wind disturbance might have larger and more immediate consequence for community assembly and ecosystem function than effects on species distributions and ranges. Long-term, permanent-plot studies - particularly those exploiting 'heritage' data-sets with multi-decade baseline data - are critical for quantitative assessment and modeling in address of questions about long-term forest ecosystem dynamics.

Converging site conditions result in loss of floristic distinctiveness in temperate forest plant communities of NE Germany

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Resurveys of old vegetation relevés allow to detect changes in species diversity and composition in response to various global change drivers. However, single resurvey studies are mostly conducted at the local scale and are confined to a narrow set of plant communities, which compromises their potential to reveal effects of large-scale drivers and changes in compositional dissimilarity. We used 11 forest vegetation resurvey datasets from NE Germany (972 plots in total), which cover the entire range of forest plant communities in the study region. The time span between first and re-survey ranged between 17 and 64 years (median: 48 years). Our main hypothesis was that several environmental drivers (climate change, N deposition, changes in canopy density and soil moisture) caused a homogenization of site conditions, i.e. more extreme conditions and their corresponding habitat specialists were replaced by more mesic conditions and mesophilous, competitive or nitrophilous species.

We quantified change over time in both vegetation response and local environmental conditions as change rate expressed in sd-units per decade, except for the mean N deposition rate, which was calculated as cumulative N deposition between surveys divided by the time span in years.

The variance of site conditions decreased significantly between surveys with respect to soil conditions (mean Ellenberg F and R) and climate (Ellenberg quotient), whereas the range of canopy density did not change. Summer drought and canopy density increased independent of initial site conditions. Species numbers of most habitat specialist groups decreased over the study period, particularly on sites with initially favourable conditions for these specialists. These groups include xero- and thermophytic species on base-rich soils, light-demanding species of oligotrophic, acidic and dry sites, and species of nutrient-poor wet, acidic soils. In contrast, the number of mesophilous forest plants increased on initially non-mesic conditions, i.e. on very acidic or neutral sites, on very dry or wet sites, and on high-light sites. Nitrophilous species increased in general, but stronger on initially acidic and initially dry or wet sites. The floristic distinctiveness decreased in general, but stronger on initially more extreme sites. Vegetation changes were related to environmental changes, for instance a decreasing floristic distinctiveness was associated with increasing shade on base-rich sites and with decreasing shade on acidic sites. Moreover, under most site conditions, floristic distinctiveness decreased with increasing summer drought.

Our resurvey study demonstrates that taking a broad range of forest communities into account, including those on more extreme sites, provides a more complete and differentiated picture of vegetation responses to environmental change.

Talk Using plant traits for the recovery of ecosystem functions and services: Trait-based ecosystem engineering?

Biotic resistance to invasive alien plants: Using functional similarity as an approach to design resistant communities

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The invasion of alien species (IAS) contributes to ecosystem degradation and complicates efforts to restore degraded systems. This is leading to the question on whether we can prevent the successful establishment of IAS during restoration by designing resistant communities. One way of increasing the biotic resistance of native communities is to include species that hold similar resource acquisition strategies, therefore, intensifying the competition with arriving IAS. Studies testing this approach have often used plant functional traits as a proxy for ecological similarity. Yet, given that easily measurable traits might not accurately portray all aspects of resource acquisition, another method is to use phylogenetic distance between IAS and the native community to represent this similarity. Even if the goal of having resistant communities is reached, other factors such as propagule pressure and time of arrival can help IAS overcome the resistance leading to the successful invasion of restored communities.

Overall, we will present results from several greenhouse experiments investigating whether we can predict biotic resistance at early stages of restoration by using multiple traits and phylogenetic distance to depict competitive strength of native communities. For doing so, we designed specific communities based on native-invasive trait similarity using native grassland species and two common IAS in central Europe (*Ambrosia artemisiifolia* and *Solidago gigantea*). We also tested whether phylogenetic distance was a better predictor of resistance, and what role propagule pressure and priority might have as modulators of establishment success.

Our results showed partial support for similarity in functional traits, pointing to other factors to be responsible for the suppression of IAS, such as native species sowing density, the presence of particular fast-developing species and of few closely related species with dominant traits (i.e. *Achillea millefolium*). We also found propagule pressure and early arrival to increase the chances of establishment. The moderate support for effects of trait similarity could be a consequence of failing to include the most important traits for competitive suppression during early development. Based on our results, we will provide some recommendations for the design of grassland communities for restoration in central Europe.

Talk Macroecological vegetation science: large grain patterns and processes of plant diversity

Global patterns of woody plants height: combining analysis of forest plots data and species functional traits

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Woody plant height is a fundamental functional trait that varies among species and also differs between vegetation types. Species/vegetation-specific tree height, which is associated with interspecific competition, species coexistence and productivity, is thought to play a central role in potential mechanisms of species assembly and ecosystem functions. Nevertheless, global patterns of tree height have remained unknown; exploring the functional diversity of tree heights is limited to local-scale studies. In this view, we created a global-scale dataset of maximum tree height for 27,201 woody plant species across tropical, temperate and boreal forests. We firstly tested phylogenetic signals (clade-specific pattern) of maximum tree heights to better understand macroecological diversification of woody plants across biogeographical regions. Then, we collated species tree height with community assembly data including 11022 tree species observed in 843 forest plots worldwide, and mapped geographical patterns of tree height distribution and its functional diversity. Based on the concept of environmental filtering and evolutionary constrains on species assembly, we identified climatic/geographic factors that explained global patterns in tree heights and examined the association between community phylogenetic properties and functional diversity of tree heights across different biomes. Finally, we discuss how macroevolutionary processes of woody plants, which may reflect a diversification of ecological niche, have influenced global-scale tree height distribution.

Habitat preferences of relict *Carex* species in an isolated coppice forest in suburban Tokyo

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Carex is one of the species-richest genera of flowering plants including nearly 2000 species. They are found in various habitats from alpine tundra to sea shore, and constitute general components of forest, grassland, and wetland vegetation in the temperate climate region. Therefore, they are useful indicator of local species diversity.

In this study, we surveyed species richness of the genus *Carex* and habitat preferences of the major nine species in a small hill (*ca* 8 ha), located on the terrace land of suburban Tokyo. Present vegetation of the hill is deciduous oak coppice, however, old maps show that this place was once used as mown grassland. Though the coppice forest had not been regenerated for more than 50 years, recently some parts were cut for restoration of a *Hemerocallis dumortieri* v. *esculenta* population which was a symbolic plant of this hill. We surveyed the *Carex* flora of the hill and made phytosociological descriptions of 116 stands with the major nine *Carex* species in spring to early summer of 2018.

As the result of our survey, 22 *Carex* species were recorded in the study area. This accounts for 8% of all 269 *Carex* species in Japan. Two of them (*C. kujuzana* and *C. longerostrata* v. *tenuistachya*) were the first findings in Tokyo, and another one (*C. phacota*) was re-discovered after about 50 years. It is clarified that diverse *Carex* including vulnerable species were harbored even in the small fragment of coppice forest of the urbanized area. Especially, *C. kujuzana* and *C. longerostrata* v. *tenuistachya* were regarded as relic species, because they occurred disjunctively from their main distribution area which was dominated by grassland.

Vegetation stands were classified into 6 communities by TWINSPAN. The major nine *Carex* species had different preferences for communities. *C. kujuzana* and *C. longerostrata* v. *tenuistachya* occurred only in a particular community characterized by grassland species such as *Calamagrostis brachytricha*, *Eupatorium chinense*, and *Hemerocallis dumortieri* v. *esculenta*. On the other hand,
C. conica v. *conica* and *C. lanceolata* occurred in four or five different types of communities including the same community as the former two species. The latter two species coexisted also with forest species such as *Pertya scandens*, *Smilax china*, and *Atractilodes ovata*. Namely, *C. kujuzana* and *C. longerostrata* v. *tenuistachya* preferred tgrassland-like environments with sparse tree canopy rather than closed forest environment. The other five species also had their own habitats connected with soil disturbance and leaf litter removal.

Sacred Natural Sites as a tool for landscape conservation – A case study from Italian forestal matrix

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Sacred Natural Sites (SNS) are defined as portions of land or sea having special spiritual significance for people and communities. It has been demonstrated that they can host substantial biodiversity and provide different ecosystem services. Indeed, they are regarded as the oldest protected areas in human history, some of them having existed for millenia. As such it can be speculated that they represent sites with higher resistance towards landuse modification compared to similar secular areas. Our aim is to test this hypothesis by analysing forest change in Italy across about 80 years.

We used a georeferenced national-level inventory of SNS and an equal number of random sites (RS) extracted with the same spatial constraints of the former. To calculate forest change we used the Italian Kingdom Forest Map 1936 (IKFM) and Corine Land Cover IV 2012 (CLC). In order to reduce inconsistencies between the data we did not account for different forest classifications limiting our analyses to forest – non-forest type and rasterized the data applying a cell 500 m x 500 m. We then calculated forest change for each SNS and RS at different spatial scales and eventually tested whether SNS are more stable.

Our results point towards an effect of SNS in conserving landscape structure, although it varies according to the evaluated spatial scale and geographic context. Also, it can be argued that IKFM has several georeferencing errors but we deem them to be negligible at national scale and secondary with respect to grid size. In addition, it is impossible with our approach to test a causal relationship of SNS, despite the correlation found.

This work demonstrates that SNS represent resistent areas with respect to landuse changes and, more generally, characterized by peculiar landscape processes. Despite many portions of Italy having suffered afforestation after the abandonment of mountain areas in the last century, traditional management at SNS has limited this phenomenon. In contrast, many lowland areas have largely been deforested over the last decades in favour of industrial agriculture whereas SNS have conserved some of the last forested patches. Further studies should first aim at evaluating these processes in a finer way and not only in a forest – non-forest perspective but trying to decouple degradation and naturalization processes.

Talk Vegetation patterns and processes

Effect of cloud frequency on the forest vegetation in Taiwan: what can we learn from the trait-based approach using evergreen broadleaf species?

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The occurrence of fog (i.e. cloud touching the ground) represents a peculiar stress factor influencing the growth and survival of plant species in the cloud-affected vegetation. In Taiwan, cloud forest is a unique vegetation type occurring at middle elevations and hosting a number of endemic and relict species. Several mechanisms explain the effect of cloud on vegetation: high air humidity with an adverse impact on evapotranspiration, low light incidence with a negative effect on photosynthesis, and nutrient limitation caused by slow decomposition in a cooler climate and water-saturated soils. We collected data along an elevation transect in the northeastern part of Taiwan and applied a trait-based approach to understand which of these explanations is the most plausible.

Taiwan is a subtropical island, located on the Tropic of Cancer less than 200 km east of the Chinese coast. Mountain ranges are reaching up to 3952 m a.s.l., with the belt of cloud forest occurring between 1500 and 2500 m a.s.l. Our elevation transect consists of six 250 m-wide elevation zones (850-2100 m a.s.l.) and extends from foothill to lower- and upper-montane cloud forest. In each zone, we sampled a set of three 400-m^2 and seven 100-m^2 plots and recorded the composition of all woody species and a set of topographical, soil and microclimatic variables. For evergreen broadleaf species, we measured a set of leaf and wood traits that are known to be functionally related to some of the environmental factors and used the fourth corner approach with Pmax test to relate these traits to selected environmental variables.

Results show patterns which are in agreement with other trait-environment studies along elevation gradients: LA and SLA decrease with elevation, while LDMC, leaf thickness and chlorophyll content increase with elevation, reflecting the switch in leaf economy strategy between fast and slow species. Marginally significant was the negative relationship of nitrogen isotope concentration with elevation, indicating changes in local soil nitrogen cycle. Interesting is the decreasing leaf water repellency along elevation, with cloud species having more wettable leaves, possibly as an adaptation to drought events occurring in the absence of the cloud.

From our results, it seems likely that the cloud affects the vegetation by limiting the nutrient availability, causing the prevalence of species with slow return on investment. Surprisingly, cloud forest can get relatively dry in the non-cloudy days, which is reflected by species adaptation (high leaf wettability). To study the effect of the cloud using elevation transect is not perfect since several other factors are correlated to elevation. After this pilot study, we plan to extend the sampling to sites along the gradient of topographical shading with decreasing cloud frequency but constant elevation, to reduce the confounding effect of other environmental factors.

Poster Vegetation patterns and processes

Species co-occurrence networks show plant community organization change under reforestation

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The role of forest plantations in biodiversity conservation has gained more attention in recent years. Forest plantations may lead to changes in the richness and composition of communities. These changes in richness and composition may, in turn, lead to altered species co-occurrence, but our knowledge of this remains limited. We used a species co-occurrence network approach to examine the impact of forest plantation on plant community structure in a mountainous region of Beijing, China. We contrasted plant communities from 15 small gullies planted by pine *(Pinus tabuliformis* Carr.), by larch (*Larix principis-rupprechtii* Mayr.), and recovered by natural secondary deciduous broadleaf forests, and test whether planted forests will change the overall co-occurrence and pairwise associations of plant community. We found that planted larch forest differed in composition and richness compared with planted pine and natural forests. Planted larch forests were also characterized by differences in co-occurrence network structure with reduced co-occurrence connectance and increased modularity of co-occurrence networks. Our work implies the value of using co-occurrence analysis to uncover impacts of forest plantation on plant community changes which sheds new light on the evaluation of reforestation on biodiversity.

How sampling method affects species richness and species-area curves at different spatial scales in grasslands?

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The species-area relationship (SAR) is one of the most fundamental patterns in ecology. It also has relevance for understanding key ecological processes. We analysed the effects of the two basic methods for recording vascular plant species richness (rooted vs. shoot sampling method) at different spatial scales. We also addressed the question how the slope (z-value) of power-law SARs changes across scales in both methods.

The sampling was implemented within the framework of the BiodivERsA project SIGNAL. In this study Palaearctic homogenous semi-natural grasslands were investigated in four countries (Germany, Hungary, Italy and Turkey). In each site, we established six blocks (min. 3 m, max. 30 m distance between them) of 40 cm × 280 cm, subdivided into 5 cm × 5 cm micro-quadrats, resulting in 448 micro-quadrats per block and 2688 per site, in which we recorded vascular plant species presence with rooted and shoot presence method. To describe the difference between the species richness obtained by the different sampling methods, linear mixed-effect models were used. For detecting differences between rooted and shoot presence methods SAR models were fitted. We calculated "local" z-values between each pair of subsequent grain sizes to test for differences due to grain size or sampling method.

We found a systematic difference in species richness and local z-values between the sampling methods, which was scale-dependent. The effect sizes varied between countries. Species richness recorded with the shoot presence method was higher at every scale at all sites. However, the relative differences became smaller with increasing plot size. Generally, z-values were higher in smaller scales and showed a broadly decreasing tendency towards to larger scales.

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Poster Vegetation patterns and processes

Intercontinental convergences between floristic quality assessment and analog European indicator systems

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Expert-based vegetation indicators are indispensable tools for scientific and conservation applications. Floristic Quality Assessment (FQA) is a primarily North American system to assess the relative quality of natural areas through species-based values called Coefficients of Conservatism. Three European systems have considerable yet unrecognized connections to FQA: 1) hemeroby scales, 2) Borhidi naturalness indicator values, and 3) Ellenberg Indicator Values. In a bibliographic review, we summarized the four systems and found considerable convergence in the four systems' principles, applications, and underlying ideologies, as well as similar criticisms leveled at these systems. Despite these similarities, we predicted that FQA authors in North America were unaware of these European analogs. To test this prediction, we performed a bibliographic coupling analysis using 880 source documents. We found a pronounced intellectual insularity in the FQA literature, but stronger exchanges among the European systems. We recommend further mutual awareness between FQA users and users of the European systems.

Poster Using plant traits for the recovery of ecosystem functions and services: Trait-based ecosystem engineering?

Which components of plant community react on their neighbor?

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Dry grasslands are natural communities of the South-Western parts of Russia, but due to intensive agriculture they are also seriously endangered. The understanding of features and structure of these communities is one of the key points on the way to save them. In this report we would like to focus on the question: what can we suppose as an interaction unit in plant-plant interactions inside our steppe community - species themselves (systematic groups), ecological groups, or morphological groups? The influence of one species on another can be put into effect through root systems and/or through above-ground parts. We would like to show some examples of these and to discuss how can we classify plants in the community to explain the differences in community structure that we have found.

We study the reaction of a plant community's elements to proximity to mullein *Verbascum lychnitis* (a large biennial tap-rooting semirosette herb, one of the largest species in this community by height and size of leaves) individuals in dry grasslands with dominating *Salvia nutans*, *Fragaria viridis* and *Festuca valesiaca* (Belgorod region, Russia). Data was collected using standard methods of sample plots, adopted in plot size and arrangement. Total coverage, species number, coverage and occurrence for individual species were recorded for each plot. We considered species and their groups as a plant community's elements. During data analysis species were grouped by ecological parameters (optimum on moisture gradient, 3 groups), type of root system (4 groups), presence of leaves (rosette and stem leaves, 3 groups), height of shoot (3 groups), lifespan (2 groups) and also life form (divided into grass and forbs). Only 15 species had occurrences higher than 5%, the variation of projective coverage caused by proximity of *V. lychnitis* was analyzed for these.

Most of the species, even the most abundant ones, did not demonstrate a reaction to neighbouring *V. lychnitis*. However, 2 species (*Plantago lanceolata* and *Salvia nemorosa*) avoided mullein (negative correlation between coverage and proximity of *V. lychnitis* with significance levels less than 0.05.

For most of the species groups we found significantly negative correlations (moderate Spearman's Rho values) between abundance of these groups and distance to mullein's stem. Two groups did not react to the presence of mullein, these were long rhizomatous herbs and herbs with short lifespan (annual and biennial). Groups assembled on the basis of different traits had approximately equal values of correlations with distance to mullein's stem. We suppose stronger reactions of functional groups of plants in comparison with single species.

We can conclude that using functional groups of plants based on their ecological or morphological features seems to be more useful for describing and explaining plant-plant interactions in this type of community, than using fundamental systematic groups of species.

Talk Vegetation patterns and processes

The impact of *Reynoutria japonica* invasion on arbuscular mycorrhizal fungi communities

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Biological invasions, after the habitat loss, are the most important human-induced factor threatening biodiversity. Therefore, we studied the effects of *Reynoutria japonica* Houtt. (*Polygonaceae*), one of the most invasive plant species globally, on arbuscular mycorrhizal fungi (AMF) communities. AMF root colonization, abundance and species richness in soils were assessed in neighbouring plots with the invader and vegetation dominated by native plants in early spring and late summer (S Poland). The level of AMF colonization was reduced in the *R. japonica* plots. The invader also decreased AMF species richness and abundance in soils. There were no differences between seasons. The AMF community alterations could be due to (i) depletion of organic C supply to AMF as *R. japonica* is a non-mycorrhizal species, (ii) secondary metabolites of the invader that inhibit AMF, or (iii) invasion-induced changes in soil properties. *R. japonica* did not eliminate AMF from invaded areas as both AMF biochemical markers, 16:1omega5 neutral and phospholipid fatty acids, and spores were detected in soils overgrown by this species. The persistence of AMF under *R. japonica* could stem from accompanying mycorrhizal plant species that were found in several plots, the transport of AMF propagules from adjacent areas, and their long-term survival from the period before the invasion.

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Author index