International Association for Vegetation Science 61st Annual Symposium

Natural Ecosystems as Benchmarks for Vegetation Science

Bozeman, Montana, USA

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ABSTRACTS

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International Association for Vegetation Science 61st Annual Symposium

"Natural Ecosystems as Benchmarks for Vegetation Science"

Bozeman, Montana, USA, 22-27 July, 2018.

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Opening Plenary, Monday 23 July, 9:00 AM, Ballroom A

Natural ecosystems as an evolving focus of North American vegetation science

Robert K. Peet

Biology Department, University of North Carolina at Chapel Hill, USA

Vegetation Science in North America has from the beginning had a strong focus on understanding natural ecosystems. In the early days ecologists like H.C. Cowles and W.S.Cooper examined succession in natural landscapes, whereas ecologists like F. Clements documented the pattern of community assembly across landscapes. Subsequently, workers like J.T. Curtis and R.H. Whittaker expanded on this early work by placing natural communities in the context of continuous variation across environmental and temporal gradients. I will summarize more recent work on natural vegetation from three landscapes (forests of the Rocky Mountains, deciduous forests of the eastern US, and pine savannas of the southeastern US). I will use these systems to illustrate how research on them has contributed to and reflects increased understanding of community assembly processes and response to disturbance. Moreover, in each case scale of observation plays a critical role as ecological processes need to be examined at scales ranging from inter-organism interactions to landscapes. In addition, all of these "natural systems" are changing as a consequence of human activities, leading to a need for further work on how to understand and best manage landscapes in a novel world that is increasing dominated by human activities. In recent years there has been an increased emphasis in North America on classification of natural vegetation as a tool for biodiversity inventory, conservation planning, and management implementation, paralleling the longer history of vegetation classification elsewhere in the world. All of this leads us to appreciate the converging perspectives of vegetation scientists from across the world, and the importance of continuing to collect, analyze and disseminate spatially extensive and long-term data on community composition, especially from natural ecosystems.

Plenary, Tuesday 24 July, 8:30 AM, Ballroom A

Understanding the distribution of plants in the Anthropocene

Naia Morueta-Holme

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Discerning the patterns of distribution of life on Earth and understanding their drivers have motivated the work of many naturalists and biogeographers since the Age of Exploration. Over the past centuries, we have learned much about the relative importance of dispersal, biotic and abiotic factors in shaping communities from local to continental scales. This knowledge has been spurred by the informatics revolution and the amassment of large amounts of data on species occurrences, functional traits, and the environment. Further, studies on distribution shifts in response to ongoing environmental change have provided insights into the processes underlying range dynamics. However, the strong influence that humans exert on ecosystems through e.g. land conversion, changes to nutrient cycles, and species dispersal may pose difficulties to the inference of the fundamental "laws" and natural processes driving species' distributions. With examples from my own work within plant geography in the Americas, I will discuss some of the challenges – but also opportunities – of doing research in landscapes increasingly dominated by humans. I will argue that it is time not only to focus on the negative impacts of humans on global biodiversity conservation, but also to account for the role of humans within basic ecology research.

Plenary, Thursday 26 July, 8:30 AM, Ballroom A

Are inherent dynamics in natural ecosystems a challenge for benchmarks in vegetation science?

Scott L. Collins

Department of Biology, The University of New Mexico, USA

The theme of this meeting addresses natural ecosystems and how they serve as benchmarks for vegetation science. At first glance, this theme seems to be simple, important and obvious, yet it can be difficult to objectively establish a benchmark for many ecosystems that are highly dynamic, and subject to tipping points. Moreover, long-term data are implicit in the concept of benchmarks, either historical data compared to current measurements, or current conditions become the benchmark for the future. Based on long-term vegetation data from arid and mesic grasslands, I will explore the rates at which these ecosystems undergo change in the absence of natural or anthropogenic disturbance. In addition, new metrics for quantifying community dynamics (species reordering, species turnover) can be used to explore how communities are changing. Together, long-term data and simple quantitative metrics can be used to measure current rates of change, embedding natural dynamics into the concept of benchmarks for natural ecosystems.

Plenary, Friday 27 July, 8:30 AM, Ballroom A

Vegetation scientists answer big questions when we work together

Janet Franklin

Department of Botany and Plant Sciences, University of California - Riverside, USA

In a 2017 paper in Global Change Biology, entitled “Big data for forecasting global change impacts on plant communities,” my coauthors and I concluded with the following thoughts: a lot of insightful vegetation science gets done by small groups of collaborators using original data. The pressing need for research on vegetation dynamics in an era of global change demands larger datasets spanning broader spatial and temporal extents than are covered in individual studies. Data registries, archives and aggregators have developed, and forest inventory data have been repurposed, to address this need. Examples of these in vegetation science include VegBank, European Vegetation Archive, Botanical Information and Ecology Network, and Global Index of Vegetation-Plot Databases. But small, legacy datasets (plots, relevés) still abound, and their full potential has not yet been exploited to address big questions in vegetation science. There is real value in including those who collect vegetation data in analyzing and interpreting them when those data are aggregated. These collaborations develop formally (research networks), and informally. I will describe several such efforts that I have been part of recently. They include a phylogenetic classification of the world’s tropical forests, studies of diversity patterns in Neotropical seasonally dry tropical forests, geographical ecology of West Indian dry forests, and species diversity and turnover in tropical islands across the Indo-Pacific. Publications from these studies had more than 150, 63, 23, and 27 authors, respectively, in an era when journals are reexamining appropriate criteria for authorship. I contrast these collaborations with my experiences as a data miner of, and data contributor to, vegetation plot archives. By working together, vegetation scientists can ask and answer bigger questions at ecological to biogeographical scales. These larger-scale efforts are also likely to include information from intact natural ecosystems in a region as benchmarks against which to interpret disturbed, semi-natural and novel plant communities in an era of global change.

IAVS Honorary Member Award, Monday 23 July, 2:10 PM, Ballroom A&B

Pain in the paradise: evolutionary ecology of nutrient-poor biomes of the world

Ladislav Mucina

School of Biological Sciences, The University of Western Australia, Australia

There are places on this planet which almost defy logic: they are stressed, extremely nutrient poor and yet – they support flora of unprecedented diversity, deep evolutionary history, and diverse vegetation types showing intricate patterns ecological and evolutionary assembly. These places are of associated with regions called hotspots of diversity and endemism, and with habitats might have served as refugia during periods of adverse climate and other, associated large-scale disturbances such as increased fire frequency. Besides being ecologically and evolutionary appealing subject to study, the high biodiversity of these habitats is rivaled only by the mesmerizing beauty of vegetated landscapes and colors of its flowers. Ecology of biomes calls these places 'peinobiomes'; these are biotic communities supported by nutrient-deprived (hungry) landscapes. The low status of available phosphorus, nitrogen, and other vital resources for plants create highly-stressful soils supporting azonal vegetation and are driving the patterns and dynamics of the ecological community assembly short-term. Many landscapes of the Southern Hemisphere dominated by peinobiomes are characterized by lack of tectonic rejuvenation (hence retarded replenishment of soil nutrients and hence producing nutrient-poor regolith), relative climatic stability (in terms of increased levels of predictability of the climate dynamics), and large-scale, long-term predictable disturbance (involving recurrent fire having a regenerative agent in providing short-term nutrient-supply, and at the same time acting as disruptor of local populations creating opportunities for isolation and later reunion and hence opening possibilities for genetic restructuring, that in turn would underpin speciation processes. The spatial coincidence of peinobiomes and these Old Stable Landscapes is the major source of survival of palaeo-geographically old habitat complexes, supporting both ancient plant relict lineages as well as evolutionary young lineages resulting from local rapid radiations. These evolutionary processes, as well as the plethora of ecological adaptations to low nutrients, lead to high gamma diversity (very rich floras) and unprecedented species turnover across habitats in these landscapes. Southern Hemisphere, preserving the oldest (and possibly also most diverse) biotic communities on this planet is home to iconic peinobiomes. Here are invite you for a journey spanning tropical, subtropical and warm-temperate peinobiomes of South America, including Guyanan Pantepui system, Campos rupestre, Southern Africa with famous Fynbos of the Cape and less famous, yet equally intriguing Sourvelds, and Australasia featuring SW Australian Kwongan, Top End ancient sandstone plateaus, and enigmatic maquis miniers of Nouvelle-Caledonie. Models of the evolution of traits pools and (endemic) species diversity will attempt to explain how the abundance and beauty of those treasured corners of our home came about.

Historical ecology of Mediterranean forests: drivers of forest cover change and effects of past land use on current soils and vegetation

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After centuries of deforestation in Europe, forest cover has been significantly increasing since the turn of the nineteenth century. We distinguish two types of forest according to their temporal continuity: ancient forests, already present before the forest transition, and recent forests, developed since the nineteenth century on former agricultural land. In temperate regions, historical maps revealed that forest ancientness influences soil properties and the presence of some plant species. However, those differences were rarely analyzed in the Mediterranean region. In the Regional Natural Park of Luberon (southern France), we characterized the biophysical, socioeconomic and landscape drivers of forest cover change using logistic regressions (GAM function). We then analyzed the effects of temporal continuity (ancient, recent or very recent forests) and past land uses (forest, pasture or crop) on forest understory vegetation with multivariate analysis (CCA) and logistic regressions (GLM function). We based our work on the comparison of the État-Major map (1860) and 1958 and 2010 aerial photographs, and on a regional floristic database of 1,429 plots with about 34,000 species occurrences. Forest persisted on the least productive land while recent forest recovered on soils with low productivity, and close to pre-existing forests. Forests with differing temporal continuities and former land use were thus distributed according to soil productivity, but also to distance from open habitat edges, and hosted species of differing traits and ecological preferences. Notably, species significantly preferring ancient forests were true forest species, phanerophytes and endozoochores, while species more frequent in recent forests developed on former crops were open-habitat species, mostly ruderals. Besides the original aspect of such a study in the Mediterranean region, this work enables to clarify the effects of past land use on forest understory vegetation with the biophysical drivers of forest cover change.

Really stable coexistence? Conflicting evidence from observations and experiments

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Stable coexistence requires intraspecific limitations to be stronger than interspecific limitations. The greater the difference between intra- and interspecific limitations, the more stable the coexistence, and the weaker the competitive release that any species should experience following removal of competitors. Using multispecies population models fit to long-term demographic data from permanent plots, my collaborators and I have found that coexistence among dominant species in semiarid plant communities is surprisingly stable. The same models predict little competitive release. However, inference about competitive interactions based on observational data is weak. We conducted a removal experiment in a sagebrush steppe to test whether our models based on observational data could accurately predict competitive release. Our treatments were (1) removal of all perennial grasses and (2) removal of the dominant sagebrush. For all three grass species, we found evidence for greater competitive release than predicted by our model, primarily reflecting individual growth rather than recruitment or survival. However, we found no evidence of higher response to removal in quadrats with higher pretreatment cover of sagebrush, or by plants experiencing higher pre-treatment crowding by sagebrush, raising questions about the mechanisms driving the positive response to the removal treatment. The differences in the observational and experimental results illustrate the challenges of studying community dynamics in natural systems, and the strengths and weaknesses of different approaches.

A new binary approach to indicator species analysis

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Designations of species indicative of particular habitats, environmental conditions, and seral stages exist in the earliest studies of plant ecology. However, focused numerical methods for identifying "indicator species" have only recently been developed, and remain relatively rare. This presentation summarizes key breakthroughs in indicator species analyses over the past 40 years, and describes a new method adapted from a prey selection index. Briefly, the method computes a score based on the degree that an individual species belongs or does not belong to a single user-defined class, compared to all other classes. In this binary context, a species may exhibit significant *preference* for a class, significant *avoidance* of a class, or neither. P-values for the null hypotheses that a species' affiliation to a class is no better than random can be generated using permutational methods or the hypergeometric probability density function. We have applied our method to both synthetic datasets with defined indicators species and publically available plant community datasets. These evaluations indicate that, despite its novel capacity to designate *non-indicator* species, our method often identifies similar *indicator* species to the widely used approach of Dufrêne and Legendre.

Tree-rings as a precise multiple proxies for spatiotemporal reconstruction of forest disturbances: example with tropical cyclones

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Northeast Asia, including the Korean Peninsula, the Russian Far East and the Japanese archipelago, harbors one of the world's richest temperate forests. Here, forest diversity and structure are affected by frequent tropical cyclones (TCs) which have significantly increased in intensity over recent decades. Knowledge of long-term spatiotemporal effects of disturbances on forest structure, tree regeneration and species composition is key for understanding forest dynamics and predicting future forest responses to climate change. Here, we aim to provide new insights into the long-term typhoon variations, and their frequency and intensity by using a combination of various tree-ring proxies. TCs cause severe damage when they make landfall on natural and human landscapes with their torrential rains and high wind speeds. We explore the complex impact of TCs, including the effect of past changes in TC activity, on vital forest ecosystem properties such as forest structure, tree regeneration and vegetation diversity. We found a mixed severity disturbance regime was prevalent over the study period in Northeast Asia. A combination of temporal and spatial pattern analysis revealed that less severe disturbances, creating small gaps, promote higher density and diversity of recruitment compared with severe disturbances. We conclude that utilization of multiple proxies for temporal reconstruction combined with spatial analyses, as presented here, is necessary to disentangle the complex drivers of long-term forest dynamics.

Very high-resolution imagery for vegetation mapping: what actually matters?

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A current biodiversity conservation challenge is to estimate the spatial extent of habitat types across landscape patterns. In absence of fine-resolution maps at large scale, which is the common case, predictive models can represent a valuable tool for the assessment of the area of occurrence (AOO) of vegetation types. However, the implementation of these tools is hampered by the complexity of natural systems due to environmental or successional gradients, plant traits and human disturbances even at local scales. Recent developments in data availability and processing link habitat monitoring to remote sensing in a continuous enhancement of spatial, spectral and temporal resolutions. It is widely accepted, but not exhaustively evaluated, that increasing image resolutions will allow defining vegetation statuses and phenology more accurately, leading to a more proper habitat type discrimination. In this study, we combined data obtained from different sources: (1) an intensive vegetation survey across a Special Area of Conservation of the Cantabria region (northern Spain), dominated by peatlands, bogs, grasslands and heathlands, (2) abiotic limiting factors (i.e. topography, climate and soil properties), (3) LiDAR data informing about vegetation height and structure, and (4) three different satellite images. In order to assess the role of image resolutions, we first chose two Landsat 8 OLI images of spring and summer (30-m pixel size) to evaluate the predictive skills of temporal resolution against a model created by using a single Landsat summer image. Secondly, we used a Sentinel-2 MSI image from summer 2016 to evaluate the combined effect of a 10-m pixel size and its enhanced spectral capability. Lastly, we used a Deimos-2 image, with a pixel size of 3.3 m, to assess the capabilities of very high spatial resolution imagery. Finally, we included two images of all sensors. Maps were validated at different levels. We calculated omission-commission errors and overall accuracy scores by using independent field data for the habitat types encountered across the study area. Subsequently, we determined how each modelling approach (i.e. using temporally, spectrally and spatially enhanced satellite imagery) differed from the baseline of a single Landsat image. Results demonstrated a compromise between spatial resolution and map accuracy, but increased spectral resolution was mandatory for getting the best map. Increased temporal resolution improved results in all cases. The results of this study advance knowledge in disentangling the important of image resolution for vegetation mapping in complex landscapes under the effects of Global Change.

Successional trajectories of the understory plant community following the 1988 Yellowstone fires

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The 1988 Yellowstone fires represent the most significant fire event of the 20th century within the Greater Yellowstone Ecosystem (GYE), consuming more than 250,000 ha. The understory plant community (forbs, graminoids, shrubs) responds rapidly after fire. Within lower subalpine elevations, previous studies have indicated rapid increases in understory cover during the first decade post fire, followed by gradual declines associated with new conifer growth. However, it is unclear whether this same pattern holds at upper subalpine elevations, where the harsher climate limits plant growth. In 1990, DFT initiated a long-term study of upper subalpine succession at Henderson Mountain, Montana and established permanent plots at study sites characterized by burn status (burned, unburned) and moisture regime (mesic, xeric). Plots were measured in 1990, 1992, 1994, 2001, and 2016 for total plant cover and species richness. Trends in community composition were assessed by NMDS ordinations. We asked the following questions: (1) How have plant cover, richness, and Shannon-evenness changed over the course of the study and how do values compare among sites in 2016; (2) Have sites become more homogeneous in community composition with time; and (3) Have burned and unburned sites converged in community composition nearly 30 years after the fires? Preliminary results indicate that richness was initially low in 1990 but peaked by 2001. By 2016, richness was greater within burned than unburned sites, as well as in mesic than xeric sites (17.18 ± 0.72 xeric-burned, 7.64 ± 0.85 xeric-unburned, 26.36 ± 0.82 mesic-burned, 18.32 ± 1.46 mesic-unburned). Similarly, mean cover was initially low in 1992 (23.18 ± 2.51 xeric-burned, 42.05 ± 4.11 mesic-burned, 35.45 ± 3.01 mesic-unburned, 23.86 ± 2.03 xeric-unburned) but peaked by 2001 and stabilized through 2016. Bootstrapped 95% high density intervals suggest no difference in mean cover among study sites in 2016 (xeric-burned [41.59, 49.32], mesic-burned [49.09, 61.05], xeric-unburned [49.32, 62.50], mesic-unburned [51.45, 62.95]). Although Shannon index values peaked in 1992 in unburned study sites, values did not peak in burned sites until 2001. Bray-Curtis NMDS of the study plots in 2016 produced a stable solution with two dimensions (stress = 0.1554), indicating persistent separation in multivariate space between burned and unburned study sites. Nearly 30 years after the 1988 fires, burned sites appear to have stabilized with regards to species accumulation and plant cover, but have not transitioned to a more forested state and remain distinct from unburned sites in terms of community composition.

Soil temperature, plant functional traits, and soil microbes on periglacial patterned ground in the Northern Rocky Mountains of Montana

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What factors influence the distribution of plant functional traits and soil microbes on periglacial patterned ground in the alpine zone? Periglacial patterns consist of alternating microhabitats in the forms of stripes, polygons, or relic rock nets. Plant functional traits and soil microbes vary with position on striped periglacial patterned ground at Glacier National Park, Montana where green stripes (> 70% cover) alternate with brown stripes (< 10% cover). Dwarf, mat-forming shrubs with adventitious roots co-dominate the green stripes. These are the evergreen *Dryas octopetala* which is symbiotic with the N-fixing bacterium, *Frankia*, and the deciduous *Salix arctica*. In contrast, the relative percent cover of xeromorphic, taprooted herbaceous species was significantly higher on the brown stripes. The brown stripes were also home to rare arctic-alpine species, including *Draba macounii*, *Papaver pygmaeum*, and *Aquilegia jonesii*. Microbes differed between green and brown stripes, with greater abundance on the green stripes and the brown stripes had a higher proportion of the thermophilic genera, *Thermacetogenium* and *Thermoflavimicrobium*. Therefore, we are exploring whether soil temperature and other soil parameters are correlated with plant functional trait and microbe distribution by installing HOBO Tidbit dataloggers 8-10 cm beneath the soil surface of periglacial patterned ground and by surveying the distribution of plant functional traits and microbes at three sites in the Northern Rocky Mountains of Montana. The dataloggers record temperature hourly and are left *in-situ* for 2 to 3 years and arranged with a pairwise configuration consisting of one datalogger on a brown stripe and one on a green stripe, one datalogger on the perimeter of a rock net and one in its center, or with one on the edge of a hexagon and one in its center. The sites are located at: (1) Glacier National Park, where there are extensive areas of striped periglacial patterned ground near what are now permanent snowfields that are predicted to retreat with climate change, (2) Goat Flat in the Pintler Mountains, where there are localized areas of striped periglacial patterned ground as well as areas with polygonal patterned ground, and (3) Mt. Fleecer in the Pioneer Mountains, where there are relic rock nets forming patterned ground near the summit. The Mt. Fleecer site is also part of the southwestern Montana GLORIA site, which is in turn part of the GLORIA (Global Observational Research Initiative in Alpine Environments) program, a network of long-term target regions established to monitor the effects of climate change on alpine plants. All three sites are excellent for long-term monitoring of the responses of alpine plants to climate change.

South (shaded) slopes show higher presence of forest species than north slopes on rocky hills in central Brazil

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Particularly distributed in Africa, Australia and Brazil, rocky savannas are characterized by savanna sparse vegetation over rock outcrops, usually sandstone or quartzite. Although most of the rocky savanna woody plant species are shared with typical savannas, some gallery forest species grow between the outcrops, indicating that rocky hills can offer particular shaded microhabitats. Opposing slopes of hills have different exposure to solar radiation which affects their physical and biotic features. It is well known that slope exposure effects are stronger in extratropical regions, once the angle of the solar radiation varies among latitudes. However, rocky hills in Central Brazil seem to provide some well-shaded south slopes, and as a result may favor significant differences between opposing faces. Thus, the aim of this study is to check floristic differences between north- and south-facing slopes, evaluating slope exposure effects in this tropical region. The study was conducted in the Pireneus State Park, located in Central Brazil, a tropical region in the Southern hemisphere. Its predominant type of soil is the Litholic Neosol with large quartzite outcrops, mainly east-west oriented. Ten rocky hills were surveyed in the Park, where one 20 x 20 m permanent plot was set on opposing slopes (north-facing and south-facing) at each of them, totalizing 20 plots (0.8 ha of sampling). In each plot woody plants with base diameter higher or equal to 5 cm were identified. Paired t-tests were performed to compare floristic parameters. We recorded a total of 1,006 individuals belonging to 108 species on the 10 surveyed rocky hills. South (shaded) plots showed significantly higher forest-species abundance and higher forest-species richness than north plots. North slopes had around 20% of forest-species in its flora, which is an expected value for a regular rocky savanna. On the other hand forest-species correspond to 47% of south slopes' flora, revealing their shaded microhabitats. South slopes had 28 exclusive forest-species, mainly individuals of Fabaceae (4 spp.), Rubiaceae (3 spp.), Clusiaceae (2 spp.) and Bignoniaceae (2 spp.). These results suggest that slope exposure effects can be important even in a tropical region. Nevertheless, effects in the tropics might be more relevant when associated with east-west oriented hills (such as in the present study). Because of the expressive presence of gallery forest species on the rocky hills, we concluded that they might be contributing to forest expansion.

Sustainable management of coppices in southern Europe: recommendations for the future from the legacy of long term experiments (Life FutureForCoppices)

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Agamic regenerated forests (coppices) cover more than 23 M ha in Mediterranean countries and 3.7 M ha in Italy, where they represent 42% of the total forest area. They are a relevant component of the economy of mountain rural areas by supplying firewood and other valuable and strategic ecosystem services. Nevertheless, agamic regenerated forests are rarely considered in the sustainable forestry management (SFM) scenarios. The Life project "FutureForCoppiceS" (LIFE14 ENV/IT/00514; www.futureforcoppices.eu) is aiming to assess weaknesses and strengths of a range of agamic regenerated forest management practices through an integrated assessment of multiple goods and services. In this paper, we focus on a core project objective that was to assess the potential of traditional vs new SFM indicators for the assessment of the sustainability of different forest management options (traditional coppice regime, natural evolution, conversion through selective thinning) in the context of the six SFM criteria indicated by Forest Europe (http://foresteurope.org). The indicators were tested over 45 long-term experimental plots managed by CREA-Forests and Wood since the 1970s and located in three European forest types (mountain beech, thermophilous deciduous forests, evergreen broadleaf forests). In these plots, the availability of long-term datasets allowed the testing of the new and traditional SFM indicators for the assessment of the status and the long-term trends of the contrasting forest management practices, through a post-hoc assessment approach. The surveys were performed following standard methods for each indicator (www.futureforcoppices.eu/en/documents/manuals.html).Among the traditional SFM indicators, those recognized as most effective were: total growing stock, carbon of standing woody biomass, defoliation from insect attacks and fungal diseases, soil pH, soil organic C, forest increment and felling, roundwood, tree species composition, contribution of forest sector to GDP, and net revenue. Among the new SFM indicators, those recognized as most effective were: total aboveground biomass, growth efficiency, chlorophyll a fluorescence, leaf traits, marketed mushroom production, herbaceous higher plant species, epiphytic lichens, wood-decaying fungi, edible mushrooms, overstory cover, understory cover, workforce, forest sector workforce, trade in wood, energy from wood resources, and accessibility for recreation. The FutureForCoppices project also produced a database with background and new data relative to the six SFM criteria, 54 (9 sites x 6 SFM criteria) informative sheets, six field manuals, spatial models implementation and maps at regional, national and European scales, new guidelines for the SFM of agamic regenerated forests in Southern Europe.

Vegetation community classification on the Snake River Plain: implications for mapping carbon sequestration in the Northern Great Basin

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Understanding vegetation community response to fire in semi-arid systems is critical to determining the trajectories of these communities with changing climate. Fire frequency and severity are projected to increase across the Great Basin. Similar fire regimes have been shown to drastically alter community structure by clearing niche space for invasive species, such as *Bromus tectorum*, placing native species at risk. Due to its recent fire history and comprehensive vegetation monitoring, the Idaho National Laboratory (INL) site provides an excellent opportunity to investigate the effects of fire history on sagebrush steppe communities. The 2,300 km^2 INL site was comprehensively surveyed in 2008 and vegetation communities were assigned. In 2017 the INL was resurveyed using 333 50-m stratified random species percent-cover transects. An optimal sixteen-cluster flexible-β (β = -0.25) linkage classification solution was found using an amalgam of classification evaluators, indicating that 16 distinct communities were present in 2017. This result was surprising considering that the 2008-2011 mapping effort found 22 distinct communities using the same methods. Since 2008, ~17% of the site burned in a series of wildfires, so we investigated fire as a possible driver of this reduction. We hypothesized that patchy invasion within burns is contributing to a regional-scale loss of species diversity and simplification of metacommunity structure at the INL, evident, in part, as a loss of plant communities. At the scale of the whole INL site, unburned transects had higher β-diversity, extrapolated richness, and β-diversity spatial turnover component (βSIM), relative to β-diversity nestedness component (βSNE), demonstrating that natural turnover and replacement is common among steppe native grasses and forbs. Seven of the 16 identified communities were free from wildfire disturbance over the last 33 years. Indicators of these communities were predominately native perennial shrubs, grasses and forbs. On the transect scale α-diversity was lower in unburned transects. However, increased α-diversity in burned transects was likely driven by patchy invasion following fire disturbance, because burned community indicators were mainly ruderal species, including *B. tectorum*. Burned locations had four times larger βSNE than unburned, and a pronounced latitudinal abundance gradient, indicating net species loss and community simplification. The discrepancy between high transect-scale α-diversity and low site-scale β-diversity within burns, emphasizes the importance of studies allowing consideration of invasion on multiple spatial scales. Our study suggests that alteration of steppe fire regimes, driven by fire-resistant and fire-prone invasive species, is contributing to the decreased species richness and diversity that is repeatedly observed in North American steppe ecosystems.

Using historical ecology to test plant community responses to climate warming in eastern Canada

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On smaller spatial and temporal scales, changes in local climatic conditions can lead to modifications of species' abundances, risks of extinction, phenology, distributions or local adaptation. Although many such changes have been observed in previous studies, the magnitude of responses varies tremendously from study to study, and we only have a limited understanding of the processes underlying these variations. Causes of community change at a single site are often assessed by comparing observed changes in community composition across space or time with predictions based on drivers of interest, such as climate warming. A key strategy used to assess long-term temporal changes in plant communities' composition is the resurvey of ancient vegetation plots, often referred to as "legacy" studies. Here we report analysis of changes in forest plant communities over four decades at three sites with contrasted warming trends. The study region (province of Québec, Canada) spans across 1,000 km East-West, over which there is a marked gradient of warming over the past 60 years. Forillon National Park is located at the eastern tip of the province where warming has been negligible. In contrast, Gatineau Park is in continental western Québec which has experienced marked warming. Mont-Mégantic Provincial Park is in between both geographically and in terms of the magnitude of warming. We took advantage of this unique combination of original studies along a warming gradient to perform a regional-scale analysis of temporal change of forest plant communities. We revisited ~150 legacy plots surveyed in the 1970s.Our core hypothesis is that areas with greater warming will have experienced stronger vegetation changes than areas with less warming. We tested the following specific predictions: (1) Significant upward elevational distribution shifts have occurred at Mont-Mégantic but not at Forillon Park. The magnitude of (2) the temporal change in species richness, (3) the temporal change in community composition, and (4) the temporal change in Community Temperature Index (CTI) vary among parks as follows: Forillon < Mont-Mégantic < Gatineau. Results were mostly consistent with our predictions, with the magnitude of biotic changes (i.e. elevational distributions, species richness, composition) most often increasing from Forillon Park in eastern Québec, where the warming trend has been relatively weak, to Mont-Mégantic where warming has been moderate, to Gatineau Park in western Québec where the warming trend has been the strongest.

Functional traits can aid predictions of species establishment

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Understanding plant establishment within communities is fundamental to understanding both basic ecological processes, such as succession, and applied ecological problems, such as invasion by exotic species. Consequently, multiple frameworks have been developed that compare plant functional traits between the establishing species and the resident community to improve the predictability of species establishment. One such framework compares the traits of observed and absent species at multiple scales to develop predictions of which sets of traits should allow species to pass both environmental and biotic filters, and thus establish. We tested this framework in an experiment distributed across 30 anthropogenic grassland sites in Estonia. At each site, we added seed and seedlings of 15 native and exotic species to both disturbed and intact vegetation plots. After two years, we measured establishment in disturbed conditions as a proxy for passing environmental filters, and calculated biotic filtering as the ratio of establishment between disturbed and intact plots. We also quantified the composition of the community and regional species list for each site, using these data to estimate which species within the region could establish, but were absent (dark diversity). These data were combined with plant traits (specific leaf area, height, seed weight, and clonality) within the framework to predict environmental and biotic filtering of each species at each site. Model predictions significantly predicted environmental and biotic filtering of seeds, explaining 9% and 3% of the variation, respectively. Predictions were less accurate, but still significant, for seedlings, explaining 5% of environmental filtering and 3% of biotic filtering. When combined with data on site productivity and community completeness, the explanatory power of the models improved (seed environment 15%, seed biotic 12%, seedling environment 13%, and seedling biotic 11%). Model accuracy was largely equivalent for native and exotic species. Given the number of unaccounted for factors that can influence species establishment (e.g. herbivory, anthropogenic disturbances, seed viability), these results can be viewed with some optimism. Functional traits may thus be a useful tool for predicting native and exotic species establishment. However, functional traits alone are likely insufficient, especially if these traits are drawn from databases rather than measured in situ, as done in this study. Nevertheless, the combination of functional traits, community completeness, and productivity show potential as predictors of establishment and invasion.

Linking ecological theory to field data with statistical modelling

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Understanding how species distribute in space and through time is at the core of community ecology because the whereabouts of a species depends on the environmental setting in which individuals of a species are found but also on how individuals of the same and of other species interact. In ecology, two general approaches have been used to further our understanding of species distribution; mechanistic models and empirical studies. Mechanistic models such as the Lotka-Volterra model can be used to quantify the abundance of species at local scale (within a habitat patch), while metapopulation models can be used to assess the probability of occurrence of individuals of a species at a regional scale (among a set of habitat patched). From these models, it is possible to infer a conceptual understanding of species distribution by having a focused vision on how species distribute. Conversely, empirical studies embrace the complexity of nature in the data gathered but it is through statistical models that the structure in the data is extracted and interpreted. Recently, a new generation of statistical techniques have been proposed, called joint species distribution models (JSDM), which have the advantage over other approaches to account explicitly for co-distribution. However, JSDMs do not currently link well with ecological theory, thus limiting the interpretation we can gain from JSDM. Here we will link the Lotka-Volterra model and the metapopulation model and show how it can be linked to empirical data through a novel development in statistical modelling based on an extension of JSDMs. We will illustrate our findings with tree distribution data from southern Québec (Canada).

European pine forest: preliminary results from the CircumMed+Euro PineForest project

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Large thematic databases of vegetation plots are increasingly needed for vegetation studies as well as for biodiversity research. With the primary aims to develop a synthesis and formalized classification of European Mediterranean and temperate pine forests, we built the CircumMed+Euro PineForest Database. The project started in October 2017 and the database now encompasses more than 3,000 pine-dominated vegetation plots and plots of related vegetation types from more than 15 countries across Europe and the adjacent areas in the Mediterranean Basin. The database is managed by the Vegetation Science Group, Department of Botany and Zoology of Masaryk University in Brno (Czech Republic) and stores data that have never been deposited in any other database. The data were collected through a detailed literature search of more than 180 publications. We also included neglected or unpublished plots contributed by different researchers from several European, Western Mediterranean and Northern African countries. All plots were digitized, georeferenced and coordinates are available with different degrees of precision according to the accuracy reported by the original authors. Standardized and updated nomenclature of taxa is offered for all plots. The database is registered in the Global Index of Vegetation-Plot Databases (GIVD) and is accessible through the European Vegetation Archive (EVA) or by asking the custodian. The pine forest data of the CircumMed+Euro PineForest Database filled the gaps present in EVA. In this talk, we will present preliminary results of the classification of Mediterranean types performed using unsupervised and supervised classification methods with the Juice Program. In the final stage, this work will provide consistent vegetation classification at the alliance level for European pine forests and logical formulas for automatic classification of all pine forest types of Mediterranean and temperate European areas. Besides the planned first synthetic classification of the European Mediterranean and temperate pine forests, this data acquisition will allow further vegetation and ecological modelling studies at the continental scale. Moreover, this comprehensive view will also offer relevant insights for practitioners in nature management and conservation.

Does Community Assembly by Trait Selection (CATS) algorithm estimate the role of mass effect correctly?

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It is widely accepted that assembly of local plant communities is neither a fully deterministic nor a fully stochastic process: non-random local niche-based processes interact with random dispersal and demographic stochasticity. However, on the relative role of these processes we have only scarce information. Modeling observed abundances by the maximum entropy approach (Community Assembly by Trait Selection; CATS) developed by Bill Shipley allows statistical decomposition of total information content that are attributable to environmental trait filtering, mass effect and demographic stochasticity. The aim of the present work to check the reliability of the estimates. For this purpose, artificial meta-communities were simulated in an individual-based simulation framework. The simulation procedure can be subdivided into five steps. (1) A species pool is created and for each species two trait values are simulated; the first trait defines the survival of a species in a given environmental condition. The second trait describes the resource use. (2) Death of individuals: In each community one random individual dies. (3) Seed production: Each community produces seeds where the number of seeds per individuals is determined by resource competition. (4) Dispersal: Each seed has a probability to remain in its community of origin or to disperse to any of the other communities. (5) Establishment: The dead individual is replaced by one new individual from the seeds choosing the winner seed regarding the survival probability in the given community. Steps 2–5 are applied to each community until there is a 100-fold complete turnover in individual identity. Setting parameter values allows to change relative importance of dispersal, demographic stochasticity, habitat filtering and competition. The simulated landscape contains two habitats whose proportion and the difference between them differs among scenarios, but 10 plots from both habitats were analyzed in each scenario. The main findings are the following: (1) CATS approach estimated lower importance of habitat filtering if the habitat is more common in the landscape; (2) estimated importance of mass effect decreases, when the difference between habitats increases; (3) estimated importance of demographic stochasticity is lower, when probability of seed dispersing into other local community is higher. The main conclusion is that interpreting results without considering the possible confounding effects of landscape structure results in misleading conclusions on the importance of assembly processes.

Good old phytosociological relevés vs. digitally available tons of data: are the beta diversity patterns comparable in the Colombian Páramo?

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Páramo plant communities (neotropical alpine vegetation) form archipelago-like systems in the three cordilleras of the Colombian Andes. A complex interplay of glacial and interglacial periods have had a strong influence on their spatial distribution, creating an extremely complex and informative pattern of beta-diversity. Moreover, due to the recent political changes in Colombia, Páramos face an inflated anthropogenic pressure that adds to the future climate change projections. Páramos are biologically diverse, provide important ecosystem services and represent an important cultural heritage, but their distribution is expected to reduce dangerously due to these threats. In order to provide guidance for conservation policies, it has become urgent to understand their biodiversity patterns and drivers. As demonstrated by the recent explosion of páramo-related publications (in the web of science: 59 publications for 2017, 64 for the 2000-2005 period), the scientific community is determined to tackle this task, but what vegetation data to use? More and more data are digitally available, most of it consisting of presence-only specimens from national and international databases. Due to the numerous registers, these data sources allow a better spatial, temporal and taxonomic coverage than any other, but they may not be appropriate for studies at the vegetation scale. Is it possible to reconstruct communities from these species' occurrences and analyze them as we do with phytosociological or plot data? We collected data from several national and international digitally available databases. After extensive data cleaning and standardization, we were able to compare their diversity patterns to the patterns from phytosociological relevés made at the same locations. In this presentation we will discuss how adequate are both data sources depending of the goal of the study. Occurrence data show proportionally higher conservation-value species and less functionally important species than the phytosociological relevés. The beta-diversity patterns obtained from the two types of data, however, are congruent, and show a particularly strong correlation at a large scale. Therefore, the use of digitally available occurrence data may be more appropriate for addressing local conservation issues, while phytosociological data may be better for understanding local ecosystem functioning. Finally, at a large scale, integrating both data sources is the best strategy for understanding large patterns and processes acting on the biodiversity of the Colombian Páramo plant communities.

The value of old timber company records in reconstructing the historical Piney Woods of Texas and Louisiana

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The Piney Woods of West Gulf Coastal Plain in the southern United States were a complicated mixture of longleaf (*Pinus palustris*), shortleaf (*Pinus echinata*), and loblolly (*Pinus taeda*) pines, with distinct patterns arising from variation in topoedaphic controls and disturbance regimes. Given a growing interest in the large-scale restoration of longleaf and shortleaf pines in this region, any descriptions of historical forest conditions would be of considerable assistance. A large-scale forest survey of the hundreds of thousands of ha of Houston Oil Company lands conducted in 1910 can provide useful information on the then still extensive old-growth pine forests of eastern Texas and western Louisiana. While stand structural information is limited to brief encapsulations of timber volume in two diameter classes for a handful of valuable species (e.g. longleaf, "short leaf" (which included both *Pinus echinata* and *Pinus taeda*), cypress (*Taxodium distichum*), and a variety of hardwoods) and pine reproduction counts by species group for three different size classes, qualitative descriptions of site (e.g. sandy or clayey soils; flat or hilly topography) and stand (e.g. "scattered" or "grouped" pine regeneration; vigorous vs. slow growth; overall tree soundness or log quality) conditions expand upon the vegetation information available. The maps affiliated with each parcel surveyed, although crude by today's standards, also add to the ecological descriptions by illustrating forest and land management (when present) patterns, including some stand boundaries, harvested areas, farms, home sites, roads and rail lines, disturbed areas, streams and prominent wetlands, and other unique features. Given the precision of the legal descriptions of these properties, digitized versions of the Houston Oil Company parcels can be readily incorporated as a GIS layer to supplement other historical information (e.g. public land survey records) to present a fuller picture of these Piney Woods in the early 20th Century.

Testing a novel method for predicting dark diversity

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Species recorded in a site represent only a subset of all the species in a region that can potentially inhabit the ecological conditions of that site, i.e. they are only a portion of the so-called habitat specific species pool of the site. Species absent from a community but with the potential to establish – i.e. dark diversity – are an important, yet rarely considered component of biodiversity. They might be missing from a given community due to mechanisms such as priority effects, species poor dispersal ability and/or a site's isolation. Some species can also remain undetected because of incomplete biodiversity monitoring. Quantifying dark diversity remains a challenge as it cannot be observed directly, and thus needs to be estimated. Here we compare two widely used approaches, based on species co-occurrence (Beals smoothing) or species ecological preferences (Ellenberg values), against a novel method based on compositional dissimilarity between plots, using an unconstrained ordination ('UNO') framework. Following existing works, we used a spatially nested sampling of 41 plots across a variety of habitats in the Czech Republic, using species from the smaller-sized plots to predict species presence in bigger-sized plots (considered to be the part of dark diversity caused by under-sampling). We assessed the importance of the size (number of plots) and scale of the reference data on the different methods considered using the Czech National Phytosociological Database (CNPD, with ~30,000 plots) as the basis for the calculations. Results indicate that both Beals and UNO were better at predicting dark diversity than calculations based on Ellenberg values or using simple species frequency. While Beals and UNO provided comparable results when using the totality of CNPD plots available, UNO generally outperformed Beals when using a portion of the reference data. Using only plots geographically closer to the target plot, as opposed to a random selection, provided higher success rates in both methods. Using relatively small reference datasets (e.g. < 800) can seriously compromise the estimations obtained with Beals if not used with plots closer to the target community, but does not negatively affect UNO. Considering that in most countries the potential reference data are limited in size, we advocate using the UNO approach to provide consistent estimates of dark diversity. We conclude that the size and extent of the reference database can be highly influential on the success of dark diversity estimations and we urge caution regarding how reference data is used in the future.

Spatial scaling of plot-specific species pools (PSSPs)

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The definition of a species pool is crucial for many types of ecological analyses and for comparing community diversity at different spatial scales. There are several attempts to define species pools, using either internal criteria (e.g. sum of all species that occur in a set of plots) or external criteria (e.g. the flora of a geographic or climatic region). However, in most cases it is difficult to define a proper geographical area for estimating species pool sizes and to fulfill the requirement that the species pool has to be habitat-specific. Here, we propose to define a plot-specific species pool (PSSP) as the probabilistic set of species that may co-occur with the species of a target community. We developed an approach based on the use of large vegetation databases with geo-referenced plots, which allows characterizing each plot by its own species pool, without requiring a pre-defined habitat classification. As in previous approaches, we suggest to use Beals' index of sociological favorability to obtain the occurrence probability of every species in the database to occur in the target community, including the resident species of that plot. Based on a number of species with the highest occurrence probability in the plot (either a fixed number or those above a threshold), we first extract all plot records that fulfill a minimum similarity criterion, i.e. have a high similarity in co-occurrence probabilities compared with the target community, and then, select those plots within a given geographic distance around the target plot. Based on observed occurrences of the species in this selection and the spatial distribution of plots, we construct species accumulation curves and estimate the size S of the target plot's species pool, using Chao's asymptotic richness estimator. Finally, we define the PSSP as comprising the first S species, when being ranked in descending occurrence probability. Thus, the species pool is no longer dependent on a cut-off value but is derived exclusively from community characteristics. Defined in this way, the PSSP can be scaled spatially by varying the radius of the selection. As a result, the PSSPs have a different spatial extent. Furthermore, the PSSPs can be aggregated at different spatial grains, using different grid sizes. For illustration, we applied the approach to grasslands and calculated the PSSP for different extents and grains, using all grassland plots in the German Vegetation Reference Database (GVRD) and in the global vegetation database (sPlot).

Vegetation dynamics in California grasslands and prairies

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Vegetation found in California's grasslands and vernal pools is difficult to quantify because of the variable and ephemeral nature of these unique systems. In this study, permanently marked relevés were placed within homogeneous stands of herbaceous vegetation across the Great Valley ecoregion of California. These relevés were re-visited both within a year (spring and summer) and between years across a 5-year timeframe. The PC-ORD suite of classification and ordination tools was used to generate multivariate analyses such as Cluster Analysis and Indicator Species Analysis to reach a formalized classification of community types. To detect the significance of environmental factors on species and communities, we interpreted a three-dimensional NMDS solution and calculated correlation coefficients for nine quantitative variables. Shifts in species composition and abundance occurred within different seasons of the same year, across different years, and along latitudinal and longitudinal gradients. These fluctuations correlated with variation in annual precipitation, timing and temperature, as well as other factors such as parent material. Summer surveys detected significantly fewer native species, fewer overall species, and significantly less relative abundance of native plants than spring surveys. Seasonal plant community analyses revealed little variation in the alliance classification of stands. This speaks to the stability of vegetation types in annual-dominated plant communities when compared across the same year. We noted significant changes in species richness over years and this change appears to be driven by the composition of native species. The richness of non-native species remained steady across repeat sampling. This highlights the adaptations of native species to thrive under specific environmental conditions and to remain dormant when the setting is not ideal. Results reveal that non-native species have partially replaced but have not eliminated native forb and grass species across much of the remaining natural habitat in the Great Valley. There are difficulties in differentiating native grassland types in drought years due to the lack of germination. We tracked cyclical dynamics within grassland and pool vegetation and conclude that patchy spatiotemporal processes enable the coexistence of native and non-native plant species. Stable definitions of California grassland vegetation must be based on a combination of indicator species presence, temporal persistence, and richness with less emphasis on the dominant cover of non-diagnostic, invasive plant genera such as *Bromus*, *Avena* and *Schismus* (Poaceae). A quantitative classification and a transparent and defensible rarity ranking system will ultimately aid in the continued conservation of these imperiled ecosystems.

Human-mediated dispersal and disturbance drive metapopulation dynamics of wild cabbage

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In a study of a long-lived wild species, growing in natural habitats, we show how human-mediated dispersal, and regular disturbance is important for metapopulation. *Brassica oleracea*, the wild ancestor of cultivated cabbages, is restricted to sea cliffs in Europe. In the highly-diverse grasslands on the cliffs of Dorset in the UK it forms a linear metapopulation. We show that this metapopulation is able to persist through the impacts of (1) local soil disturbance by, e.g. animals and (2) long distance anthropogenic seed dispersal via shoes of hikers. We collected a large and unique multi-population demographic data-set, which we used to create Integral Projection Models (IPM) of metapopulations with dispersal by multiple processes. These findings suggest that a protectionist approach to conservation would be counter-productive for these and similar plant populations, despite the near-natural state of the vegetation. We followed tagged plants of this long-lived perennial for seven years in three populations providing over 4,500 data-points for adult survival, growth, likelihood of flowering, and fecundity. We experimentally assessed the effect of soil disturbance on germination and seedling survival, and conducted seed bank survival studies. We developed IPMs, both with and without soil disturbance. We constructed a linear metapopulation model with these IPMs, initialized using survey data on the distribution and population sizes gathered over 13 years. In our model we connected populations by natural wind and/or human-mediated dispersal kernels based on extensive empirical studies in this system. Small disturbances resulted in 2-3 fold increases in germination and seedling survival rates. A population's growth rate λ was highly sensitive to these seedling survival rates. The modelled metapopulation size was similar to that seen in the field when the yearly soil disturbance was held at a realistic $\approx$15% area per population and combined with human-mediated dispersal. In these simulated populations metapopulation dynamics was driven by human-mediated dispersal and not wind dispersal. We discuss the somewhat counter-intuitive finding that the persistence of a wild plant species appears to be dependent on human activities.

Long-term effects of afforestation and deforestation at forest-grassland interfaces

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In temperate Europe, landscapes are dominated by a mosaic of forests, grasslands and crops since several centuries. This long time allowed the specialization of species within the habitats and their interfaces. However, frequent land-use changes have occurred in the past, challenging the stability of plant communities and their environment. Among them, the afforestation and deforestation processes between forests and grasslands, mostly resulting from the progression and regression of the edges, have been poorly studied. Within forest-grassland interfaces, in addition to an edge effect induced in each habitat by the proximity to the adjacent habitat, a history effect can appear in recent habitats, i.e. an environmental and/or floristic legacy (extinction debt, colonization credit). To check this hypothesis, we assessed the relative influence of the edge and history effects in 132 plots along 22 forest-grassland interfaces (divided in three types: stable, issues from afforestation or from deforestation), by studying (1) environmental conditions, (2) plant communities richness and composition, and (3) trait values within communities. Our results showed increasing gradients of light and soil nutrients ranging from grassland edges to grassland cores. In response, a strong edge effect on the composition of plant communities was found in grasslands. These floristic differences between edges and cores in grasslands are explained by the presence of numerous transgressive species among the forest species (60% of them), which have trait values favoring their transgression in grasslands. Besides, an extinction debt of grassland species was found in recent forests (up to 12% persistent species), which was responsible for a higher vegetative height compared to ancient forests. These results can be explained by the fact that light remained higher in recent forests, even after several decades. An extinction debt of forest species has also been demonstrated in the recent grassland edges (up to 8%) resulting from an interaction between edge effect and history effect. In recent grasslands, the edge effect favors the maintenance of forest species. According to our findings, forest and grassland edges, most of which have moved in the past two centuries, are home to many forest and grassland plant specialist species, sometimes in extinction debt. A re-evaluation of the distribution of species within forest and grassland plant communities then seems necessary, taking into account both distance-to-edge and habitat history. In a context of increasing forests and grasslands instability, the identification of species experiencing extinction debt represents an opportunity for the conservation and restoration of plant biodiversity.

The devil is in the details: intraspecific variability and interspecific integration in trait-based models of plant communities

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Trait-based models of ecological communities are used increasingly because they promise greater generality, predictive power, and ability to scale between levels of organization. These models often assume that intraspecific variation in traits is negligible and a single value can be used to represent each species in the community. Yet, traits are likely to vary along environmental gradients. This variability is particularly problematic if it is associated with species cross-over (i.e. shifts in trait rankings among species). Trait-based models also aim to characterize the ecological strategies of species efficiently using the fewest but most critical traits. Yet the extent to which traits, and suites of traits associated with trait spectra, are correlated is not well established. We examined (1) the assumption that intraspecific variability can be ignored in the development of trait based models, and (2) the degree to which a suite of leaf, stem and root traits are integrated among 56 coexisting species in understory plant communities of coastal Douglas-fir forests in western Oregon, USA. Our results indicate that interspecific variability exceeds intraspecific variability for most but not all traits. While there was a lack of observable cross-over, traits varied along measured gradients in resources and environmental conditions. Our preliminary interspecific network analyses indicated a low degree of independence among integrated trait modules; central network traits characterized the leaf economics spectrum and rooting depth. Preliminary multivariate analyses identified three main axes of trait differentiation that explained 92.9% of species differences. The primary axis reflected plant size (e.g. plant height and rooting depth) and the secondary axis reflected leaf economic traits. The third axis separated species with large leaves from those with heavier seeds. Species groupings accounted for less than 50% of multivariate differences among species. In conclusion, trait-based models reduce entire communities to a single number, simplifying efforts to model effects of changes in environmental conditions on plant community composition and associated ecosystem functions and services. Intraspecific variability, often ignored, has the potential to introduce bias in trait-based models. However, the use of a single trait value to represent a species seems reasonable if investigators collect trait data from a standard set of conditions. Additionally, trait networks of forest understory species were highly integrated. However, rather than a single correlated dimension, trait-based models will benefit from information about plant size, leaf economics, and leaf size/seed mass.

Hydrological regime and climate interactively shape riparian vegetation composition along the Colorado River, Grand Canyon

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How closely do riparian plant communities track hydrological and climatic variation in space, and how do interactions among hydrological and climatic filters influence success of flow management strategies? Multi-year vegetation surveys were conducted along the Colorado River in Grand Canyon across three hydrological zones – active channel, active floodplain and inactive floodplain – within each of 42 sandbars that vary geographically in temperature and precipitation along a 400-km river segment. Ecological niche models were used to estimate locally optimal conditions of maximum inundation duration, elevation above daily peak flow, mean annual precipitation, and mean maximum and minimum temperature for 16 of the most abundant woody and 58 most abundant herbaceous plant species. These estimates were used to calculate community-weighted mean (CWM) environmental preferences, which were used to determine how closely vegetation preferences tracked local variation in environmental factors, and to assess interactive responses of species and communities to variation in hydrology and climate. Communities closely tracked hydrological variation across zones, but less so within zones. Communities tracked variation in minimum temperature more closely than maximum temperature or precipitation. At the species level, woody plants that were more abundant in wetter hydrological conditions were also more abundant in wetter climatic conditions, and vice versa. This relationship was even stronger at the community level, where there were significant negative relationships between CWM preferences of inundation duration and temperature for both woody and herbaceous vegetation. The climate-hydrology linkages found in this system suggest that increasing temperatures and drought are likely to reduce the inundation tolerance of riparian vegetation within the Grand Canyon. Increasing the duration of high flow events would likely reduce the abundance of encroaching woody vegetation, but could also reduce the resilience of remaining vegetation to heat waves and drought. The reinforcing effects of climatic and hydrological filters are likely to generally result in greater sensitivity of species composition to environmental change than if those environmental filters acted independently. These results have implications for predicting resource responses to environmental change, as well as prescriptions for direct vegetation management to enhance resilience.

Variation in leaf traits of Mediterranean shrub communities along a water-stress gradient

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Several studies have explored trait-environment relationships in different regions, but the Mediterranean region is still largely unexplored despite its relevance in the face of climate change and biodiversity conservation. Here, shrublands represent one of the most extended vegetation types, and field measurements of leaf traits related to water-use strategy [e.g. specific leaf area (SLA), and leaf area (LA)] are useful to interpret vegetation response under changing climatic conditions. We aimed to assess the changes in community weighted mean (CWM) values and relative variability of SLA and LA linked to different species assemblages in the NE-Sardinian study area (Italy). Furthermore, we explored the relative contribution of species turnover and intraspecific variation to shifts in CWM values along the gradient. Forty sampling units of 5 x 5 m were selected in a probabilistic way along a 1300 m elevation gradient which crossed four Thermotypes (T), representing differences in temperature and water stress, from the Limbara Massif and surrounding hilly areas to the Tyrrhenian coast. To observe differences in terms of species composition and abundance along the four Ts we performed a PERMANOVA test, while ANOVA and a trend test for monotonic changes in variance were used to assess respectively CWM variations and changes in both the leaf traits. Variance decomposition of CWM values was used to identify the role of inter- and intraspecific variation. Plant communities differ between Ts ($P < 0.05$ for all pairwise tests). Significant differences in CWM values of SLA were found between the two extremes of the gradient, with lower values in the driest T. CWM SLA variability showed a significant increasing trend with increased water availability. LA showed significant differences between T2 and T4, and T3 and T4 ($P < 0.05$), with the lowest mean values found at T4, while no significant trends in variability were detected along the gradient. Intraspecific trait variation was significant for both the leaf traits, but was higher for SLA with a relative contribution of 45% to the community-level response along the gradient, while the relative contribution of LA stands around 33%. Besides confirming that both the analyzed leaf traits converge in smaller and less variable community values at the arid end of the gradient, our results suggest that SLA and LA respond differently along the gradient, suggesting higher plasticity of SLA. Moreover, neglecting intraspecific variation in leaf traits along gradients in Mediterranean contexts can result in underestimating the response of communities to environmental changes.

Advances in geobotany and new tools in biogeographic maps: Sierra de Guadarrama National Park, Spain

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Dynamic catenal studies are becoming increasingly important tools in vegetation science. Our main goal is to establish the basis for separating biogeographical units of lower level (districts and countries), and to ascertain biogeographical boundaries, using synphytosociological criteria in addition to bioclimatic and floristic data and soils. For the vegetation series study we used dynamic-integrated phytosociology procedures, where the basic unit is the sigmetum. The sigmetum expresses the whole set of plant communities or stages which can be found within similar teselar spaces as a result of the succession process, and includes both the representative association of the mature stage or series head, which is used as a nomenclatural reference, and the initial or subserial associations that may replace it. The vegetation geoseries or geosigmetum is the basic unit of dynamic-catenal phytosociology. It corresponds to a catena of vegetation series which is found around a given bioclimatic belt and biogeographic territory in the heart of the universal crest-slope-valley model. The vegetation geopermaseries, also known as geopermasigmeta, is the catenal expression of a set of neighboring permaseries or permasigmeta, delimited by changing topographic or soil situations. The biogeographic country is an important biogeographical level unit characterized by its correspondent landscape cells as well as a group of bioindicators (species and plant communities). The district is a very big group of biogeographic countries made independent by the existence of a lot of differential species, associations, series and geoseries which are absent in nearby districts. The biogeographic typology units of highest rank are the sector, the province and the region. The Sierra de Guadarrama (Central System) is a mountain range in the center of the Iberian Peninsula. The National Park was created through the 25th June 7/2013 law. It occupies 96,847 ha of forest, woodland and supratimberline cryophilous natural vegetation, as well as, seral and mantle shrublands, grassland and meadow vegetation, among others. The difference in altitude ranges from 950 m south of La Pedriza to 2428 m on the Peñalara summit. We recognize in Sierra de Guadarrama National Park a total of 8 homogeneous spaces (countries), included in other larger spaces (2 districts, 2 sectors and 2 biogeographic provinces), which shape the biogeographic typology of the territory. The recognition of homogeneous territories is an essential tool for the management of the National Park.

Human-induced land degradation and biodiversity of karst landscape: the example of karst depressions (dolines)

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In the karst landscape of Kras Plateau (SW Slovenia), we studied the impact of historic human-induced land degradation on biodiversity by studying the characteristics and changes in vegetation of degraded and non-degraded karst depressions (dolines). Intensive human-induced land degradation began as a consequence of the abandonment of traditional land use, thus many dolines have disappeared by being completely filled with waste material and overgrown. The study is based on a chronosequence approach and assesses whether vegetation (e.g. community succession stages) can be used as a bioindicator of land degradation to estimate approximately the duration of degradation on the basis of the stage of succession. The locations and duration of degradation of dolines were identified in advance by analyzing a time series of aerial photographs, topographical maps and digital elevation models. Ecological evaluation was based on sampling the floristic composition and the top soil. In this study, three vegetation measures were established as indicative of degradation: (1) the appearance of ruderal species, (2) hemeroby and (3) alien and invasive species. A succession model of degraded karst landscape was produced based on identified chronosequences to assess the long-term spatial impact of doline degradation on karst biodiversity. The model is showing the tendency towards the vegetation homogenization of karst landscape.

Drought and biotic interactions influence species-specific responses

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Plant communities are structured by abiotic factors (resource availability) and biotic interactions (competition). In temperate grasslands, where soil moisture is the primary driver of plant community structure, changes in precipitation can alter plant performance (productivity). Under drought, plant species with water-use efficiency should outcompete those that lack such a strategy. Consequently, relative competitive ability of a plant may be used to predict its abundance in a plant community. We tested drought effects (160 mL water/week, half of the control) on temperate prairie graminoids growing in a pairwise treatment interaction that included: alone (single individual in a pot), intra-specific (two individuals of the same species) and interspecific (two individuals of different species). The species were selected from an existing field experiment undergoing drought conditions: C3 grasses (*Dichanthelium oligosanthes*) and C4 grasses (*Bothriochloa ischaemum*, *Schizachyrium scoparium*, *Sorghastrum nutans*); C4 species are known to have better water use efficiency under drought stress. We measured plant traits (photosynthesis, specific leaf area [SLA] and leaf dry matter content [LDMC]) as predictors of plant strategies to environmental factors and plant biomass (overall performance). Drought, not pairwise interactions, affected biomass across species ($P = 0.0049$). Contrary to expectation, drought promoted biomass driven by the response of *S. nutans* (drought: 5.48±1.44 g, control: 2.21±1.45 g, $P = 0.0003$). Conversely, intra-specific pairwise interaction lowered *D. oligosanthes* biomass relative to when grown alone and interspecifically ($P = 0.0028$). Likewise, interspecific interaction promoted performance of *S. scoparium* ($P = 0.0371$). Species growing alone had higher SLA compared to intra-specific and interspecific; whereas mean LDMC was 0.29 $mg.g^{-1}$ for all types of interactions, 0.30±0.17 $mg.g^{-1}$ for control and 0.27±0.09 $mg.g^{-1}$ for drought treatments. Notably, *S. scoparium* SLA (> 313) was higher compared to other species. None of the photosynthetic traits significantly changed with the treatments ($P > 0.05$). Taken together, altered abiotic factors significantly affected overall plant performance, but at the species-level, pairwise interactions also played an important role in shaping plant performance. While *S. nutans* strongly responded to drought by producing more biomass; intraspecific pairwise interactions seem to negatively impact species-specific responses relative to inter-specific or no interactions. Surprisingly, physiological and functional traits did not relate to plant performance in response to drought and pairwise treatments. This experiment allows us to determine the underlying processes (biotic vs. abiotic) driving the responses we observe in the field. Furthermore, pairwise interactions can predict the abundance of species in more complex communities, since species identity and performance can influence the trajectory of the systems in response to drought. Finally, changes at the individual level can scale up to influence the structure and function of terrestrial communities.

Fitting plant community mechanistic models to empirical data through functional traits

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In the field of biodiversity modeling, mechanistic models have been recently advocated as responses to the conceptual and practical limitations of correlative approaches (such as species distribution models). In particular, the inclusion of biotic interactions is still a challenge that has yet to be solved to construct biodiversity modeling frameworks that provide reliable predictions at small spatial scale. Ecological theory has produced multiple models that could be used for that purpose: scientists have used them extensively to demonstrate theoretical properties of communities and to provide insights into the causes of biodiversity structure. However because they often include a large number of parameters, they can only be calibrated on empirical data provided by simplified experimental settings, thus strongly limiting their use for wide scale biodiversity modeling projects. Here we propose a way forward by presenting a modeling framework that uses functional trait data as an a priori constraint to estimate the parameters of a community model. Our approach uses a transfer function between the empirical functional traits and species phenomenological parameters in the model. The transfer function is then calibrated to maximize the fit to empirical species abundance data using distribution sampling algorithms (MCMC). We demonstrate our approach on a dataset of 22 plant communities spread along an elevation gradient in the French Alps. Traits for 148 species (Height, SLA, LDMC, LNC, LCC, leaf δ13C and leaf δ15N) were sampled on site to construct the species trait space. Species abundances were estimated using pin contacts. We used a simplified Lotka-Volterra model of competition to predict species abundances: the model includes a temperature-dependent growth function and plant sensitivity to competition. We show that the calibrated transfer function suggests links between phenomenological model parameters and functional traits that conform to expectations: for instance, a positive relationship between species growth rate and Height. The model further reproduced well species turnover along the elevation gradient. We conclude that our framework outlines a flexible methodology to efficiently calibrate mechanistic models on species-rich systems through the use of functional trait data.

The shifting extent and surprising mutualism of an invasive dune stabilizer post-Hurricane Sandy along the mid-Atlantic coast of the USA

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When storms impact coastal areas, high winds can denude once vegetated dunes, thereby opening up previously colonized habitats for recolonization. The plant species that recolonizes an area can have a multitude of implications with regards to plant-soil feedbacks, habitat structure, dune topography, and dune stability related to erosion. Only a handful of plant species worldwide can survive and thrive in the foredune, the first dune mound closest to the ocean and thus the first line of defense during storms. Despite their stressful abiotic conditions, foredunes and other habitats within the dune system are not immune to the effects of invasive species. Along the mid-Atlantic coast of the USA, invasive Asiatic Sand Sedge (*Carex kobomugi*) has been a prominent species on dunes since its introduction to the US from Asia in 1929 at Island Beach State Park, New Jersey. It has since spread along the coastline from Massachusetts to North Carolina, outcompeting native American Beachgrass (*Ammophila breviligulata*). We have been following *C. kobomugi* stand expanses at Island Beach State Park, since Hurricane Sandy, October 2012 by mapping the population extent along 3 km of foredunes with a Trimble GeoXT GeoExplorer. Similarly, we have been mapping the changing expanse of the denuded wind hollows, bowls, created by Sandy. We are observing both invasive stand expansion and reduction and can examine colonization in areas where the invasive must outcompete *A. breviligualta* for space vs. into plant barren bowls. Lastly, we collected spatially referenced root and soil samples from both *A. breviligulata* and *C. kobomugi* within the foredune. We stained the roots with trypan blue and used the root intersect method to examine colonization of the field roots as well as of sorghum roots used for mean inoculation potential assays conducted with the soil. We found that *C. kobomugi*, a species considered non- or facultatively-mycorrhizal, is actually well colonized, as much so as *A. breviligulata*, which is mycorrhizal dependent; similarly, the soil of invasive stands contained mycorrhizal propagules. These results shine a hopeful light on the potential for the natural reclamation of invaded expanses by natives as a result of obligate mutualistic fungal partners being ubiquitous in vegetated expanses. Understanding the factors underpinning species distributions is important for predicting how these habitats will change over time, this is especially important in coastal dunes, where localized distribution shifts have real biogeomorphic implications for storm response and recovery.

Dynamics of forest composition and growth in Alabama, USA under human activities and climate fluctuation

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Integrated analysis of forest dynamics under both anthropogenic influence and climatic change is crucial to meeting objectives of climate change mitigation. In this study, the dynamics of forest composition and growth in Alabama, USA was studied in relation to human activities and climate fluctuation during the last several decades. The results indicated that the species (or species group, hereafter) composition in Alabama's forests was significantly different between all reported times except from 2012 and 2015 based on Simpson's index. Eastern hemlock trees declined dramatically. Positive or negative correlation existed in abundance among some species. The overall forest communities appeared to be less homogenous. The distribution of tree abundance along diameters for tree species followed exponential models. Both annual tree mortality and net growth rate across increased from the 1960s. The total volume of growing stock increased from 14.4 million cubic feet in 1963 to 39.5 million cubic feet in 2016. The average volume of growing stock per acre also increased linearly with annual average air temperature, but not with annual precipitation. Based on the responses of Alabama's forests under climate fluctuation and human activities, some suggestions on developing strategies for the sustainability of Alabama forest were discussed.

Estimation of large-scale species richness by integrating sample-based with purposive data

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Estimating the number of species in a whole community or even large ecosystem is one of the basic questions in ecology. Species richness can be assessed through purposive surveys or sample-based incidence data, with the latter eventually combined with estimator methods such as the non-parametric ones. Despite their interest, there is no general consensus on species richness estimators, because of their underlying assumptions. We recently introduced a new method to estimate total species richness, that uses of the list of species obtained by purposive sampling to improve the sample-based estimations of species richness. The new estimator, named SPEED (SPEcies richness Estimator based on Difference), exploits the combined information coming from purposive list of species and sample-based incidence data. In particular, the presence of species in the purposive list is exploited to correct the sample-based estimator, as customary in the difference estimator, while incidence data are used to estimate the species inclusion probabilities. If the purposive list used to support the estimation is complete the estimator guesses the true species richness without error. Moreover, contrary to the non-parametric estimators, SPEED estimator provides values invariably greater than the number of species detected by the combination of sample-based and purposive surveys. An asymptotically conservative estimator of the mean squared error is also provided. A simulation study based on two artificial populations is carried out to check the performance of the SPEED estimator with respect to the familiar nonparametric estimators. Finally, the proposed estimator is adopted to estimate species richness in some field based case studies.

Richness estimation in the presence of species identification error

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Species richness is widely used as a biodiversity index since it is an intuitively understandable ecological concept and is very simple in form. However, complete species inventories are almost unattainable goals. Therefore, the observed richness in the sample always underestimates the true species richness of the assemblage. The approaches of species richness estimation are extensively discussed in the literature. Among them, the nonparametric methods, including the first order Jackknife approach, second order jackknife approach, and Chao1 lower bound estimator, are widely used in practical application. They all use the observed rare species in the sample (i.e. singletons and doubletons) to estimate the unseen richness in the sample. Besides, species identification error could be another big problem in estimating species richness. Species identification error includes overlooking error (i.e. recorded species not present) and misidentification error (i.e. species is not correctly identified), which are caused by characteristics of vegetation and personal bias of investigators. However, this type of error is often ignored in the literature even though it may lead to seriously problematic conclusions. Based on our simulation study, the observed richness will be more seriously underestimated with increasing misidentification error rate. In this study, we propose a new method to correct the bias in estimating species richness caused by species misidentification error. To estimate the species misidentification error rate, a few small subplots were randomly sampled from the target region, and each subplot was independently re-censused within a short period of time by different field teams or observers. When the misidentification error rate of each species is assumed from a random distribution with a mean e, we theoretically prove that the mean species misidentification error rate e can be derived based on the ratio of pooled observed richness and the mean observed richness of different investigators. Meanwhile, its variance estimator can be estimated by the bootstrapping approach. For the integrated sample of the interested region collected by these different field teams or observers, the observed species richness, singleton richness and doubleton richness of this integrated sample can be corrected with the estimated error rate. Therefore, the unseen richness in the sample can be estimated by using the adjusted singleton and doubletons based on nonparametric richness estimation approaches, and the species richness of the interested region can be obtained by the corrected observed richness plus the unseen richness estimate. In the simulation study, the new proposed estimator can significantly reduce the bias induced by species identification error in many widely used species composition models (e.g. Log-Normal, Broken-Stick, Random Uniform, and Log-Series) with different mean species misidentification error rate.

Plant dispersal strategies: a new classification based on multiple dispersal modes of individual species (and a new online database)

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The diaspores of vascular plants are transported by vectors from which the dispersal modes are inferred, such as anemochory as a spread by wind. Traditionally, each species was being assigned a single dispersal mode, based on the morphology of its diaspore; for example the presence of pappus indicated anemochory. Here we present a different approach to plant dispersal, based on the fact that plant species are spread by multiple vectors that differ in terms of how frequently they are employed and how efficiently they work. The combinations of dispersal modes are repeated in species with similar ecology and diaspore morphology. For example, for species from wetland and riparian habitats (e.g. those from the genera *Phragmites*, *Typha* or *Salix*) possessing very small seed with hairy flying apparatus, the dispersal by both wind and water is important, but the seed can also attach to animal fur or human clothes and a portion of seeds fall off close to the parental plant. Even such less common dispersal modes contribute to species' spread and cannot be disregarded. To characterize such repeatedly occurring combinations of dispersal modes, acting with different frequencies, we propose the concept of 'dispersal strategies'. We tested this approach by using the flora of the Czech Republic. The data on the type and morphology of above-ground diaspores and on dispersal modes of plant species were taken from the literature sources and available databases, and completed by expert knowledge. We describe nine dispersal strategies that are defined by the combinations of dispersal modes and their relative importances, and named after representative genera: Allium, Bidens, Cornus, Epilobium, Lycopodium, Phragmites, Sparganium, Wolffia and Zea. The Allium strategy is the commonest in the Czech flora, despite being least specialized, hence seemingly poorly equipped for successful dispersal. This indicates that morphological adaptations to dispersal by natural vectors might be less important for plants than previously thought. We related these strategies to vegetation types of the Czech Republic and found a remarkable non-random pattern. Some applications of this new concept of dispersal strategies in vegetation research are presented. The new database of plant dispersal strategies for 3,163 taxa of vascular plants is a part of the new online PLADIAS Database of the Czech Flora and Vegetation, which contains data on species distribution, traits and role in different vegetation types (www.pladias.cz).

Ecological site descriptions of the Carolina-Georgia sandhills

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Ecological site descriptions (ESDs) are documents that are composed of site concepts, with State and Transition models which illustrate relic, successional vegetation trends, and provide information with interpretations on ways to manage and restore ecological communities. They serve as a repository of relevant information to identify conservation challenges, implement solutions, and evaluate progress in an increasingly complex and rapidly changing environment. These efforts have facilitated interactions with resource planners and landowners, in particular with regards to conservation programs supported by the 2014 Farm Bill. NatureServe and the US Department of Agriculture (USDA) fostered a partnership to develop Ecological Site Descriptions (ESDs) in the North Carolina-Georgia Sandhills, a special region which supports the imperiled longleaf pine ecosystem. NatureServe is a network connecting science with conservation, and is a leading source of information about the rare species and vegetation of North America. The USDA has technical expertise in soil science, and the productive capabilities of the lands of the United States. For this effort, six sets of descriptions were developed, representing most of the lands of the North Carolina Sandhills. Here we present the overall effort, and focus on one ESD, for Xeric Sandhill Scrub.

Are rural hedgerows effective corridors for forest plant species? Yes, but this is a matter of time and spatial connectedness!

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As linear wooded stripes, hedgerows are often considered as potential ecological corridors between forest patches across many landscapes. However, whether hedgerows are suitable habitats for forest plant species and effectively act as corridors is still questioned. Here we ask whether time can be the key, that is whether the more ancient a hedgerow (i.e. the longer it has continuously existed, irrespective to the age of constituting woody plants), the more likely it (1) hosts forest plant species and (2) serves as corridor for these species when connected to forest patches. To answer these questions, we assembled a chronosequence of 99 hedgerows, spanning a time period of more than 300 years, in rural landscapes from North France. Each hedgerow was intensively surveyed for vascular plant species (occurrence data) and a set of descriptors was recorded: length (m), width (m), height (m), connection to a forest (0/1), distance to the nearest forest (m), cumulated forest cover in a 500 m-radius around the focal hedgerow (m^2), adjacent land use on both sides (path, grassland, cropland). We used linear regression models to assess the effect of hedgerow age on plant species richness while controlling for the potential confounding variables mentioned above and their interaction whenever relevant. To further assess whether the response to hedgerow features is species-specific and can be predicted from plant traits, we used a subset of 29 hedgerows for which vegetation was recorded into each 5m-long segment. We used logistic regression to analyze the response (presence/absence) of forest generalists and forest specialists to hedgerow age and connectedness. We found that species richness tended to increase linearly with hedgerow age, all else being equal, confirming that ancient hedgerows are more suitable habitats for forest species than recent ones. The rate of forest species accumulation averaged three species per century. Interestingly, hedgerows that were connected to a forest patch hosted eleven species more on average than isolated hedgerows. Among other factors, a low intensity of adjacent land uses, a high height and, to a lesser degree, a large width, of hedgerows had a significant positive effect on species richness. The effects of time and connection to forest were disproportionately higher for dispersal-limited forest specialists than for forest generalists, revealing that ancient hedgerows are effective corridors for ancient forest species. We thus conclude that the conservation of the most ancient hedgerows and of their structural integrity should be a priority target.

Evolution of flower color polymorphisms in sunbird-pollinated Erica (Ericaceae)

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Diverse pollinators are often implicated as drivers of floral diversity and speciation. The guild of bird-pollinated *Erica* species (Ericaceae) in the fynbos biome, however, stand out in having high flower color variation within species, despite all being pollinated by the biome-endemic Orange-breasted Sunbird *Anthobaphes violacea* (Nectariniidae). Almost half of these species are flower color polymorphic and similarly colored species often co-occur and co-flower. We investigated whether flower color diversity was driven by color mimicry or divergence within communities. Flower color and morphology and pollinator visitation rates were sampled in ten communities of bird-pollinated *Erica* species in the south western tip of South Africa. Flowering phenology was recorded in three of these communities. The less-preferred species of each community (which had the lowest visitation rate) had significantly higher pollinator visitation rates when their flower colors were more similar to the preferred species in the community. We propose that color similarity encourages sunbirds to forage randomly with respect to species, which likely benefits less-preferred species but could result in fitness costs due to interspecific pollen transfer. We quantified the probability of interspecific pollen transfer between species pairs as the differences between their anther and stigma lengths (flower morphological overlap). We found that color differences between co-occurring species were greater in species pairs with high flower morphological overlap, particularly for polymorphic species and when flower phenological overlap was high. Species pairs with similar flower morphologies are thus under greater selection to diverge in flower color in order to promote assortative foraging (flower constancy) by sunbirds. This points to the possibility that color and other morphological polymorphisms may be the result of a combination of mimicry and competitive interactions.

The use of ash to restore grasslands invaded by spotted knapweed

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Grasslands provide many ecological benefits and ecosystem services in British Columbia; however, the spread of invasive species puts this already endangered ecosystem more at risk. Spotted knapweed (*Centaurea stoebe*) is one such invasive forb that has managed to spread to most parts of North America in a little over a century. Armed with a deep taproot and an innate ability to produce an incredible amount of seed, *C. stoebe* is a top invader in BC's grasslands. Furthermore, this plant is suspected to be allelopathic where it may release inhibitory chemicals through its roots into the soils which prevents the growth of native grassland plants. These can accumulate over time in heavily invaded areas leaving a legacy effect behind. In other words, native vegetation still experiences suppression in the physical absence of *C. stoebe*. Controlled experiments in the past have used a material known as activated carbon (AC) to adsorb the allelopathic compounds in the soil, making the environment more hospitable to native plants. While it may be used in a laboratory or greenhouse setting for experiment purposes, laboratory grade AC remains expensive and thus not applicable in a field setting. Pulp mill fly ash, on the other hand, has an AC component to it and is much more attainable. Two major questions emerged: (1) can we detect soil legacy effects from *C. stoebe*? And, (2) can we use ash as a restoration tool for grasslands invaded by *C. stoebe*? Soils were collected from both invaded and pristine sites, where each soil type received 3 treatments: control (no amendment), AC, or ash. Rough fescue (*Festuca campestris*) and *C. stoebe* were planted in each soil treatment to test how well the ash works in comparison to the laboratory grade AC, and in comparison to a field condition. Height and biomass data will be collected in March 2018. By addressing this mode of invasion by *C. stoebe*, we further our understanding of the invasive weed and how to best overcome its spread.

Continent-scale landscape conservation design for temperate grasslands of the Great Plains and Chihuahuan Desert

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In support of natural resource agencies in Canada, the USA, and Mexico, we report on a series of component analyses and an updated Landscape Conservation Design for temperate grassland conservation. We targeted twelve major grassland ecosystem types that occur across the Great Plains and Chihuahuan Desert regions. Component analyses included: (1) documenting long-term trends in extent by grassland type, (2) identifying species of concern associated with the major grassland types, (3) documenting current protected areas including each grassland type, (4) assessing landscape intactness and connectivity among grassland areas, and (5) identifying Grassland Potential Conservation Areas to advance grassland conservation. Most severe declines in grassland extent have occurred in tallgrass prairie types, followed by mixed-grass, shortgrass, and semi-desert grasslands. Similar trends by type were documented for landscape intactness and connectivity. Some 174 species of vertebrates, invertebrates, and plants considered by NatureServe as critically imperiled, imperiled, or vulnerable, are strongly associated with these grassland types, and 103 are listed under protective legislation in one or more country. Just 1.2% of historic extent for all types combined is currently found within designated protected areas. A total of 177 Grassland Potential Conservation Areas (GPCAs) were identified to represent grassland type diversity in areas least likely to conflict with other land uses. Within identified GPCAs, type-specific representation varied from a low of just 1% of historic extent for Texas Blackland Tallgrass Prairie to a high of 27% for Western Great Plains Sand Prairie. Combined across all twelve grassland types, 15% of historic extent is represented.

Forest in freefall: 50-years of demography and spatial interactions in the southern boreal forest

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Variation in tree recruitment, mortality, and growth can fundamentally alter the community composition of a stand and the ways in which tree species interact. Individual recruitment and mortality events are generally infrequent, and long-time scales are needed to understand trends in forests. However, long-term datasets are specifically lacking for the southern boreal forest transition zone, a region experiencing unprecedented forest die-back in response to recent severe droughts. To address this gap, we completed a 50-year demographic and spatial analysis on a forest plot located within the aspen parkland, the ecotone between boreal forest and Canadian prairies. All stems were censused and mapped in a 1.4 ha forest plot in 1967, 1977, 1988, 1997, and 2017. Increment cores from the dominant species were used to reconstruct disturbance history and continuous growth records from 1925 – 2017. Spatial patterns were assessed for conspecific and heterospecific negative density dependence. Patterns of recruitment were analyzed to identify patterns of density dependence around mature trees. Further, demographic and spatial patterns were compared for significant differences across census intervals. Here, we show that the last 30 years have seen a collapse in biomass, basal area, growth, and recruitment along with a precipitous rise in mortality across the dominant tree species. The combined effects of facilitation, competition, and density-dependent mortality resulted in near-spatial equilibrium over the lifetime of the stand. However, among decades, the strength and direction of these demographic and spatial processes varied in response with time and disturbance severity. Additionally, the stand experienced periods of drought in combination with multiple defoliation events by forest tent caterpillar (*Malacosoma disstria*) and spruce beetle (*Dendroctonus rufipennis*), an insect novel to this region. These insect disturbances interacted to strongly influence mortality rates within the stand and decrease stand density. Taken together, our results indicate that endogenous factors can strongly influence stand dynamics late in succession. Moreover, the interaction of endogenous and exogeneous factors may shift forest ecotones in this region onto a novel successional trajectory.

Development and application of herbaceous- and shrub-dominated existing vegetation classification for the Middle Rocky Mountain Steppe ecological province

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We classified existing herbaceous and shrub-dominated vegetation on National Forest lands in the Middle and Southern Rocky Mountain Steppe and Great Plains-Palouse Dry Steppe Ecological Provinces in Montana and northeastern South Dakota. This classification is the first of its kind in the Forest Service Northern Region and is needed for the Forest Service Region-wide existing vegetation mapping, for assignment of inventory point data to specific vegetation communities, and for large- and small-scale habitat assessment and project planning. Using plant species canopy cover, elevation, aspect, slope, and general location from legacy plot data we developed the classification over three phases: (1) assignment of plots to dominance types based on absolute cover of selected indicator species; (2) division of plots through the results of the Optpart package in R; and, (3) refinement of Optpart community type groups into community types based on key species cover and expert knowledge of ecological provinces. Once community types were finalized, they were grouped into dominance type groups (DTGs) for use in mapping and inventory. We found that problems in the first two phases of classification development necessitated the third phase. Creation of true dominance types based solely on absolute canopy cover of indicator species resulted in far too many types to be useful for management or mapping, especially given the small scale of mapping. There was no ideal solution in numerical analysis that provided us with usable community types without some manual refinement. Our dominance type group classification has been used to classify Northern Region inventory plots. Subsequently, where these inventory points intersect the Region-wide existing vegetation herbaceous- and shrub-dominated map polygons, the map units have been refined from broad vegetation types. For example, “Dry Shrub” can be refined to one of 11 DTGs, such as Big Sagebrush Steppe DTG or Juniper-Skunkbrush-Yucca DTG. More refined non-forested vegetation mapping is vital for habitat planning for grassland and shrubland dependent wildlife species (e.g. sage-grouse). In addition, our community types will provide much-needed consistency in the description of vegetation composition for different plant community phases within states of defined Natural Resource Conservation Service “Ecological Site Descriptions” (ESDs). This will add value to ESDs, particularly in sage-grouse habitat.

Re-wilding forests in Central Europe: the dilemma of wildness and naturalness

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Central European landscapes are to a large extent shaped by long-term human interventions. At present, re-wilding forests, i.e. setting aside forest stands from active management in order to allow natural processes to predominate, has become a main conservation concept. The German National Strategy on Biodiversity aims at 5% of the forests and 2% of the terrestrial area to be set aside from human interventions. However, wildness (= uncontrolled, free from human intervention) and naturalness (= native, aboriginal, indigenous) are two related but independent aspects of wilderness. Prospective wilderness areas may contain a large variety of novel, semi-natural and natural forests, and thus may not meet the primeval character traditionally expected from wilderness. The German Natural Heritage comprises c. 55,000 ha of forests that are or will be released from management in the foreseeable future. We explore, which attributes of forest structure, composition and ecosystem functioning can serve as benchmarks for their naturalness. Our supra-regional study is based on 16 lowland forest clusters that span an Atlantic-continental transect of 600 km. Each cluster contains three forest stands: a pine plantation, a near-natural beech, oak or oak-pine-mixed forest, and a hybrid stage. Supposing that these three forest types represent a naturalness gradient, we compare them based on a large data set derived from our permanent plot surveys, including forest structure (tree layers, dead wood, carbon stores), functional characteristics (productivity, regeneration patterns) and synecological data on the tree species, vascular plants of the herb layer, fungi, saproxylic beetles and bird guilds. We define structural, functional and biodiversity old-growth forest attributes, and we discuss the suitability of these attributes for evaluating forest naturalness. However, there is the risk of promoting novel ecosystems in wilderness areas. Using additional results from a large forest restoration experiment, we hence discuss which restoration measures might promote naturalness in even-aged pine forest before releasing them from management.

Exploring the drivers of the latitudinal diversity gradient of vascular plants in North America across scales

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The latitudinal diversity gradient (LDG), that is, the increase in number of species towards the equator and decrease towards the poles, is one of the most widely recognized patterns in biogeography and ecology. This LDG can present multiple underlying causes, which can be grouped into three distinct, but not necessarily competing, explanations. The historical-evolutionary hypothesis states that the pattern we observe today results from diversification taken place over long time periods within large areas, driven by past climate conditions and glaciations, for example. According to the local determinism hypothesis, local habitats and environmental conditions shape species interactions within populations and communities, ultimately controlling the outcome of diversity at broader scales. Lastly, the energy hypothesis, which is also related to climate, says that productivity of an area (measured through evapotranspiration, for example) will determine how many individuals that habitat will support and that the physiological tolerance of organisms for low energy environments limits the number of species. The aim of this study is to sort out and, possibly, reconcile these different explanations through scale. For that, we analyzed data from 1800 floras from North America north of Mexico (a subset of the FloraS of North America Project) along with positional, climatic and environmental variables related to the three main explanations for the LDG. We developed models to assess their relative effects on vascular plant species richness at four different spatial scales. Preliminary results indicate that productivity-related variables are the most influential, followed by terrain variables (related to the local determinism hypothesis), current climatic conditions and a measure of the extent of the last glacial maximum (historical-evolutionary). The results are moderately consistent across the three spatial scales analyzed so far and the relative influence of variables is subtle. To this point, we observed that the different forces driving the LDG are not easily disentangled, suggesting that the pattern is generated and maintained through complementary mechanisms.

Four decades of beech-spruce interactions in a Central European old-growth mountain forest: who succeeds on which soils and how?

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European beech (*Fagus sylvatica*) and Norway spruce (*Picea abies*) are the two most important tree species of Central European submontane and montane regions. The species share large part of their ecological niches and often grow together. However, they also differ significantly in some respects, such as demands for nutrients, water and light, tolerance to certain stressing factors or the way they influence their environment. Recently, an expansion of beech has been observed across Europe. We aimed to study this expansion in an old-growth mountain beech-spruce forest with exceptional soil diversity, focusing mainly on how the expansion and its drivers vary between different soils. We analyzed a spatially and temporally extensive dataset from the Boubín Virgin Forest, one of the oldest forest reserves in Europe, whose 46 ha core zone has never been cut. All living and dead trees (diameter ≥ 10 cm) in the core zone were censused in 1972, 1996 and 2010, each time recording several tree characteristics, including exact position, species identity and diameter. Data on more than 16,000 tree individuals recorded during the 38 years were combined with an extensive soil survey carried out on 950 points regularly covering the forest. Among seven soil groups identified during the survey we distinguished two main gradients: water influence (hydromorphism) and degree of weathering and leaching (podzolization). We studied how the ratio between beech and spruce differs between soils and what drivers of population dynamics are responsible for temporal changes in the ratio. As expected, spatial distribution of populations of the two species reflected primarily the gradient of soil hydromorphism with beech and spruce dominating drier and wetter soils, respectively. A significant differentiation was observed also along the gradient of podzolization where spruce was more common on most and least leached soils while beech occupied soils in the middle of the gradient. During the 38 years beech expanded on all major soils, yet the important drivers differed. The only driver acting in favor of spruce was species-specific growth on certain terrestrial soils. However, its effect was weaker than the effect of drivers that prioritized beech, comprising mainly tree mortality. Fine-scale mortality (deaths of individual trees) was more significant on terrestrial soils while the effect coarse-scale mortality (deaths from a single severe windstorm event) increased towards hydromorphic soils. Beech was also more common in recruitment and strongly outnumbered spruce in regeneration on all but the wettest soils.

Accounting for directional trends in species synchrony through time: problems and solutions

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Changes and fluctuations in the environment cause variation in different components of community structure and functioning. What determines the stability of communities under such fluctuations remains one of most debated questions in ecology, but scholars agree that the similarity in the temporal fluctuations between species is a key determinant of stability. Synchrony in species' fluctuations describes the degree to which the abundances of species in an ecological community covary positively though time. Concordant fluctuations of species abundances through time (synchrony) decrease stability while discordant fluctuations (asynchrony) stabilize communities. Researchers have interpreted the community-wide degree of synchrony in temporal fluctuations as the outcome of different underlying processes (concordant or discordant species response to environmental fluctuations and species competitive replacements), with studies showing a general predominance of synchrony over asynchrony. However, it is unclear to which extent existing measures can actually capture the signal of species fluctuations in the presence of directional trends in species composition. For instance vegetation can directionally change in response to changes in land use (e.g. fertilization, ceasing of grazing, succession) and climate change (nutrient deposition, global warming etc.). It is reasonable to expect that directional trends in species composition can cause a general increase of synchrony (i.e. increased positive correlation between species) as species that similarly increase or decrease over time will appear as correlated, even if they fluctuate discordantly from year-to-year. Therefore, trends in species composition could mask potential year-to-year asynchrony between species. The opposite trend, though, is also conceivable. We propose two solutions for testing and overcoming the effect of trends in species composition by modifying the way existing measures of synchrony are computed. The first approach is based on three terms local variance, i.e. computing synchrony over 3 years-wide movable windows. The second is based on computing synchrony over the residuals of fitted species trends over time. We discuss these methods using simulations and data from real plant communities sampled over 16 years, discussing when one approach can be preferred over the other. Results show that correcting for temporal trends is feasible and necessary to evaluate the extent of year-to-year fluctuations in natural communities.

Naturalness and habitat pattern of sand, loess and floodplain landscapes of Csongrád county (southeast Hungary) on the basis of habitat maps with different scale

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In Hungary the state of vegetation and its pattern is studied with the help of the habitat categories of Hungary's General National Habitat Classification System (ÁNÉR), (Bölöni et al. 2011) and Natura 2000 habitats as well as the categories of naturalness due to Németh-Seregélyes. The national system describes the vegetation-pattern in detail as Natura 2000 system contains categories just for the most valuable natural habitats. Naturalness due to Németh-Seregélyes is a five grade system. Best (5) grade is given to the most ancient-looking habitats with no weeds or adventive species. Those communities which don't contain rare, special, protected species, but are in natural state due to their species composition receive a good (4) value. Weedier habitats containing some main characteristic species of natural communities represent the medium (3) state. Weak (2) grade is given to weed communities which may contain adventive species, while artificial habitats (arable lands, settlements, establishments) and stocks of non-native species are awarded with worst (1) grade. The criteria for each habitat are defined in the book: Habitats of Hungary. The habitat-pattern and naturalness of Csongrád county are described in this work on local level with 1:4000 scale polygonal maps whereas on landscape level with raster maps of MÉTA (Landscape Ecological Vegetation Database & Map of Hungary) using 35-ha sized hexagonal sample units. The most natural-looking habitats with 4-5 grade cover 5.4% of Csongrád. Only 8 % of these can be sorted into the most valuable category (5), and half of them belong to the most salty habitats (annual salt pioneer and *Puccinellia* swards) of this landscape. A total of 58% of the more natural areas have good (4) naturalness (mainly *Achillea* steppes, *Artemisia* salt steppes, reed-beds with 8-10%, sand steppe grasslands, *Molina* meadows and riverine willow-poplar forests with 4-6% share are the most common habitats in this category), whereas 1/3 of them are in a transitional state between these two classes (40 % are salt meadows, but *Artemisia* salt steppes, *Puccinellia* swards and riverine willow-poplar forests have also a remarkable around 10 % share). Sand landscapes contain natural habitats in dune areas and in the closure of temporarily inundated deflation depressions. Floodplains contain natural habitats mainly inside the dykes due to the remaining willow-poplar forests and mesotrophic wet meadows. On loess covered alluvial cones salt berm vegetation represents high naturalness, where loess vegetation remained just mainly in their closure as well as on kurgans and verges.

Plant dispersal in agricultural landscapes: the role of landscape and habitat filters in shaping species composition of isolated grasslands

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Landscape and habitat filters are major drivers which can influence plant species composition of terrestrial habitat islands. In our study we assessed the effects of landscape and habitat filters on the species richness, abundance and trait composition of grassland specialist plants in small habitat islands. We studied traits related to functional spatial connectivity (dispersal ability by wind and animals) and temporal connectivity (clonality and persistent seed bank) using model selection techniques. We sampled grassland specialist plants, landscape filters (level of local and regional isolation) and habitat filters (slope, woody encroachment and disturbance) in 82 grassland islands in Hungary, Central-Europe. We found that isolation decreased the abundance of good dispersers due to the lack of directional vectors transferring seeds between suitable habitat patches. Persistence by clonal reproduction was an effective strategy in small habitat islands, whilst persistent seed bank did not support the survival of specialist species in the studied habitat islands. We found that clonal plants could cope well with increasing woody encroachment due to their high resistance against environmental changes; however, they could not cope with high disturbance. Steep slopes which provided favorable dry habitat conditions and environmental heterogeneity for specialist plants had an overall positive effect on their species richness. Grassland specialist plants were influenced by the interplay of landscape filters influencing their abundance, and habitat filters affecting plant species richness. Landscape filtering by isolation influenced the abundance of specialist plants by regulating seed dispersal and thus the fitness of individuals. Habitat filters sorted species that could establish and persist at a site by influencing micro-site availability and quality.

Contrasting the responses of two montane meadow forbs to experimental warming

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Minor changes in temperature within montane meadow ecosystems can elicit major responses by flowering plants that provide critical nectar sources to pollinators. These changes can be manifested in terms of phenology, growth patterns, nectar characteristics, or reproduction. We evaluated the responses to experimental warming (timing of flowering, annual height, frost-killed buds, and nectar characteristics) of two dominant flowering plant species in a montane meadow ecosystem in the Rocky Mountains USA. The two forb species included arrowleaf balsamroot (*Balsamorhiza sagitatta*), an early-season, large-leafed species, and buckwheat (*Eriogonum umbellatum*), a late-season, small-leaved, semi-woody species. These two forbs are both important to pollinator and nectar-using animal communities and are widely distributed and locally abundant in Western N. America. We used open-sided chambers with a roof of clear polyethylene slats to experimentally increase temperatures. Plant responses were evaluated in plots with and without open-sided chambers. Warming chambers increased daily minimum temperatures of plant and soil surfaces by approximately 2 °C. Warming treatments increased heights of *B. sagittata* by 20%, reduced frost-killed buds, decreased nectar volume, and increased recruitment of seedlings. Warming had no effects on height in *E. umbellatum* or seedling recruitment, but it decreased nectar volume and increased sugar concentration of the nectar. Neither species showed changes in timing of flowering. These data suggest that small changes in temperature during critical parts of the growing season may result in changes in plant growth and reproduction as well as the characteristics of the nectar resources available to pollinators in montane meadow ecosystems. Although the results presented here focus on two plant species, they represent both early and late blooming, and both woody and non-woody perennial forbs found in montane meadows of the Rocky Mountains. As such, the results provide generalized insight into how the larger plant community maybe expected to respond.

Historical ecology in vegetation science: back to the future

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Since the second half of the 19th century some human and social sciences have increasingly incorporated the natural environment when interpreting the development of human societies. On the other hand, ecological sciences increasingly took into account human factors when studying biodiversity and ecosystem functioning. Historical ecology emerged as an interdisciplinary approach which broadly views the ecosystems as legacies of past interactions between human activities and the environment over historical times. In this presentation, we will attempt to outline the past and present developments in this field from the perspective of vegetation science. Earlier research focused on landscape-scale vegetation changes using e.g. old maps for recent land cover changes, and fossil remains (pollen, soil charcoal, etc.) for longer time periods. A major achievement has been challenging of the myths of the closed-canopy forest as natural vegetation in temperate Europe and of the "virgin" forest in Amazonia and North America. This came with the evidence for the crucial role of big herbivores and fire in creating large clearings within forest matrices, since pre-historical times. More recently, historical vegetation ecology challenged the traditional view of plant communities as a result of purely niche-based assembly rules. The comparison between ancient and recent forests highlighted the role of dispersal limitation, leading to the concept of ancient forest species. By confirming experimentally that some plant community are largely dispersal-assembled, historical ecology showed that it can implement experiments to test some hypotheses it has previously derived. This has also led to important concepts such as the extinction debt - colonization credit dyad, two facets of hysteresis of plant communities. Other examples include the archaeological evidence in explaining current patterns in biodiversity; and the resurveys of historical vegetation records in order to reveal plant community changes and their drivers at scales from local to global. Historical vegetation ecology has strong links to restoration ecology, especially when defining the target communities to be restored. The future of historical ecology in vegetation science implies (1) getting closer to other disciplines such as history, environmental archaeology, palaeoecology for example; (2) developing robust theoretical and conceptual backgrounds; and (3) making use of innovative tools such as, for example, remote sensing, archaeosciences, ancient DNA, soil organic matter analyses, etc. Historical ecology may improve our understanding of current vegetation patterns and ecosystem functioning and provide a strong interdisciplinary-based platform for prediction of the responses of ecosystems to global environmental changes, a hot topic in ecology.

Response of weed communities to different agricultural practices including or not tillage and permanent plant cover

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In many rural landscapes across Europe, biodiversity has experienced a dramatic decline following the "Green revolution" of the 1960s and the widespread use of agrochemicals. This decline considerably reduced the amount of ecosystem services delivered by agroecosystems. Increasing food production while reducing negative environmental impacts is challenging for the 21stcentury. This leads to the use of ecologically based management strategies such as no-till systems or the use of permanent plant covers. There is thus an urgent need for assessing the impact of such novel farming techniques on biodiversity. Using vascular plant species as a model, we here present a controlled experiment, which aims at comparing the effect of contrasted agricultural practices on the weed community. These practices involve the presence/absence of permanent plant cover (in summer: sunflower; and/or in winter: Leguminosae or *Camelina sativa*) and tillage/no-tillage in a randomized complete block design with three replicates per treatment. Our experimental field thus comprised 24 plots (4 x 1 m) of eight different modalities in triplicate. In each plot, seeds of 42 weed species were sown in May 2017 and seedling emergence was subsequently monitored four times in June, July, August and September 2017. Species were ranked by their abundance (i.e. number of individuals) in the plots at each date, from the most abundant to the least abundant species and delta rank values were computed for each species between two consecutive surveys (e.g. July to August). Using delta rank values, we distinguished between five status: establishment, extinction, decrease in relative abundance (i.e. decrease in the ranking), increase in relative abundance (i.e. increase in the ranking), and persistence without change in relative abundance (same rank between two consecutive surveys). We then used linear mixed-effect models to test whether agricultural management techniques significantly affect the change in the species' rank over time. Our results reveal that tillage suppression negatively affects some species (therophytes, e.g. *Polygonum persicaria*) but favors others (perennials, e.g. *Artemisia vulgaris*). Similarly, a permanent plant was deleterious to some species (shade-intolerant species, e.g. *Cirsium arvense*) but beneficial to others (shade-tolerant therophytes, e.g. *Coriandrum sativum*). These results provide a better understanding of which weed species are sorted by which technique, paving the way for trait-based approaches of the impact of these techniques on community assembly.

Movin' on up: mycorrhizal mutualisms and assisted migration of coastal plant species

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Coastal marshes are among the first ecosystems to be altered by climate change. With increasing sea level rise, assisted migration may be necessary to establish founder populations in more favorable upslope habitats. Mycorrhizal mutualisms could play a key role in determining the success of these moving populations. The objectives of this study are: (1) to identify potential mycorrhizal relationships by determining whether assemblages of spores exhibit zonation mirroring that of coastal plant communities and (2) to test whether abundance and composition of mycorrhizae in roots of a dominant marsh species (*Juncus roemerianus*) differ with simulated assisted migration into upslope soils. Soil samples and seeds for trap plants were collected from the coastal coenocline at Grand Bay National Estuarine Research Reserve in coastal Mississippi. A total of 1694 unique operational taxonomic units (OTUs) was found across the entire gradient. The soil samples had an average of 196.25 OTUs per sample while the root samples were less diverse with an average of 29.04 OTUs per sample. The DNA analysis of the soil samples show that the Glomeromycete spores exhibit little to no zonation on the seaward end of the gradient (salt and brackish marsh), but moving upslope to the fresh marsh and pine woodlands, the spore composition becomes increasingly zoned. Species richness and abundance in the soil samples increased along the elevation gradient; they were highest in the pine woodlands and lowest in the salt marsh. The salt marsh showed isolation in its species composition sharing only two OTUs with the other three zones. The brackish marsh, fresh marsh and pine woodlands exhibited species overlap among most of the dominant OTUs. These results indicate that apart from the salt marsh, these plant-mycorrhizae relationships can persist after upslope migration of coastal plant species.

Comparative evaluation of the robustness of numerical clustering methods for vegetation classification

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Numerical clustering methods offer objective classifications of vegetation and are often regarded as less biased than expert-based classification systems. Despite the widespread use of these methods, there have been few comparative evaluations in which the clustering structure and other properties of the data are known. Instead, most recent comparisons of clustering methods use metrics calculated from the clustering solutions themselves and there is no absolute measure of clustering success. The current study used simulated plant community data to assess the performance of numerical clustering methods that are commonly used, or have been proposed for use in vegetation classification. Model communities varied in community properties (β-diversity, α-diversity) and the clustering structure of the data (cluster dispersion, cluster separation, and number of samples per group). Cluster recovery was measured using the Adjusted Rand Index, which measures the proportion of samples classified similarly in two clusterings – one being a clustering solution and the other being cluster identity in the generated model – so that scores near 1.0 are favorable, and lower scores indicate less accurate cluster recovery. Methods tested were flexible beta clustering, Ward's method, modified TWINSPAN, average linkage, complete linkage, K-means, Partitioning Around Medoids (PAM), ISOPAM, OPTPART, OPTSIL, Noise Clustering, and Information Analysis. In general, all methods performed relatively poorly (mean ARI < 0.70) in models with low β-diversity and low α-diversity. When β-diversity and α-diversity are moderate to high, methods perform better, with flexible beta, K-means, ISOPAM, and Information Analysis consistently achieving the highest ARI scores. Most hierarchical and all non-hierarchical methods performed poorly when the number of samples was not equal between clusters. Average linkage and modified TWINSPAN are exceptions, with mean ARI scores > 0.90. Thus, when choosing which clustering method to use, we must recognize potential risks in choosing them. Average linkage and modified TWINSPAN are robust to unequal cluster sizes, but not to models that have low β-diversity or α-diversity. Most other methods are not robust when group sizes are highly unequal. Among the overall top performing methods, flexible beta clustering is least affected by unequal group sizes (mean ARI > 0.85 when some groups have as few as 10% of the number of samples as others). Considering the current set of models and methods, flexible beta clustering represents the best option for the initial representation of grouping within the data when classifying vegetation.

Joining hierarchical clustering, diagnostic species and expert system definitions into a coherent classification approach: dry grasslands of the Balkan Peninsula as an example

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Dry grasslands of the Central and Eastern Balkan Peninsula are of high conservation relevance and host a diverse flora, but the countries of the region were lacking a comprehensive and consistent typology of these. Thus, we aimed at developing a hierarchical classification system based on extensive vegetation-plot data, translating it into phytosociological syntaxa and providing an electronic expert system (ES) that allows the automatic assignment of new plots to this system. The study region included the territories of Bulgaria, Serbia, Kosovo, Republic of Macedonia and N Greece (approx. 268,000 km²). We extracted from the Balkan Dry Grassland Database (BDGD) with the European Expert System those plots that presumably correspond to the eight classes of dry grasslands reported from the region. This initial dataset (5,734 plots) and later the plots within each of the derived subunits corresponding to orders separately were subjected to a new numerical approach: Starting with an initial partitioning (here: based on expert-interpreted TWINSPAN classifications), diagnostic species (defined by absolute phi values + phi value difference to the closest unit) were determined, they were then fed into an ES to create a new partitioning and so forth, until diagnostic species and species of the ES converged. The iterative optimization procedure converged in all cases. With our approach we succeed to classify 95% of all plots to alliance level. We distinguish four classes with eight orders and 12 alliances: 1. Sub-Mediterranean acidic grasslands (class and order unclear) with *Trifolion cherleri*; 2. sub-Mediterranean basiphilous grasslands (class and order unclear) with one unclear alliance; 3. *Festuco-Brometea* with *Brachyopodietalia pinnati* (with *Chrysopogno-Danthonion calycinae* and *Cirsio-Brachypodion pinnati*), *Festucetalia valesiacae* (with *Festucion valesiacae*), an order of rocky steppes (with *Pimpinello-Thymion zygoidis*) and an order of rocky grasslands (with *Centaureo-Bromion fibrosi*, *Saturejion montanae* and *Saturejo-Thymion*), 4. *Koelerio-Corynephoretea* with *Sedo acris-Festucetalia* (with *Festucion vaginatae*) and *Trifolio arvensis-Festucetalia ovinae* (with *Armerio rumelicae-Potentillion* and a new alliance with *Poa molinieri*). Building on the widely used concepts of electronic ESs and diagnostic species defined by phi values, we created a unified hierarchical classification framework. This proved to allow the classification of a large heterogeneous dataset into meaningful units of several hierarchical levels with hardly any unclassified plots. This approach thus has high potential for similarly complex classification tasks at national to continental levels, particularly if in the future it would be fully implemented in a single computer program.

GrassPlot: the database of multi-scale plant diversity in Palaearctic grasslands

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GrassPlot is a collaborative vegetation-plot database organized by the Eurasian Dry Grassland Group (EDGG) and listed in the Global Index of Vegetation-Plot Databases (GIVD ID EU-00-003). GrassPlot collects plot records (relevés) from grasslands and other open habitats of the Palaearctic biogeographic realm. It focuses on precisely delimited plots of eight standard grain sizes (0.0001; 0.001; 0.01; 0.1; 1; 10; 100; 1,000 m²) and on nested-plot series with at least four different grain sizes. The usage of GrassPlot is regulated through bylaws that intend to balance the interests of data contributors and data users. The current version (v. 1.00) contains data for approximately 170,000 plots of different sizes and 2,800 nested-plot series. The key components are richness data and metadata. However, most included datasets also encompass compositional data. About 14,000 plots have near-complete records of terricolous bryophytes and lichens in addition to vascular plants. At present, GrassPlot comprises data from 36 countries throughout the Palaearctic, spread across elevational gradients and major grassland types. The poster will provide an overview on the current content of GrassPlot and demonstrate some possible analyses of the data, including the provision of richness benchmarks (= mean richness values for certain grassland types and regions at specific spatial scales) and the study of species-area relationships (SARs). GrassPlot with its multi-scale and multi-taxon focus complements the larger international vegetation-plot databases, such as the European Vegetation Archive (EVA) and the global database "sPlot". Its main aim is to facilitate studies on the scale- and taxon-dependency of biodiversity patterns and drivers along macroecological gradients. GrassPlot is a dynamic database and will expand through new data collection coordinated by the elected Coordinating Board. We invite researchers with suitable data to join GrassPlot. Researchers with project ideas addressable with GrassPlot data are welcome to submit proposals to the Governing Board.

A multi-level classification of eastern Montana grassland and shrubland existing vegetation types and relationship to the US National Vegetation Classification System

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The Northern Region of the Forest Service utilizes existing vegetation classifications together with existing vegetation maps and inventories to characterize and monitor terrestrial ecosystems across the Region. There was a need to develop a hierarchical dominance type group and community type classification for grassland and shrubland vegetation types to provide more specific information about the components of existing vegetation map units and generate summaries about community composition from inventory data. We utilized a Forest Service legacy data set of 2,986 grassland and shrubland vegetation plot locations to classify existing herbaceous and shrub-dominated vegetation on three central and eastern Montana National Forests. In addition to the Forest Service classification, mapping, and inventory system there are other classification and mapping systems used by other agencies and organizations for statewide or regional assessments and conservation planning. The National Vegetation Classification System (NVCS) is a hierarchical classification system for describing existing vegetation types. LANDFIRE and Pacific Northwest Gap Analysis Program (NWGAP) are two national and regional mapping and assessment systems based on NatureServe's Ecological Systems. The Montana Natural Heritage Program uses only NatureServe's Ecological Systems to describe Montana's ecosystems. Given a growing interest in developing and coordinating assessments or conservation strategies that are regional in scope and encompass all lands, it is important to be able to relate Forest Service existing vegetation classifications to the NVCS and other classification hierarchies. Additionally, there is a Federal Geographic Data Committee (FGDC) requirement for Federal agencies to utilize the National Vegetation Classification System (NVCS) for classifying and describing existing vegetation. Utilizing diagnostic and characteristic species and differentiating criteria in NWGAP Field Keys and NVCS descriptions, we can nest the Forest Service grassland and shrubland community types and dominance type groups within NVCS Macro Group and Group levels. Additionally due to the relationship between Nature Conservancy Ecological Systems and NVCS Macro Groups we can also nest the Forest Service grassland and shrubland classes within LANDFIRE and NWGAP classification systems and map units. A subset of the Forest Service community types may be similar to alliance and association levels in the NVCS hierarchy. This subset of community types and associated vegetation plot information may be useful for adding information to current alliances and associations or be used to initially identify additional types at the NVCS floristic level.

Patterns of long-term vegetation change vary between different types of semi-natural grasslands

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Semi-natural grasslands are among the most diverse vegetation types in Central Europe, on a local scale holding the world records in vascular plant species richness. They are sensitive to changes in management, and already in the 19th century the range of semi-natural grasslands in Central Europe started to decline as a result of altered land use practices. This study presents the results of a meta-analysis of re-survey vegetation studies from semi-natural grasslands, asking whether plant species richness has changed over the past decades, whether the temporal trends of habitat specialists differ from those of habitat generalists, and whether there has been a homogenization of the grassland vegetation. In total 23 data sets were compiled, spanning up to 75 years between the surveys, including 13 data sets in wet grasslands, six in dry grasslands, and four in other grassland types. All data sets included sites located in different regions of Germany except for three studies from the UK. For each plot, the total number of vascular plant species, the number of habitat specialists and mean Ellenberg indicator values for soil moisture, nitrogen and reaction were calculated. Changes in species richness and environmental variables were evaluated using response ratios. Total species richness had declined in the majority of wet grasslands, while habitat specialists had almost completely disappeared. Species losses increased with increasing time between the surveys and were associated with a strong decrease in soil moisture and increase in soil nutrient availability. Wet grasslands in nature reserves, however, showed no such changes or even opposite trends. In dry grasslands and other grassland types, total species richness did not change in a consistent way, but there was a general decline in the proportion of habitat specialists over time. The changes in local plant species richness were accompanied by changes in species composition, especially in wet grasslands that had mostly turned into intensively managed, highly productive meadows or pastures. There was no general homogenization of the vegetation in any of the grassland types. The results document the widespread deterioration of semi-natural grasslands, especially of those types than can easily be transformed to high-productivity land. The main causes for the loss of grassland specialists are altered management and the intentional or unintentional deposition of nitrogen, the relative importance of which being difficult to disentangle.

Vegetation diversity of southern Croatia

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South part of the Republic of Croatia, namely Dubrovnik-Neretva County - the area investigated here, includes surface area of 1,782 km^2. It has coastline length of 1,025 km and altitude range from sea level to 1,234 m a.s.l. The area belongs to the Dinaric karst. The region has 122,568 inhabitants (in 2011) and the average population density of 69 inhabitants per km^2. The two major economic activities in the area are tourism (around the city of Dubrovnik) and agriculture (around the River Neretva). From the phytogeographical point of view, the study area is situated in the Mediterranean Region, Eastern Mediterranean Subregion, Adriatic Province, and Epiro-Dalmatian Sector. The area has a Mediterranean pluviseasonal-oceanic bioclimate, and it is situated within the lower meso-Mediterranean belt. Vegetation was studied in accordance with the principles of the Braun-Blanquet approach (Braun-Blanquet, 1964). The aims in carrying out this research were to: (1) present phytosociological study of the area, (2) adjust this vegetation survey to the European syntaxonomic system (EuroVegChecklist) in order to meet the common European standards. The phytosociological overview presented in this work is based on a synthesis of literature data and our own investigations. The vegetation belongs to the Mediterranean vegetation zone of the *Quercetea ilicis* Br.-Bl. ex A. Bolòs et O. de Bolòs in A. Bolòs y Vayreda 1950 class. The number of syntaxa shows high vegetation diversity in relation to study area size which is related to high floristic richness, endemism and environmental heterogeneity. Climazonal forest vegetation can be found only in a small part of this area because, due to intensive anthropogenic activities, it has been degraded to a greater or lesser extent. Such degradation caused the formation of very significant, permanent vegetative forms like shrublands (macchia), garrigue, dry grasslands and rocky pastures. Finally, the present study offers a contribution to the knowledge of the phytocoenological diversity of the southernmost part of the Republic of Croatia. Therefore, our results may serve as a guideline for further studies that will result in complete elaboration of Croatian vegetation.

Process-based modeling of tree species responses to changing fire and climate dynamics

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Climate-driven changes in fire disturbance could potentially alter tree species regeneration catalyzing abrupt changes in forest composition, structure, and function. Our ability to predict species' responses under novel conditions is dependent on the development of ecosystem models that can represent complex interactions between disturbance, climate, species competition, forest demography, and increasing atmospheric carbon dioxide. Dynamic Global Vegetation Models (DGVMs) are process-based models that represent these interactions and are therefore widely used to predict climate change impacts on terrestrial vegetation, frequently at the continental to global scale. DGVMs require input parameters including physiology, biochemistry, structure, and allocation to characterize generalized plant functional types. The potential for modeling vegetation at the landscape scale with DGVMs is promising, but presents a challenge for parameterizing individual species with limited data. Yet when accomplished, the species-level approach is exciting because it enables investigation of interactions between species composition, forest demography and fire dynamics. Here we present results from parameterization of the dominant tree species in the Greater Yellowstone Ecosystem (GYE) for the DGVM LPJ-GUESS to explore the causes of recent changes in plant productivity detected from satellite-derived vegetation indices. We hypothesized that increased post-fire regeneration of the dominant species, lodgepole pine, explains areas of increased productivity. For the dominant tree species in the GYE, bioclimatic limit parameters were extracted from Daymet gridded climate data using Forest Inventory Analysis (FIA) occurrence data. Other parameter values were gathered from literature and the TRY Plant Trait Database. Original parameter values resulted in unrealistic modeled species compositions, such as a relatively rare tree species dominating the landscape. Sensitivity analysis revealed the importance of parameters dictating growing degree-day requirements and photosynthesis temperature limits. Parameter optimization based on satellite-derived MODIS leaf area index (LAI) for these influential parameters resulted in improved agreement in modeled species compositions and FIA plot data. Using the newly parameterized regional plant species improved agreement with both MODIS LAI and FIA plot data compared to using the generic global plant types. Results from fractional factorial model simulations indicate a strong carbon dioxide fertilization effect on post-fire forest regeneration, while climate change is reducing post-fire productivity. These results suggest that the ability of plants to benefit from increasing atmospheric carbon dioxide depends on the bioclimatic context and the physiology of individual species and demonstrates the utility of process-based DGVMs for modeling species responses to future novel climate and disturbance conditions.

Testing the interval squeeze model: evidence for declining seed stores in two woody species as climate warms and dries

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The Interval Squeeze model (Enright et al. 2015) proposes that, as climate warms, many woody plant species globally will be threatened with decline due to the combined impacts of three interacting drivers: (1) shifts in fire regimes (especially fire intervals), (2) shifts in demographic rates (e.g. seed production), and (3) post-fire seedling recruitment decline/failure. We present evidence of large reductions in seed production and storage over the past 20 – 40 years for two woody plant species, *Banksia ornata* and *Hakea decurrens* (Proteaceae), from fire-prone Mediterranean woodlands and shrublands in SE Australia. Slowed onset, and decreased rates, of seed production correlate with an increasingly hot and dry climate as measured by the 12-month Standardized Precipitation-Evapotranspiration Index (SPEI). Results support the demographic shift component of the Interval Squeeze model and imply a markedly increased risk of species decline, particularly if fire becomes more frequent as climate changes.

Are microsites essential for new colonizers at mountain summits?

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In the European Alps, the ongoing climate warming was found to enhance plant species numbers at mountain summits from the treeline ecotone to the subnival zone. New species mainly arrive at the southern and eastern compass directions. Warm adapted species and species with broad ecological distribution ranges are expanding upwards whereas cold adapted species such as alpine-nival ones may lose their habitats. Thus, the future of high altitude plant species diversity is a matter of debate. New insights can be obtained by experimental approaches or by long term observations. Within the long term project GLORIA (Global Observation Research Initiative in Alpine Environments), vegetation changes at mountain summits are monitored throughout decades at two different scales: at the1 m² plot level and at the summit area section level, 5 m and 10 m below the highest summit point, respectively, taking in account each compass direction. Per mountain region, four summits from the treeline ecotone to the lower and upper alpine and the subnival-nival zone are chosen and revisited every 5-10 years. Using the data set from two GLORIA regions situated in the Central (siliceous rocks) and South Alps (limestone), we analyzed the effects of microsites on the appearance of new colonizers by means of generalized mixed models. According to the niche concept, newly arriving species need empty microsites without competition. However, according to the facilitation model, species in high altitudes benefit from the presence of already established species because they offer safe sites which favor the colonization of new species. Negative effects might result from the presence of a litter layer caused by resident species or from the presence of a rocky surface, both inhibiting seed germination and seedling establishment. The number of new species varied from a minimum of zero to a maximum of ten new species per 1 m² plot. The cover of the different microsite types (scree, bare ground, solid rock, vegetation, litter) showed significant differences between the summits: vegetation and litter cover decreased, whereas scree and bare ground increased with altitude. The highest impact on the number of new species had the summit but also correlations of new arrivals with some of the microsites were found. We conclude that negative effects of litter and solid rock on the arrival of new species did not occur during the last 15 years. Our results highlight that different filters affect species arrival at new sites in high mountain regions.

Contributions of two California vegetation programs to the US National Vegetation Classification

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The California Native Plant Society (CNPS) and the California Department of Fish and Wildlife (CDFW) have active cooperative programs for vegetation classification and mapping of the rich variety of California's vegetation. Both programs have become early adopters of the EcoVeg approach supported by the US National Vegetation Classification System. Over the past few decades, the two programs have become the California "node" of the USNVC, largely responsible for building baseline information for California Mediterranean Climate vegetation patterns. Both programs are represented on the USNVC Peer Review Board and Vegetation Panel. Within the state, we collaborate and cooperate as internal peer reviewers of locally defined vegetation descriptions based on analyses of our shared field data. Due to its climatic isolation, vegetation in the California Floristic Province such as Mediterranean chaparral tends to be unique compared to the larger neighboring biomes of the Great Basin, the Northwestern Coniferous forests, and the Southwestern Warm Desert. Fortunately, our programs have been able to inventory, describe and map vegetation patterns across these different biomes as they extend into California, and we have reaped multiple benefits from working within the framework of the USNVC. In some cases, a better understanding of floristic and ecological definitions of alliances and associations exists within ecological regions outside of California; thus, our classification concepts have been improved by exogenous knowledge. Likewise, we are drawing from the collective wisdom of the USNVC to tackle onerous confusion made by the high diversity of endemic vegetation within the California Mediterranean woodlands, shrublands, or grasslands. For example, the significant speciation of certain indicator species within diverse California genera such as *Arctostaphylos, Ceanothus, Quercus, Amsinckia, Phacelia*, and *Lasthenia* can be simplified by treating ecologically similar species as analogs, either by grouping analog species at the genus level or within related genera which share life history traits. Our two programs have benefited immensely from both internal and external collaboration and they will continue to do so as we refine and measure changes in the state's vegetation. We also are beginning to apply the California expression of the USNVC to various conservation planning processes, including efforts in the desert and coastal areas to help assess potential impacts and conservation needs of both rare and common vegetation assemblages.

Red list of ecosystems in temperate North America: some preliminary findings for terrestrial ecosystems

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Accelerating land use and climate change threaten ecosystems worldwide. Conserving biodiversity hinges on our ability to understand changes in the condition of ecosystems and the species they support. One important step is to document the at-risk status of ecosystems. With generous support of major foundations and others, we have initiated the development of the IUCN Red List of Ecosystems across the Americas. Like the IUCN Red List of Species, a system that ranks species based on their risk of extinction, the Red List of Ecosystems ranks ecosystems based on their risk of ecosystem collapse, and assigns comparable status of categories of "Vulnerable" (VU), "Endangered" (EN), or "Critically Endangered" (CR). Side-by-side with species ranking of conservation concern, the Red List of Ecosystems provides a more complete picture of the status of biodiversity. The Red List process requires that we address a series of technical issues and challenges, including how ecosystem types are classified, how we map their distribution, and then identify key ecological processes that could lead to their decline. Further, we need to define and measure key drivers and thresholds for ecosystem degradation and collapse, adjusting these definitions as needed, across different ecosystem types. We address these issues in an analysis of over 400 upland and wetland ecosystem types in temperate North America. Our results indicate that about 17% of types assessed likely classify at VU, EN or CR. These types currently occupy about 12% of the current land surface and are most strongly associated with agricultural and urbanized environments. We discuss the underlying reasons for their status, and consider information needs and approaches to complete the picture.

Arctic vegetation types and the EcoVeg approach: US and Canadian perspectives.

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Completion of circumpolar arctic vegetation classifications and maps is a priority for Arctic ecologists, conservationists and resource managers. Substantial progress is being made through floristic approaches (in particular the Braun-Blanquet approach used by the Arctic Vegetation Classification or AVC) and physiognomic approaches (especially the Circumpolar Arctic Vegetation Map or CAVM). Here we introduce the EcoVeg approach, which provides an integrated set of physiognomic, floristic, and ecological criteria, and is used by the US National Vegetation Classification (USNVC) and Canadian National Vegetation Classification (CNVC). We first summarize the key levels of the hierarchy for the Arctic, from formation to association, identifying the parallel levels from other approaches. We then describe a preliminary set of types at each of three USNVC levels (2 macrogroups, 7 groups, 21 alliances). We demonstrate the correspondence between Group level types and CAVM map units, thereby providing a mapped perspective on Arctic vegetation types, and a means of stepping down to alliance and association maps. We summarize the status of Alaskan and Canadian association and alliance plot data analyses and their input to refining AVC and EcoVeg types. Further, we provide a detailed comparison of all USNVC types with the plant community type listed by the Alaska Arctic Tundra vegetation map and with the Braun-Blanquet types of the AVC. We conclude by outlining potential steps for collaboration between the AVC, the USNVC and CNVC.

How does fire history affect the regeneration strategies in Cerrado?

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Open savannas in Brazil regenerate mostly by resprouting from belowground organs, where buds are protected by the soil from fire, or from aboveground buds inserted in the thick bark. Therefore, it is rare to see seedlings in the field after fire events, because the seed bank does not have a significant importance on vegetation regeneration. This might be true for areas where fires are frequent and aboveground vegetation has no time to fulfill the seed bank, or seeds are lost due to fire. Would resprouting be the most important regeneration strategy in recently burned areas, that has not been burned for longer periods? We investigated the number of seedlings, resprouts (ramets) and number of species of the different functional groups in areas that are burned annually (B1) and burned areas that have been previously excluded from fire for 6 (B6) and 12 years (B12). We hypothesized that resprouting would be the most important regeneration strategy in the annually burned plots, and the longer the fire exclusion, the higher the number of seedlings. Additionally, most of the seedlings would be from forbs and shrubs, since most graminoids depend on fire to flower. We established randomly 30 plots of 0.5 x 0.5 m 3 months after fire events (during the rainy season) and counted the number of seedlings, and species for each functional group. We found a total of 1058 seedlings, being 90% found in B12 plots, and only 2.9% of seedlings in annually burned plots. Most of the seedlings found in B12 areas were graminoids (70%), belonging mostly to *Mesosetum loliiforme*. These seedlings probably came from the seed bank, since this species did not produce flowers after fire, but every rainy season. Forbs were also very frequent in B12 areas, however, in annually burned plots, the few seedlings found were forbs (74%). Most shrubs were also found in annually burned plots (24%). As we hypothesized, more seedlings were found in burned areas that were previously excluded from fire for a longer period (12 years). However, in these areas, graminoid seedlings coming mostly from the seed bank represented the species in the aboveground plant community, showing that some species, such as *Mesosetum loliiforme* can form a persistent soil seed bank. Thus, fire history affected the post-fire regeneration strategies from Cerrado: frequently burned areas will regenerate mostly from the bud bank, whilst areas with longer intervals between fire, seedlings will have a higher importance.

Opposite effects of species diversity on community and ecosystem stability revealed by removal experiment

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We report results of a biodiversity experiment developed on old-growth grassland in which we manipulated species richness by removals for studying the effects of species diversity on community and ecosystem stability. Diversity may increase stability by allowing efficient resource acquisition and thus decreasing community invasibility and temporal variation in primary productivity. The experiment assessed the effects of richness reduction (0, 50 and 70%), applied on 0.2 x 0.2 m experimental units (25 replicates), on the rates of species colonization and extinction, and primary productivity and its temporal variation. By using linear models, and controlling for the amount of removed biomass (a proxy for disturbance), after two years we found that species richness significantly increased primary productivity ($P = 0.0001$), colonization ($P = 0.0433$) and extinction ($P = 0.0001$), while decreased primary productivity temporal variation ($P = 0.0043$). Species diversity showed opposite stability effects at the two organization levels evaluated, by enhancing ecosystem processes stability to the detriment of community constancy. Niche complementarity and more efficient resource acquisition may explain increased biomass productivity and more even distribution of primary productivity in time on rich communities, while competition might be lading rich communities to instability by increasing their temporal turnover.

Effects of spotted knapweed (Centaurea maculosa) on grassland arthropod communities: use of genomic barcoding tools for ecosystems reclamation management

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British Columbia's (BC) grasslands are home to 30% of the province's species at risk and are one of Canada's most endangered ecosystems. In BC's interior, human activities such as mining, recreation, and in certain instances, heavy livestock grazing are altering grassland ecosystems, which may leave them susceptible to the colonization of invasive species. Invasive species can cause changes to native plant communities and nutrient cycling, and by doing so, may alter the amount and quality of habitat available for animals at multiple trophic levels, including arthropods. Arthropods are diverse and contribute to energy flow and nutrient cycling and are therefore an important group to study as a way of determining the effects of changes to ecosystem functioning. Spotted knapweed (*Centaurea maculosa*), a perennial forb native to Eastern Europe, is considered one of the most ecologically harmful invasive species in Western North America. The objectives of the study are (1) to determine if spotted knapweed is altering arthropod and native plant communities in grassland habitats; and (2) to DNA metabarcode all arthropod specimens collected using methodology that could be implemented to expedite mining site restoration efforts. Our results suggest that spotted knapweed density indirectly affects arthropod functional groups through changes in plant community composition, and ground temperatures. These indirect effects show different correlations between different functional groups; suggesting that both top down and bottom up control is at play with the introduction of spotted knapweed. DNA barcoding research that adds to our grassland species catalogue can be applicable to both invasive species conservation efforts and in helping to improve remediation work in disturbed grassland sites.

Strong snowpack signal in Rhododendron ferrugineum L. shrubs above the treeline in the French Alps

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High-latitude and high-altitude ecosystems are amongst the most sensitive to climate change. Numerous studies demonstrate that recent global warming leads to an increase in shrub cover and productivity in the Arctic. In the Alps, a similar greening phenomenon has been detected since the 1980s as a response to the increase of air temperatures and the induced reduction of snowpack depth and duration. However, the climatic drivers of shrub growth remain poorly understood. Dendroecological data, i.e. multi-decadal time series of annual growth rings usually obtained from trees, offer great opportunity to explore climate–growth relationships in long-lived shrubs. The available data, mostly acquired on Arctic shrub species, point to a positive response of radial growth to increasing summer temperature although strong differences between species and sites remain. Only two comparable studies have been proposed so far in the Alps. This study aims to fill this gap by determining the response of *Rhododendron ferrugineum* (Rf) to climatic fluctuations over the last decades. Rf is a widespread shrub species growing at elevations ranging from 1,500 to 2,500 m a.s.l. in the European Alps and therefore offers opportunity to investigate various climatic contexts. We analyzed the relationship between climate and radial growth on 49 Rf individuals sampled at three altitudes (1,800, 2,000 and 2,500 m a.s.l.). Growth-ring width chronologies were developed at each site. Daily-resolved and homogenized series of temperature, precipitation and snow cover depth were obtained for each sampling site. Climate-growth analyses were computed for the period 1959-2016. We show that the growth of Rf is governed by late spring climatic conditions. Growth-ring width is positively and significantly correlated to May temperature at each site. However, snowpack duration in late spring affects radial growth at each site differently. A positive correlation is observed with snowpack duration and depth at 1,800 m, while at 2,500 m the correlation is significantly negative. This is due to late snowmelt inducing a very short growing season at high elevation. Interestingly, extremely warm springs associated with early snowmelt (as have been observed several years during the last decades) constitute an exception to this rule. Indeed, they are associated with thin ring width in Rf populations. Finally, the analysis of growth trends reveals a growth decline at the highest sites since 2000. We will discuss the relationship of this trend to recent climate changes.

Development of the US National Vegetation Classification

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The Federal Geographic Data Committee (FGDC) Vegetation Subcommittee, the Ecological Society of America Panel on Vegetation Classification, and NatureServe have worked together to develop the United States National Vegetation Classification (USNVC). The current standard was accepted in 2008, after the work of a subcommittee, the Hierarchical Revisions Working Group (HRWG), offered several suggested changes that applied to the usability of especially the middle levels. These middle levels have proven important for mapping, management, and potentially international classification of biomes. This talk will outline steps taken to develop the classification system, discuss some application of the classification system, and future steps needed for its completion. Building of the USNVC was accomplished with both a top-down and bottom-up approach, the EcoVeg approach. Top down, the HDWG also wrote the descriptions for all concepts of the top four levels that subsequently went through peer review by Panel and Subcommittee members, international colleagues, and experts of regional flora. From the bottom, the network of State Heritage Programs of The Nature Conservancy had for years compiled both plot data and publications and in the late 1980s started an effort to bring these state classifications into a national context. Their descriptions of associations and alliances were screened for quality. Subsequently, Group level descriptions were developed and reviewed, followed by Macrogroups and ultimately linking top down and bottom up efforts comparing Macrogroups with their Division. In addition, the USNVC is structured as a dynamic standard, where changes to types at any level may be proposed at any time with new information, so the infrastructure and peer review process were developed to accomplish such updates. Current efforts focus on gaps in knowledge and descriptions of vegetation concepts, expansion to Hawai'i and subtropical types, incorporation of recent classifications in Alaska, and coordination with international neighbors and classification approaches.

The flora of Rome after 25 years: changing distribution patterns in an urban context

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In an epoch of urban sprawl, the study of urban ecology is an important challenge. Over time, urban areas undergo a series of changes in land use, management and shape. To these agents of change should be added heat-islands. Cities, at least at mid latitudes, are often richer in plant species than surrounding rural areas. This is due to their providing heterogeneous habitats, many of high biodiversity conservation interest. Rome's flora is composed of about 1300 vascular species. After centuries of study, it is now possible to accurately assess changing patterns in an urban context, since the same patterns supply an efficient tool at several levels. Our point of departure in this regard is the *Atlas of the flora of Rome* (Celesti-Grapow, 1995), a complete census of the vascular flora made on a grid of 190 squares of 1.6 km^2 each. We chose 77 of the original 190 squares, selected at random according to the quincunx method, in order to make a new ecological census of the flora, aimed at detecting main differences in composition after 25 years. Results show a slight but generalized increase of number of species per square, both in those squares characterized by a substantially unchanged land use and urbanization and in those characterized by different management policies and land use. The increase in these species is represented most by ruderal, alien and xerothermic species (including *Chenopodium murale, Chamaerops humilis, Solanum chenopodioides*); such a situation is quite generalized, highlighting homogenization of the flora; this is possibly due to several factors, such as the general increase in temperatures, the spreading of urban heat island and urban sprawl. Natural areas, on the other hand, tend to be more stable. In a period when urban areas are undergoing constant change, our own study aims to analyze some of the factors involved, so contributing to the conservation of biodiversity in an otherwise often radically altered ecosystem.

Permanent plots in seminatural dry grasslands in central Italy

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Conservation and maintenance of priority habitats, defined as areas with high biodiversity of conservation interest, present the EU Habitat Directive with their main challenge. This category includes seminatural dry grasslands, which host a huge biodiversity of both plants and animals. Such a variety of habitats can be ascribed to a subtle balance between natural features and human presence, the latter's impact being fundamental to shaping the patterns described here. In the context of the EU Life+ project "RI.CO.PR.I.-Restoration and conservation of dry grasslands in southern and central Italy", two priority habitats were chosen for conservation measures. These habitats are the 6210(*): Semi-natural dry grasslands and scrubland facies on calcareous substrates (Festuco-Brometalia) (*important orchid sites) and the 6220(*):Pseudo-steppe with grasses and annuals of the Thero-Brachypodietea. Both are located in the Lazio region, within the province of Rome. Here, two permanent plots, 16 m^2 each, were created, so as to protect these portions of grassland from overgrazing. The first, located in the Ruffi mountains chain, dates back to 2011, while the other, on the nearby Prenestini mountains, was created in 2013. Floristic surveys and phytosociological relevés began with the installation of permanent plots and are still ongoing. Since 2011, a fast growth of phytomass has been detected in contrast with that of surrounding grazed areas, although with differences between the plots due to the different thickness of the installation's substrate. Especially in the case of the Ruffi plot, an overgrowth of unpalatable and nitrophilic plants (such as *Centaurea solstitialis* subsp. *solstitialis*) was observed for the first 2 years. Subsequently, there has been a gradual but progressive substitution by Poaceae *s.l.* species. Nevertheless, after just 3 years of grazing exclusion, shrubs started to grow inside the plot, proving invasive, with respect to ground cover, from there to the following years. By contrast, the Prenestini plot proved less prone to invasion by ruderal or invasive species while maintaining a slower species turn-over, probably because of its higher altitude (1,203 m a.s.l.). Although the permanent plots were limited to 2, over the short time of the study they provided important information about ecological secondary succession processes and about the conservation measures that need to be undertaken to maintain and conserve these habitats' rich biodiversity.

Twenty years of plant invasion research in the Portuguese coastal dunes

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Coastal ecosystems are home to a unique flora and fauna, which are extremely vulnerable to disturbances of natural and unnatural sources. In Portugal, of the 1,230 km of coastline, about 60% is occupied by sand dunes, making it one of the most important ecosystems in the country. Plant species inhabiting coastal dunes have developed several adaptations that allow them to establish in an environment characterized by harsh and dynamic conditions of solar irradiation, water availability, salinity, wind speed and direction, and substrate mobility. Some exotic plants, such as *Acacia longifolia, Acacia saligna* and *Carpobrotus edulis*, have invaded extensive areas of the Portuguese coastal ecosystems, transforming plant communities dominated by herbs and small shrubs into woody dominated communities, in the case of Acacia species. We will present 20 years of invasive research in Portuguese coastal ecosystems, namely with *A. longifolia*. This species decreases native species richness, plant cover, diversity and species turnover; changes of plant communities intensifies with invasion time and invasion promotes a diversity of structural and functional changes which are dynamic over a few years, but that tend to stabilize after several decades. Furthermore, at the ecological network level, invasion by *A. longifolia* causes an alarming simplification of plant communities, with cascading effects to higher trophic levels, namely to gall communities, with a decline of overall gall biomass, and on the richness, abundance and biomass of galler insects, their parasitoids, and inquilines. Correspondingly, the richness of interactions between plants and galls decreases significantly. The invasion tends to increase overall interaction evenness by promoting the local extinction of the native plants that sustain more gall species. In nutrient-poor sand dunes, soil carbon and nutrients, especially total nitrogen, progressively increase after invasion, but these increments only become evident after several decades, although microbial processes and mineral nitrogen are affected much earlier. As the invasion becomes protracted, the autogenic recovery potential of invaded areas decreases: native seed banks become more impoverished, reinvasion potential (*Acacia* seed bank) increases and soil carbon and nutrients, especially nitrogen, become and remain high for long periods. Aiming to mitigate these impacts and decrease the invasive potential of *A. longifolia*, from 2015, a biocontrol agent (*Trichilogaster acaciaelongifoliae*) that targets reducing seed production was introduced along the Portuguese coast. Despite the inherent difficulties associated with transferring the insects between hemispheres, *T. acaciaelongifoliae* successfully completed its life cycle in Portugal in the wild, and after three years is starting to proliferate.

Assessing post-fire oak and pine regeneration in Shenandoah National Park

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Fire-adapted oak (*Quercus*) and pine (*Pinus*) ecosystems are an important component of Shenandoah National Park (SNP), Virginia, USA, and comprise approximately 39 percent of the landscape. Without periodic fire, xeric species such as oak and pine are gradually replaced by shade-tolerant, mesophytic species such as red maple (*Acer rubrum*), black gum (*Nyssa sylvatica*), and sassafras (*Sassafras albidum*). To quantify oak and pine regeneration in SNP in relation to fire, we sampled a total of 100 plots selected by a stratified random design within 6 recently burned areas (burn years 2002 to 2016, including both natural and prescribed burns), and 2 areas that have not burned since before 1935 (when SNP was established). Within each of the 8 areas, we stratified plot locations on vegetation type (fire-dependent oak or pine) and dNBR (estimated burn severity based on satellite imagery). Within each plot, we recorded data on oak and pine seedling counts, and abiotic and biotic factors thought to influence seedling establishment. A total of 412 oak seedlings were found in 68 plots; 32 plots had no oak seedlings. A total of 56 pine seedlings were found in 23 plots; 77 plots had no pine seedlings. We used AIC to select among negative binomial regression models of oak and pine seedling counts. The best predictive models for both oak and pine seedling counts included seed tree availability (expressed as a distance-weighted seed rain index), canopy openness (as estimated by densiometer readings), and site (as an additive categorical variable). Pine regeneration was sparse, but only sites with recent fires (2002 or later) had any pine seedlings counted in any plots ($P = 0.036$; Fisher's exact test). Estimated burn severity (dNBR) was significantly correlated with several variables associated with seedling success, including canopy openness ($r = 0.614$), duff thickness ($r = -0.402$), and litter thickness ($r = -0.387$). Oaks were regenerating in all sites, whether recently burned or not, but seedling counts were higher where the canopy was opened by fire or other disturbance. Pine regeneration also depends on canopy openings and fire, as expected, but the extreme sparseness of seedlings may indicate that the current regime of infrequent natural or prescribed fires – or some other environmental condition such as climate – is not conducive to maintenance of fire-dependent pines on this landscape.

Phytosociological comparison of deciduous Quercus and Fagus forests in eastern North America

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Over the years there have been only a few geographically extensive classifications of the forest vegetation of eastern North America, mainly by field-based regionalization (e.g. Braun 1950), by dominant species, or by statistical ordination. A phytosociological study by Okuda, using part of the data-base from the Eastern North American Vegetation Survey (ENAVS, 1988-90), ascribed the deciduous forests to the Querco-Fagetea grandifoliae Knapp 1957 (Okuda, 1994). The present study analyzes more of the ENAVS data, plus other samples, from Québec to Florida and west to Louisiana, by phytosociological methodology, with an emphasis on deciduous *Quercus* versus *Fagus* forests, for comparison with other continents. This analysis identified several basic types of deciduous forest, including (1) *Acer-Quercus rubra*, *Acer-Fagus* and *Acer saccharum* forests near the northern limit of deciduous forests, especially in Canada; (2) mixed forests with *Tsuga canadensis* from Nova Scotia to Virginia; (3) Appalachian-piedmont *Acer-Fagus* and *Quercus* forests; (4) *Quercus* forests, including secondary forests, over much of southeastern North America; and (5) *Quercus nigra* and *Magnolia-Fagus* forests on the southeastern coastal plain. These types seem related clearly to climate, topography and soil types. Earlier cross-projection of climatic ranges between eastern North America and Europe had emphasized the "southern" and "continental" status of some major tree species in both regions. Interpretation of the forest types identified here, both taxonomically and within a climatic framework, suggests further parallels to forest types in both East Asia and Europe, especially the ideas of 'typical-temperate' forests in the piedmont and 'warm-temperate deciduous' forests on the southeastern coastal plain. In particular, *Quercus* forests spread after human impacts, including *Q. nigra* as secondary forests on the coastal plain (warm-temperate region). This phenomenon appears to correspond to *Q. serrata* forests in Japan and some other warm-temperate deciduous forests in China. Species richness, environmental differences and other comparisons with East Asia will also be discussed.

Ecotourism and botanical conservation: a case study of regionally endemic cushion plants in exposed calcareous outcroppings in Park County, Wyoming, USA

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Conservation of rare plant species is often within the context of extensive landscape disturbances or land use planning and development. However, in the mountainous rangelands of the western United States, conservation of rare plant species can also occur at aesthetically pleasing topoedaphic positions on the landscape such as mountain peaks. It is at these intersections between relatively small and isolated landscape positions that are used by humans greater than their availability where society and rare plant conservation intersect. Here were present biophysical descriptions for the distribution of three rare species: scented pussytoes (*Antennaria aromatica* Evert), Howard's alpine forget-me-not (*Eritrichum howardii* (A.Gray) Rydb.), and Shoshone carrot (*Shoshonea pulvinata* Evert et Constance) from The Nature Conservancy's - Heart Mountain Ranch Preserve northwest of Cody, Wyoming, USA as a case study of the intersection of ecotourism and botanical conservation. These species are a conservation concern and limited information about their habitat is available to develop an effective recreational management plan to conserve them. The vegetation survey was carried out in June of 2017 to detect locations with the three endangered plant species. Vegetation was sampled using plots of 1 m² in size and each vascular plant species inside the plot was identified and its abundance was estimated using a decimal scale. Structural components of vegetation (i.e. percentage of litter, standing dead biomass, bare soil, and rocks) and height of canopy were also measured. We then performed a constrained ordination projecting onto the ordination diagram species' cover distribution per plot and environmental variables and altitude. The axis 1 and 2 explained, respectively, 56.1% and 28.7% of species distribution being all three endangered species directly associated with presence of rocks which occur at the peak of Heart Mountain. Moreover, evidence of human trampling by displacement of rocks due the main hiking trail ends at the peak and primary location of this assemblage of rare species. As a consequence, human-induced modification to the habitat of these species could increase their extinction risk. Increasing hikers' awareness about the conservation status of these species by marking their presence restricting off-trail travel would merge ecotourism with botanical conservation.

Soil seed bank of Oenothera drummondii, an invasive species of coastal dunes: assessing the impact on local soil seed bank community

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O. drummondii is a perennial herb native to the coasts of Southeastern USA and Eastern Mexico that has invaded coastal dune systems throughout the world. In this study we had two objectives: (1) to describe seed bank of *O. drummondii* in space and time, and determine how long the seeds remain viable in the soil, and (2) to establish the impact of this invasive on the local seed bank. In addition, because seed dispersal occurs mainly by barochory, we compared the number of *O. drummondii* seeds deposited underneath and in the vicinity of *O. drummondii* plants. The study area is located in a dune system of the Gulf of Cádiz (Spain) where we compared the seed bank of areas highly invaded by *O. drummondii* with non-invaded areas (3 sites each). Seasonal dynamics and vertical distribution of seeds in the soil were investigated in five 2 x 2 m plots per site by collecting soil cores in June and October, over a one-year period. Soil cores were collected beneath and in the vicinity of *O. drummondii* plants, and were divided into five 1 cm categories (from 1 to 5 cm). Seed bank composition was estimated through seedling emergence. After the germination period in June, *O. drummondii* formed a short-term persistent seed bank at the invaded area, with a mean of 527 ± 323 germinating seeds/m^2. In October, after the dispersal period, we counted 2,080 ± 1,348 seeds/m^2. Most of the seeds (82%) were located in the first cm of soil. In the field, we observed that most dispersal seeds germinated during the first germination period, but only 25-50% emerged as seedlings; a small percentage (5-10%) did not germinate and remained in the soil seed bank until the next germination period. In total, 12 species were recorded from the bank invaded by *O. drummondii*, compared with 15 species recorded in the non-invaded area. The seed bank of invaded communities was significantly less diverse than those of uninvaded areas, and showed a higher dominance, even when the invader was not included in the analysis. The seed bank of invaded areas was composed of a very high proportion of *Polycarpon alsinifolium*, an annual species characteristic of stabilized dunes, which is favored by the increment in plant cover produced by the invasion of *O. drummondii*. The results showed that *O. drummondii* has the capacity to profoundly alter the seed bank, both quantitatively and qualitatively.

Impact of plant invasion on the diversity patterns of plant communities along the beach-dune gradient

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Plant communities vary along the beach-dune gradient, mostly in response to salinity and sand movement, which gradually decrease inland. However, these patterns may change when invasive species appear. This study analyses the impact of an American invasive species, *Oenothera drummondii*, in the plant diversity patterns of a beach-dune system in the Gulf of Cadiz (Spain). We focused on the diversity patterns within different areas of the environmental gradient and also considered the dune system as a whole. We conducted a stratified sampling (zones: upper beach, embryo dunes, foredunes and inland dunes) in two areas (300 x 300 m), invaded and not invaded. In each area, 100 plots (2 x 2 m) were randomly established and georeferenced. In each plot, the composition of species was sampled and their covers were estimated visually. For each plot, we calculated species richness (S) and Shannon's diversity index (H') based on species covers. Two-way fixed-factor ANOVA tests were used to test whether total cover, *O. drummondii* cover, annual and biannual cover and perennial cover (omitting *O. drummondii*), bare soil, S, H 'and λ were different between invaded and uninvaded sectors across the beach, foredune and inland dune zones. The relationship between the different variables and the distance to the sea of each plot of invaded and non-invaded areas was also explored through regression analysis. To assess the response of plant communities to plant invasion we performed a repeated measures permutational multivariate analysis of variance (PERMANOVA), with post-hoc pairwise comparisons. The results showed that *O. drummondii* abundance increases along the beach-dune gradient inland. At plot scale, diversity was significantly higher in the non-invaded area. At dune system scale, the total species richness was greater in the invaded area, 49 species, than in the non-invaded area, 35 species. Regression analysis showed that *O. drummondii* alters the spatial diversity patterns by turning the plant community of inland dunes more homogeneous. The invasion also affected the composition of species, by reducing the cover of perennial species typical of coastal dunes and increasing the cover of annual and biannual species that are characteristic of other types of inland habitats. In conclusion, the invasion of *O. drummondii* has modified coastal dune diversity, especially in inland dunes. Here, the total number of species increased but diversity decreased (H') and dominance increased. In addition, the presence of specialized dune species has been reduced while the generalist species increased.

Assessing the effect of grazing on an endangered Ranunculus amplexicaulis population in a mountain grassland

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Extensive livestock farming is a traditional economic activity in the European mountains. Grazing is necessary for the conservation of mountain grasslands, a highly diverse group of habitats, some of them included in the European Habitats Directive. Nevertheless, some particular species may be affected by grazing pressure, especially the populations growing in the distribution limit of the species. Pastures developing in the siliceous summit, above 1,300 m, of Mount Gorbeia (Basque Country, northern Spain) represent relict subalpine communities in this area and harbor several endangered species, such as *Ranunculus amplexicaulis*. Previous monitoring studies of these population showed a reduction of recruitment and establishment of new individuals, which may lead to population collapse. After observing that livestock consumed the flowers of *Ranunculus amplexicaulis* before fruit formation, we set the objective to analyze the impact of early grazing on the population dynamics of this species. We used the BACI (Before After Control Impact) methodology, a sampling design frequently used in environmental impact assessment due to its usefulness in cases were replication of samples is not possible. In 2014, four permanent plots of 100 m^2 were installed in order to monitor the demography of the species. Since 2016 two plots have been annually fenced during the breeding season (May to July) and the other two have been used as controls. Each plot was divided in 100 subplots of 1 m^2 and the number of individuals with their phenological stage was counted in each subplot. Additionally, 10 subplots in each plot were randomly selected in order to monitor vegetation changes. A list of all the species present in each subplot abundance measured as percentages was recorded. Our results showed that the population of *Ranunculus amplexicaulis* has remained constant over the study years and no significant differences were observed after fencing. Regarding vegetation changes, some trends were observed in the fenced plots, where an increase of some Ericaceae species, such as *Erica cinerea* and *Vaccinium myrtillus*, and a decrease of *Nardus stricta* occurred.

Diversity and ecological differentiation of mixed forest in northern Montenegro (Mt Bjelasica) with reference to European classification

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The goals of this study were (1) to floristically characterize mountain forests in an Eastern Mediterranean region and (2) to assess their physical site properties as determinants of forest types. Research was based on data collected from 158 sampling plots in the territory of the mountain Bjelasica, north-east Montenegro. The influence of topographic, climatic and edaphic site characteristics on the differentiation of vegetation and formation of forest types was assessed using numerical ordination and classification. Three types of mountain forests were separated based on their floristic composition, which can be easily characterized by the composition of their tree layer: (1) mixed forests with spruce, silver fir and beech, (2) monodominant beech forests resulting from over-exploitation of type 1, and (3) heliophytic mixed forests with pioneer species (pine, aspen and birch) and European hop-hornbeam. The types are discussed regarding their physical site characteristics and put in a European context. The mountain forests of Montenegro are classifiable according to existing classification systems such as the natural vegetation types of Bohn et al. (2000).

Phenotypic plasticity and plant water use in a changing climate: a multi-species, multi-site investigation

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Current predictions of environmental change threaten to out-pace developmental, genetic and demographic capacities of plants. Phenotypic plasticity is a mechanism by which plants may persist under rapidly changing environments. However, many crucial questions remain, including: (1) what functional traits exhibit plasticity? (2) does the degree of plasticity differ within and between species? and, most importantly, (3) does phenotypic plasticity in plant functional traits correlate with plant fitness? To try to answer these questions, phenotypic plasticity in key functional traits was estimated for 36 species spanning semi-arid, alpine and coastal habitats. Each of the three habitats were represented within Australia with six species per habitat, and once within each of the overseas countries; Spain - semi-arid, Germany - alpine, and the US - coastal, with six species each. Two years of observational data revealed plasticity in traits such as SLA and leaf area to stem mass ratio varied highly among species, with substantial seasonal variation occurring within some species. Preliminary analysis also indicates that increased plasticity in traits such as SLA is associated with fitness, measured as higher growth rates. Trait variation has important implications for current sampling efforts to build trait-based models to improve the predictive power of vegetation and bioclimatic models. We discuss these issues with regards to the contrasting patterns of variation in plasticity observed within and across species as a function of habitat, growth form, species and season and provide some guidance as to the approaches that can be taken in order to capture and understand this variation.

Defining functional modalities in vascular plants: the functional modus and its potential role in vegetation science

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The relative contribution of a single trait to whole-plant function or fitness can be described as its functional modality. At the whole-plant level two main questions arise: (1) are there traits representing key interacting elements of plant function that, when combined, define a functional modality for an individual plant? (2) If so, is there a role for an expression of whole-plant modality in vegetation science? The first question is addressed through the use of a minimum set of 36 functional traits that underpin key plant strategies of resource acquisition and conservation in which whole-plant trait combinations (plant functional type or PFT) are derived via a trait assembly rule. Traits included metabolic pathways, green stem (cortical) photosynthesis, leaf traits (size, longevity, inclination, rosette phyllotaxis, stomatal distribution, venation, succulence) and a modified Raunkiærean vascular support system. With traits combined in this way, the functional modality of a plant individual can be expressed as a functional '*modus*' distinguishing it from PFTs otherwise described by traits assumed to be functionally independent or non-interacting. The second question is approached through an analysis of *modal* PFTs recorded in 1,322 (200 m^2) gradient-based relevés across all major biomes using a standard protocol. Altogether 36,207 vascular plant taxa and their 24,530 unique *modal* PFTs were subjected to multivariate statistical and pattern analysis. The presentation will show how, when compared to studies involving non-*modal*, standalone traits quantified via community weighted means, *modal* PFT counts significantly improved ecological insights into patterns of plant biodiversity and vegetation dynamics. These studies support the *modal* concept as a potentially useful tool in vegetation science.

Probability of fire occurrence in the northeastern boreal forest

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In the northeastern boreal forest, ecological succession is influenced by natural and anthropogenic disturbances such as logging, fire and insect epidemics. As logging activities are mainly coerced in southern areas, fire and insect epidemics trigger regeneration in the northern zone of the boreal forest. Fire dynamics in boreal ecosystems had been extensively studied in recent decades. However, its probability of occurrence in forest stands is poorly documented and most of the time associated with climatic conditions. Recent studies, however, demonstrate the importance of vegetation, physical environment, and human activities in explaining the likelihood of a fire occurring. This project aims to quantify the probability of fire occurrence in the boreal forest (49° to 51° N of latitude and 68° to 70° W of longitude) depending on stand characteristics, physical environment, the density of the road network and normal fire-weather indices. Three maximum entropy models were developed for fires occurring between (1) 1971 and 1985, (2) between 1986 and 2000 and (3) between 2001 and 2015. Analysis of data over a 15-year time interval allowed consider changes in the landscape caused by stand disturbances. Following a fire, the ecological succession generally leads towards a dense forest that resembles the pre-fire stand. We used historical data and national forest inventories to draw a global portrait of burned areas and forest succession over the last 40 years. The results showed that the forest-weather indices and the time since the last disturbance (TSD) contribute significantly to the probability of fire occurrence. In particular, forests of about 50 years would be the most likely to burn with a probability of fire occurrence of about 70%. Despite their smaller contribution to the model, the probability of occurrence was also lower in stands (1) with high density; (2) with a surface deposit and a topography favoring the accumulation of water and (3) with a component of balsam fir or other hardwood species. Incorporating this new knowledge into forest management and planning will help to better locate areas at risk of burning and optimize dispersion of logging activity.

Woody species encroachment, prescribed burning and restoration from the seed bank: perspectives for the conservation of dry basiphilous grassland in Transylvania, Romania

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Transylvanian semi-natural grasslands are of global importance in terms of high plant species diversity, but recent land use changes (abandonment) in peripheral areas put them at risk. In order to halt secondary succession and the establishment of native and non-native woody species, prescribed burning of encroached grasslands has recently been intensified. Little is known about underlying mechanisms and specific effects of encroachment by native and non-native woody species and burning on vegetation and soils in Transylvania's non-fire-prone grasslands, and there is a lack in efficient measures to restore grassland already invaded by woody plants. We ask: (1) in which ways do woody species encroachment and prescribed burning influence plant species composition and soils, (2) do native and non-native woody species differ with respect to their impact on grassland species composition and structure, (3) is controlled burning a useful management tool to control shrub encroachment and to preserve biodiversity of these grasslands, and (4) can soil seed banks contribute to the restoration of dry basiphilous grasslands in Transylvania? We collected data on plant species composition and vegetation structure, site conditions and topsoil- and seed bank composition in 16 shrub encroached grasslands in Transylvania and adjacent un-encroached grassland. Data were analyzed with regard to the impacts of woody species encroachment (native vs. non-native) and fire on grassland vegetation, soil and seed bank. We used NMDS for visual exploration of the datasets and LME-Models combined with ANOVA and Tukey contrast tests for inferential statistics. Woody species encroachment in Transylvanian grasslands was accompanied by a decrease in light availability, altered soil conditions (e.g. increase in soil nutrient concentrations) and a decrease in plant species diversity. We found no difference in impact size between native and non-native woody species on tested vegetation-, soil- or seed bank parameters, but evidence for fire effects on grassland diversity and soil conditions. While the effects of fire on vegetation and soil were weak compared to the effect of woody species encroachment, burning failed to reduce the cover of woody species sustainably. Grassland vegetation and the seed bank differed significantly in species composition and diversity, indicating a limited potential for restoration from the seed bank alone. We conclude that there is an urgent need for further research and the development of locally adapted, sustainable and cost-effective management practices to preserve grassland diversity in Transylvania.

THIS is like THAT, only bigger and messier

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Cluster analysis is a core tool of vegetation science; we have always wanted to divide a complex world into manageable chunks. Various types of spatial classifications are used to delineate agroecological land units and standardize management. These classifications consider qualitative differences in soils and climate, but often do not have a consistent quantitative basis. Can these agricultural land unit classifications be improved? Recent work on categorizing agricultural phosphorus loss risk in Pennsylvania explored the utility of four types of cluster analysis (hierarchical, partitioning, density-based, and model-based) for grouping complex, continuous environmental data into useful agroecological clusters. Hierarchical clustering produces a nested series of progressively larger (or smaller) groups. The algorithm chosen, for instance single or complete linkage, determines the cluster shape. Partitioning clustering, such as k-means, requires the number of groups to be specified in advance, and sets of clusters may not nest. Many partitioning methods tend to find clusters of similar size and often spherical shape. Density-based clustering identifies heavily-occupied regions of multivariate space, and can identify clusters of arbitrary size and shape. Model-based clustering assumes that clusters are a mixture of Gaussian distributions. Ensemble methods enabled the use of computationally intensive methods on large datasets. These techniques can give extremely different results even on simple datasets. For complex environmental problems there is no one clear "correct" method. Instead, the desired use must be balanced against the assumptions about cluster shape and size inherent in each technique. Advances in methodology, particularly the use of ensemble methods to combine small, tractable data subsets, make a greater range of techniques usable, and improve the ability of cluster analysis to provide meaningful and useful results.

Third generation structural equation modeling: why and how

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One methodology increasingly used in investigations of vegetation patterns is structural equation modeling (a familiar variant being path analysis). The intent of the method is to enable investigators to propose hypotheses in the form of causal networks and then test their expectations against data patterns. Typically, this technique is brought into the analysis process to evaluate ideas about the web of relations among community predictors and vegetation responses. Additionally, it can be used to test ideas about latent factors generating patterns in the plant community itself. Structural equation modeling (SEM) has a long, dynamic, and interesting history. It has evolved through two major generations and is currently going through a fundamental reinvention that calls for a third-generation version of the method. In this talk, I outline the history of development and some of the current advances being made to the methodology. I also provide a commentary on the fragmentation process that is emerging due to discipline-specific viewpoints and the information explosion. I then lay out a vision for a third-generation SEM designed to serve the needs of scientists as they progress “from theories to queries and back again”.

The introduction of non-native species to the vascular flora: a historical perspective from Ohio

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The introduction of non-native plants is almost always the result of human activity, whether intentional or unintentional. Many plants were brought to North America by European settlers for use as food, medicine, for fiber production, forage, erosion control, to provide wildlife habitat, or for ornamental purposes. Other introductions have been accidental, often through contamination of agricultural and nursery seed or the transfer of seeds or other reproductive plant parts in ballast or packing material. This study used the published catalogs of vascular plants in Ohio to reconstruct changes in the flora over that last 150 years. The first checklist of vascular plants for Ohio was published in 1860, at which time about 7% of the species were identified as non-native. By 2001, when the most recent statewide survey of vascular plants was completed, 34% of the species present in Ohio were found to be non-native. While some of this increase in the non-native component of the flora represents better detection and identification of species, many of the non-native species can be tracked as novel and intentional introductions. For example, of the new taxa that have been recorded in Ohio since 1932, over 40% are woody landscape plants that have escaped cultivation. While the accidental movement of invasive species is difficult or impractical to manage, the continued influx of new non-native species through horticulture represents a pathway of introduction that is entirely within our control.

Preliminary results of research into grazing patterns of bison and cattle in response to prescribed burning and impact on wildlife and Species at Risk habitat in a northern mixed prairie

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Grazing by large ungulates and fire are key ecosystem disturbances that have been part of northern grasslands since glacial retreat 10,000 years ago. These disturbances have created conditions over that time to which species have become adapted. Fire suppression and alteration of grazing regimes by European settlers are recent phenomena to which grassland species have not become accustomed. Fire and grazing create heterogeneity at multiple scales and may increase habitats available to a greater variety of species. Our research tracks movements of bison and cattle on adjacent land management units in response to spring or fall prescribed burning and monitors the effect on soil and vegetation metrics and responses of wildlife and Species at Risk (SAR). We work on a Northern Mixed Prairie at Nature Conservancy Canada's (NCC) Old Man on His Back (OMB); OMB and surrounding large blocks of native prairie form part of a key corridor for wildlife and SAR in the region. Experimental treatment plots (8.9 ha) in a block of up to 8 per pasture were established in 6 pastures grazed by bison or cattle in a Randomized Complete Block Design. Within each treatment plot a subset of permanent soil and vegetation plots were randomly sampled in 2017. Initial comparison of pastures grazed by bison and cattle shows that grazing reduced grass and total biomass compared to ungrazed exclosures at OMB. Plants native to Northern Mixed Prairie evolved under grazing by large ungulates, fire, and periodic temperature and precipitation extremes and have developed mechanisms adapted to these disturbances and can recover quickly from such events. The interaction of disturbances, however, may have longer lasting effects. Litter and total biomass varied significantly depending on grazer, with higher amounts of litter and total biomass found under bison grazing. Cattle have been shown to select areas of higher plant biomass and may explain why litter and total biomass are higher under bison. Bison tend to favor graminoids while cattle consume a wider variety of grasses, forbs, and shrubs but no differences were detected. Prescribed fire and the interaction of fire and grazing at OMB should create additional heterogeneity. This research includes an examination of grazer movements via GPS collars in response to fire and evaluating changes in plant community composition, structure, and function at multiple scales to better understand impacts to wildlife and SAR and inform conservation agencies, landowners, and livestock producers managing land for improved economic and ecological outcomes.

Life forms and seed dispersal strategies suggest disturbance-driven vegetation changes on a Mediterranean islet 350 years after its first exploration

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Surprised by a gale during his travel to Malta, more than 350 years ago the pre-Linnaean naturalist John Ray had to spend two days on Isola di Capo Passero, a tiny islet just in front of the SE corner of Sicily, where he recorded the occurrence of 66 vascular plant species. After a thorough investigation led by one of us (S.P.), only six of the plants described by J. Ray remain unidentified. Even if the Ray's list is probably not exhaustive, the exceptionally long time elapsed since his investigation on the islet raises some considerations on the extent of the species turnover in the local vegetation. Significant differences have been found: (1) in the richness (both at infrageneric- and family-level) of annual vs. perennial herbs (quite surprisingly, very few perennial herbs occur in Ray's list), (2) in the ratio between Poaceae and Fabaceae and (3) in the ratio between long- and short-distance seed dispersal strategies. The pattern of the remaining life forms and families did not show any significant change, especially if we consider the data in terms of percentage. These facts can be interpreted taking into account the human history of the islet and the current knowledge on Sicilian vegetation. At the time of Ray, when a Spanish fortress was recently built on the islet; almost certainly most of its surface was still colonized by a well preserved low maquis referred to *Pistaciolentisci-Chamaeropetum humilis*, in which the Spaniards could have introduced a few goats or sheep: this could explain the occurrence of *Galactites tomentosus* and *Silybum marianum* in the Ray's list. In any case, the people living on the islet had not yet begun to burn the vegetation with the regularity and frequency that caused the currently observed perennial grassland (*Hyparrhenietumhirto-pubescentis*) to take over the *Pistacio-Chamaeropetum humilis*. This could be the reason for the very low number of hemicryptophytes recorded by Ray. In more recent times, generic disturbance and an increasing number of synanthropic naturalized species recorded from the whole of Sicily have increased the incidence of long-distance seed dispersal strategies on the islet of Capo Passero. However, the exceptionally low number of Poaceae (only one species) recorded by Ray remains unexplained, unless we presume a personal dislike for the representatives of this family.

Are there consistent drivers of taxonomic and functional diversity in West African Sudanian savannas?

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Which factors influence the different aspects of taxonomic and functional diversity in Sudanian savannas of West Africa? Grasslands' health and functioning is closely related to the diversity of plants and their traits. Plant diversity is interactively driven by biotic and abiotic environmental factors. The importance of these drivers for plant diversity, and particularly for functional diversity, is still poorly understood. Because data quality and spatial coverage is usually low, there is limited knowledge about diversity patterns in space and time. Additionally, there is inadequate understanding on how different aspects of taxonomic diversity relate to functional diversity measures. These knowledge gaps affect ecosystem management and services provision. By sampling a wide area (covering ~106,000 km²), this study investigates the relationship between different diversity measures and environmental variables using a combined gradient approach. The study area comprises a steep gradient of climatic aridity across West Africa's Sudanian savannas ranging from northern Ghana to central Burkina Faso, in combination with local gradients of topo-edaphic conditions and land-use intensity. Using three taxonomic diversity indices and three functional diversity indices as response variables, linear mixed-effect models and model selection were applied to test the links between ten environmental variables and the diversity indices. We found that climate and disturbance were more important than topo-edaphic variables; particularly for functional diversity indices. Precipitation seasonality was the most important driver of species richness, functional evenness and functional divergence (> 50% explained variance). Grazing pressure was most important for functional richness (> 60% explained variance) while soil clay content and slope position were most important for species evenness and Simpson's diversity index (> 60% explained variance). Our study showed inconsistent diversity-grazing relationships for different diversity indices suggesting that the intermediate disturbance hypothesis cannot be extended to all measures of diversity. There were no strong correlations between any of the taxonomic and functional diversity indices suggesting that single taxonomic diversity measures should not be used to represent functional diversity. These results are useful for land managers and can be used as a guide for conservation planning and rangeland management in general.

Cold, wet and harsh: alpine species and communities experience the most stress in low temperature, high precipitation habitats

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Functional traits can be used to understand how plant communities respond to environmental factors such as temperature and precipitation, and how communities affect ecosystem functioning. With ongoing climate change, understanding how plant functional traits change with temperature and precipitation, and how ecosystem functioning changes because of these shifts in traits is pressing. Climate projections show that western Norway will experience warmer and wetter conditions in the future. In this study, we investigated how the traits of alpine and boreal plants in semi-natural grasslands change with temperature and precipitation across a climate-grid of 12 sites. The grid has orthogonal mean summer temperature (6.5-10.5 °C) and precipitation (650-2,900 mm/year) gradients. Altogether, 2,780 leaves from 88 species were collected and used to calculate functional traits related to the trade-off between photosynthetic capacity and protective strategies: specific leaf area (SLA), leaf dry matter content (LDMC), leaf thickness, carbon to nitrogen ratio, and vegetative height. We found that community trait distributions change due to different abiotic and biotic stressors in the interaction between temperature and precipitation. We found that communities in the warm and dry end of the grid exhibit community traits related to high productivity, and found evidence for increased competition in these sites. By contrast, the cold and wet end of the grid has community traits that indicate a more conservative and protective strategy because of the abiotic stressors of low temperatures and thick cloud covers leading to light limitation stress. Community trait shifts are driven by both species turnover and intraspecific trait variability, although some species show contrary patterns. This study provides evidence that intraspecific trait variability in alpine and boreal semi-natural grasslands is relatively high compared to other habitats, and that it contributes to gradient-wide patterns. These findings suggest that the warmer and wetter alpine grasslands of the future are likely to lead to changes in species composition, traits, and ecosystem functioning caused by increased abundance of species and genotypes with higher photosynthetic capacity.

The semi-natural grassland in an urban area

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Semi-natural grassland is created by mowing or burning, and a unique herbaceous plant community develops. In Japan, semi-natural grassland has been maintained for a long time, because people used it as feed for livestock and for construction materials. However, after the 1960s (in the period of high economic growth of Japan), Japanese semi-natural grassland almost disappeared in urban areas as a result of abandonment of grassland management due to changes in human lifestyle. Meanwhile, in recent years, the conservation and creation of grasslands in the urban area has become one of the tasks in formulating urban planning with the aim of promoting biodiversity. Recently, we discovered some semi-natural grasslands in the urban residential area of Yokohama City, Kanagawa Prefecture, Japan. In these grasslands, many semi-natural herbaceous plants are growing, such as *Sanguisorba officinalis*, *Adenophora triphylla* var. *japonica*, *Arundinella hirta*, *Spodiopogon cotulifer*, *Campanula punctata*, *Thalictrum minus* var. *hypoleucum*, and *Artemisia japonica*. These species are categorized as rare species in urban areas of Japan. In this study, we conducted a vegetation survey at places where semi-natural grassland species grow and where they do not grow, in order to clarify the reason why these grasslands remain in the urban residential area. In addition, we analyzed the residential area development process from before development to the present days by aerial photo interpretation. As a result, these semi-natural grasslands were distributed on small vacant lands and slopes, where (1) there was no change in the topography, (2) there was no building construction in past and (3) there has been regular grass cutting. These results show that semi-natural herbaceous plants can survive in locations that satisfy the above conditions in urban areas. In addition, our results provide important data for preserving grasslands and rare grassland species in urban areas.

Reproductive success of palms in the cerrado sensu stricto of Brazil

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The palm community of the cerrado *sensu stricto* in Central Brazil is composed of six species: *Allagoptera campestris*, *A. leucocalyx*, *Butia archeri*, *Syagrus comosa*, *S. flexuosa* and *S. petraea*. In many species of palms less than 50 % of individuals which produce flowers successfully ripen their fruits due to losses by abortion and seed predation. This low success in the production of mature fruits and seeds may be due to the influence of different factors, either intrinsic to the parents, such as inbreeding depression, abnormalities in the formation of eggs and genetic factors, or external agents, physical or biological, such as restricted resource deficiency in pollination and predation. To characterize the reproductive success of these Cerrado palm species we collected data on the patterns of fruit abortion and pre-dispersal predation of seeds. We randomly collected mature infructescences of each species between January and October of 2012 in cerrado *sensu stricto* in areas in three separate conservation units in the Distrito Federal, Brazil. After collection, the following data were recorded for each infructesence: (1) total number of female flowers, (2) number of aborted fruits, (3) number of mature fruits and (4) number of fruits with pre-dispersal predation. The number of infructescences collected varied from 3 (*B. archeri*) to 89 (*A. campestris*) and the total number of mature fruits analyzed varied from 62 (*B. archeri*) to 2,337 (*A. campestris*). In general, there was a consistent pattern among congeneric species, with the genus *Syagrus* having the highest values and the genus *Allagoptera* having the lowest values in the measured rates. The reproductive success of these species was positively correlated with the fruit maturation rate and varied from a minimum of 8.9% in *A. leucophylla* to a maximum of 50.4% in *B. archeri*. Predispersal seed predation was generally lower than 10% except for *S. flexuosa* that had a value of 36%. However, neither abortion nor pre-dispersal seed predation showed consistent patterns with reproductive success in these species.

Invasive and ruderal plant species in beach and foredune in South Atlantic coastal communities in Brazil

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The coastline of Brazil is over 7,000 km long (4º 27´N to 33º 45´S) and the predominant first interface with the Atlantic Ocean are sandy beach plant communities. A great extension of this coastline is suffering anthropogenic disturbances which may facilitate the colonization of these areas by invasive plant species and there is a lack of information on the importance of alien species and their distribution in the beach and foredune plant community. This study presents information on the occurrence and distribution of invasive plant species in 15 sites located along the coast of Brazil (0º 45´ S to 31º 30´ S) in studies that were published between 1987 – 2015 that had reliable data on the species composition of the beach and foredune plant communities. The species were classified in three categories: native coastal, ruderal and invasive and the importance of each category was evaluated at each site. The classification of ruderal and invasive species was done using the available data bases, GBIF, GRIIS (only for Brazil) and from the Instituto Horus. A total of 123 native, 60 ruderals and 15 invasive species were found, with total species richness for individual sites ranging from 6 to 44. *Cenchrus echinatus* (40%) was the most frequent invasive species in these sites followed by *Cassytha filiformis* (20%), while the majority had only one occurrence. No trend between latitude and importance of invasive species in these plant communities was observed. The observed pattern of invasive and ruderal species was opposite. The importance of invasive species in community composition diminished with increasing number of native and ruderal species while the number of ruderal species increased with the total number of species in these communities.

Multi-temporal scale monitoring of plant community changes: insights from a deciduous temperate forest

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Long-term monitoring of (semi)-natural plant communities is a main approach to understanding the mechanisms of species coexistence and revealing the factors potentially leading to change. However, monitoring systems are often quite simple settings, while the plant community dynamics involves short- and long-term trends as well as cycles of various length. Disentangling the complexity governing the plant community dynamics at various temporal scales thus requires a multiple temporal-scale monitoring of the target community. Furthermore, monitoring is normally a forward-looking approach, only rarely covering time periods longer than a decade or two (depending on the longevity of the PI). For longer perspectives, "retrospective monitoring" by resurveys of historical vegetation plots constitutes probably the only widely applicable approach covering the decades-long changes. The method has been recently intensely discussed among the vegetation scientists. In the present paper, we introduce a multi-temporal scale monitoring system operated in LTER-site Devin, a deciduous temperate forest in the Czech Republic. The forest hosts an exceptionally biodiverse forest understory community (up to 41 vascular plant species per 3.14 m^2 and up to 86 species per 225 m^2). The monitoring system includes four temporal scales and two types of plots: (1) Permanent plots with a 5-year monitoring step run since 2008, a subset of which has been monitored yearly in spring and summer, and every month during one of the years; (2) Historical plots from the 1950s resurveyed in the 2000s, with the next resurvey planned in the 2020s. The results suggest large spatiotemporal heterogeneity of forest understory vegetation within the site. Some plots showed extremely large seasonal variation, while others showed relative uniformity. Ten years of yearly monitoring indicated a marked fluctuation in species diversity and heterogeneity within plots, and a moderate trend detected as increasing compositional dissimilarity. A jump-increase of species richness due to the light-pulse following tree cutting as a part of the traditional management restoration complemented to the long-term (over seven decades) trend of species impoverishment and homogenization due to succession after the management abandonment. As a whole, the monitoring data show complex and consistent patterns of vegetation dynamics. It is recommended that the long-term vegetation monitoring projects take in account multi-temporal scales sampling designs in order to cover the short- and long-term fluctuations, cycles and trends.

Historical vegetation ecology: an invitation to the new IAVS Working Group

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Working groups are essential parts of any scientific society. They add dynamics to the society's life, feed the variation of topics and help to track the current trends. IAVS is no exception to it, hence we would like to announce the foundation of a brand new working group focusing on historical vegetation ecology. It will be covered by one of the special sessions and established through a series of formal steps and events that will be held at the current IAVS Symposium in Bozeman. However, to keep the working group running and continuously developing, it is vital that the IAVS members get involved in its activities. To increase the awareness of, and to invite the IAVS members to participate on the new working group, we would like to poster-display the basic concepts and ideas. They will cover the reasons and motivations, scope and suggested variation of the topics, possible cooperation with other scientific societies, as well as information about the functioning of the working group on a long-term and daily basis. Regarding the motivation, we feel that IAVS, a renowned scientific society dealing with vegetation, needs to reflect also the ecosystems' past. Particularly important is the history connected with the human activities, which is essential for understanding of the current patterns in vegetation. The temporal scope may get no strict limitation, so the coverage would span from prehistoric times typically dealt with paleoecology to more recent periods, i.e. the historical ecology in a strict sense. As for the cooperation, two similarly oriented scientific societies expressed their preliminary interest to interact: they are European Society for Environmental History (ESEH) and International Association for Landscape Ecology (IALE) with its Historical Landscape Ecology working group. Having outlined the vision and the proposed activities of the newly established IAVS working group, we believe that it will attract many current and possibly new Society's members. The IAVS Symposium in Bozeman provides an excellent opportunity for it.

Factors determining distributions of the vegetation boundary between evergreen and deciduous broad leaved forests in eastern Asia

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An understanding of the determinants of vegetation boundaries (ecotones) is of interest in vegetation science and climate change impact assessments. The northern range limits of broadleaf evergreen forests are thought to be determined by winter minimum temperatures. However, the relationships between climate and evergreen–deciduous forest boundaries are inconsistent within eastern Asia as well as between eastern Asia and the eastern United States. In this study, we assessed factors determining vegetation boundaries between broadleaf evergreen and deciduous forests in eastern Asia using distribution data for Quercus species, representative of both evergreen and deciduous forests in the Northern Hemisphere. Species distribution models (SDMs) for four evergreen species (*Q. gilva, Q. sessilifolia, Q. glauca,* and *Q. myrsinaefolia*) and five deciduous species (*Q. acutissima, Q. variabilis, Q. dentata, Q. serrata,* and *Q. aliana*) were developed by down-weighted Poisson regression, a state-of-the-art presence-only modeling method based on an inhomogeneous Poisson process. We used four climatic factors (and their interactions) as explanatory variables: minimum temperature in the coldest month, mean temperature in the warmest quarter, and precipitation in the warmest and coldest quarters. The variables that were most influential in explaining the distributions of both evergreen and deciduous trees were: the interaction of winter coldness and precipitation, and the interaction of summer and winter temperature. The evergreen Quercus species used in this study occurred at high altitudes in southern regions, where winter temperatures dropped below –5 °C. However, they seldom occurred in northern regions, where winter temperatures ranged between –5 and –10 °C. The predicted vegetation boundaries between broadleaf evergreen and deciduous forests in eastern China and Japan were to the north of the actual boundaries. These results suggest that evergreen *Quercus* species distributions do not yet extend to the northern boundaries of their climatic niche. It is possible that past climatic conditions and migration from refugia following the Last Glacial Maximum (LGM) continue to influence current distributions of vegetation boundaries between broadleaf evergreen and deciduous forests.

Arbuscular mycorrhizal fungi in the arid Himalayas

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One of the most common mutualistic plant-fungal association is formed between arbuscular mycorrhizal fungi (AMF) and the majority of terrestrial plants, where the fungus receives plant-synthesized carbon in exchange for nutrients. Little is known about AMF diversity and distributional patterns in high altitudes and in very cold or dry habitats characterizing high elevations. Existing studies on AMF diversity patterns along elevational gradients mostly cover relatively short differences in altitude or include a limited number of plant hosts. Our aim was to describe diversity patterns of AMF along an elevational gradient and to determine the abiotic and biotic factors shaping the richness and community composition of AMF. Our study area is situated in Ladakh, on the dry flanks of NW Himalayas. In total, we sampled fine roots of 344 plant individuals (ca 200 species) in 85 sites across a range of 1940-6100 m a.s.l. The sites were located in six major habitat types (from lowest to highest): forests, cold deserts and steppes, alpine grasslands, screes, lower and upper subnival zones. DNA-based virtual taxa (VT) of AMF were identified using 454-sequencing of the SSU rRNA gene. Climatic and abiotic factors measured include air and soil temperature, relative air humidity, soil moisture content, snow cover, length of the growing period. Biotic factors include host plant functional traits such as plant height, biomass, LDMC, leaf C, N and P concentrations, root N and P concentration, and content of non-structural carbohydrates. In total we detected 101 AMF VT (mean 5.6; range 0-27 VT per sample) spanning across nine Glomeromycota genera, most common of them being *Glomus* (66 VT), *Acaulospora* (10 VT) and *Diversispora* (7 VT). There was a significant negative relationship between AMF VT richness and altitude ($P < 0.001$; Spearman rho = -0.27), with highest richness around 2,200 m and 4,300 m a.s.l corresponding to forest and alpine grassland habitat types, respectively. The most important abiotic and biotic factors determining AMF richness and composition will be discussed during the presentation. The results of this study will significantly advance our understanding of microbial, and specifically AMF diversity patterns and their underlying mechanisms at multiple spatial scales across a range of habitat types.

Pyric herbivory in the northern mixed grass prairie: testing the use of fire as a management tool for Species at Risk habitat on rangelands in Saskatchewan, Canada

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The Great Plains of North America evolved with fire and grazing by bison. With the arrival of Europeans settlers, bison herds were hunted to near extinction, fires were suppressed, and the natural disturbance processes occurring on the prairies were altered. Cattle are now the main source of grazing disturbance on native prairie. Cattle and bison cause different impacts on grasslands and grassland community structure, due to differences in management practices, foraging preferences, and social behaviors. Fire is a natural disturbance which creates a landscape that is variable in vegetation structure, composition, and biomass. Both cattle and bison seek out recently burnt areas, leaving other areas on the landscape to recover from previous grazing. The attraction to burnt areas further promotes a heterogeneous landscape that varies in maturity, structure, and composition. Heterogeneous landscapes are important to maintaining an environment that provides habitats to many at-risk grassland species. This research will determine the effectiveness of using planned fire as a livestock management tool through conducting prescribed burns on native mixed grass prairie in Saskatchewan, Canada. Research is being conducted in partnership with Nature Conservancy Canada at their Old Man on His Back Prairie and Heritage Conservation Area (OMB) property located in southwestern Saskatchewan. Research objectives will be tested by collecting plant community data and cattle and bison movement data over two field seasons. Plant communities were sampled extensively in the summer of 2017, prior to fire treatments in spring 2018. Initial results show that grazing by cattle reduced total biomass compared to ungrazed exclosures. Grassland monitoring will continue through the summer of 2018. Twenty cattle will each be fitted with a GPS tracking collar to obtain data on their movements during each of the 2017 and 2018 grazing seasons. Initial examination of GPS data collected in 2017, indicates that the cattle spent a large portion of time near water sources and avoided steep slopes. Prescribed burns will be conducted within research plots in late fall and early spring each year of the study. Forage quality will be tested to compare vegetation in unburned plots to vegetation in burned plots. GPS and plant community data collected will be analyzed using univariate and multivariate statistical methods and structural equation modeling to identify the effects of grazing and fire on plant community productivity and composition.

Incorporating succession into classification: tundra communities following wildfire in Arctic Alaska

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Rapid climate change is affecting climate-sensitive disturbance regimes throughout the world. In particular, the impacts of climate change on Arctic disturbance regimes are poorly understood because landscape-scale disturbances are infrequent or occur in remote localities. Wildfire in Arctic Alaska is presently limited by ignition source and favorable burn weather. With rapid climate change, a lengthening growing season, and subsequent increase in plant biomass and productivity, wildfire frequency and annual area burned in tundra ecosystems is expected to increase over the next century. Yet, post-fire tundra vegetation succession is inadequately characterized except at a few point locations. We identify succession stages of tussock tundra communities following wildfire using a chronosequence of 65 relevés in 10 tundra fire scars (1971-2011) and nearby unburned tundra from sites on the Seward Peninsula and northern foothills of the Brooks Range. We used the Braun-Blanquet approach to classify plant communities, and applied nonmetric multidimentional scaling (NMDS) to identify ecological gradients underlying community differentiation. Ordination revealed a clear differentiation between unburned and burned tundra communities, and in particular communities corresponded to fire history variables such as time since last fire, number of times burned, and burn severity. Post-fire species richness was less than unburned tundra and primarily reflected a decrease in lichen species and turnover of bryophyte species immediately post-fire. Species richness of grasses increased post-fire and was greatest in communities that burned more than once in the past 30 years. We review and discuss our results focusing on the implications of a changing tundra fire regime on vegetation succession trajectories, and subsequent community classification.

Thirty to forty years of vegetation change in the Mizunara oak forest in northeastern Japan

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Resampling of vegetation using the same method with the same plot size on the same site where previous data was taken is a valid method to obtain precise data of vegetation change during a research interval. Mizunara oak forests are widely distributed fuelwood forests in the cool temperate zone of northeastern Japan. Matured natural Mizunara oak forests in Hokkaido were aggressively logged in the 19th century because this location was famous as the origin of a type of wood specific to oak barrels and furniture with a high commercial vale. Consequently, existing forest stands are mostly substitutional. The purpose of this study was to clarify the recent change of species composition and plant species diversity in Mizunara forest and to detect the cause of these changes, such as abandonment of coppice management and influence of deer browsing. I resurveyed Mizunara oak forests where the first survey was done during 1970 and 1980 to study the phytosociological classification of the forest. As a recent increase of the sika deer population seems to affect the diversity of the forest understory, I also aimed to obtain information about the effects of over-abundance of deer on the diversity of plant species in the forest. The study areas are the Hokkaido and Tohoku districts, northeastern Japan. Resampling of vegetation at the same plots surveyed from 1970 to 1980 was done from 2015 to 2017. Intensity of deer impact on the plot was measured simultaneously. The average species number in the plot decreased over ca. 30 yrs. Occurrences of grassland species, such as *Miscanthus sinennsis, Pteridium aquilinum* subsp. *japonicum, Iris ensata* var. *spontanea*; pioneer tree; and shrub species, such as *Alnus hirsuta* var. *sibirica, Salix caprea,* and *Pinus densiflora*, were decreased. Conversely, an increase in occurrence of forest floor herbaceous species like *Teucrium viscidum* var. *miquelianum* was observed. Increase of woody liana such as *Vitis coignetiae, Vitis flexuosa,* and *Celastrus orbiculatus* var. *strigillosus* was observed in the Tohoku district. Effects of deer were observed in more than half of the plots in Hokkaido, but the decrease of species number in light-impact stands was lower than that of no-impact stands. Disturbances by light impact of sika deer maintained species richness of plant at stand level. From the results of NMDS ordination, I found that the first axis of the ordination correlated to winter climate conditions (e.g. winter precipitation, snow duration) and the second axis correlated to temperature in the growing season, respectively. Major changes in species composition of the forest were the result of forest development toward mature stage in succession.

Neighbour identity matters: evidence from pair-wise interactions between native and invasive plants

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The study of competitive effects and responses among invasive and native species provide helpful information for understanding the main mechanisms behind the invasion process. Our study highlights two important aspects that are still neglected in the literature: (1) the need of considering both the effects and the responses of an invasive species, as a whole strategy for invasion success; and (2) the importance of including a coexisting native species interaction, as a species identity control for disentangling the relative effect of an invader. We explored both the competitive effects and the responses of *Eragrostis plana*, the most invasive plant in southern Brazil natural grasslands. A pair-wise competitive experiment was performed, which consisted in four different treatments that varied the identity of the neighbor species: (1) no neighbor; (2) same neighbor; (3) native *vs.* invasive neighbor; and (4) native *vs.* coexisting native neighbor. According to each treatment, target species were the invasive *E. plana*, and three native grasses: *Aristida laevis, Eragrostis neesii* and *Paspalum notatum*. *Eragrostis lugens* was the coexisting native species for treatment (4). As a result, we obtained interesting outcomes not only about invasive species effects and responses, but also regarding intra and interspecific competition between plants. We showed that interspecific competition could be stronger than intraspecific, at least for native species. Moreover, target species showed distinctive responses if the neighbor species was native or invasive. We demonstrated that invasive species have greater effect on native species performance than a coexisting native grass. The competition between the invader and native species was relatively more intense than other coexisting native grass, suggesting that the invasive species may be competitively superior than natives. Besides, *E. plana*'s responded positively or neutral when interacting with native grasses neighbors. We conclude that the combination of *E. plana*'s negative effects and the positive or neutral responses when interacting with native grasses, demonstrated its high competitively ability, which may explain its success for invading natural grasslands in southern Brazil.

The higher the slower: range dynamics of mountain plants decrease with elevation

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Mountain plants are shifting upward in elevation. The majority of reports about shifts focus on upper limits, but little is known about the dynamics of the lower limit, distribution optima and species abundances. Here, we simultaneously analyze changes of 183 mountain plant species for these four range attributes. We therefore re-surveyed 1,576 vegetation plots first recorded before 1970 in the European Alps. Both range limits and optima shifted upward in elevation, but the most pronounced trend was a mean increase in species abundance. The upslope shifts were faster the lower the limits and optima were situated historically, and species' abundance increased more for species from lower elevations. Indicator values revealed that elevational ranges of thermophilic species tended to expand while those of cold-adapted species tended to contract. Abundance increases were strongest for nutriphilous species indicating that the observed dynamics were driven by climate warming interacting with airborne nitrogen deposition. So far, the majority of species appear as 'winners' of recent changes, but 'losers' are overrepresented among cold-adapted species from high elevations with low nutrient demands. In upcoming decades, high alpine species may hence face the double pressure of climatic changes and novel, superior competitors that move up faster than they themselves can escape to even higher elevations.

Preliminary insights: five years of change in permanent plots in the unpredictable semi-arid climate of Australia following removal of commercial grazing

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Rainfall of semi-arid and arid eastern Australia is highly unpredictable and species have had to evolve mechanisms to cope with this inherent predictable un-predictability. In addition, these landscapes have been largely overgrazed for 200 years by introduced ungulates which have no counterpart within the natural environment. The Paroo River and its major tributaries form the last un-regulated river system in western New South Wales Australia. Two adjoining private conservation reserves (Bush Heritage Australia and South Endeavour Trust) have been established on the Cuttaburra Creek and Yantabulla Swamp which flow into the Paroo (37,000 ha in total). The floodplain is inundated monsoonal rains that fall 500 km to the north which may take four weeks to reach the properties. None floodplain vegetation is wetted by local rainfall and overland flow only. Here we have established 78 permanent plots stratified across management, soil and landscape types which have been monitored currently for five consecutive years. The monitoring years have been characterized by increasing drought conditions (a deficit greater than one years' average rainfall) after above average rainfall years prior to the establishment of the plots with two small flows into the floodplain. Herbaceous biomass decreased by 68% across the properties in-spite of a total grazing pressure reduction of 58%. Initially the 20 species contributing most to ground layer biomass (70% of the total) was characterized by 16 grasses and 4 herbs which is now characterized by 5 grasses and 15 forbs. Average species richness per plot was also found to drop significantly. Loss of condition was not universal and due to floodplain water pulses being decoupled from local rainfall. An expectation exists within conservation managers that changes within permanent plots will lead to measurable improvement in scored attributes within a reasonable timeframe. Our results are discussed in the context of the requirement of managers to see that landscape change is dependent on the context of the prevailing conditions, that some landscapes may recover at very different rates, and that vegetation may enter alternate states. Furthermore, we are now within the context of novel ecosystems with no previous counterparts in terms of introduced herbivores, predators and plants that managers have no ability to fully control which necessarily affects the trajectory of vegetation change.

Environmental drivers of Net Primary Productivity: geographical patterns

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Primary Productivity (PP), the photosynthetic conversion of carbon dioxide to glucose and structural and storage molecules formed from glucose, is arguably the most important biological process that has evolved on Earth. The rate at which this critical process occurs is known to change from one location to another, and to be affected by a number of different factors. The importance of PP for supporting human society through agriculture and forestry, as well as its role in supporting all animal life, and in maintaining a balance of atmospheric gases favorable to life, demands a full understanding of the spatial and temporal factors that promote (or limit) PP, particularly in the context of climate variation or directional change. On the production side, light, carbon dioxide, water, and certain elements generally provided by the soil, regulate the rate of PP, approximately according to Liebig's "Law of the Minimum." On the negative side, PP is reduced by processes, particularly cellular respiration, that convert some of the glucose and other molecules back into CO_2, leaving the remainder as Net Primary Productivity (NPP). Since cellular respiration is temperature-dependent, higher temperatures produce a greater loss of PP than lower temperatures. There are good data, from direct measurements and remote sensing, as well as mechanistic models, that reveal the spatial and temporal patterns of most of the factors that influence NPP over the Earth's surface. The intensity and duration of direct-beam solar radiation is well-quantified and understood, but is affected by cloud cover, which can reduce light at the Earth's surface, as well as cool or warm the surface. This report is based on a review and synthesis of average monthly cloud density data with regard to its reduction of total photosynthetically active radiation (PAR) at the surface at one-degree resolution. The cloud cover data are also used to estimate average air temperatures during the day and the night, which affect respiratory losses of glucose produced during the day. Integration of these positive and negative effects predicts a global pattern of NPP that differs from the pattern predicted by remote sensing and computer models of NPP.

Biodiversity deficit lingers nine decades after agricultural abandonment

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Earth is rapidly losing many species of plants and animals, but it remains unclear whether there is corresponding loss of biodiversity within ecological communities, at the local scales at which species loss is known to decrease ecosystem functioning and stability. Trends in biodiversity over time have shown as many sites with local species gains as losses during recent decades, leading some ecologists to argue that there has been no systematic loss of local biodiversity. In contrast, comparisons of biodiversity across space have found systematic biodiversity loss at places most impacted by human activities. Here we reconcile these contrasting results, leveraging the strengths of both approaches by considering three decades of local biodiversity changes across more than one dozen grasslands with known land use histories. We show that local grassland plant diversity gradually, but incompletely recovers during the 90 years following agricultural abandonment. Local species gains were due to the return of formerly present species during post-disturbance succession, rather than to the introduction or arrival of new species. Therefore, local species gains during recent decades are not necessarily evidence against the systematic loss of local biodiversity, and cannot necessarily be attributed to exotic species introductions or range shifts due to climate change. Instead, local species gains can occur even, and perhaps especially, in places where there has been a prolonged deficit in local biodiversity. Given that many ecosystems worldwide are recovering after anthropogenic disturbances, and that it can take a century or more for their recovery, we suspect that many of the local plant species gains observed during recent decades represent the gradual reduction of a biodiversity deficit, rather than a biodiversity surplus.

Influence of historical landscape on aquatic plant diversity

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The historical composition of landscapes is recognized as an important factor for explaining plant diversity patterns, because current species assemblages are not only patterned by current ecological conditions, but also represent legacies of the past. Indeed, historical landscapes can represent past anthropogenic impact on the environment whose effects could still be observed nowadays. However, the influence of history on diversity patterns has mostly been investigated for terrestrial ecosystems, but has rarely been considered for aquatic ones. Here, we examined the effect of historical landscapes and land-use changes on the taxonomic richness and composition of aquatic plant communities in French freshwater shallow lakes and ponds. We aimed to test the relative influence of environmental variables and landscapes legacy on macrophyte species assemblages. We surveyed the macrophytes communities in 100-m sections of the shoreline of each lake (n = 17) up to 1 m depth. We used water chemistry and physical features of lakes as environmental variables, and reconstructed historical land-use of each lake's watershed with aerial photos from 1945, 1965, 1985 and 2000. Landscape changes were examined with transition matrices and principal component analysis (PCA) and species composition with non-metrical multidimensional scaling (NMDS). The relative influence of physical, chemical and historical factors on species richness and composition were tested with variation partitioning methods. We found that the landscape of all watersheds exhibit a trend toward an increase of urban and arable areas at the expense of semi-natural ones. Environmental variables and historical factors are strongly correlated with macrophyte diversity but current landscape composition seems to have only a weak influence. Especially, historical landscape factors appeared to be strongly associated with macrophyte species composition. These results underline the importance of historical factors in explaining aquatic plant diversity and suggest delayed responses of plant communities to anthropogenic pressures. Integrating historical factors in future analyses of aquatic ecosystems would thus greatly contribute to understand ecological processes governing their species assemblages, and would be crucial for their conservation and management.

Using permanent and quasi-permanent sample plots to identify winners and losers of vegetation change in Germany

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In the view of drastic biodiversity changes, recent efforts aim at establishing a consistent monitoring system in Germany. However, assessment of biodiversity change over time also requires the use of data which documents changes which have already occurred in the past. We here present a synthesis on temporal changes of plant species in vegetation records. A key challenge to identify changes based on historic vegetation records is that sampling was predominantly non-systematic, non-random and spatially and temporally irregular. The most detailed information is provided by records of permanent plot time series, but these are relatively scarce. The analysis of a time series in a permanent sample plot allows accurate detection of species turnover at the specific site, but is of limited spatial representativeness. With the objective to maintain the highest possible level of accuracy in space and time we have combined species abundance information from vegetation records of more than 4,000 permanent plots, quasi-permanent plots and resurvey studies from Germany, covering a time period of about 70 years (1927-2016). For every species out of the total of about 1,900 species in the dataset we calculated the relative change in cover across all available intervals, resulting in more than 180,000 species-interval observations. For 270 species, we encountered a significant positive or negative trend across all observation intervals. There were about the same number of species that showed cover decline and increase. The numbers of observation of losses and gains were distributed highly unevenly among species, with more evenly distributed losses than gains. Summarizing species-specific changes by decade shows that most losses occurred already in the 1970s, when also evenness became different between losses and gains. Furthermore, we show how gains and losses depend on species characteristics and on habitats. We discuss the results in the light of ongoing monitoring efforts to measure biodiversity change in Germany.

On reliability of space-for-time substitution in studies of vegetation succession

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The space-for-time substitution (SFT) is frequently used in ecology as an alternative of direct long-term studies. This technique extrapolates a temporal trend from a series of different-aged samples. The aim of our contribution is to assess the validity of space-for-time substitution in a study of secondary grassland succession focusing on the above-ground vegetation and the soil seed bank. In our substitution approach the time was substituted either by the distance (plots differing in position along the spruce colonization gradient were interpreted as consecutive successional stages), or by the depth (the lower soil depth layer was supposed to represent an earlier successional stage than the upper one). The validity of these substitutions was evaluated by comparison of the SFT-based generated trends with the directly re-sampled data from permanent plots after the 11-years period. Patterns in species composition and species richness of the above-ground vegetation revealed by the SFT-approach were similar to those indicated in the re-sampled plots. It means, that the species turnover and decline along the succession gradient in the understory could be successfully predicted from the initial spatial patterns. On the other hand, seed bank composition did not reflect the successional development of the above-ground vegetation and no differences in species composition were detected between the soil depth layers. Differences in seed bank species richness indicated in the re-sampled data were reproduced by depth-for time substitution but not by distance-for time substitution. However, seed bank density was successfully predicted from both depth-for time and distance-for time substitutions. Our results show that the developments of seed bank composition and seed bank species richness during the secondary grassland succession cannot be reliably predicted from spatial patterns recorded during a single unrepeated observation. We conclude that also with respect to a huge variance of succession-induced outcomes, the space-for-time substitution should be used with caution.

Climate change and ecosystem composition across large landscapes

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Climate change alters the vegetation composition and functioning of ecosystems. Measuring the magnitude, direction, and rate of changes in vegetation composition induced by climate in the modern context remains a serious and unmet challenge. Such information is required for a predictive capability of how individual ecosystems will respond to future climates. In this study we identified the relationships between 20 climate variables and 39 large landscape ecosystems across the southwestern USA, covering an area of about 1,228,167 km^2. We sought to understand the magnitude of relationships between variation in vegetation composition and bioclimate variables as well as the amount of ecosystem area expected to be affected by future climate changes. Data used in this study consisted of mapped ecosystem distributions, field plot observations of plant species composition across each ecosystem, and bioclimatic variables at each field plot location. Bioclimate variables best explaining the plant species composition of each ecosystem were identified. The strength of relationships between beta turnover within each ecosystem and bioclimate gradients was calculated, the spatial concordance of ecosystem and bioclimate configurations was shown, and the area of suitable climate remaining within the boundaries of contemporary ecosystems under future climate projections measured. Across the study area four climate variables account for most of the climate related variation in vegetation composition. The plant species composition of twelve ecosystems comprising about 238,285 km^2, almost 20% of the study area, is highly sensitive to climate change. By 2070, two ecosystems are projected to lose 4,000 and 7,000 km^2 of suitable climate area within their current boundaries. The climate areas of riparian ecosystems are expected to be reduced by half. Results provide specific climate-vegetation parameters for anticipating how, where and when ecosystem vegetation is expected to transform with climate change. Projected loss of suitable climate for the vegetation composition of today's ecosystems sets priorities for ecosystem conservation and restoration across the southwestern USA.

Large-scale vegetation mapping using systematic surveys and remote sensing-based spatial modelling

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Vegetation mapping has been a determinant tool for landscape management in the last decades. The introduction of remote sensing data and spatial modelling have allowed producing high-resolution maps in a more efficient way than traditional methods based on intensive field work and photo interpretation. However, vegetation maps at large spatial scales generally use large grain resolutions that do not match with field data on vegetation typologies, making them poorly applicable for biodiversity assessment. Here we present one of the few examples of large-scale vegetation mapping based on systematic field surveys, remote sensing and distribution modelling. In the context of a project for nature conservation in Central Anatolia (Turkey), 20 field botanists collected ca. 60,000 GPS points of pre-defined vegetation types during two field campaigns in an area of 180,000 km^2. With these data, we applied a hierarchical modelling approach to predict (1) the potential area of occupancy of each vegetation type at 1 km^2 of resolution using climatic and soil predictors; (2) the local area of occupancy by incorporating remote sensing variables at 30 m (Landsat 8 OLI) and 20 m (Sentinel 2A) resolution; and (3) the realized area of occupancy by selecting the vegetation type with the highest probability of occurrence and smaller uncertainty during class assignment to produce a vegetation map. The models performed well in predicting the occurrence of vegetation types across the study area, while the relative influence of environmental versus remote sensing predictors provided further information about their main ecological drivers. Results were useful for assessing the rarity and conservation status of each unit and for establishing a monitoring network of natural habitats in Central Anatolia. This study demonstrates how systematic surveys and spatial modelling may produce high-resolution vegetation maps in large regions and in relatively short time. These maps are suitable for national ecosystem assessment, ideally by complementing traditional approaches requiring more effort in small natural areas.

Multilevel formalized classification of grasslands (Molino-Arrhenatheretea) in Poland

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One of the most important goals of contemporary vegetation science is to create a universal and consistent classification system of vegetation at least at continental scale. This goal is becoming more and more realistic with the advent of new numerical methods and intensive development of vegetation-plot databases around the world. Formalized vegetation classification can be achieved by creating Cocktail definitions of vegetation units. Multi-level formalized classification approach has been proposed for the first time by Janišová and Dúbravková (2010) under the name Hierarchical Expert System. This approach has subsequently been used to create formal definitions of higher vegetation units at the level of alliances or classes. Formal definitions of vegetation units developed so far comprised at most two hierarchical levels, while theoretical basis of vegetation classification according to Braun-Blanquet approach requires development of complete hierarchical systems. The goal of our study was to create a multi-level and nested hierarchical classification system comprising associations, alliances, orders and classes. This system requires the assignment of a relevé to an association to be allowed on condition that this relevé was matched by the definition of alliance, order and class. In order to create formal definitions of vegetation units we used the Cocktail method and methodological achievements of Bruelheide (1997, 2000) and Landucci et. al (2015). Formal definitions were created using two types of groups: sociological species groups and functional species groups. A sociological species group is recorded in a relevé if the relevé contains at least a half of species from the group. Functional species group is recorded in a relevé if total cover of species from the group exceeds the arbitrarily set threshold. Functional species groups include species with a diagnostic value of particular vegetation unit from a hierarchical system. In order to create a functional species group we grouped species based on expert knowledge and extensive phytosociological literature surveys. Multi-level expert system was developed for grassland vegetation of the class *Molinio-Arrhenatheretea*. We used 85,000 relevés from the Polish Vegetation Database and 9 500 from Grasslands in the Polish Carpathians database. The main focus was on mesic grasslands. We created formal definitions for 17 associations and their superior syntaxonomical units (alliances: *Arrhenatherion*, *Polygono-Trisetion*, *Cynosurion* and *Poion alpinae*, order: *Arrhenatheretalia*, class: *Molinio-Arrhenatheretea*).

Alien species pool influences habitat levels of invasion

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Habitats differ significantly in the number of alien species established, i.e. habitat levels of invasion. Numbers of alien plant species can be determined by (1) habitat invasibility and (2) propagule pressure. Here we suggest another important factor: (3) habitat-specific regional pools of alien species. Traits of alien species are influenced by adaptations to original (donor) habitats in their native range. Because individual donor habitats provide different species pools for invasion, regional species pools of aliens available for invasion to individual habitats in the invaded range will also differ. Observed levels of invasion of analogous recipient habitats should therefore depend on these differences in alien species pools. Using the Czech National Phytosociological Database and the Carolina Vegetation Survey Database, we identified native and alien vascular plant species occurring in 27 habitats in temperate regions of Central Europe and eastern North America. We calculated each habitat's level of invasion as the proportion of alien species in a representative sample of vegetation plots from the habitat. We also calculated the contribution of each donor habitat to the regional alien species pool as the proportion of species in a habitat that are native to one continent and donated as aliens to the other. The relationship between each habitat's levels of invasion and the size of its regional alien species pool was significant for both the invasion of European plant species to North American habitats and the invasion of North American species to European habitats. We found that the more native species a habitat contributed as aliens to the other continent, the more of them established in the analogous recipient habitat on the other continent, creating a direct species-pool effect. We also found that the proportion of alien species in a habitat increased with the proportion of its native species that same habitat donated to the other continent. Donor habitats contributing large numbers of alien species to regional species pools elsewhere are thus themselves subjected to higher levels of invasion by alien species from analogous habitats elsewhere, creating a reciprocal species-pool effect.

Elevational patterns and ecological determinants of mean family age of angiosperm assemblages in temperate forests within Mount Taibai, China

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Species assembly is shaped by the interactions among ecological and evolutionary processes. By integrating niche conservatism and evolutionary history, the tropical niche conservatism hypothesis (TCH) has clarified species latitudinal diversity gradient at large scales. One of the TCH's central predictions, though lacking empirical evidence, implies that positive relationship between clade age and temperature along the altitudinal gradient should also be observed. Thus, we aim to test this prediction using a data set derived from forest communities of Mt. Taibai, central China. We systematically established 49 plots (20 × 30 m) along the north slope on Mt. Taibai, China. We calculated the mean family age (MFA) and its corresponding standardized values through rarefication and standardization, for woody and herbaceous angiosperm assemblages in each community respectively. Generalized linear models with Akaike weight and correlation analysis was used to evaluate the relationships between MFA with seven environmental predictors. For both woody and herbaceous assemblages, the standardized MFA showed significant decreasing tendencies along the elevational gradient and positive associations with minimum temperature (measured as mean temperature of the coldest month). Additionally, minimum temperature is the dominant predictor compared with the others in the regression models. These findings are generally consistent with the age-related predictions of the TCH, but are contrary to the results of related studies conducted in tropical regions.

Vegetation changes in high-latitude semi-natural grasslands

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Semi-natural grasslands have been a mainstay of pastoral agriculture in Europe for centuries. Today, these grasslands are among the most diverse and species rich habitats. In Northern Europe, however, ongoing changes in climate and increased land abandonment put the diversity and functioning of these habitats at risk. We used vegetation data from the Norwegian agricultural landscape monitoring program (3Q) to detect changes in grassland vegetation and to relate these to changes in land-use and the physical environment. Both in 2004-2008 and in 2011-2017, vegetation was analyzed in grasslands with varying intensity and type of use from 400 permanent plots (8 x 8 m) that were placed within 1 x 1 km monitoring squares systematically distributed throughout the mainland of Norway (58-70° N). From each plot, vascular plant species composition and species' covers were registered. Information on land-use type and intensity was noted. We applied ordination method and weighted average approaches using species indicator values (mean plot scores and species' individual optimum scores) to identify changes in species composition in relation to environmental gradients. GLM was used to evaluate relationships between changes in species richness and land-use. Total number of species was 482 (444 species in both sampling periods). 76 species occurred in either of the samplings (38 species each were 'lost' and 'new' in the resurvey). Number of species on average for plots (α-diversity) decreased from 28.3 to 27.4 species (not significant; $P = 0.189$). However, α–diversity was significantly reduced when grasslands were changed by, for instance, clearcutting or more intense use. Of 301 species tested for changes in occurrence frequency, 27 and 55 species were found to have significantly increased and decreased, respectively. Of those species that increased, 44% were typical forest species, while 84% of those decreasing were typical grassland species. Indicator value analyses did not find a change of species composition in favor of an environmental gradient. Species composition of the studied grasslands was relatively stable and has not shifted along specific environmental gradients. However, the observed changes in species occurrence frequencies indicate an ongoing succession from grassland to forest, which most likely is caused by land-use cessation in combination with a warmer and wetter climate. Our results suggest that keeping up an active traditional use of these grasslands is decisive to maintain high species diversity even under a changing climate.

Last-century changes in subarctic vegetation of northwest Russia

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Climate and land-use are important factors determining the distribution and composition of species in terrestrial ecosystems. Changes in these factors are considered to be most critical for alpine and arctic vegetation, which is dominated by slow-growing species highly adapted to short growing seasons. We resurveyed vegetation at Fisher Peninsula in the north-westernmost part of the Russian mainland to learn how vegetation has changed over c. 85 years of climate and land-use change. The vegetation at Fisher Peninsula was studied for the first time in the 1930s (Kalela 1939). Kalela conducted a plant-sociological sampling in meadows distributed around villages that have been mown and grazed since the 19th century. Since 1939/40 all land-use has ceased. In 2016, we resurveyed vegetation (species composition, species covers) in these meadows using similar methods. We used ordination method (DCA) and weighted average approaches with species indicator values as indirect methods to evaluate shifts in species composition relative to environmental change. Restricted permutation tests were used to test for significant changes in species' optima, richness and occurrence frequencies to account for not permanently marked plots and unequal intensity of sampling (n_{1930s} = 428, n_{2016} = 249 plots). Total number of species was 213 (179 in 1930s, 177 in 2016). Plot species richness (α-diversity) decreased significantly from 11.8 to 10.6 species (P = 0.027). Considering habitat types separately, α-diversity decreased significantly in tall-herb wet meadows at floodplains (P = 0.010), in mesotrophic and eutrophic fens (P < 0.001), and in snowbeds with tall herbs and ferns (P < 0.001). Of 152 species tested for change in occurrence frequency, 42 species decreased (in particular the tall herbs *Ranunculus acris* and *Trollius europaeus*) and 24 species increased (in particular the dwarf-shrubs *Vaccinium vitis-idaea* and *Empetrum nigrum ssp. hermaphroditum*) significantly. The number of species that changed their optimum along environmental gradients was: 37 (temperature), 36 (soil moisture), 34 (nutrients), 33 (light) and 25 (soil pH). This study found significant changes in species composition and species' occurrence frequencies over the past c. 85 years. Changes in favor of dwarf-shrubs and more shade tolerant vegetation are most likely the effects of both a warmer and wetter climate and land-use cessation coming along with e.g. changes in the nutrient regime in soils. This study shows that land-use cessation in subarctic vegetation can lead to drastic reduction in species diversity.

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

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Meadows underlie serious changes in Middle 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.

Ecological network of green habitat patches: grassland vegetation in urban habitats

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Urbanization is a leading process on the Globe causing a massive loss of natural habitats; it considerably changed natural ecosystems and formed new artificial habitats, seriously affecting urban biodiversity. In parallel a variety of habitats were created in urban environments, which may also support species diversity. We investigated the vegetation of urban habitat types (vacant lots, urban parks, and peri-urban grasslands) in the city of Debrecen (East-Hungary). The studied habitat types were characterized by species typical to semi-natural grasslands and ruderal assemblages. Our aim was to (1) identify urban green areas and their connections with the Regional Ecological Network surrounding the city, (2) and to explore the biodiversity potential of urban habitats. We used five spatial replicates of each habitat type and five random plots (5 × 5 m) in every site. Our findings suggest that the species composition of urban habitat types is considerably affected by the specific disturbances and site histories associated with the habitats. The urban parks harbored the lowest number of species and were characterized by the lowest plant diversity. The ratio of weeds and disturbance-tolerants was the highest in the vacant lots due to the high-intensity trampling and soil disturbances. Plant species of vacant lots were more drought-tolerant compared to the species of peri-urban grasslands, which is likely due to the increased level of drainage in the city centers. The ratio of nitrogen-demanding species was lower in urban parks and peri-urban grasslands than in vacant lots. The proportion of alien species was high both in vacant lots and peri-urban grasslands, even though their disturbance regimes differed considerably. The proportion of cosmopolitan species was significantly higher in vacant lots compared to urban parks and peri-urban grasslands. The large proportion of alien and cosmopolitan species together with the continuous human disturbance put native species at a competitive disadvantage, and accordingly the proportion of these species was lowest in the vacant lots. We found that the green space system of the city is well connected to the Regional Ecological Network. We found that 65% of the functional green spaces are potentially connected thus there is a possibility for species typical to semi-natural open habitats to disperse between the green spaces of the city. Our results suggest that the studied urban habitats have some biodiversity conservation potential; they mostly harbor species which can cope with the local environmental conditions of the city parks, such as increased temperature, drought and nutrient enrichment.

Plant diversity and habitat variation in subtropical riparian areas on Amami-Ōshima Island, southern Japan

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Amami-Ōshima Island is in the central Ryukyu Islands, in southern Japan. The vegetation of these islands is characterized by the subtropical island climate. The natural vegetation here is very important for the biodiversity of Japan because it includes many endemic and endangered species. Riparian areas along small island rivers are essential habitats for endemic species with characteristic life forms, such as rheophytes and epiphytes. Therefore, we analyzed the species diversity of subtropical riparian vegetation and the effects of river habitats on the diversity pattern. There are six types of habitat along the rivers on Amami-Ōshima Island: (1) river channels, (2) sand and gravel bars (mainly in the downstream area), (3) exposed rock on the river bed, (4) rock walls along the river channel, (5) small terraces, and (6) lower side-slopes. The riparian plant communities were classified into four types: evergreen broad-leaved forest, communities of small shrubs and herbs, communities of large grasses and pioneer trees, and submerged plant communities. Evergreen broad-leaved forest was mainly established on small terraces and lower side-slopes in upstream areas. These forests were dominated by evergreen trees, including *Castanopsis sieboldii* subsp. *lutchuensis* and *Schima wallichii* subsp. *noronhae*, with some deciduous trees such as *Lagerstroemia subcostata*, *Acer insulare,* and *Toxicodendron succedaneum.* The high species richness of large ferns, orchidaceous plants, and epiphytes was remarkable. The communities of small shrubs and herbs were established in very limited spaces on exposed rock in the river bed and rock walls, in the upper and middle reaches of the river. The species included many endemic/endangered rheophytes, including *Viola amamiana, Lysimachia liukiuensis, Lagenophora mikadoi,* and *Salvia pygmaea*. The endemic shrub *Rhododendron scabrum* grows on the lower rock wall along the channel. This community type was characterized by high species heterogeneity within and between the rivers. Communities of large grasses and pioneer trees were established on sand/gravel bars, and dominated the riparian vegetation in downstream areas. The dominant species were *Phragmites karka, Miscanthus condensatus, Typha domingensis*, and several species of *Persicaria* and *Cyperaceae.* These native species were distributed separately, and were affected by the water table and frequency of disturbance. These communities had high species diversity, but included many alien species. The submerged plant communities located in the river channels consisted of the native aquatic plants *Limnophila sessiliflora* and *Callitriche palustris* and invasive alien species.

Application of the EcoVeg approach to vegetation classification and mapping of an East African savanna landscape

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Between 2015 and 2017, a team of California ecologists in cooperation with the Tanzanian Wildlife Research Institute (TAWIRI) produced a vegetation classification and map for a 26,000-ha wildlife corridor between Lake Manyara and Tarangire National parks. The 'EcoVeg' approach is the basis for the vegetation classification and map. The purpose was to provide fine scale, defensible vegetation mapping and land use data to inform conservation decisions critical to the long-term stability of large mammal populations in the region. The project provided an opportunity to test the development of the EcoVeg system in East Africa and to determine its utility to TAWIRI as a tool for ecosystem assessment and monitoring. A two-week field season enabled collection and identification of botanical specimens and sufficient vegetation data to develop a preliminary vegetation classification and map. One year later, a second field season of similar duration added more vegetation sampling for adequate representation of vegetation classes, and map verification. In all, 362 stands were subjected to Sorensen's Flexible-Beta clustering and Indicator Species Analysis, and developed into a classification with 25 fine-level entities. These broke into general categories of forest, woodland, scrub, savanna, herbaceous wetlands, and cultural vegetation. We used existing information on the upper levels of the EcoVeg hierarchy and our local classification analysis to develop the full 8-level hierarchy for the study area. Eight EcoVeg macrogroups are proposed, containing 12 groups, 18 Alliances, and 25 associations. Although the classification remains provisional until further developed, mid-level group and macrogroup levels coupled with structural information, were useful to demonstrate specific project conservation needs for large ungulates. Alliance and association levels of the hierarchy were useful for habitat definition for smaller mammals. TAWIRI researchers were involved in all aspects of the project and have begun plans for similar projects in other high priority wildlife areas of Tanzania.

New aspects of grazing-mediated facilitation: small-scale edge effect and density dependence

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There are both positive and negative plant-plant interactions in community organization and their net effects may depend on the disturbance regime, including grazing. Unpalatable plants can act as biotic refuges by physically protecting neighboring species from herbivores. This is a well-known mechanism; however, little is known about the spatial pattern of the effects of unpalatable plants on the protected species (i.e. growing beneath or in the edges of biotic refuges). Moreover, only few studies have focused on the density dependence of biotic interactions in pastures. We aimed to disentangle these topics by testing the following hypotheses: (1) Net outcome of biotic interactions differ in the interior and in the edge of the biotic refuges. (2) Species richness and flowering success follow unimodal curves along the gradient of biotic refuge density. We performed our study in the Great Hungarian Plain, in meadow steppes with medium intensity cattle grazing. First, we assessed the effects of small shrubs on species performance by studying three types of microsites both on currently grazed and ungrazed pastures: shrub interior, shrub edge and open pasture. After this, we studied the changes of species richness and flowering success of understory species along the density gradient of an unpalatable herbaceous plant. Regarding the first topic the highest species density was found at the edge of shrubs, both in grazed and ungrazed vegetation, while species density did not differ between shrub interiors and the open pasture. In grazed vegetation, flowering success was higher in shrub interiors and edges than in the open pasture; no significant trend was observed for this measure in ungrazed vegetation. In contrast to previous studies, we did not detect competitive effect of small-sized shrubs on plants in ungrazed vegetation. Our results indicate that edge effect plays an important role for the maintenance of small-scale species diversity in sparsely shrub-encroached pastures. Regarding the second topic, the relationships between the biotic refuge density and both the number of flowering shoots and species richness were unimodal, indicating a humped-back pattern of facilitation along the biotic refuge density gradient. The explanation of this pattern was the protection against herbivory at the initial part of the gradient and the increased level of competition at height biotic refuge density. Our study underlines the beneficial effect of biotic refuges in pastures and suggests that retaining a sparse population of unpalatable shrubs or herbs is advantageous from a conservation point of view.

Use of potential natural vegetation for restoration of forests in Kenya

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Natural forests have been under intense pressure from anthropogenic activities globally and specifically in Kenya and other African countries. According to the FAO, Africa lost the highest percentage of tropical forests of any continent during the 1980s, 1990s, and early 2000s. In 1963, forest covered 10% of land in Kenya and by 2006 that dropped to 6.6%. Reports show that by the year 1990, Kenya had an indigenous closed canopy forest cover of 1,240,000 ha which progressively reduced to 1,190,000 ha in 2000, 1,165,000 ha in 2005 and 1,140,000 ha by 2010. This is an average loss of 5,000 ha per annum in that period. The traditional methods of rehabilitation include indigenous tree planting activities and exotic commercial plantations using a method locally known as the 'Shamba system' or plantation system which involves pitting, planting and maintenance for at least 3 years. The shamba system involves giving parcels of land to farmers to till where tree seedlings are planted and the farmers manage the seedlings for at least 3 years while they benefit from the produce harvested from the plots. This has had its drawbacks mainly in seedling survival which results to delayed speeds of recovering forest cover. Until recently, there has been no proper scientific guideline of choice of species with regard to their ecological suitability to help restore environments with potential natural vegetation. We present results from use of vegetation science in species selection, rehabilitation and growth rates using the 'Miyawaki method' at the University of Nairobi's Chiromo campus data for the last 5 years. There was a highly significant difference in absolute growth in height for species planted in 2013 ($P < 0.001$) with *Ehretia cymosa* having an absolute mean growth of 375 cm and a total mean height of 413.19 cm by day 1250 after planting. The least mean absolute and mean total growth recorded in this site was by *Calodendron capens*e which reached 54.6 and 87.8 cm respectively. Species planted on a constructed mound were also significantly different both in absolute change in height (Final Height-Height at Planting) and actual total height of individual species ($P < 0.001$). At the lower part of the mound, *Cordia africana* reached an average total height of 600.25 cm by day 1251 after planting while *Olea europaea* ssp *africana* only reached a mean height of 121cm recording the slowest growth. The absolute mean growth of *Cordia africana* was 552.5 cm while *Olea europaea* ssp *africana* was only 67 cm by day 1251 after planting. At the top part of the mound, *Cordia africana* reached a mean total height of 673.25 cm while the slowest growth was by *Vepris simplicifolia* which attained a mean height of 162.33 cm. *Olea europaea* ssp *africana* had a better performance at this site with a mean growth of 184.95 cm. A similar pattern was observed for absolute mean growth where *Cordia africana* reached mean height of 626.25 cm while the species that had the least growth in height was *Vepris simplicifolia* (115.67 cm) followed by *Olea europaea* ssp *africana* (124.44 cm) by day 1151. The results show that condition and drainage of soils is also important in determining species performance. Individuals on created mounds or slopes performed better than those on potentially flooding soils. In general, a scientific application of knowledge of species suitability is very important in selection of species and rehabilitation of the environment with potential natural vegetation.

Biomass stability-diversity relationships in annual plant communities in Mediterranean and semi-arid ecosystems

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Stability-diversity relationship has been little studied in ecosystems with high dominance of annuals. Here, we examined rainfall effects on temporal relationships between plant species diversity, species population dynamics and stability (mean/SD) of biomass production in herbaceous vegetation of Mediterranean and semi-arid ecosystems subjected to rainfall manipulations. A trend of decreasing rainfall occurred during the study period in both study sites. Rainfall manipulation treatments were applied using rainout shelters and irrigation setups that reduced or increased rainfall by 30%. Above-ground biomass production and species abundance were measured at peak season in spring during eight consecutive years in randomly placed quadrats within permanent plots. Results showed that herbaceous vegetation was highly diverse, with 214 and 166 species in the Mediterranean and semi-arid sites, respectively. Annuals produced 80-90% of the biomass at each site. Constancy in the identity of the main species contributing to community biomass diminished the "portfolio effect", since a small set of stable species produced most of the biomass in both sites across time. Changes in species composition occurred after grazing cessation, concomitantly with the trend in rainfall decrease. Species richness and diversity, species dominance and evenness decreased with time in the Mediterranean site, and to a less extent in the semi-arid site. Above-ground biomass production was relatively constant across years in both sites, despite the decreasing rainfall trend and grazing cessation, as shown by decreasing species similarity compared to the initial vegetation state. Stability of biomass production was higher in the Mediterranean site. At the species population level, biomass production stability was increased by decreasing species synchrony in their biomass variation across time. In contrast to biomass production, species richness and plant density decreased gradually with time, while average plant weight (plant size) increased, resulting in fewer but larger plants in the community. "Plant size groups" were classified and temporal changes of their relative contribution to community biomass were analyzed. In both sites, size groups showed "compensatory changes" (large plant groups increase vs. decrease in small plant groups; "competitive interactions"), while productivity remained relatively constant. Thus, community biomass stability was regulated by compensatory changes and biomass stability of dominant larger annual species. Rainfall manipulations applied (both decreased and increased rainfall) did not modify these temporal patterns of change in the annual plant community and had negligible and inconsistent effects on biomass production. These ecosystem and community properties may provide resistance against climate change in this region.

Is inter-annual variability of biomass production in Mediterranean and semi-arid annual plant communities caused by variation in number of species, species plant mass or plant density?

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Primary biomass production (productivity) is one of the fundamental processes of ecosystem functioning. In Mediterranean ecosystems ephemeral herbaceous species are a major source of annual biomass production. Productivity in this annual vegetation is the sum of the biomass produced by individual plants of co-occurring species. Therefore, inter-annual variability (assessed by Coefficient of Variability = CV) of productivity is the direct result of variability in the number of species, combined with variability in plant density and average individual plant mass of the different co-existing species. In order to assess the relative importance of these components for inter-annual variation in productivity, we analyzed data collected during 9 years in two contrasting sites, Mediterranean and semi-arid, with seasonal winter rains (540 and 290 mm rainfall), in fenced plots protecting from grazing. Annual species were the largest contributors to biomass production (80-90%) compared to geophytes and herbaceous perennials. Even though 214 and 166 herbaceous species co-exist in the Mediterranean and semi-arid sites, 85% of the biomass was produced by just 17 and 9 species, respectively. We found large inter-specific differences in average plant mass of annual species, but variability within species in plant mass across years was independent of species plant mass. Variability in plant density of annual species arising yearly from the soil seed-bank was the main source of inter-annual variation in productivity of the herbaceous vegetation, not variability in species plant mass.

Recolonization of native and invasive species after large-scale clearance of a temperate coastal dunefield

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It remains challenging to enhance the establishment of native plants, while suppressing the expansion of invasive counterparts in coastal dune ecosystems. Much advancement has been made in this topic in the context of removing vegetation within invaded areas; however, many studies of this sort adopt a plot-based approach by which researchers establish a set of experimental (often topographically homogeneous) plots where post-clearing recovery of plant species is monitored for a given period of time. Therefore, the literature still lacks a detailed understanding of *where* (i.e. under what *spatial* circumstances) native and invasive plants are likely to recolonize after clearance across a large dunefield. In this research, we report an unusual case in which a vast field (ca. 11 ha) of vegetation had thoroughly been cleared out at the Sindu dune of western Korea in the fall of 2012. The vegetation included four broad types: dune plants, xerophytes (primarily invasives), hydrophytes, and trees. The trees were cut by chainsaws at ground level and the other species were manually pulled out by local employees. After the removal, we exhaustively mapped the entire study area focusing on the regeneration of native dune and invasive species in the spring, summer, and fall of 2013, 2014, 2015, and 2016 (i.e. 12 times). We found continuous expansion of native dune species (3.6 to 9.9 ha) between 2013 and 2016, which was well expected and encouraging. However, there also were substantial increases in the extent of invasive plants from 0.5 to 1.3 ha during the same period. Indeed, such increases occurred again during mid 2015 even after an additional removal in fall 2014. Based on a suite of spatial regression analyses using selected environmental factors (surface elevation, slope angle, slope aspect, distance to coastline, and distance to trails) as predictor variables, we determined that distance to trails was of foremost importance to the presence of invasive plants. This implies that the recolonization of invasive species was not a spatially random process, but was rather concentrated along the trails through which the local employees walked and drove in order to transport chainsaws and cleared plant bodies. We conclude that removal is often costly, but if executed without a very careful plan for the movement of workers, equipment, and plant debris, it may even dramatically increase the extent of invasive plants from the initial state.

Clonal plants rule the world, don't they?

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Plants possess the two modes of reproduction, sexual and asexual (clonal). While it may be assumed that the potential for asexual reproduction gives plants a fitness advantage, this does not seem to be the case. In temperate Europe, only about half of the flora is capable of clonal growth and clonal plants are only slightly more abundant than non-clonal plants. One of the reasons for this pattern may be a trade-off between sexual and asexual reproduction. We searched for this trade-off in several data sets from temperate plant communities for which we have data for clonality (database of clonal growth in flora of Central Europe CLO-PLA). The data generally show that clonal plants produce fewer seeds and their seeds germinate and establish less readily than those of non-clonal plants. On the other hand, clonally produced offspring are larger and are able to outcompete seedlings. When only seedlings, but not adult plants are present, clonal plants are less successful during establishment than non-clonal plants but with time (after several years) they take the advantage of clonal multiplication and compensate for initially poor sexual reproduction. All these effects become more pronounced with increasing intensity of clonal growth, namely lateral spread. These findings imply that clonal growth incurs costs in sexual reproduction; therefore clonal plants are not generally more successful than non-clonal plants, at least in the studied flora.

Community-weighted means are misleading bioindicators of environmental change

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Temporal changes in community-weighted means of species ecological optima are routinely used to bioindicate changes in the environment. For plants, the most often used ecological optima are Ellenberg indicator values. However, this popular bioindication rests on two crucial assumptions. The first – and already tested – assumption: mean Ellenberg values reflect local environmental conditions. The second – and surprisingly never tested – assumption: changes in mean Ellenberg values reflect environmental changes. To test both assumptions, we analyzed 2302 forest vegetation plots surveyed across the Western Carpathians in the 1950s-70s and resurveyed in the 2000s. First we correlated mean Ellenberg values with measured soil pH, C:N ratio, annual mean temperature and canopy openness within each survey. Then we compared changes in mean Ellenberg values and changes in environmental variables re-measured on the same plots. Finally we compared overall changes in Ellenberg values and environmental variables between the surveys. The first assumption holds – bioindicated and measured variables correlated within both surveys. But the second did not – bioindicated and measured changes in environmental variables were not correlated at all. On individual plots, measured changes in soil pH, nitrogen availability and temperature were not significantly related to changes in mean Ellenberg values. On large-scale, weak overall shifts in mean Ellenberg values between surveys hide major observed environmental changes – climate warming and soil acidification. Our results showed that changes in community-weighted means of species ecological optima do not reflect environmental changes on individual plots, nor large-scale trends in the environment. Because community-weighted means are calculated directly from species composition, any non-random turnover in species composition will change also community-weighted means. Non-random turnover in species composition can be however triggered by many non-environmental drivers like changes in habitat management or species invasion. Community-weighted means of species ecological optima are therefore misleading bioindicators and new approaches are needed to reveal environmental changes from species assemblages.

Species pool properties tell historical diversification processes: species abundance, phylogenetic and functional structure of woody plants on East Asian archipelago

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The numbers of individuals and species are fundamental properties of biodiversity patterns. Species abundance distributions (SADs), as the division of individual number between species, played a central role in the development of ecology. SAD represents commonness or rarity that is a product of multiple filtering effects related to species/clade-specific ecological niche and evolutionary fitness. Both at local and regional species-pool scales, the SAD is an emergent property associated with the mechanisms of macroevolution and community assembly. Nevertheless, exploring the SADs is limited toward local-scale studies, because the numbers of individuals for many species (macro-scale SAD) are not readily determined. Species pool properties, in which how many individuals and how many species occur regionally/globally, are inevitably hidden in the macroecolgical black box. A precise estimate of macro-scale SAD that improves the definition of the species pool along geographical gradients should provide a methodological advance in phylogeny/trait-based community ecology that identifies deterministic macroevolutionary processes, e.g. abiotic filtering and adaptive radiation, leading to better understanding the origin and maintenance of biodiversity. In this view, we developed a novel model for estimating the SADs of woody plant species across different biomes, based on large-scale replicated vegetation plots (species presence-absence data), species range map (known-absence data) and herbarium specimens (known-presence data). Using the estimated macro-scale SAD of woody plants, we investigated species pool properties of mid-latitude forests containing hemiboreal, temperate and subtropical forest vegetation. Specifically, we explored historical diversification of woody flora by neutral models that assumed different speciation modes (e.g. point mutation, random fission or protracted speciation), and then clarified phylogenetic and functional assembly patterns at species pool level. In addition, we examined how species-pool definition (pooled species abundance over sampling plots) bias ecological inference of local-scale species assembly; predicted macro-scale SAD could solve a circular issue between α diversity and γ diversity pooled over all local sites that have often weaken statistical inferences such as Type II error in null model analyses.

Beta diversity of angiosperm tree communities: roles of climate and geography

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Beta diversity, compositional dissimilarity of taxon among sites, is one of central topics in macroecology. Taxonomic dissimilarity increases with increasing geographical distance and differences of environmental conditions between local communities or assemblages, and beta diversity in a given locality varies between regions in different continents or latitudes, and the latitudinal pattern of beta diversity is associated with species pool size. To explain these general patterns, many factors related to ecological and evolutionary processes and idiosyncratic geohistorical events have been examined. Geohistorical processes, isolation and/or connections between regions, affect colonization, extinction and speciation, and thereby result in dissimilarity of species diversity among regions, while ecological processes, e.g. species sorting through environmental filters determine local species diversity by the niche specialization among species. Nevertheless, the mechanism of beta diversity including various processes at different spatial and temporal scales has remained unknown. Large-scale gradients and regional differences in angiosperm tree diversity provide an ideal opportunity to understand the mechanisms of beta diversity in forest communities. To test the predictions of the climatic filtering and isolation hypotheses, we examined the pattern of beta diversity between biogeographic regions and how differences are correlated with specific environmental factors. We compiled global-scale dataset of species abundances for angiosperm woody plants, and focused on abundance-based patterns of taxonomic beta diversities to unravel the influence of biogeographical constraints on community assembly. Specifically, we partitioned turnover and nestedness components at order, family, genus and species levels between paired local communities across the continents and within biogeographical regions; balanced abundance variation (turnover) and abundance gradient (nestedness) is evaluated by population size of member taxa that reflect ecological and phylogenetic sorting in a site. Based on the patterns of distance decay of taxonomic similarities between plots, we tested the predictions of the climatic filtering and isolation hypotheses: (1) taxonomic and phylogenetic dissimilarity between local communities is predominantly significant between continents and increases as climatic difference or geographical distance increases because of abiotic filtering and dispersal limitations; (2) the responses of beta diversity to geographical distance between local communities differ between the continents or biogeographical regions because of center-of-origin effect related to geohistorical factors; and (3) nestedness component of beta diversity is predominant in climatically harsh regions and/or isolated conditions because of climatic filtering and/or vicariance effect. Finally, we discussed how evolutionary divergence over large time scales have influenced global-scale beta diversity patterns of woody plant communities.

Vegetation concept is a key tool in the biodiversity management and conservation

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The maintenance of biodiversity in forestlands has become one of the major concerns of forestry in the European Union (EU) as well as globally. The EU implements it through the Forest Europe process, which promotes sustainable forest management, and through the Natura 2000 which is network of sites selected to ensure the long-term survival of Europe's most valuable and threatened species and habitats. The Natura 2000 network stems from two EU Council directives – Birds and Habitats directive. Habitats directive addresses threatened plant and animal species, their habitats and habitat types. In Slovenia (Europe), most of Natura 2000 forest sites and forest habitat types are selected according to vegetation criteria. Although the Natura 2000 helps to tackle a broad range of biodiversity problems, there remain some open issues, including the vaguely defined concept of a forest habitat type, and the need for more dynamic approach to biodiversity management. To make the definition of a forest habitat type more concrete, a hierarchical order was introduced into the current concept of forest habitat types. A hierarchical relationship between forest habitat types and their subtypes was established by employing a vegetation concept by using the bottom-up approach and classification key, developed by studying the vegetation and eco-geographical characteristics of the forest habitats' subtypes. The method was tested in three main Natura 2000 forest habitat types in Slovenia: 91K0–Illyrian *Fagus sylvatica* forests, 9110–*Luzulo-Fagetum* beech forests and 91L0–Illyrian oak–hornbeam forests. The results showed that dividing forest habitat types produced less heterogeneous forest habitat subtypes, and suggested the preferred course of development of these forest habitat types. Moreover, information on vegetation status and plant species composition also play an important role in assessment of conservation status of forest habitat types and their day-to-day management. The 91K0–Illyrian *Fagus sylvatica* forest habitat type and 5130–*Juniperus communis* formations on calcareous grasslands were used to demonstrate that biodiversity in the Natura 2000 habitats is not static. The study revealed that the dynamic management approach to biodiversity conservation needs to be applied.

Productivity – diversity relationships change across sampling scales and converge to a global richness-productivity relationship

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The shape of the diversity-productivity relationship has endlessly fascinated plant ecologists. Thinking on this subject expanded from Grime's original hump-shaped conception through debates on the predominant shape(s) of the relationship, to current acceptance that a plurality of shapes are possible. Here we investigate how diversity – productivity relationships change across sampling scales within individual communities using case studies from a Canadian mixed grassland and a tropical forest. In each case we have continuous stem maps and measures of individual plant biomass or productivity. By dropping virtual quadrats of varying size on these communities we are able to fit species – productivity relationships at multiple scales. Two general patterns emerge from this work. First, within each sampling grain there is a general trend for hump-shaped relationships at smaller spatial scales transitioning to linear relationships at larger scales. Second, across sampling scales there is a general log-linear relationship between diversity and productivity that converges replicate the species area curve. Much of the debate regarding the shape of the productivity-diversity relationship may be driven by differing sampling scale decisions between studies.

The integration of environmental filtering and species interactions

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Community assembly is commonly viewed as a hierarchical process where species are first 'filtered' by the environmental conditions of a site based on their physiological tolerances. Those species that can tolerate the site then interact with one another as they compete for the limited resources within the site. However, predictive models of environmental filtering and species interactions have been developed in isolation even though they jointly influence community assembly. Given the known importance of interactions for influencing species distributions, the integration of these processes within a synthetic model would improve our predictions of ecological responses to global change. We propose that carrying capacities provide the conceptual and mathematical link for integrating interactions into models of environmental filtering because carrying capacities must vary along environmental gradients due to species physiological tolerances. Our new framework broadens the concept of carrying capacity to be the likelihood that a species can occur at a site based on the matching of its phenotype to the environment and is therefore analogous to a fundamental niche. Using Lotka-Volterra interaction matrices, these probabilistic carrying capacities can then be used to predict species relative abundances while accounting for competition. The model was tested in an ephemeral wetland in New Zealand, where rapid compositional turnover of a turf community occurs along a steep hydrological gradient. Environmental filtering along the gradient was driven strongly by variation in root aerenchyma among species, where species with high root aerenchyma were more likely to occur in frequently flooded zones. Within each local quadrat, we modeled the interactions by assuming a competitive hierarchy, where taller species would outcompete shorter species. The model predictions of species relative abundances were positively correlated with observed relative abundances, and therefore performed well in predicting species distributions along this hydrologic gradient. Our new quantitative synthesis offers a new way forward for predicting species and community-level responses to changing environmental conditions while simultaneously accounting for competitive interactions.

Do cushion plants act as facilitators due to seed trapping?

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Several mechanisms have been suggested through which facilitative plant-plant interactions may occur, including benefactor species ameliorating environmental conditions, increasing resource availability and decreasing exposure to herbivores. While there is some evidence for all of these mechanisms, seed trapping may be a simpler, and potentially complementary, explanation for observations of increased abundance and richness of species in association with purported facilitator species. Here we examine the potential for seed trapping to give rise to species association patterns typically interpreted as indicating facilitative interactions. We use two cushion-forming plant species which have been shown to host higher species biomass, cover and/or richness than adjacent vegetation from two different biomes as our study systems, contrasting the density of seeds on the substrate surface between cushion plants and the adjacent substrate. In both study systems, seed densities were higher on cushion plants than in the surrounding sites. However, at the sub-Antarctic site seed density was higher at the edge of cushion plants than at their center, while the opposite was observed in a South African montane grassland. Furthermore, in the sub-Antarctic, seed densities were also higher around large rocks (which are common in the landscape) than the adjacent plots. Due to the occurrence of dominant north-westerly winds in the sub-Antarctic, the directionality of seed accumulation was also examined at this site. Cushion plants and rocks differed significantly in which aspects accumulated the highest abundances of seeds, with greater seed trapping in the lee of rocks, but on the windward side of cushion plants. These results suggest that cushion plants may, at least partly, host higher abundances and richness of plants due to acting as seed traps, although variation in the nature of this effect was observed between the two study systems. Moreover, this research suggests differing processes of seed trapping between biotic (e.g. cushion plants) and abiotic (e.g. rocks) features, and highlights the importance of understanding seed dispersal processes for interpreting species association patterns.

Splitting and lumping in the US National Vegetation Classification: a data driven examination

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The US National Vegetation Classification (USNVC) is a hierarchical vegetation taxonomy intended to serve as a classification standard for all vegetation found within the United States. The association is the finest taxonomical level of the USNVC and is widely applied to resource inventory and conservation work. Since the consistency of the application of the association apparently had never been tested over a large geographical span using quantitative data, I examined the consistency of the USNVC as it has been applied in classification projects within US National Parks, comparing numerical and data-supported classification schemes between areas in the eastern and the western continental United States. The specific focus of the examination was to determine whether the taxonomic span ("lumping" versus "splitting") of individual units was consistent between the regions. I computed the mean maximum span of floristic heterogeneity of individual associations, as represented by Steinhaus distance, Bray-Curtis distance, and log-transformed Bray-Curtis distance, between all possible pairs of numerical plots that were assigned to an individual association by the classifiers. By these criteria, the eastern associations were broader than the western associations, regardless of the distance measure applied. In order to control these results for floristic coherence, I also compared the mean silhouette widths of eastern associations with those of western associations. The eastern associations were comprised of more coherently grouped sample units than were western associations. From these two broad findings, I conclude that that western ecologists tend to define the association as a floristically narrower and more specific entity than do eastern ecologists. However, the differences in coherence (mean silhouette width) presents uncertainty as to how much of this trend may be a result of a simply narrower (more "splitting") perspective allowed by western USNVC practitioners and how much may be due to substantially different classification criteria, as practiced by practitioners between the regions. I hypothesize that broad differences in vegetation diversity patterns between the regions may foster different perspectives on what an individual plant community is and may result in regionally different models for plant associations. Ultimately, the reconciliation of differences between classification practices between regions in favor of more consistent spans of heterogeneity and of floristic coherence would seem to be a desirable objective for the USNVC, if it is to be applied as a conservation standard across the United States.

Preliminary results from the trait-based numerical classification of Molinio-Arrhenatheretea grasslands in Poland

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Descriptive vegetation science has witnessed rapid progress in the last decades due to the improvement of broad-scale electronic databases. Most synthetic works aimed to delimit vegetation types on the basis of numerical analysis of species composition of sample plots. Such classifications are often used as multi-purpose references of habitat types, since the diversity and composition of natural communities are known to determine general ecosystem properties. However, it has been recognized that focusing on species composition may fail to reveal certain patterns of vegetation that are strongly linked with the functioning of ecosystems. Instead of the taxonomic identities of species, their functional traits could offer more relevant information. Functional classifications are expected to have more general validity than species-based classifications because often the same traits respond to the same environmental gradients in very different places of the world due to convergent evolution. In contrast, species are dispersal-limited, thus their local abundances are informative only within their respective distributional limits. Our aim was to classify managed herbaceous vegetation on deep soils and temperate climate of *Molinio-Arrhenatheretea* syntaxonomical class in Poland on the basis of phytosociological relevés, plant trait data, and using numerical methods. A total of 19,995 vegetation plots representing all major grassland types of Poland were retrieved from the Polish Vegetation Database, from which a narrower subset of ca. 6061 *Molinio-Arrhenatheretea* relevés were resampled. Records of specific leaf area, canopy height, seed mass, clonality and bud bank were obtained from the LEDA and CLO-PLA databases. Gaps in the species by traits matrix were filled using Bayesian probabilistic matrix factorization, thus we had measurements or estimates for over 900 species. Several methods for expressing between-plot dissimilarities, noise elimination, and grouping plots were examined. The tested combinations of methods resulted in very different classifications in terms of biological interpretability. Among the several trials, Rao functional dissimilarity index with noise elimination by principal coordinate analysis and Ward's agglomerative clustering provided the biologically most relevant results. Although, this classification did not reproduce the hierarchy of the syntaxonomical categories at a coarse scale, at finer resolutions the main subtypes of *Molinio-Arrhenatheretea* were differentiated: mesic and wet hay meadows and pastures, marshes and wet grasslands rich in sedges, herb-dominated tall-forb vegetation, trampled and grazed grasslands. After the first promising results, more specific differences between types in individual traits are subject to further research.

Rarity along altitudinal gradients

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Rarity is the key concept in Conservation, Evolutionary and Theoretical Ecology. The definitions of rarity are diverse. In an ecosystem, most species are rare, and only a few species are abundant. In this study, the rare species are defined as that species have sparsely spatial distribution. These species are often missed in most of the samples. How many rare species are there in one altitudinal range? What is the proportion of rare species in each range? And, what are the patterns of those rarities along the altitudinal gradients? We used the woody species data from the National Vegetation Database of Taiwan to answer the above questions. Firstly, we divided the 7,823 relevés into each altitudinal range which was 200 m wide. Secondly, we applied the statistical estimations of species richness at the completeness of 0.97 and 0.8, which were calculated by the incidence data of all species recorded in the relevés in the same altitudinal range. Then, the differences of these two estimations were defined as the rarities at those altitudes. The results showed that the estimated species richness pattern at the same completeness level along the altitudinal gradient depends on the dominance of evergreen broad-leaved species. High rarities maintained in the evergreen broad-leaved forests in Taiwan where their altitudes are less than 1,600 m a.s.l. A high proportion of rarity features in the coniferous forests at altitudes higher than 2,600 m a.s.l. At altitudes between 1,600 m and 2,600 m a.s.l., which are dominated by the mixed evergreen broad-leaved and coniferous species, rarity decreases and the proportion of rarity increases along the altitudinal gradient. In the subalpine region, where the altitudes are higher than 3,600 m a.s.l., both rarity and the proportion of rarity are low.

Above ground biomass estimation of dry tropical forest on the northwest coast of Madagascar

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The dynamics of tropical dry forest woody plants was studied in the protected area of Antrema, Northwest Madagascar. Trunk density, basal area and above-ground biomass were estimated from three large permanent plots, in the forests of Badrala, Ankoririaka and Ambanjabe. They were established in contrasting locations and monitored three times, first in 2014, at Badrala, then again in 2016, and the third time in 2017 along with Ankoririka and Ambanjabe forest. Mean trunk density was 462 trunks ha^{-1} in 2014, 460 trunks ha^{-1} in 2016, and 466 trunks ha^{-1} in 2017 in the Badrala forest, with a basal area 11.96 m^2ha^{-1} in 2014, 12.29 m^2ha^{-1} in 2016, and 13.37 m^2ha^{-1} in 2017. Trunk mortality rate ranged from 0.65% to 1.25% y^{-1}. In this plot, trunk density increased slightly over the study period, however logging had increased over the same period. In Ankoririka and Ambanjabe forests, trunk density was 392 trunks ha^{-1} and 420 trunks ha^{-1}, with respective basal area of 6.73 m^2ha^{-1} and 11.26 m^2ha^{-1} in 2017. In recent years, seven trees were cut in Ankoririka and 28 in Ambanjabe, which represent 10% of total basal area in the latter. The species and the diameter of logged trees are selected according to various uses. Overall, the difference in trunk density, basal area, and logging practices is consistent with the different pedological typologies, the distance between villages and Doany (a sacred place for local people) and the selection of human use. Forest dynamics is the result of the natural functioning of ecosystems and human activities.

Vegetation classification at association level under the current China vegetation classification system: an example of six Stipa steppe formations in China

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Vegetation classification is critical to systematically describe vegetation characteristics and prepare vegetation maps. China's territory spans several climate zones, from tropical to cold temperate, and has large relief variations from coastal to the Himalayan Mountains. Chinese territory is richest in vegetation types in the world. The latest China vegetation classification system (China-VCS) was revised in 2014. The classification criteria include vegetation physiognomy, dominant species, floristic composition, and environmental attributes; thus, it is an integrated physiognomic-ecological-floristic-dynamic classification approach. The classification system for natural/semi-natural vegetation has eight hierarchical levels: Association < Association-group < Subformation < Formation < Formation-group < Vegetation-subtype < Vegetation-type < Vegetation-type-group. Among them, Association, Formation and Vegetation-type are the main lower, middle and upper level, respectively. To date, 1,519 formations of 40 vegetation-types of seven vegetation-type-groups were defined. However, this classification system was largely based on expert opinion and qualitative information, and there is not a systematic census of associations for the entire country due to the lack of adequate plot data. The main challenges in Chinese vegetation study are how to refine this system into association level using the available plot data and improve its compatibility with the main international classification systems. We proposed a framework for plot-based vegetation classification from formations into associations under the current China-VCS, by successfully re-defining six *Stipa* steppe formations and classifying them into 23 associations. We applied a combination of hierarchical clustering and ordination to partition each formation into associations, and then used supervised noise clustering to improve the classification and define the core plots for each association. The concept of consistent classification section was applied to combine cover and biomass data sets to optimally use the available data, facilitating Chinese national vegetation classification. Both dominant species in the dominant layer and diagnostic species of the core plots were used to define vegetation types at formation and association levels, improving its compatibility with US national vegetation classification. This study could be a model for how to refine vegetation classification from formation level into association level under the framework of current China-VCS.

Alien flora of the European sand dunes

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Coastal sand dunes are among the most dynamic habitats on Earth, restricted to narrow coastal tracts. Their specific physical environment and biodiversity make them an important source of ecosystem services. Nonetheless, they are highly vulnerable, and the rapid recent increase of human pressure on the European coasts resulted in these environments being among the most threatened on this continent, as recently highlighted in the European Red List of Habitats. One of the biggest threats is the introduction of alien species, which often become invasive, locally reducing species diversity and modifying physical conditions of the habitat. Improvement of our knowledge on the status of alien flora of European sand dune coastal habitats is a key task for the invasion risk management. Here, the alien flora on the pioneer habitats of sand dunes is characterized at the European scale, comprising the coasts of the Atlantic Ocean and the Baltic, Black and Mediterranean Seas. We obtained data from the European Vegetation Archive (EVA), selecting 22,000 vegetation plots belonging to the phytosociological classes *Ammophiletea*, *Honckenyo-Elymeteaarenarii* and *Koelerio-Corynephorete- acanescentis*. Plots were classified at alliance level by an expert system and converted to the corresponding EUNIS habitat types; finally, we identified alien species occurring in these types using the DAISIE database. Descriptive statistical analysis on alien flora distribution in these habitats considered two alien species groups, those originating from other continents, and species native to certain European region but naturalized in another part of this continent. A set of indicators, related to different aspects of the alien flora, were quantified: alien species richness, differences in the growth form and reproductive strategies, origins of invasion, residence time and invasion status. Finally, the data were related to geographic and socioeconomic variables. Results showed that shifting dune habitats hosted more alien species than those of grey dunes, and the Atlantic coasts attracted more species both from outside Europe and from other areas of the continent, while Mediterranean, Baltic and Black Sea coasts showed some affinities in their alien components. Most of the alien flora came from North America, but many species from South Africa are hosted in the Atlantic and Mediterranean coasts, while the European aliens originated mainly from continental, South and Eastern Europe. In the European sand dune alien flora short and long living growth forms are represented approximately equally, with dominance of cosmopolitan and subcosmopolitan neophytes.

Physiognomic diversity of the vegetation on limestone outcrops in Brazil

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Outcrops of limestones and dolomites (carbonate rocks) cover 2.8% of the Brazilian territory. The relief of this areas with soluble rocks known as “karst” is characterized by typical landforms. Karst landscapes can be classified in different dissolution types, Covered Karst – CK, with rocks covered by soil, or Exposed Karst – EK, not covered by soil. This study presents a review of the vegetation studies in areas with limestone outcrops in Brazil, aiming to answer the questions: (1) What vegetation types occur on limestone outcrops? (2) Which are the relationships between vegetation types and the dry season length and dissolution types? The dataset was compiled from literature review and fieldwork, comprising records of the vegetation and dissolution types on each site. We defined each site as a single carbonate rocks outcrop with co-occurrence or not of different types of vegetation. The Chi-square test (χ^2) was performed to verify the significant association between vegetation types with the different dissolution types and dry season lengths. We carried out the Chi-square tests through the contingency tables, and for all analyses, the significance level was set at 0.05. To classify the vegetation types we used the criterion annual precipitation less than twice the annual temperature, and four groups were defined: non-seasonal (dry months ≤ 2), seasonal (dry months > 2 & dry months ≤ 5), and xeric (dry months ≥ 6; annual precipitation < 800 mm), seasonal / xeric (dry months ≤ 6; annual precipitation 800-1,000 mm). We verified the existence of seven distinct vegetation phytophysiognomies: Atlantic Rain Forest with *Araucaria angustifolia*, Atlantic Rain Forest, Deciduous Forest, Semi-deciduous Forest, Xerophytic Arborescent-Shrubby Open Vegetation (Caatinga), Karst Open Vegetation, and Riparian Forest. A total of 79 sites from literature and fieldwork were evaluated. We found that in general the dissolution type strongly determines the physiognomy, based on a strong association between vegetation type with dissolution type ($\chi^2 = 152$ and $P < 0.01$) and dry season length ($\chi^2 = 11.08$ and $P < 0.01$). Karst Open Vegetation occurs on the EK, regardless of dry season length, while the forest formations occur only on the CK, with soil in rock interstices, and their phytophysiognomy type depends on the dry season length.

The patronus charm in The San Joaquin Desert: a contrast of foundation plant specificity

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Deserts globally are subject to significant anthropogenic pressure. Global change, agriculture, energy projects, urbanization, and other ongoing drivers introduce stressors on the resilience of arid and semi-arid ecosystems. The capacity to buffer against these changes in the environment and biodiversity are important considerations for ecosystem functioning and applied decision-making frameworks. Foundation species analyses can be a solution to rapidly assess ecological function for a specific region. A foundation species is defined as species that exerts and promotes a positive set of processes for the network of resident species. Shrubs and cacti in California are both candidate representative functional grouping of plant species that benefit other plants and often animals within a region. Herein, we sampled the effect of shrubs and cacti on other plant species through systematic plant surveys on environmental gradients. The hypothesis tested was that the direct effects of dominant plants lead to facilitation of other plant species and thereby function as buffers to undue change. Colloquially, this can be termed a patronus charm effect within facilitation ecology because regardless of the form of the protector, the species provides a talisman against local loss of function. From the northern extent of the San Joaquin Desert to the southernmost extent, we documented consistent positive effects of dominant plants including cacti on other plant species. Richness was not always increased and environmental context was important but this research suggests that using landmark species within an impact desert region accelerate identification of fundamental positive dynamics locally irrespective of species identity.

Evolutionary determinants of phylogenetic and functional diversity in European plant communities

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An integrative approach to model the ecological and evolutionary patterns in communities and species pools across large spatial scales is increasingly expedient to understand the major drivers of biogeographical changes and species distributions. In recent decades, the use of metrics of phylogenetic and functional diversities (PD and FD) as emergent community properties has increased exponentially and helped to understand community assembly processes. Phylogenetic diversity and functional diversity of plant communities tend to be correlated. Cases in which they are not can indicate specific ecological and evolutionary processes of community assembly. Aim of this study is to identify PD and FD of European plant communities, and to detect relationship between PD and FD and age of its habitat. The first pilot study based on species pools of main terrestrial vegetation types of the Czech Republic was focused only on the PD pattern. It detected that age of habitats influences largely the phylogenetic structure of current diversity because species pools of older habitats can be assembled from a wider range of major lineages, whereas species pools of younger habitats are limited to a few lineages which have undergone radiation. Such old vegetation types which tend to be phylogenetically diverse are forest, subalpine and mire plant communities with constituent lineages diversified already in the Tertiary. In contrast, phylogenetically homogeneous are mostly grasslands, which developed more recently in open landscapes of late Tertiary and Pleistocene; therefore they consist mainly of species from a few lineages with preadaptions to open environments. Next step is to identify the relationship between obtained patterns of PD with those obtained for FD.

Climate controls diversity of urban floras across Europe

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Urban land-use provides new habitats by creating new combinations of abiotic factors and bringing together species that otherwise would live in different regions of the world or in different habitats within the same region. Current urban plant communities are thus composed of species of different origin and belonging to various life forms. It is likely that different species will respond to current climate change in different ways. The aims of our study were to identify factors which shape composition of European urban plant communities, and to predict their future change under climate scenarios for the 21st century. Potential changes in the distribution of species currently growing in 60 large cities in Southern, Central and Western Europe were modelled using generalized linear models and four climate-change projections for two future periods (2041–2060 and 2061–2080). These projections were based on two global climate models (CCSM4 and MIROC-ESM) and two Representative Concentration Pathways (RCP 2.6 and 8.5). In studied cities, native species prevail over aliens, and annual and perennial herbs prevail over woody species. According to the considered climate-change scenarios, mean annual temperature in studied European cities can rise by 1.5 to 3.3 °C until 2070, while total annual precipitation is expected to slightly decrease. Our study shows that these changes may lead to changes in urban species composition. Surprisingly, even under the most severe climate-change scenario no differences were found between future distributions of native and alien species. However it is likely that due to progressing naturalization processes some of already established alien species can enter the invasive stage and spread quickly to new localities. Our results suggest that mainly annual species of Mediterranean origin will increase their occurrence frequency in European urban floras by 2070. In contrast, perennial herbs, woody species as well as most species of the cool-temperate zone will represent smaller proportion of future European urban plant communities in comparison with the present.

Invasive Bromus tectorum experiences enemy release from an important guild of generalist herbivores

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Perhaps the best-known explanation for the success of invasive plants in novel environments is enemy release, which predicts that (1) native herbivores limit populations of invasive plants in native but not recipient communities, and (2) native herbivores in recipient communities limit populations of native but not invasive plants. Despite considerable empirical attention, very few studies have fully tested these basic predictions, especially with respect to generalist herbivores. Because generalist herbivores could be present in both the native and recipient communities of translocated plants, theory indicates that escaping generalists is an essential aspect of enemy release. We tested whether cheatgrass (*Bromus tectorum*), an annual species native to Eurasia but invasive across much of western North America, has experienced enemy release from an important guild of generalist herbivores (granivorous rodents) using experimental exclosures and seed addition experiments in both the native (Iran) and non-native (USA) ranges of cheatgrass. We found that (1) granivorous rodents limited cheatgrass establishment by 60% in Iran but had no effect across the western USA, and (2) granivorous rodents across the western USA limited the establishment of a suite of native species by at least 74% each but had no effect on cheatgrass. Together, these results suggest that invasive cheatgrass has experienced enemy release from an important group of generalist herbivores (granivorous rodents), which may help explain its explosive success across the western USA.

Quantifying hydrologic refugia at fine scales in the northern jarrah forest, southwestern Australia

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Refugia are important areas for biodiversity conservation during climate change, but identification and application to management has been slow. Mapping hydrologic refugia requires quantification of the relationship between reduced water availability and biotic persistence. This is challenging due to limitations in modelling data from different scales and data-availability. The northern jarrah forest (NJF) of southwestern Australia has undergone strong climatic and hydrological shifts since the 1970s. Rainfall has decreased 15-20%, resulting in decreased surface run-off (40-100%), a falling water-table and shifts from perennial to ephemeral streams. Using comprehensive, fine-scale vegetation mapping data (31,000 plots, 432 km^2, 120 m^2 grid) and widely-available topographic variables, we automated community types to model their distribution under projected drying. Multinomial logistic regression modelling and accuracy assessment were undertaken in R and ArcGIS. To circumvent mismatches in the resolution and quality of available climate and topographic data, we used a non-parametric streamflow elasticity estimator modulated by rainfall to detect areas of refugia to 2090. We then explored changes in the distribution and environmental profile for each community type. Community types were automated with medium to high accuracy (mean accuracy = 0.70, SE = 0.02; mean kappa = 0.25, SE = 0.05). The weakest detectability (54% accuracy) was found in a well-recorded, upland type, and the highest accuracy (80%) in a rarer, range-restricted type. Changes in extent varied from 50% contraction in a riparian type underlain by deep clays (92-350 m elevation, key indicator species: *Banksia littoralis, Eucalyptus patens and E. rudis*), to 95% expansion by a predominantly sandy type found across ridge-tops and plateaus (210-480 m elevation, key species: *Allocasuarina fraseriana and E. marginata*). Patterns of expansion and contraction were overlain to indicate areas of potential refugia and mapped to a fine resolution for the study area (30 m grid). Perennial stream-zones provide the basis of refugia in the forest, with vulnerable floristic communities contracting tightly into remaining waterways. Our work quantifies the importance of lowland areas as important habitat for at-risk plant communities in the NJF. With streamflow-elasticity estimations available for over 500 catchments worldwide, fine-scale refugia modelling and mapping can be carried out using this method in landscapes where climate data may only be available at coarse resolutions. Landscape scale refugia maps provide local area managers with a basis for monitoring and conservation decision-making under climate change.

What do forest plants think about climate?

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Climate in the forest understory is substantially different from the regional macroclimate, because forest canopies buffer topographic effects and simultaneously create fine-scale temperature variability through variation in canopy openness. Actual drivers of understory temperature and their effects on plant species distribution are however poorly understood, especially at the landscape scale. We complemented vegetation survey in temperate deciduous forest (České středohoří Mountains, Czechia, central Europe) with direct microclimate measurements on 46 sites to explore which temperature variables explain the landscape-scale distribution of forest understory plants and link these variables to terrain topography and local canopy openness. Further, we resurveyed 171 historical records of forest vegetation within a region to get a reference data on long-term vegetation dynamics under changing climate. Our results show superior importance of maximum temperatures for forest understory vegetation (dbRDA: 8.2% explained variability, $P < 0.001$), with noticeable part of spatial variability driven by terrain topography (topography effect size = 4.12 °C vs. elevation effect size = 4.72 °C). Besides elevation, the main topographic drivers of maximum temperatures were: heat load index, topographic position index and topographic wetness index. Surprisingly, we found no signal of increasing temperatures over past 50 years on plant communities (mean Ellenberg indicator values for temperature: change (recent-old) = -0.029, $P = 0.73$). Effects of rising global temperatures on understory plant communities are probably masked by variability in forest microclimate, transition in forest management from former coppiced stands towards the high-forest and eutrophication.

Can ecological rules survive in Himalaya?

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Several ecological rules were postulated for an altitudinal gradient: Mid-domain effect; Rapoport's rule and Asymmetric abiotic stress limitation hypothesis. We used more than 95,000 floristic records from the Himalayan Ladakh region (NW India) to test the predictions from these hypotheses. This mountain region, isolated by glaciated mountain ranges from south, west and north, with elevations ranging from 2,600 up to 7,700 m a.s.l., including highest locality for vascular plants at 6150 m, provide unique opportunity to study diversity patterns on a broad elevation gradient. Primary productivity is limited by precipitation in lower elevations and low temperatures in high elevation, excluding the presence of forests throughout entire area. We applied randomization null models, species response curve modelling using logistic regression and generalized regression to test three ecological predictions on diversity and distribution of plants: (1) the diversity will peak in the middle of the gradient due to geometric constraints (mid-domain effect); (2) species from higher elevations have broader distributional ranges (Rapoport's rule); and (3) species response curves will be negatively skewed toward more stressful ends of the elevational gradient (Asymmetric abiotic stress limitation). We found very weak support for mid-domain effect, refuted Rapoport's rule and confirmed the Asymmetric abiotic stress limitation hypothesis for low temperatures.

Modelled biogeoclimatic units of the northwestern conterminous USA for climate change modelling in British Columbia

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A climate change informed species selection (CCISS) tool is being developed in British Columbia to guide adaptive management strategies in reforestation. The tool is based on the Biogeoclimatic ecosystem classification (BEC) approach that integrates vegetation classification with site classification at bioclimatic and site-levels. BEC is a fundamental tool for determining tree species ecological suitability for different site conditions (site series) within each mapped biogeoclimatic (BGC) unit of British Columbia. The CCISS tool uses a PRISM-based climate surface for western North America (ClimateWNA) to parameterize spatially mapped BGC units and create a RandomForest model of contemporary BGC climate space. ClimateWNA has Global Circulation Model projections of climate built into the surface allowing future projects of BGC distribution based on the RandomForest BEC model. The challenge of this approach is that the model requires analogue climates for all future conditions. In the southern portions of British Columbia, future analogue climates are likely to be found outside of BC in the conterminous USA. For successful application of the CCISS tool in these border regions, BGC-equivalent units for the USA are required. The same tools that are used to model future BGC distribution can be used to spatially model new BGCs from training point data. We apply BGC classification rules to publicly available National Forest Ecosystem and Forest Inventory plot data for northwestern USA to build a suite of prospective USA-BGC units and to apply classified plots as training point sets to build a RandomForest climate model of USA BGCs . BGC membership for each climate surface raster point is then predicted from this RandomForest model to create a USA_BGC for use in the CCISS tool. A USA BGC zone map created in this way matches closely with equivalent zones at the international border suggesting that the analysis is producing a sufficiently accurate map for the purposes of modelling climate futures into British Columbia. However, the authors need knowledgeable US reviewers to assess both the accuracy and completeness of the prospective USA_BGC units and their spatial distribution.

Creeping loss of biodiversity in Central European semi-natural grassland: estimation with Beals-smoothing by using sub-recent datasets

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Semi-natural grasslands of Central Europe are still hotspots of biodiversity, but there is enough reliable evidence on hand that they are subject to a continuous loss of species. The most important factors are fragmentation, dispersal limitation by abandonment of traditional grazing systems, and nutrient increase. Even in areas where the management takes nature protection into account, species decline is frequently observed. Usually this is a slow process and its precise assessment a difficult task. We present a rather simple method to reveal endangered plant species before their extinction in a given area. In many regions, collections of sub-recent relevés (starting with the 1970s) from grasslands with a high nature value are available. We used a set of more than 600 relevés as background for calculating the dark diversity of recent grasslands with high nature value by Beals-smoothing. Provided that those sites are still managed, we found that the results are plausible, and as long as the background data originate from the same region as the recent relevés and are based on a similar species pool, the method is rather robust. The majority of the dark diversity species revealed by our method belongs to a group of low growing, poorly competitive plants, a result which is also supported by earlier studies on declining grassland species. We think this method could also contribute to the estimation of the extinction debt in different regions.

Changing alpine tundra, Glacier National Park, Montana

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Alpine tundra may be threatened by global climate change. In the northern Rocky Mountains, models predict increasing temperatures and altered precipitation. Current species distributions seem to be weakly controlled by climatic variables. Using plots not originally selected for monitoring change, we examined plots sampled in the mid-1990s and again in 2012. The species cover was ordinated to create dependent variables of plot change and plot divergence from 1990s centroids in ordination space. These were examined relative to environmental and location variables and a Braun-Blanquet classification of the original plots using a general linear mixed model. Abundant species were examined for change in percent cover and frequency. The environmental relations of those showing the greatest increases or decreases were examined using nonparametric multiplicative regression. Change and divergence were greatest on southern plots with deep soils, where xeric tundra species (e.g. *Dryas octopetala*, *Phyllodoce glanduliflora*) increased in cover and frequency. Change was less on mesic sites, where some species decreased in cover and frequency (e.g. *Carex nigricans*, *Sibbaldia procumbens*). At a species level, no difference in change was seen between dicots and monocots nor between mesic- and xeric-typical species. Because the sample confounded the southerly location with deep soils under relict solifluction treads and risers dominated by *D. octopetala*, firm conclusions as to the sensitivity to climate change of components of alpine tundra cannot yet be determined.

Towards a synthesis of plant diversity drivers: a Mediterranean experience

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In light of the global biodiversity loss, syntheses of the available vast body of knowledge describing drivers of biodiversity are becoming increasingly important. Despite the high number of studies analyzing patterns of plant species diversity, few attempts have been made to synthesize findings across different ecosystems. This work represents an effort towards a synthesis of plant diversity drivers using Mediterranean coastal dunes as a testing ground. Specifically, the relative role of a wide set of predictors imputable to three conceptual-methodological domains (abiotic, human-mediated disturbance and landscape domain, hereafter AD, DD and LD) was simultaneously analyzed in 644 random plots distributed along the coastal dunes of central Italy. These three domains were chosen in consequence of their documented power in explaining plant diversity patterns in Mediterranean coastal dunes. Native species richness and focal species cover, both field-recorded, were used as response variables. Predictors pertaining to the three domains were derived from both field surveys and high resolution remotely sensed imagery (LiDAR and aerial orthophotos). To test the influence of AD, DD and LD over native species richness and focal species cover, a GLM and a linear model were fitted respectively. To assess the relative influence of the three domains on each response variable two different approaches were implemented. For native species richness, three reduced models, each time excluding from the model the set of predictors corresponding to a different domain, were ranked according to their delta QAIC. For focal species cover, the three domains were ranked according to their contribution to the amount of explained variance. Although the contribution of the three domains was always significant, they turned out to unequally contribute to the explanation of native species richness and focal species cover patterns. For Mediterranean coastal dune ecosystems, AD appears to be the key biodiversity driver, followed by DD and LD. Our results suggest that as long as human disturbance is limited, plant biodiversity will distribute according to species' abiotic tolerances regardless of habitat loss and fragmentation *per se*. Bringing order to the vast ecological findings produced so far in coastal dune ecology, such a synthetic framework relegates the landscape domain to a minor role compared to the others, despite its recognized power in driving biodiversity.

To protect or not to protect? Biodiversity conservation in forests of the Himalayas

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Humans are altering the composition of ecosystems, at local, regional and global scales, affecting rates of species invasions and species extinctions. These anthropogenic changes in biodiversity have deep consequences for the provisioning of ecosystem services and goods. We investigated the efficiency of legal protection as a means of conserving biodiversity in forest ecosystems of the Himalayas. Nepal is part of a biodiversity hotspot as well as a developing country where rural livelihoods are profoundly dependent on forest resources. Nepal is also on the top-20 list of countries with a large percentage (23%) of protected land area globally, and second in Asia. We analyzed the diversity of woody species; trees, bushes and woody climbers (in 0.1-ha plots, n = 540), at three paired sites in legally protected and un-protected forest ecosystems in the Nepalese Middle Hills (2,000-2,500 m a.s.l.) of the Himalayas; in the Annapurna region, the Kathmandu Valley and the Langtang region. We found higher species richness in protected forests. However, within the protected forests there are large differences in species richness due to different intensities of biomass extraction. Consequently, it is not protection *per se*, but the pressures from the nearby human population that determines forest health and woody species richness. The closer the forest is to settlements, the heavier degradation it suffers. This is largely determined by the walking distance from village to forest. The region with the least contrast in woody species richness was found in the Annapurna region, where the protected area is represented by a conservation area, rather than a national park as in the case of the two other regions. The alternative informal protection by means of community forestry has trade-offs in that it may take the form of silvicultural activities and become too intensive for the sake of biodiversity conservation. Our results support the idea that protected areas provide global benefits while costs are disproportionally borne by residents in and around protected areas, in this case subsistence farmers. Finding ways to strengthen park-people relationships is critical to the long-term success of protected areas. Future studies should investigate how best to mitigate this degradation, even inside protected areas, by identifying and mitigating drivers of illegal resource extraction.

Niche widths of plant species in European beech forests

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We calculated ecological niche widths of plant species in beech forests on the latitudinal geographical gradient from the Mediterranean (Greece) to the North Sea (Norway), with a total length of 2,300 km. Both extreme ends of the gradient area represent the latitudinal extent of natural distribution of beech (*Fagus sylvatica*) forests in Europe. Our research is based on a dataset of 16,080 geocoded phytosociological relevés made in beech forests. The aim of this study was to determine niche widths of plant species and to test the hypothesis that in different parts of the gradient area, habitat generalists and specialists are not the same plant species. We wanted to determine whether plant species´ niche width in different areas is changing and whether their typical functional traits and life forms are different. We found 1463 plant species thriving in beech forests. Following the protocol published in Manthey and Fridley (2009), we calculated *theta* values (the degree of habitat specialism/generalism) for 373 species, which were presented in at least 100 relevés, and we ranked them along a continuous gradient of habitat specialization. Additionally, we correlated theta values of individual plant species with their functional traits and ecological and distribution characteristics. The dataset was subsequently divided into three parts, regarding geographical position: southern, central, and northern. The same calculations were made for these three groups. We found out that the most prominent habitat specialists in the whole latitudinal gradient of beech forests are endemic species (e.g. *Paederota lutea, Valeriana saxatilis, Phyteuma scheuchzeri)* or mountain species (e.g. *Luzula nivea, Carex brachyctachys, C. ferruginea*). The most prominent generalists turned out to be Eurasian species (e.g. *Pinus sylvestris, Salix caprea*), Eurosiberian species (e.g. *Populus tremula, Melampyrum pratense*) or European species (e.g. *Quercus petraea, Veronica chamaedrys*). The following functional traits of habitat generalists were significantly different from habitat specialists: *leaf dry matter content* (LDMC) and *average canopy height* and *number of inhabited floristic zones* (positive correlations for generalists). We also found other traits to be significantly different between habitat generalists and specialists, such as *life forms, pollen vector, oceanity, altitudinal level, CSR strategy* and *seed production*. Also, there are thirty species occurring in all three parts of the studied area. The degree of their habitat specialization varies with position on the geographical gradient, but we did not detect a uniform trend. Our work complements the knowledge of the distribution of realized ecological niches of plant species along various gradients, the coexistence of species and their characteristic functional traits and relatedness to certain ecological conditions.

Invasive species on coastal dunes: what do we know?

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Human activities are altering biodiversity and ecosystem functioning at a large scale, and one of the most relevant drivers is the invasion of ecosystems by alien species. The search for patterns of biological invasions has revealed that there are differences in the species that become invasive and the habitats that become invaded. However, some trends indicate that invasion levels are low in harsh climatic conditions and nutrient-poor habitats. In addition, invasion is expected to be high when disturbance is high. Thus, the predictions for coastal dune environments are difficult to make, since they are typically nutrient-poor with harsh climatic conditions (a low invasiveness would be expected) but are exposed to recurrent disturbances (sand movement) which would favor biological invasions. The aim of this study was to perform a literature review of case studies of invasive plant species in coastal dunes, and determine their impacts in plant communities. We searched the literature in the ISI Web of Knowledge database, with no restriction on publication year or type, and used the following search-term combinations: ("coastal dune*") AND ("plant invader"OR"exotic plant"OR"alien plant"OR"plant invas*"). We found a total of 154 studies from 33 countries. The topics related to biological invasions of plants are varied. Most of the studies we found (18%) focus on the impact of invasive plants on plant communities and ecosystem functioning, although physiological responses of invasive species, soil pathogens and rates of expansion have also been frequently studied (13% of the studies, each). Additional findings indicate that urbanization and human impact promote species invasions. Some studies (< 5%) have shown that species invasion is facilitated by climate change, and that invasives modify dune geomorphology and affect animals. The most frequently studied coastal dune invasive plant species are *Ammophila arenaria*, *Carpobrotus* sp., *Rosa rugose* and *Acacia* spp. Finally, there is a relatively large number of studies in dunes from the Mediterranean coasts, northern Europe and the USA. Invasive species in South Africa and New Zealand dunes are also noteworthy. In general, there is almost a total lack of studies of invasive species on tropical dunes. This study shows that, although coastal dunes offer a harsh and nutrient-limited environment, they are highly vulnerable to biological invasions, and this seems to occur at a worldwide scale. Nevertheless, most studies focus on temperate latitudes, which shows that the tropics need to be further explored. Finally, the impact of invasive species should be considered in restoration/management practices.

Effect of disturbance on clonal versus non-clonal herbs: the cost of clonal growth revealed

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Disturbance is an omnipresent selective factor shaping plant strategies. While annual species relying on rapid generative reproduction dominate in habitats frequently affected by severe disturbance, long-lived woody species occupy habitats where the effect of disturbance is less substantive. These are however extremes of the disturbance gradient. Habitats under intermediate disturbance are occupied by the whole spectrum of plant strategies relying on both seeds and sprouts but in different proportions. In this study, we hypothesized that clonal herbs relying more on sprouts withstand disturbance better than non-clonal perennials relying more on seeds. We conducted a greenhouse experiment with 17 congeneric pairs of clonal and non-clonal herbs cultivated from seeds, to test the effect of disturbance on their survival and performance during their first year of life. We applied 5 disturbance regimes: biomass removal 2 cm above the soil surface, removal of 70% of aboveground biomass, late-spring frost (two events spanning one week: -3 °C /3 h and -10 °C/3 h), flooding (week-long submersion) and root system cutting in situ. Clonal herbs had larger belowground biomass and lower specific root length than non-clonal ones when intact. However, their biomass was relatively more reduced under disturbance regimes suggesting that clonal species suffered more than non-clonal species. The disturbances that reduced the biomass production more strongly were the flooding and both biomass removals. Further, under disturbance, clonal plants were less senescent and increased specific leaf area compared to non-clonal species. Mortality differences were negligible except under the flooding treatment where clonal plants survived more than non-clonal ones. Although clonality is supposed to evolve as an adaptation to disturbance, our results imply that during the first year of life, clonal herbs are more sensitive to disturbance regimes than non-clonal ones. This is caused by the fact that the belowground organs of the clonal plants are being formed in this ontogeny stage. Under disturbance, and during this period, the formation of belowground organs brings about costs of clonality rather than benefits. The theory about the evolution of clonality should take ontogeny and organ investments into account.

Bud bank of Cerrado legume species

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Plants from the Cerrado usually have developed belowground organs, forming belowground bud banks, which have an important role on the regeneration of the aboveground vegetation after fire. Usually, these bud banks are protected by the soil (belowground) or by the thick bark (aboveground), which can be used as functional traits to describe vegetation responses to fire. Thus, the aim of study was to identify and quantify the presence of buds in underground system of Fabaceae species from Cerrado, at different ages, to understand the development of the bud bank and their potential to survive fire. Seeds of eight species (*Bauhinia dumosa*, *Chamaecrista clausseni*, *Harpalice brasiliana*, *Mimosa sp. nova*, *Mimosa kalunga*, *Mimosa gracilis*, *Mimosa leiocephala* and *Senna corifolia)* were collected in Central Brazil and put to germinate in greenhouse. Three plants/specie at different ages (two, four, six, nine and twelve months old) were then sampled and fixed at FAA70. In addition, the belowground systems of three adult individuals/species were sampled in the field for later quantification of the buds. Already at the age of two months, three species presented a bud bank, showing potential to regenerate: *B. dumosa* (1.3±0.7), *H. brasiliana* (1.0±2), and *M. kalunga* (1.3±0.8). *C. claussenii* (0.6±0.6), and *S. corifolia* (0.6±0.4), presented buds at four months. However, when plants were one year old, none of them presented a viable bud bank. All adult species presented a belowground bud bank (*B. dumosa* 5±2.5; *H. brasiliana* 28±14.6; *M. gracilis* 6.3±3.2*; M. leiocephala* 10±8*)*, except *M. kalunga*, *M. sp nova*, which do not resprout from a belowground bud bank. *C. claussenii* and *S. corifolia* resprout from the belowground bud bank, but no viable buds were found in adult individuals, because they might have endogenous buds from where the new shoots are formed after disturbance. The only species that did not show buds in any of the age stages was *Mimosa sp nova*, which might be a seeder species. Thus, our study showed that species at the beginning of the development already allocate resources for the formation of a viable bud bank, being thus able to regenerate at the beginning of the establishment phase, if a disturbance occurs in the area, showing that Cerrado species are very resilient.

Frequency and co-occurence of grassland species in long-established golf cources in Japan

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Semi-natural grasslands are one of the most important habitats for plants in Japan. However, the species richness of semi-natural grasslands has decreased because of land use change. Most semi-natural grasslands have been abandoned and these areas have declined for several decades. Remaining semi-natural grasslands are confined to agricultural land and commercial grasslands. In agricultural land, field margins of traditional paddy fields are important grasslands, exhibiting species-rich vegetation. Some endangered species exist in commercial semi-natural grasslands such as ski slopes, pastures, and golf courses. Whereas long-established pastures and ski slopes have been investigated, golf courses were not previously investigated. Rough and out-of-bounds areas in golf courses might play a role as seed sources and refugia of grassland species, if the management method of the course matches the lifecycle of grassland species. The aim of this study is to determine the frequency and co-occurrence of grassland species in long-established golf courses to promote conservation and preservation. We selected five golf courses in Hyogo Prefecture, western Japan. All courses have been established for more than 60 years (113, 90, 86, 64 and 60 years). In 2015-2016, we set 50 plots (1 x 1 m) in rough and out-of-bounds areas of each course, where the frequency of cutting is low and the height of cutting is higher than on the green and fairway. We recorded the cover of all vascular plants in each plot. We divided each plot into nine sub-plots and recorded the presence-absence of species in each sub-plot. We calculated sub-plot similarity and a co-occurrence index of species both among each plot and among each sub-plot in a plot. Most of the species combinations that occur simultaneously in the same plot and in the same sub-plot consisted of non-competitive species, such as *Solidago virga-aurea* var. *asiatica* and *Gentiana scabra* var. *buergeri*, *S. virga-aurea* var. *asiatica* and *Liriope minor*, or *Zoysia japonica* and *Carex nervata*. On the other hand, the species combinations that occurred in the same plot but not in the same sub-plot include competitive species, such as *Artemisia princeps* and *Miscanthus sinensis*, which may exclude non-competitive grassland species. Intensive management of greens and fairways may disturb most grassland species, but the infrequent and low intensity of rough and out-of-bounds management may result in the dominance of competitive species and exclusion of non-competitive species. Thus, intermediate disturbance as management may be necessary to conserve grassland species diversity in golf courses.

Conservation status of US National Vegetation groups and macrogroups of the conterminous US

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The recent release of the USNVC Classification (Version 2.01) allows for the first time an assessment of the conservation status of the Groups and Macrogroups of the conterminous US. While a previous assessment focused on detailed land cover based on NatureServe's Ecological System Classification, a cross-walk between that map legend and the NVC, as well as an update to the map itself provides for an assessment based on 2011 conditions and the newly described mid-levels (Macrogroups and Groups) of the National Vegetation Classification Hierarchy. Specifically by combining the USGS GAP/LANDFIRE National Terrestrial Ecosystems data with USGS's Gap Analysis Projects Protected Areas Database of the US we were able to quantify the level of representation of each of the mapped existing vegetation types. At the Macrogroup level there were 112 types, and at the Group level of the hierarchy 240 types are represented. Using the Aichi Biodiversity target we found that the majority (162 of the 240 Groups, and 73 of the 112 Macrogroups) have less than 17% of the mapped area in GAP Status 1 & 2 lands. The range of protection varies greatly between types. The Vancouverian Alpine Tundra Macrogroup centered in the high elevations of the Northern Cascade Mountains had the highest representation with 87.7% of the mapped area in Status 1&2 lands. Groups with the lowest representation (< 1%) tended to be remnant vegetation types in the central US Three specific examples include (1) Tamaulipan Dry Grassland from on the Texas/Mexico border; (2) Central Great Plains Mixedgrass Prairie ranging from the Canadian to Mexican border; and (3) Northern Great Plains Aspen Woodland centered in North Dakota. In each case these types occur in landscapes dominated by agricultural land uses and few protected areas. In this session we will present data development, assessment results and plans for future refinements.

A standardized ecosystem classification for the coordination and design of long-term terrestrial ecosystem monitoring in Arctic-Subarctic biomes

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A Canadian Arctic-Subarctic Biogeoclimatic Ecosystem Classification (CASBEC) is proposed as a standardized classification approach for Subarctic and Arctic terrestrial ecosystems across Canada and, potentially, throughout the circumpolar area. The CASBEC is grounded in long-standing terrestrial ecosystem classification theory, and builds on concepts developed for ecosystems in British Columbia, Quebec, and the Yukon. The fundamental classification unit of the CASBEC, the plant association, is compatible with the lower level classifications of the Arctic Vegetation Classification (AVC), the Canadian National Vegetation Classification (CNVC) and the United States National Vegetation Classification (USNVC), and is used to generate a classification and nomenclature for Arctic and Subarctic terrestrial ecological communities. The use of a multi-scalar ecosystem framework, such as that developed by the British Columbia Biogeoclimatic Ecosystem Classification provides an ecological context to use classified plant associations to delineate and define climatically-equivalent regional scale climate units (biogeoclimatic subzones), and ecologically-equivalent local-scale site units within biogeoclimatic subzones. This paper proposes that a standardized framework and taxonomy of ecosystem classification for Subarctic and Arctic terrestrial ecological communities will facilitate the planning, coordination, and applicability of terrestrial ecological monitoring and research. Example applications being used to design long-term ecosystem monitoring experiments at the Canadian High Arctic Research Station (CHARS) in Cambridge Bay, Nunavut are presented. Widespread adoption of the CASBEC could provide a spatial and functionally scalable framework and a common language for interpreting, integrating, coordinating, and communicating Arctic and Subarctic monitoring, research and land management activities across the Canadian North, and around the circumpolar area.

Shrubs as keystones features for spiders functional beta diversity in Campos Sulinos grasslands

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Interactions among species should be studied in multiple spatial levels to be fully understood. Diversity partitioning into levels alpha, beta and gamma is an interesting approach in this sense, as it allows not only to analyze at two spatial levels of diversity but also their relation (beta diversity). Here, we partitioned the functional diversity of plants and spiders of Campos Sulinos grasslands to better understand how these groups interact in a mesic landscape under traditional management. Plants and spiders were sampled once in eight grids, each grid with nine sampling units. Plants were classified into nine functional groups reflecting above-ground structure, and spiders were classified into six foraging guilds. Functional diversity was calculated with Rao index and partitioned with the multiplicative method (beta = gamma/alpha). Alpha and gamma plants and spiders diversities behave alike, which is in accordance with habitat heterogeneity theory. This way, the higher the habitat complexity, more species diversity. Spiders and plants show contrasting patterns of beta diversity, related to the abundance of shrubs within the grids. Shrubs act as keystone features, promoting spiders' beta diversity with little influence over plants beta diversity. However, current grassland management frequently leads to an overgrazing scenario, simplifying the vegetation structure. In addition, practices of landscape homogenization by shrub mechanical and chemical removals are also common in grasslands. Our results support the habitat heterogeneity theory, even in rather mesic grasslands, and highlights the importance of shrubs in these environments for the maintenance of spiders' functional diversity and the ecosystem functions provided by them.

Winter rainfall continentality an overlooked dimension of drought in biogeography

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Drought, a major climatic constraint in biogeography and ecophysiology, has dominantly been quantified during plant growing season. However, a number of climatic classifications taking into account rainfall seasonality – and especially winter rainfall - have been shown to be efficient in explaining large-scale vegetation distribution along climate gradients, noticeably in mountain ranges exhibiting strong rain shadow effects. In this study we choose the eleven states of western USA, subjected to both contrasting summer and winter rainfall conditions, to test the hypothesis that winter rainfall continentality highly contributes to explain vegetation distribution across regions from subtropical to temperate latitudes. We selected 500 sites located in the vicinity of climatic stations and sampled all trees and dominant shrub species between 2000 and 2012. We relied on the Worldclim data base to calculate several climate indices including the winter rainfall continentality index as proposed by Gams 1932 (modified Michalet 1991). We applied multivariate analysis to interpret community relationships to climate. Winter rainfall continentality showed the highest correlation with observed floristic turnover across western USA together with minimum winter temperatures. It opposed in particular the oceanic vegetation from the coastal ranges of western states to the continental vegetation from the Rocky Mountains, Great Basin and southern deserts. The length of the growing season, calculated using the number of growing days and varying in response to the combined effects of latitude and altitude, was identified as the second main determinant of vegetation distribution. Interestingly, summer drought, calculated using the ratio of summer rainfall to temperature, was only the third climatic factor explaining differences in vegetation composition, in particular between Mediterranean and temperate climates, both for oceanic and continental vegetation. Our study highlights the relevance of using both winter rainfall continentality and summer drought to investigate climate-vegetation relationships at the biogeographical scale. First, both climatic factors explain different variation in vegetation composition that are very likely related to different plant traits and functions. Second, rainfall continentality can be more determinant of vegetation composition than summer drought in some regions such as western USA. Our results emphasize the need to account for rainfall amount and seasonality in attempts to predicting vegetation distribution in a changing climate.

Competition between coniferous seedlings and bush species after a partial harvest along a creek in a Pacific northwest forest, Canada

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In managed forests, partial harvest within riparian areas is one way to provide harvest opportunities and maintain some of the functions of riparian vegetation. On the other hand, partial harvest may severely disturb understory vegetation and constrain regeneration of tree seedlings according to the degree of harvest. We examined the response of coniferous seedlings and saplings to a 50%-partial harvest in a second-growth, coniferous riparian forest in the Pacific Northwest, Canada. We chose two sites, a harvested and a control site (no germinants were found at this site), along a creek. The harvested site was partially harvested in 2004. We established a 1 × 45 m transect along the environmental gradient from the creek to upslope on each site. Ten plots (1 × 1 m) were set along each transect for counting seedlings and other major understory plants. All seedlings encountered on each plot were counted, and heights were recorded. To evaluate the potential influence of shrub species on seedlings, we measured cover (%) of shrub species in same plots. Percentage of canopy openness was quantified at four points (10, 20, 30 and 40 m from the creek) on each transect based on a spherical densiometer. Partial canopy opening facilitated the establishment of *Tsuga heterophylla* and *Thuja plicata*. Increased light availability also stimulated growth of shrub species, *Gaultheria shallon* and *Rubus spectabilis*, especially in moist sites, and the dense cover precluded establishment of coniferous seedlings. Once *R. spectabilis* established, continued stem recruitment maintained a dense stable cover, and even intense disturbance did not affect the stability of the populations. *R. spectabilis* would be a major competitor constraining conifer seedling regeneration in riparian zones. Although *G. shallon* extended their cover, competition from dense *G. shallon* was not as severe as from *R. spectabilis*. One study reported that cover density of *R. spectabilis* declined for about ten years, and there is a possibility that growth of conifer seedlings and saplings would succeed. In this study site, however, we did not observe decline of *R. spectabilis* exuberance, but rather an increase. Growth and survival of conifer seedlings and saplings seem to be good in areas remote from the creek, so they have survived against competition with shrub species.

Using dark diversity in nature management: what can we learn from missing plant species?

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Many ecosystems across the world today are deprived of species due to habitat degradation and human influence. Restoring such ecosystems and their biodiversity is highly dependent on our knowledge about which species could potentially thrive in these ecosystems, but also why they are absent. This may hold the key to cost-effective management and restoration. I will present our work on Dark Diversity, the diversity of absent species that could potentially thrive in a focal ecosystem. Firstly, I will demonstrate how analyzing plant characteristics of typical dark diversity plant species in nature areas in Denmark revealed important insight for managing those nature areas, notably that dispersal dynamics and mycorrhizal relationships are important factors for typical dark diversity plant species. In the second part of this talk, I will present a new project – aiming to continue this voyage into understanding the dynamics between local dark and actual diversity. More specifically, this new study will attempt to shed light on which habitat types typically have the highest overall dark diversity and what characterizes these. We will apply a combination of light radar (LiDAR) point-cloud data, measured abiotic data, plant data from a huge national vegetation plot database and deep learning methods. LiDAR data is becoming increasingly available and usually at a resolution suitable for local scale vegetation studies. Moreover, LiDAR has been shown to capture both structural and some abiotic conditions yielding it ideal for characterizing local habitats.

A test of invasional meltdown between two invasives and one native tree of the southeastern US

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The need to understand the effect co-occurring species have on one another is becoming increasingly important due to increased invasive plant richness. Invasional meltdown refers to the process that invasive species facilitate one another's invasion in various ways, possibly increasing the magnitude of the impact. Here, we specifically examined invasional meltdown between two common invasive trees and one native tree of the southeastern US to determine whether allelochemicals from *Ailanthus altissima* increases nodule production in the invasive *Albizia julibrissin* and the native *Robinia pseudoacacia*. We used a fully factorial design that consisted of planting combinations of each species interspecifically, intraspecifically, and alone. We randomly assigned these planting combinations to one of two fertilization treatments (fertilized and non-fertilized) in two blocks. The overall design was 9 planting combinations x 8 replicates block^{-1} x 2 blocks. We used Three Way ANOVAs to examine if there were differences in species, neighbor, and fertilizer treatments for the dependent variables: total biomass, shoot, and root biomass, along with the competition index lnRR (natural log of the response ratio) and nodule production of *Albizia* and *Robinia* when grown in different planting combinations. lnRR = natural log of $P_{control}$ / $P_{mixture}$. For the biomass analyses, all variables were natural log transformed prior to analysis to meet the assumptions of normality. Three Way ANOVAs indicate that there were no significant differences in the interactions of species, neighbor, and fertilizer treatments. Total biomass, shoot, and root biomass showed significant differences in neighbor and fertilized treatments. When examining the competitive index among these three species, no factor was significant. Nodule production did show significant differences among species and neighbor x fertilizer treatments. This finding contradicts what much of the literature suggests, in that nodule producing species produce more nodules when nutrients are limiting. Our research suggests that when under increased nitrogen applications, species will produce more nodules regardless of the neighbor. Further, these results suggest that given the current state of our environment, with increasing nitrogen added to the atmosphere, invasive nodulating species may up-regulate nodule production, which could potentially facilitate other invasives into areas where they would not normally invade.

Identifying ground vegetation species in the natural, semi-natural, and constructed urban riverbanks of Ciliwung River, Bogor City, Indonesia

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Urban riverbank ecosystems tend to be sensitive to human disturbance. Vegetation along urban riverbanks is highly vulnerable to infrastructure development, including the vegetation along the Ciliwung River in Bogor City, which flows to the Megacity Jakarta, Indonesia. Twenty-seven percent of the river banks in Bogor City have already been occupied and filled with urban construction. Ground vegetation has no space to live and the number of species has continuously declined. Only some patches of the natural riverbank that preserve vegetation are still available. The objectives of this research were to observe the vegetation characteristics in three different types of urban riverbank—natural, semi-natural, and constructed riverbank—and to analyze differences in species richness among three different types of urban riverbank in Ciliwung River, Bogor City, Indonesia. A 250-m sample from four sites was selected to represent the 14.43 km length of Ciliwung River. Ground vegetation species was sampled by using point method and photographic sampling. Three representative locations of natural, semi-natural and constructed riverbank were taken from each site. Then, five replications of a 1 m^2 plot at three transects were settled on each location. SamplePoint software was used to train the images of vegetation sample plot in overcoming the obstacles in the field observation. Principal Components Analysis (PCA) was used to analyze the ground vegetation pattern. A Monte-Carlo test was also used to identify the significance of ground vegetation structure and composition in three types of urban riverbank. The results show 55 ground vegetation species exists in urban riverbank—where 38 species are in the natural riverbank, 36 species in the semi-natural riverbank, and 28 in the constructed riverbank. Based on the analysis, ground vegetation species richness is significantly higher in the natural riverbank than in the semi-natural and constructed riverbank. The natural riverbank was mainly characterized by the presence of *Asystasia nemorum. Pilea nummulariifolia* represented the ground vegetation on the semi-natural riverbank and *Pogonatherum crinitum* characterized the ground vegetation on the constructed riverbank. The ground vegetation species that represented each of the three different riverbanks can be used and managed for supporting ecological engineering in an urban riverbank, for enhancing riverbank landscape quality, and for contributing in river quality improvement.

How do Cerrado woody species respond to different fire management systems?

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Fire plays an important role in ecosystem dynamics and its regime especially influences the demography of plants and the vegetation structure in tropical savannas. Many tropical savannas, such as the Cerrado (Brazilian savanna) experience frequent and extensive wildfires, mainly occurring in the late dry season (LDS). Since 2014 a new fire management program is implementing early dry season (EDS) prescribed burns in a few Cerrado protected areas as an attempt to change the predominant fire regime - LDS fires. We assess the response of woody plants subjected to different fire regimes in an open woodland savanna in a Cerrado PA in northern Brazil, Chapada das Mesas National Park. For two years we monitored woody species in permanent plots with time since fire (TSF) of two and three years, that received different fire treatments: no fire (NF); high intensity, noon LDS fire - LDS (September, low humidity and high air temperature); high intensity, noon EDS fires - high-EDS (May, low humidity and high air temperature); and low intensity, evening EDS fires - low-EDS (May, high humidity and low air temperature). One year after fire, LDS and high-EDS fires resulted in higher stem mortality in two year TSF plots, whereas in plots with three year TSF, low-EDS fires presented higher stem mortality. Stem recruitment was remarkably lower in plots subjected to LDS fire (7%) in comparison with NF (18%) in plots with two years TSF. Two years after fire, stem mortality was similar between treatments and fire histories. However, the rate of stem survival was significantly lower in LDS, two years TSF plots (45%) compared to the other treatments (66-69%), and lower in NF, three year TSF plots (62%) compared to high-EDS ones (70%). All plots that were burned had notably more stem topkills than unburned ones, where in plots with two year TSF 36% of stems were topkilled in LDS treatment against only 2% in NF. More frequent fires are shown here to cause more stem mortality. Fire in dryer and hotter weather conditions caused more stem topkills in both monitoring years. Therefore, fire management should indeed be used to establish different fire regimes to achieve local conservation goals.

Arctic-alpine vegetation in the EuroVegChecklist

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EuroVegChecklist (EVC) represents the first continental-wide comprehensive system of syntaxa of the floristic-sociological approach. EVC covers extended Europe (including Greenland, Arctic archipelagos, Caucasus, etc.) and features alliances, orders, and classes further combined into informal high-ranks categories of biome conceptual framework of the Walterian zonal, intrazonal, and azonal categories. This paper present major ideas underpinning the classification of the vegetation of arctic and alpine regions of Europe, focusing on major ecological drivers, using the bioclimatic classification of the Arctic into zones/subzones by Walker et al. as the reference. The relationship between the Arctic and Alpine vegetation is analyzed in the light of refugial theory and post-glacial vegetation dynamics. The Arctic vegetation in EVC comprises 3 zonal classes (*Drabo corymbosae-Papaveretea dahliani* 'Polar deserts of the Arctic zone of the Arctic Ocean archipelagos'; *Carici rupestris-Kobresietea bellardii* 'Circum-arctic fellfield and dwarf-scrub graminoid tundra, and relict wind-exposed short grasslands on base-rich substrates in the alpine and subnival belts of the European boreal and nemoral mountain ranges'; *Loiseleurio procumbentis-Vaccinietea* 'Arctic-boreal tundra scrub and relict alpine acidophilous dwarfheath mountain tundra of Eurasia and North America') and two intrazonal classes (*Saxifrago tricuspidatae-Calamagrostietea purpurascentis* 'Cryo-xerophytic steppe and associated scrub on base-rich and (sub)saline substrates in continental Greenland and North America'; *Saxifrago cernuae-Cochlearietea groenlandicae* 'Vegetation of open grassy tundra disturbed by zoo-anthropogenic activities and cryoturbation in Svalbard and Greenland'). At least eleven azonal classes are also represented (at the order and alliance levels) in the (sub)artic zones. Except for the polar-desert vegetation of the *Drabo-Papaveretea*, and the intrazonal *Matricario-Poetea arcticae* 'Anthropogenic vegetation in human-disturbed habitats in the subarctic and Arctic zones of Russia, Siberia and North America', all those classes are also represented in alpine to nival belts of the boreo-nemoral mountain ranges of Europe. The Alpine vegetation of the boreo-nemoral mountain systems contains relicts of the Arctic vegetation (all zonal classes, except for the *Drabo-Papaveretea*). The class *Salicetea herbaceae* is listed as 'azonal' by the EVC, yet it may well be defined as intrazonal, depending on the interpretation of the Walterian concept of orobiomes. The biome position of the *Elyno-Seslerietea* remains unresolved. The Oromediterranean summit vegetation, often containing arctic-alpine elements or phylogenetically related lineages, will also be briefly discussed, focusing on its fragmentary character, regional/local taxonomic and syntaxonomic endemism, and links to the boreo-nemoral elevational zonation.

Integrating vegetation data into rapid ecological assessments: a map-based approach for wetlands and riparian areas

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Rapid ecological assessments are becoming increasingly refined in addressing physical attributes of ecological integrity, but using vegetation data in this context has been challenging. Notably, botanical expertise in organizations that make use of rapid assessments is often limited, so implementing floristic metrics that reflect ecological conditions must balance usability with feasibility. Accordingly, we developed a vegetation map approach that focuses on common indicator species and dominants that most practitioners will know or can be trained quickly to recognize. As part of our New Mexico Rapid Assessment Method (NMRAM) for wetlands and riparian areas, practitioners first map the vegetation community patches of an assessment area and describe those patches in terms of the abundance of the top two species in the tall woody, short woody, and herbaceous strata. These patch maps are then used to compute metrics on the status of alien, invasive, and wetland species at a site. The metrics were developed and calibrated against 181 sample sites from across New Mexico that reflect a human disturbance gradient from low to high. At each sample site, we took full species vegetation plots to evaluate how well the limited sample of six species compared to local species diversity. Based on a sensitivity analysis, the floristic metrics were able to reflect a range of ecological conditions across the reference disturbance gradient that can complement abiotic measurements in rapid assessments. While the floristic metrics we developed optimize usability by reducing the botanical knowledge requirements, inertia to their implementation by practitioners remains. To address this, we have developed botany short courses that target those species most likely to be encountered during the rapid assessments. Next steps are to develop additional metrics that focus on assessing relative ecological diversity by tying the vegetation patch maps to the US National Vegetation Classification, which provides a standardized framework for comparing community-level complexity among sites and across spatial domains of interest.

Litter production, decomposition and nutrient input of lianas in a secondary rain forest in Ile-Ife, Nigeria

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The study determined the contribution of lianas to litter production, leaf litter decomposition and nutrient input and evaluated the relative contributions of liana and tree litter to nutrient cycling in a secondary lowland rain forest in Ile-Ife, Nigeria. This was with a view to determining the contribution of lianas to moist tropical forest functioning. The study was carried out within a 20.5 ha secondary rain forest in the Biological Gardens of the Obafemi Awolowo University, Ile-Ife. Litter traps were randomly positioned for the collection of liana and tree litter fall for a period of one year (September, 2015 to August, 2016). The collected litter was sorted into liana leaf, tree leaf, twig, reproductive parts and trash, oven-dried at 80^0C and weighed separately. Litter decomposition of three liana species was studied using litterbag method. The litter fall and decomposing litter samples were ground and analyzed for total N, C, Ca, Mg, K, S and P using standard methods. A two-way analysis of variance was used to test significant differences in the monthly litter fall, concentrations and amounts of elements deposited via litter fall in the forest. The results showed that the annual litter fall (t $ha^{-1}yr^{-1}$) was 4.16 (total), 0.96 (23.1%) (liana leaf), 1.50 (36.1%) (tree leaf); 1.15 (27.6%) (twig); 0.05 (1.2%) (reproductive parts) and 0.50 (12.0%) (trash). Reproductive litter had the highest and trash litter the lowest concentrations of all nutrient elements. There was no significant difference in nutrient element concentrations of liana and tree leaf litter. The annual deposition of the elements via total litter fall in the forest floor (kg $ha^{-1}yr^{-1}$) was C (1733.86) > Ca (175.77) > N (98.79) > K (95.66) > Mg (56.67) > P (15.13) > S (7.40). Tree leaf, twig and liana leaf litter contributed more to the nutrient deposition in the forest than reproductive parts. Nutrient element deposition via tree leaf litter was higher than that of liana leaf litter. Among the liana species, *Parquetina nigrescens* had the highest leaf litter decomposition rate (0.27), followed by *Acacia ataxacantha* (0.25) and *Montandra guineensis* (0.09), after six months of decomposition. Nutrient release during decomposition was highest in *P. nigrescens* and lowest in *M. guineensis*. The study concluded that lianas which play important roles in moist tropical functioning by contributing substantially to carbon and nutrient cycling in the forest should be taken into consideration in the conservation and management of tropical forests.

Habitat and seasonal preferences of fiddler crabs across Gulf Coast tidal marsh vegetation zones

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Interspecific facilitation influences tidal marsh structure and function by ameliorating stress, thus filling an important role in estuarine ecosystems. Research in salt marshes dominated by the grass *Spartina alterniflora* indicates that plant characteristics affect fiddler crab burrowing and in turn, crab activity can enhance primary productivity by increasing soil oxygen and nutrient cycling. Crab-plant interactions have not been well studied in microtidal Gulf Coast marshes where *S. alterniflora* is restricted to a narrow band along the low intertidal zone, the rush *Juncus roemerianus* forms the most extensive vegetation zone, which grades upslope into a narrow fresh marsh, and hypersaline salt pannes are patchily distributed. It is unknown how structure of these dominant vegetation zones affects density of crab burrows and how burrows may influence primary productivity. We hypothesized that fiddler crabs would be most abundant in marsh zones with intermediate substrate hardness and vegetation density (Goldilocks Hypothesis). To determine fiddler crab usage of these zones, we conducted a seasonal habitat preference study in tidal marshes at Grand Bay National Estuarine Research Reserve in coastal Mississippi using burrow density as a proxy for crab abundance. We also sampled plant above- and below-ground biomass, burrow proximity to vegetation and soil hardness as potential drivers of fiddler crab populations. Our results indicated that fiddler crabs burrow in all four zones, but to varying degrees and that burrow density was highest during our autumn survey. The fresh marsh had the highest average density of burrows as well as vegetation and soil parameters most representative of intermediate habitat, thereby supporting our hypothesis. The brackish marsh also proved to be important fiddler crab habitat. Preferential fiddler crab usage of upslope habitat like fresh and brackish marsh in our Gulf Coast sites suggests that transitions to higher elevations with sea level rise may be relatively smooth.

Variation in leaf functional traits through the early development of coastal heathland plants

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The seedling phase is a vulnerable stage of the plant's life cycle, and seedling growth and survival might be more affected by environmental stressors, such as climate, than adult individuals. Global environmental change impacts on seedlings thus can affect community assembly and ecosystem functioning. Plant functional traits are important tools for understanding changes in vegetation with global change, as traits underlie both plant responses to environmental stressors and their roles in ecosystem functioning. Plant functional traits are measured on adult plant individuals, hence we don't know how traits vary within and especially between species through their ontogeny. To fill this knowledge gap, we tested how functional traits develop over the seedling phase by measuring leaf functional traits of 20 vascular species through the first 16 weeks of growth. The species were selected to represent the most common species of two functional groups (forbs and graminoids) in our target habitat, coastal heathlands, a threatened vegetation type in Norway and Europe. Traits related to productivity and growth were measured; leaf area, specific leaf area (SLA), leaf dry matter content (LDMC), leaf thickness, as well as whole-plant functional traits like plant height and relative growth rate (RGR). We hypothesized that seedlings should have relatively similar trait values, and that species should become increasingly differentiated towards the adult stage. Further, we hypothesized that species within the same functional group will show similar development and expression of traits. Preliminary analyses show that seedlings differed from adult plants in leaf functional traits; seedlings had smaller leaves, higher SLA, lower LDMC and thinner leaves. For leaf size and LDMC the trait variation between species increased during the ontogeny. For SLA and leaf thickness the trait variation between species was as high in the seedling stage as in the adult stage. Leaf thickness, SLA and LDMC varied significantly over the 16 weeks. Leaf thickness and SLA did not vary significantly between the two functional groups. In contrast, LDMC values varied significantly between the groups. Additionally, graminoids had little within-group variation relative to forbs. The ranking of the species in terms of the leaf trait values changed during the ontogeny. Our findings suggest that leaf trait differentiation appears early in a plant's life, but adult traits can still not predict the seedling traits, and hence species-specific seedling vulnerabilities to environmental stressors. This study can contribute to understanding how the future climate might affect seedling recruitment, and hence biodiversity and ecosystem functioning of coastal heathlands.

Assessing biodiversity and management impacts in mountain pastures using diagnostic species

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In several European regions, the last decades have been marked by a management aiming to increase the productivity of grasslands, conducting at the same time to an important decrease of the plant diversity. To characterize the community diversity, and the impact of agricultural practices, we stress the need of easy-to-use indicators in the field. Diagnostic species used to characterize and differentiate syntaxa are there useful to assess the various facets of community diversity and the impact of agricultural practices on managed grasslands? Here, based on 311 phytosociological relevés, considered as references for mesic grassland classification in the Franche-Comté region, we proposed a selected list of 10 diagnostic species of grazed grasslands (*Cynosurion cristati*) applying the phi coefficient of association. We then compared the number of observed diagnostic species with taxonomic, phylogenetic and multi-trait functional diversity indices, as well as with agronomic variables describing stocking rate and fertilization of 45 pastures. To account for the role of diagnostic species identity, we compared Spearman rank correlations obtained from these diagnostic species with correlations calculated from 500 random samples of 10 species. The number of diagnostic species in the grassland plot was significantly positively correlated with most taxonomic, phylogenetic and functional diversity metrics. However, only the positive correlations with Simpson taxonomic diversity, Rao phylogenetic diversity and functional dispersion were significantly different from those obtained from random samples of 10 species. Moreover, the number of diagnostic species was significantly negatively correlated with stocking rate and fertilization intensity, although only correlation with industrial fertilizer input was significantly different from results obtained from random samples. These results show that the number of diagnostic species observed in a pasture may be a good indicator of a high taxonomic, phylogenetic and functional diversity and of a low mineral fertilization. Thereby, a special attention should be given to diagnostic species to assess the status of grassland biodiversity, including functional aspects.

Comparison of vegetation classification methods for optimal legend design on a 1:25,000 scale national vegetation map of Japan

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Since 1999, Japan's Ministry of the Environment has led a project to produce a nation-wide 1:25,000 scale vegetation map. As of 2017, over 29,330 vegetation relevés from field surveys are stored in a vegetation database. Currently, 892 discrete legend categories are used across the entire 1:25,000 vegetation map series, however, some of these categories are not based on a phytosociological approach, and therefore consistency between the legend categories is not secured. To develop a seamless nation-wide vegetation map, a phytosociological approach should be considered. In this study, three methods of vegetation classification were examined using a common dataset collected during project work. The study area for this project is in the Kanto district (20.43-37.16°N, 136.07-153.99°E) that covers various climatic zones from subtropical islands (Ogasawara archipelago) to temperate and subalpine areas (western Kanto mountains). Using datasets of deciduous broad-leaved forest (1,623 relevés), evergreen broad-leaved forest (387 relevés) and coniferous forest (554 relevés) for vegetation classification, the data were divided using a physiognomic approach. The study examined the following vegetation classification methods, modified TWINSPAN (mTS), Isopam (Iso) and *k*-means (kmn) using the JUICE software for vegetation classification analysis. Using the results of the vegetation classification, deciduous broad-leaved forest was classified into 8-15 types (mTS: 10, Iso: 15, kmn: 8), evergreen broad-leaved forest by 5-10 types (mTS: 10, Iso: 5, kmn: 6), and coniferous forest by 6-10 types (mTS: 10, Iso: 6, kmn: 8). The identified vegetation unit was considered as a level of alliances, or an intermediate level of alliances and associations. Vegetation types with a high independence of species composition such as *Pandanion tectorii* (subtropical), and *Abietion mariesii* (subalpine), were classified similarly by the three methods. Whereas temperate vegetation types with a large overlap of species composition such as *Quercion acuto-myrsinaefoliae, Carpino-Quercion serratae,* and *Carpino-Quercion grosseserratae* were identified by the species with less frequency in the lower level division, and, depending on the method, different results were obtained. Results from this research suggested it was possible to identify a level of alliances by selecting an optimal classification method for the target vegetation types. However, there was difficulty identifying a level of associations by simply increasing the depth of the division levels or the number of clusters in these methods. For the classification of a nation-wide dataset, evaluation methods should be examined to appropriately select classification methods and division rules.

Winners and losers of meadow, heath and mire translocation: the first insights after four years of experiment

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How does species composition of different vegetation types respond to translocation? How do they respond to encroachment of expansive native or alien species? How many species, particularly diagnostic plants for phytocoenoses, increase or decrease in cover after displacement? The study location comprised meadow, heath and mire plots in Radzionków Habitat Botanical Garden, South Poland (50º23'49", 18º55'24", 343 m a.s.l.). The experiment was established in 2013 and lasted four years. Between June and October 16 500 pieces of turf blocks, each 80 x 120 cm in size and 40 – 50 cm deep, were transferred from the donor site to the newly constructed artificial basins. Temporal changes of species composition were observed in 163 permanent plots 2 x 2 m. The winners and losers were identified by counting the fidelity to a particular year (2013 - 2016) expressed by the phi coefficient and by performing constrained ordination analysis with the time as the explanatory variable. For changes in species richness, diversity, herb and shrub layers, contribution of woody species, diagnostic taxa, archaeophytes, neophytes, native expansive taxa and ruderal plants a one-way variance analysis (ANOVA) was applied. We found that only 16 species have a positive correlation with time. However, the total number of species significantly decreased only within meadow plots. Mires and heaths also experience a slight decrease of species number. The changes in species diversity in heath and meadow communities reveal the peak of the index value in the second year of the experiment. Significant changes of abundance of diagnostic species were observed in all the plant communities. The abundances of diagnostic taxa were maintained during the first two years, and then dropped considerably. The highest decrease was noted in heathlands. Turf translocation appeared only partially to be an effective compensatory measure. After four years of experiment, the three different habitats still maintained their specific structural features, however a number of diagnostic taxa considerably decreased, particularly in heathlands and wet meadows.

Vegetation changes in Norwegian boreal spruce forests: results from 30 years of monitoring

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Monitoring of understory vegetation in protected Norwegian old-growth spruce forests was established in nine sites, dominated by Norway spruce, between 1988 and 1992. All sites include the local environmental variation typically found within submesic spruce forest of bilberry and low-herb types which prevail over large parts of Norway, spanning regional gradients related to temperature and oceanicity. For the last three decades 458 permanently marked 1-m^2 vegetation plots have been reanalyzed regularly (every fifth to eighth year). For all plots data on tree cover, tree heights, crown heights etc. (used for calculating tree influence indices), as well as topography and soil humus chemistry, were sampled between 1988 and 1992. Relationships between species composition and environmental variables have been analyzed previously. So far, all plots have been analyzed five times while 160 of them have been analyzed six times. Species abundance has been recorded for all species, as subplot frequency (0-16) and as percentage cover, in the 1-m^2 plots. Changes in (1) number of species per plot for different species groups, (2) single species' abundances, and (3) species composition, have been analyzed for each area and by univariate and multivariate statistical methods. Since the start in 1988, we have observed a significant reduction in plant species numbers for most species groups, most notably for herbs and pteridophytes, mosses and hepatics. In three of the monitoring sites, the average number of species recorded has decreased with 5–6 species per plot. Many vascular plants, mosses and hepatics have decreased significantly in abundance during the monitoring period while only a few species have increased. Temperature increase and an extended autumnal growing season are proposed as major causes of these changes while changes in soil humus chemistry, changes in the forest structure, successions following past selective logging of large and dominant trees and interactions between different plant species groups, may all have contributed to the observed biodiversity loss and abundance changes. Our empirical data support the hypothesis that the increase of abundance observed for a few dominant (large-sized) bryophyte species favored by longer growing seasons has had a negative impact on smaller bryophytes and germination of some vascular plants. The proposed explanations should be tested in future studies.

Clonal plant response to disturbance in the montane spruce forests of the Tatras (Slovakia)

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We examined clonal plant response to disturbance in the Tatras Mountains, Slovakia, at both the community and population levels. We hypothesized that communities in canopy gaps had greater dominance of clonal species than those in large wind throws and greater diversity, due to the greater heterogeneity of the canopy gap communities (such environmental heterogeneity should favor clonal plants over non-clonal plants). We collected 10 plots (10 x10 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 (totally 80 plots). The data included cover of all species, spatial diversity (heterogeneity) indexes and clonal connectedness data (through dye experiments on three species). Based on the variance to mean ratio as a measure of heterogeneity, wind throw sites that were not salvaged exhibited the greatest environmental heterogeneity while all other sites were more uniform and similar. Further, diversity was driven by litter and woody debris as grass and herbaceous vegetation heterogeneity were similar among sites; however, both herbaceous and grass diversity were noticeably lowest in forests without gaps and this habitat had the lowest heterogeneity. Additionally, conductivity was lowest and pH highest in salvaged sites. Forests sites had the greatest richness while forest gaps and regenerating wind throw sites had the greatest diversity. Nearly all species had some aspect of clonality (86%), but only those species with roots with adventitious buds had significantly more cover in wind throw sites; rhizome species also tended toward more cover in gap and salvaged sites. All dye parameters differed between treatments for *Rubus* and were generally higher is wind throw plots. For *Calamagrostis*, only mean length differed between treatments and was highest in wind throw sites, suggesting consistency in both species. The data confirm disturbance favors at least some types of clonal plants.

How widespread are snow roots in alpine snowbed environments?

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Snow cover is one of the most important pattern-forming factors in the alpine vegetation of temperate mountains. Depressions in relief often accumulate snow and this leads to late snowmelt and a short vegetation season. Temperature conditions under deep snow (more than0.5 m) in winter can be characterized as constantly moderately cold (temperature around 0 °C almost without diurnal or seasonal fluctuations). The aim of the present study is to estimate how common it is that plants may use snow as a substrate to get nutrients by such a special plant trait as snow roots. To study snow roots we (1) extracted native roots from snow samples by filtering snowmelt water, (2) made field observation of snowbeds during snowmelt time, (3) added ^{15}N enriched NH_4NO_3 to snow and measured recovery of the isotope in snowbed plants, and (4) performed morphological and anatomical analysis, as well as sequence of the barcode DNA marker (rbcLa), obtained from snow roots. We discovered intensive snow root development in the snowbed plant *Corydalis conorrhiza* in the north-west Caucasus. We have shown that the snow roots of this species have a high specific root length and take up mineral nitrogen from the surrounding snow. As a result, leaves of *Corydalis conorrhiza* have the highest N content (about 5.9%) among other snowbed species. Analysis of winter snow showed a significant abundance of snow roots even in the beginning of January. Since root growth is slow at temperatures close to zero we suggest that the development of these roots starts after the establishment of a permanent snow cover in late autumn – early winter (November-December). Thus, these roots are relatively long-lived, their lifespan apparently exceeding 7 months, quite in contrast to their aboveground shoots. Another species clearly forming snow roots is *Gagea pusilla* in the alpine snowbeds of Mt. Aragats (Armenia, Lesser Caucasus). But the nitrogen content of this species did not differ from other snowbed plants in this area. We obtained that there are more alpine plant species which can develop snow roots (*Poa alpina, Matricaria caucasica, Taraxacum stevenii*). So, this specific trait independently appears in distant angiosperm phylogenetic groups. The principal unresolved question is why this adaptation is known only from (or restricted to) the Caucasian Mountains *sensu lato* (including the Turkish and Iranian Mountains).

Establishing vegetation monitoring plots in the National Petroleum Reserve, Alaska

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The Bureau of Land Management's (BLM) Assessment, Inventory, and Monitoring (AIM) Strategy is a national initiative that was developed to provide a reliable mechanism for reporting on the status of vegetation, associated habitats for wildlife, and the supporting ecological components of soil, permafrost, and water on public lands. The BLM Alaska State Office and the Alaska Center for Conservation Science (ACCS) at the University of Alaska-Anchorage conducted a pilot AIM project within the National Petroleum Reserve-Alaska (NPR-A). The intent is for the pilot plots to test AIM methods in Arctic Alaska and for those methods to become part of the long-term extensive monitoring design and protocol for the entire NPR-A. Beginning in 2012, ACCS, in collaboration with USDA-Agricultural Research Service Jornada Experimental Range, BLM Alaska State Office and Arctic Field Office, began collecting ecosystem monitoring data in NPR-A. We developed a conceptual model representing ecosystem function to provide a framework for the implementation of the nationwide AIM protocol in Arctic Alaska and identified core and supplemental environmental indicators to monitor in the Arctic. ACCS identified AIM plot locations by randomly selecting accessible points across landscape strata identified from previous land cover mapping of the North Slope. AIM sampling covered the range of known ecological variation within NPR-A. Following five summer field work efforts, ACCS compiled 188 plots of AIM data, collected in 13 different biophysical strata throughout NPR-A. In addition to refining AIM methods for the Arctic, ACCS identified seven supplemental indicators of Arctic ecosystem function which were sampled in the field, including: active layer depth, moss/duff depth, surface water, surficial permafrost features, vegetation pattern, area by vegetation type, and productivity and phenology. ACCS has used these data to provide plot-based support for the development of Arctic vegetation types, understanding distributions of Arctic plant species and communities, and evaluating how permafrost depth affects Arctic vegetation. More widely, data from the AIM program are being used to answer management questions, establish baseline condition for vegetation, soils and permafrost in NPR-A, and to inform vegetation classification of Arctic Alaska. Finally, these AIM data are one component of a larger data set that is being assembled as part of the circumpolar Arctic Vegetation Archive.

The effect of the past grassland area on the survival and colonization of each species in semi-natural grasslands

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There is a time lag between loss of semi-natural grassland and a reduction of population size that leads to the extinction of grassland plant specialists; thus, current species richness in the grassland may include an “extinction debt”. However, previous studies have not tried to detect the presence of an extinction debt from individual species loss and colonization rates in an assemblage of plant species. In addition, few researchers have studied extinction debt using factors other than landscape changes (e.g. the impacts of management [mowing or burning], habitat use by large herbivores, or climate factors). In the present study, we examined an extinction debt for vascular plant species by monitoring their survival and colonization dynamics. We performed the study at abandoned and managed semi-natural grasslands in central Japan where the area of grasslands has decreased considerably. We re-surveyed species compositions in the 2000s in plots that had been surveyed in the 1980s, and estimated the impacts of the past (1910s) and recent (1980s to 2000s) proportion of the total grassland area and the abovementioned factors on species dynamics during the past 20 years using hierarchical Bayesian models. In abandoned grasslands, the past grassland proportion was significantly positively associated with the probabilities of survival of 96% of the grassland specialists and of colonization by 21% of these specialists. The effects of the past grassland proportion on the specialists were much stronger than those of recent grassland proportion and the other factors studied (i.e. herbivores, and climate). In managed grasslands, however, the past grassland proportion had little effect on survival of and colonization by specialists from the result that few specialists were significantly affected by past grassland proportion in managed grasslands. We found higher probabilities of both survival of and colonization by grassland specialists at sites with larger past habitat areas, which suggest that there is a time lag after habitat loss before the loss of specialists. In addition, we found that continuous management inhibits payment of the extinction debt created by the habitat loss.

Monitoring grassland phenology: relating vegetation characteristics to NDVI throughout the growing season

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Monitoring of our grassland and rangeland resources is essential to maintaining their ecosystem services and productivity. Perennial grasslands in western North America often exist near the threshold of water limitation. With changes driven by short and long term climate cycles, the task of monitoring grassland phenology, especially during drought, is increasingly difficult for regional planners and managers that are in charge of large areas. By using MODIS (Moderate Resolution Imaging Spectroradiometer) satellite data, the NDVI (Normalized Differential Vegetation Index) of grassland areas as small as 6 ha can be calculated on short time scales (e.g. a week). NDVI can serve as a measure of land surface "greenness" or overall phenological condition. The use of near-real time remote satellite data to provide timely information to managers would be a valuable tool as they make management decisions related to grassland phenology and grassland disturbances such as fire and grazing. However, it is important to relate NDVI to grassland vegetation characteristics that managers regularly use. We measured vegetation characteristics across 21 sites every 1-2 weeks throughout an entire growing season on Buffalo Gap National Grassland, a 242,000 ha mixed-grass prairie in western South Dakota, USA. Each site was located in the center of a MODIS 250 x 250 m pixel (~6 ha). At each site, the leaf developmental stage of dominant C_3 and C_4 grass species, grazer presence, % cover of plant functional groups and bare ground, and visual obstruction readings (VORs) were measured. Additionally, a visual % estimate of greenness and a photograph with a colorboard were taken. Spring NDVI readings (April-June) were most highly correlated with VOR and leaf developmental stage of the dominant C_3 grass, *Pascopyrum smithii*. Visual estimates of % greenness were also highly correlated with NDVI but explained less of the variation than the combination of VOR and leaf developmental stage of *P. smithii*. These relationships are currently being used to create and calibrate PhenoMap, a web mapping application that features weekly land surface phenology layers including NDVI, NDVI as a percentage of historic (2000-2015) maximum, and NDVI as a percentage of the historic median for the current week for the grasslands of the western USA.

Drought and belowground buds: examining the impact of precipitation on belowground bud traits of the perennial grass Andropogon gerardii

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In perennial grasslands, most stem recruitment occurs from belowground buds rather than from seeds. Therefore, bud banks are a key mechanism determining grassland response to climate and other disturbances such as fire and grazing. In addition to affecting bud bank densities, precipitation could affect the provisioning, viability and dormancy of buds and the provisioning of bud-bearing organs. Using the dominant North American tallgrass perennial grass *Andropogon gerardii*, we examined how grass bud traits respond to annual precipitation. Our main objectives were to: (1) determine how tiller density, bud production, bud size and mass, and rhizome mass differed among years varying in precipitation (570 mm, 915 mm, 1153 mm; MAP = 835 mm) at Konza Prairie Biological Station, Manhattan, KS, USA and (2) evaluate if drought altered the allocation of resources to bud production. Over three precipitation years, 32 plants of *A. gerardii* were harvested at the end of the growing season. Five tillers from each tiller cohort and developmental stage of each plant were dissected. For each tiller, the rhizome was weighed and buds on the rhizome were counted, identified as live or dead, and weighed. The mid-bud size was measured for each rhizome. Total nitrogen and carbon of rhizomes and buds was also measured. Precipitation had minimal effects on the numbers of buds produced in that year (the demographic component) but did affect the size and mass of individual buds and rhizomes (potential bud quality). Growing season tiller production and bud production per tiller of *A. gerardii* was relatively unaffected by annual precipitation. Although years differed in their cumulative precipitation from May until December, their early season precipitation did not differ enough to greatly impact tiller recruitment and subsequent bud production. Wetter conditions increased bud survival of *A. gerardii* by ~10% but drought did not increase bud mortality when compared to the average precipitation year. Drought reduced the overall mass of rhizomes and buds but the proportional allocation of biomass to buds versus rhizomes remained constant across years and tiller generations. Total carbon content of buds and rhizomes did not change across years but the driest year yielded an increase in nitrogen in rhizomes but not buds. Drought-induced reductions in bud and rhizome quality could affect their ability to break dormancy when good growing conditions return. Continued examination of how drought can affect bud production, survival, and dormancy under different precipitation regimes will enable better predictions of how drought will affect grassland productivity and resiliency.

Effects of seeding treatments on vegetation succession following fire in semiarid ecosystems of the Great Basin

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In areas where invasive plants have the potential to disrupt natural vegetation recovery following disturbance, management interventions are often considered necessary to prevent undesirable invasive-dominated vegetation from taking hold. Artificial seeding is a common management intervention following fire disturbance in semiarid ecosystems of the Great Basin region (USA) where invasive annuals such as cheatgrass (*Bromus tectorum*) are problematic. Non-native forage species have frequently been used for post-fire seeding treatments in this region, sometimes with intent of creating an alternative vegetation state geared toward livestock production, but other times as a short-term rehabilitation fix for sites where recovery of natural vegetation is desired. In the latter case, seeding using native species is a more logical but often more costly choice. To better understand long-term effects of post-fire seeding on vegetation recovery and succession, we revisited study sites in Tintic Valley, Utah, where seeding experiments had been initiated following a 1999 wildfire. Four different seed mixes, including two comprised entirely of native species, had been applied at two different sites. New vegetation data collected in 2015-2017 revealed changes relative to the early post-fire period (2000-2002). We found significant increases in overall cover of seeded species although the relative differences between treatments did not change. Cheatgrass increased in some of the treatments, especially the unseeded control and to a lesser extent the treatments where only native species had been seeded. The non-native seeded species were more effective than native species at suppressing cheatgrass, but the non-natives also had the undesirable effect of inhibiting establishment of shrubs. Our results indicate that post-fire seeding has lasting effects on vegetation composition and structure, implying that if seeding treatments are applied, seed mixes should be carefully formulated to promote vegetation states desired on the long term.

Integrating spatial data in the development of ecological site descriptions

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United States Department of Agriculture-Natural Resource Conservation Services (USDA-NRCS) is implementing an ambitious program to develop spatial decision management tools based on systems ecology. These tools serve as guidance to assist conservation planning and are organized by landscape features (footprints) that respond similarly to management actions and disturbance regimes. The footprints are called 'Ecological Sites' (ES) and use correlations between soil types and vegetation communities to define their spatial extent. The ESs are further defined by state and transition models that describe the disturbance or management actions required to move the system from one successional state to the next. The program is currently working to fully document the ESs for the US and those Ecological Site Descriptions will be publicly available through an on-line interactive map service. Once completed, the end-user will be able to access the descriptive narrative of an ESs in an area of interest or at a specific point. To meet the programmatic goals of this large scale effort, the USDA-NRCS has developed a novel data-informed process to accelerate the establishment of ecological sites by spatially relating three separate databases: (1) USDA-NRCS gSSURGO soils database, (2) a detailed land cover dataset, the GAP/LANDFIRE's National Terrestrial Ecosystems data and (3) NatureServe's Ecological Systems descriptions. Here we will present our process to develop the footprints for the Ecological Sites proposed for the East Gulf and Atlantic Coastal Plains. This process creates these footprints by intersecting the above ground spatial accounting of current land-use of GAP/LANDFIRE spatial inventory of soils represented in the USDA-NRCS gSSURGO data. By intersecting these spatial datasets, we are able to identify the soils that correspond to the areas that are mapped as natural plant communities, and to use the relationships between those mapped Ecological Systems and soils to hypothesize about the distribution and extent of plant communities on areas that are now mapped as cultural or developed land use types. While we applied this approach in a single ecoregion, the analysis is potentially widely applicable as a way to relate the USDA-NRCS gSSURGO database with land cover data as a starting point in creating Ecological Site Descriptions that can be used to inform conservation planning throughout the US

Natural ecosystems impacted by exotic weed invasion on a transcontinental scale

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Many exotic species have become more abundant outside their native ranges and exert greater community transforming effects in their new environment. However, in many cases we do not know whether the invader's behavior is only different in its non-native range, or if they also respond similarly to certain ecological factors (e.g. disturbance, competition) in their native range. The fundamental objective of our research was to use a biogeographic approach to study the performance of cheatgrass (*Bromus tectorum*) in its native and non-native range. Cheatgrass originates from Eurasia and dominates vast areas of North America. In cheatgrass habitats we surveyed 71 plots in the native range (Europe) and 161 plots in the non-native range (Northwestern US), and correlated the cover of cheatgrass with associated plant species richness. In addition, we tested the effect of disturbance on cheatgrass abundance along a gradient (28 transects) in both ranges, and explored the relationship between cheatgrass cover and community composition. Our results show that increasing cover of the invader correlated with significant decreases in total species diversity and native species diversity in the non-native range, but not in the native range. Cheatgrass grew significantly bigger when its cover increased. Disturbance had a significant effect on the spread of cheatgrass in both ranges, however, it was more pronounced in the non-native range. Native plant species richness and cover increased with decreasing cheatgrass cover in the non-native range but not in the native range. In the studied North American plots we found a large number of Eurasian species co-occurring with cheatgrass that might also contribute to its invasive success. Based on the invasional meltdown theory, this relationship may result in further invasions if cheatgrass were to be eradicated. Cheatgrass, and many of its co-occurring non-native species are winter annuals, a life cycle strategy that is rare in the native flora of the Northwestern US which provides these invaders an empty niche to fill. Our results are consistent with a growing body of research demonstrating a strong biogeographic context to exotic plant invasions, and indicate that the biogeographic origin of species can affect community organization, as well as individual performance in native and non-native ranges.

Noncanonical patterns in the size of North American species pools

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Modern vegetation scientists recognize that plant communities are open systems, highly influenced by the species available in the regional 'species pool'. The number of species in the pool is influenced by well-documented "canonical" biogeographic trends such as species-area relationships, latitudinal gradients, elevational gradients, and increase in exotic species through time. In this study, I use data from 4067 published floras from North America north of Mexico, and verify the robustness of canonical trends at broad grains (e.g. $> 10^6$ ha). However, at finer grains (e.g. $< 10^3$) noncanonical patterns emerge. The latitudinal gradient is inconsistent, the elevational gradient flips in direction, island species-area relationships are not inviolate, and exotic richness does not increase markedly through time. At spatial grains between 10^0 and 10^3 ha, we have a 'scale of ignorance' where traditional variables explain richness poorly. I conclude that little progress can be made in 'species pool' studies until we know the most relevant scales of analysis, and that counterintuitive richness patterns must be taken into account.

Assessing the impacts of climate-altered fire regimes on projected extinction risk of whitebark pine in the Greater Yellowstone Ecosystem

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Climate change is expected to cause local ecosystem state changes, population extirpations, shifts in geographic distributions, and altered demographic rates. Most climate models for forested systems in western North America predict more frequent and more severe fires. Taken together, these conclusions predict increased extirpation probabilities of slow-growing tree species. Because of long generation times for most tree species, these predictions are difficult to test, but models are useful for exploring potential population-level consequences. We present a density-dependent, stage-based projection model to investigate the effects of climate-driven changes to fire regimes on the probability of and time to extirpation for a metapopulation of whitebark pine, a long-lived species of management concern in western North America. We parameterized the model using demographic data collected between 1990 and 2017 from whitebark pine communities in (1) areas recovering from the 1988 Yellowstone fires, (2) contiguous unburned locations, and (3) other locations within the Greater Yellowstone Ecosystem. We used the model to explore the effects of reducing fire return intervals from more than 200 years to less than 30 years over a 100-year time horizon by quantifying population extirpation risk and elasticity of the stochastic growth rate. In preliminary model runs for only one subpopulation, whitebark pine extirpation occurred in 6% of iterations, indicating the species is likely to persist despite decreasing fire return intervals. Stochastic elasticity estimates indicate that reproductively mature individuals have the highest influence on growth rate. Although preliminary results suggest that whitebark pine persistence is likely despite changing fire regimes, this is based on the assumption that nearby seed sources are available. Incorporation of metapopulation dynamics will allow us to more directly assess the impact of increased risk to the seed source.

A dark diversity estimation method based on expected probabilities of species co-occurrences

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Community ecology has traditionally relied on species recorded in sampled sites. Each site, however, likely hosts a fraction of the potentially suitable taxa available in the surrounding region. Suitable but absent taxa of a study site constitute its dark diversity, the counterpart to observed diversity. When both observed and dark diversity are known, the general biodiversity potential (site-specific species pool: observed + dark diversity) can be estimated, that is how much of the species pool is realized locally. Intrinsically, dark diversity cannot be measured directly but we can only be estimated. Techniques based on species co-occurrences, such as the commonly-used Beals index, allocate to dark diversity absent taxa which otherwise often co-occur with present taxa. The Beals index represents for each absent and present taxon pair the ratio of the number of co-occurrences divided by the frequency of the present taxon; these ratios are averaged for all present taxa. This results in a continuous value between 0 and 1 which depends on absent species frequency. To account for frequency, a threshold is applied, resulting in a binary dark diversity. However, dark diversity is really a fuzzy set including taxa with different likelihood of membership. We suggest a method based on the hypergeometric distribution describing the exact probability of two taxa co-occurring randomly. This requires the frequencies of both taxa and the total number of sites. The observed and expected co-occurrences are used to estimate a standardized effect size for each pair of species which can be transformed into a probability reflecting the strength of association between the two taxa. We compared the performance of this method to other techniques by using datasets of nested vegetation samples. We use the smaller scale samples to estimate dark diversity and compared the performance of these methods using a larger nested sample scale. We examined the power of these methods to estimate rare and common taxa. Finally, we examined the sensitivity of the methods to the number of samples used to determine species co-occurrences.

Drying up: the effects of long-term drought on the invasiveness of spotted knapweed on temperate grasslands in British Columbia, Canada

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Grasslands in British Columbia are exceptionally important ecosystems to maintain and protect for both socioeconomic and ecological reasons. However, grasslands are being threatened due to land conversion, climate change, over-grazing, and the introduction of invasive species. High invasive species abundance is considered as one of the greatest threats to grassland ecosystems and can reduce plant diversity, decrease forage availability, and alter soil communities. Furthermore, our changing climate may increase susceptibility to invasive species and may help them establish. The combination of drought and invasive species is detrimental to grassland ecosystems and may increase vulnerability to land degradation. I investigate the impacts of drought on native and invasive species growth and if drought influences the competitive ability of the invasive species, spotted knapweed. Using soils taken from the field, treatment combinations of fertilizer, imposed drought and species were assigned to a randomized block design in a greenhouse. Four weeks after germination, the drought treatment began and water was restricted. Plants were grown for 90 days and at the end of the experiment, above and below ground biomass was harvested. Preliminary results show that fertilizer increased growth in both species and drought reduced growth. Field surveys conducted over 3 years found an increase in cover of spreading needlegrass in drought plots compared to the controls. Future plant surveys and further analysis will be conducted.

Consumer versus environmental control of litter decomposition in Yellowstone grasslands

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Plant litter decomposition is a key process that influences carbon and nutrient cycling in terrestrial ecosystems. Litter decomposition is controlled by factors such as litter quality, soil temperature, and soil moisture, all of which influence the activity of microbial decomposers. Consumers can influence decomposition rates by changing the relative role of these factors. However, the impact that consumers have on litter decomposition and how their effects may vary across ecosystems with steep environmental gradients remains unclear. We examined the effect of large mammalian herbivores on litter decomposition by comparing rates of mass loss over 1.5 years inside and outside ungulate exclosures at 10 grassland sites that spanned natural gradients of productivity, grazing intensity, and elevation in Yellowstone National Park (YNP). Based on previous findings that Yellowstone grazers stimulate soil organic matter decomposition (Frank and Groffman 1998), we predicted that grazers would also stimulate litter decomposition in YNP. We found that litter decomposition rate was a function of litter quality and shoot production. Even though grazers improved litter quality, they had no effect on its decomposition. Consequently, grazers did not influence litter decomposition in YNP despite having facilitating effects on SOM decomposition. Instead, litter decomposition was controlled by environmental gradients that influenced litter quality and productivity.

A probabilistic approach to integrate functional diversity and species pools

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In the last years, approaches considering habitat-specific species pools and dark diversity (DD; the unobserved part of the pool) and approaches based on the functional trait diversity of organisms (FD) have greatly contributed to our knowledge on the mechanisms that maintain biodiversity. Incorporating DD has allowed analyzing the relative importance of processes shaping local diversity, the traits that determine species absences from local communities, or the restoration potential of degraded habitats. The concept of community completeness (how much of the local pool is realized in a given community) has been key in this sense. On the other hand, functional traits determine organisms' fitness in a given environment, their interactions with other organisms and their effects on ecosystem processes. However, DD and FD have been mostly disconnected to date, despite the remarkable potential gains of ecological knowledge that could be achieved when both sources of information are considered. Recently, however, both fields' directions are starting to converge thanks to the implementation of probabilistic-based approaches. There is already an existing framework to include all aspects of FD into a unified probabilistic framework that can be operationalized at any spatial/organizational scale. Similarly, recent advances in species pools are adopting a probabilistic perspective. This implies abandoning the dominant binary criteria used to determine whether a species belongs or not to the local species pool, and rather estimating the probability of each species from the regional species pool to be part of the local species pool. In this contribution, we will show how adopting a probabilistic point of view allows reconciling species pools and functional trait diversity while fully recognizing the uncertainty associated with ecological information. Combining FD approaches with estimations of species pools appears as a significant advance towards a higher ability to predict the composition of communities and the temporal stability of individual species and functions. We will illustrate these potential advances by introducing the concept of functional completeness, the functional counterpart of community completeness, which we will estimate using a dataset with nested vegetation samples. We then will generate new hypotheses about how community completeness changes in relation with the redundancy of species in the pool. Further, we will show how community completeness, and the functional redundancy of species in communities and in the local and regional species pools, can be used to improve predictions on aspects such as community invasibility or the temporal stability of species and functions in communities.

A safety-efficiency framework to explain invasiveness of alien plant species

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In the last decades, functional traits-based studies raised as a novel approach to assess the plant's characteristics favoring the invasion process. Recent meta-analyses have compared functional traits of species with different growth forms and biogeographical origin, finding consistent patterns in traits' differences between alien and native species. Invasive species usually have higher values for traits related to performance than native ones, confirming the previous hypothesis whereby they occupy a position along the leaf economic spectrum (LES) that favor fast growth (e.g. high specific leaf area or SLA, high photosynthetic rates, etc.). Despite this, it is still unclear which traits can directly confer invasiveness, and which are rather correlated to these fundamental features. "Mechanistic" traits, defined as traits characterized by a clear association with a specific physiological function, have been scarcely included in traits-based studies but they could provide deeper knowledge on ecological processes than general functional traits (e.g. SLA), which rather represent a "syndrome" possibly associated to several physiological functions. We measured several leaf and wood mechanistic and functional traits both in herbaceous and woody alien and native species in different habitats ranging from arid to mesic conditions. Our results showed that alien species invested less energy in the construction of leaves and stems (higher SLA and lower wood density). Interestingly, we detected a trade-off between leaf and stem production costs and drought resistance, as alien species had higher water potential at turgor loss point (less resistance to drought stress). Moreover, leaf minor vein length per unit area (VLA_{min}) was higher in alien species, suggesting that water transport efficiency within leaves could be higher in alien rather than in native species. We hypothesized that the higher growth rate often measured in alien species could be a result of a risk-it-all strategy, whereby alien species reduce investment costs in traits related to stress resistance in favor of traits related to high resource capture efficiency.

Make it simpler: alien species decrease functional diversity of coastal plant communities

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Sand dune ecosystems are peculiar environments rich in rare species and endemism. Over the last decades, these habitats that naturally suffer harsh abiotic conditions have been heavily threatened by human-induced alterations and biological invasions. However, mechanisms of plant invasion in these habitats are not fully understood, especially in relation to the role of functional diversity of native communities in filtering alien species. In this study, we sampled psammophilous vegetation along belt transects in two sampling sites in northern Adriatic coastline. Our aims were: (1) to assess eventual differences in functional traits between native and alien species; (2) to highlight traits favoring the invasion process; (3) to explore functional diversity patterns in sand dune habitats and detect eventual signals of small-scale functional homogenization induced by the occurrence of alien species. Plant species richness and abundance have been assessed in 128 plots along with a suite of plant functional traits. Differences in trait values between species group within habitat were tested through Wilcoxon rank sum test, and a multiple linear regression was computed to assess traits related to invasiveness. Multivariate statistics (β functional diversity and functional rarefaction curves) were used to explore functional diversity patterns. Our results showed that alien species display different ecological strategies than natives, owing higher values of performance-related traits such as Specific Leaf Area, and displaying lower functional diversity. Moreover, we were able to distinguish a suite of functional traits possibly favoring the invasion process. Our data confirm also that alien species invasion drives the community towards small-scale functional homogenization, with deleterious effects for ecosystem functioning and potential loss of species or reduction in the functional space.

Response of the super-páramo plant communities to climate change

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The super-páramo is the highest elevation ecosystem (~4,200-5,000 m) in the northern Andes of Ecuador, Colombia and Venezuela. With a distribution restricted to the highest summits, the super-páramo presents true continental insularity, and as a result, its flora is highly specialized and endemic. The super-páramo current environmental conditions, including poor soils and severe climate, considerably limit both biodiversity and human activities. Climate change is expected to pose a major threat to the super-páramo biota and plants in particular in the near future, challenging their ability to migrate, adapt to new environments and compete with lower elevation species. Therefore, understanding how plant species and communities might respond to climate change is primordial and would provide key information to support future decision-making in Andean biodiversity management. In this context, our study aimed at predicting the future distribution and composition of super-páramo plant communities by 2100. We used a vegetation dataset of 1970 plots and 363 species obtained from the *VegPáramo* biological database (www.vegparamo.com) and adapted the *Spatially Explicit Species Assemblage Modelling* (SESAM) framework to estimate potential changes in plant communities by 2100 for different socio-economic scenarios of the *International Panel for Climate Change*. We first evaluated each species dispersal capacity based on plant traits and the presence of biogeographical barriers and assessed specific dispersion force with gradually increasing time. Then, current and future potential *Species Distribution Models* (SDM) were conducted for each species, considering bioclimatic and dispersal factors. The SDMs were stacked and constrained by potential local plant richness, obtained from a macroecological model for the super-páramo region. Finally, the *Probability Ranking Rule* was applied to predict the final super-páramo plant assemblages. Our results showed important changes in plant communities composition and distribution throughout the super-páramo by 2100. We also identified particularly vulnerable areas that would require further scientific focus to encourage local management and conservation strategies.

Ammophila arenaria invasion ecology in coastal dunes of North America

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Ammophila arenaria (marram or European beach grass) is a dune-building grass native to northwestern Europe and the Mediterranean coastline. Due to its sand-binding abilities, it was introduced to the continents of North America, Australia, and Africa at the end of the 19th century to stabilize mobile dunes. *A. arenaria* naturalized in all three continents and became invasive in North America and the southern hemisphere. *A arenaria* is more abundant and persists longer in its introduced range than in its native range. It reduces biodiversity through both direct competition and apparent competition, the latter through mediation of native herbivory. Rhizome buds of the species are tolerant of up to 7 days of saltwater immersion, allowing for long-distance dispersal after establishment. In the 20th century, its congener *Ammophila breviligulata* (American beach grass), native to the east coast and Great Lakes, USA, was introduced to the Pacific northwest USA, where it is currently displacing *A. arenaria*. Although evidence exists for biotic resistance limiting its spread in South Africa, and specialist feeders were found to be absent in introduced populations in the southern hemisphere, the enemy release hypothesis is not supported for North America. *A. arenaria* has been extensively controlled using Integrated Pest Management on the west coast USA in recognition of its detrimental impacts on biodiversity and endangered species. Successful restoration to native dune communities has been demonstrated over three decades, and reinvasion has been prevented through minimal ongoing management practices. Recent studies in the Pacific northwest USA have focused attention on the ability of *A. arenaria* to trap more sand and build higher foredunes than *A. breviligulata* or its native analog *Elymus mollis*, resulting in its promotion as protection from wave overtopping and coastal flooding during extreme events and sea level rise. The correlation between *A. arenaria* and foredune height is not supported on the coast of northern California and the characterization of *A. arenaria* as adaptive for sea level rise further ignores the issue of biodiversity as well as the morphodynamics underlying dune migration with sea level rise. Research is currently underway in California to determine the role of foredune vegetation in climate change resiliency. Cross-shore topographic transects and vegetation sampling is occurring on a 32-km stretch of northern California coastline over a five-year period, with the goal of modeling differential morphodynamic response in native and invaded dunes with respect to climate change.

Effect of forest management on species composition in ravine forests

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Ravine forests grow in harsh habitats on steep slopes that are usually covered by rubble. Due to slope processes, frequent disturbances are characteristic in these ecosystems. Ravine forests occupy places that have been mostly inaccessible and in many regions these ecosystems are the only remnants of unmanaged forests with high biodiversity value. However, in SE Poland some stands of ravine forests localized outside protected areas have been the subject of low-magnitude management treatments. Due to hindered access, these treatments are usually limited to low intensive cuttings. In this study we aimed to examine how these management practices influence species composition and diversity indices in ravine forests. We used 215 vegetation plots representing the same community type (sycamore forest with hart's tongue fern, *Phyllitidi-Aceretum*) localized within the Polish part of the Carpathians. Two groups of plots were distinguished as plots under strict protection (national parks and reserves, 83 plots) and plots within complexes of managed forests (state and private forests, 132 plots). We compared different compositional and structural characteristics between these two groups. As a result, we identified only slight differences between managed and protected ravine forests. Protected forests had significantly lower cover of shrubs and lower, but not significantly, cover of trees. There were no differences in the herb layer cover. In addition, we identified significantly lower indexes of evenness in the protected plots. All other metrics, including species richness (both at plot level and cumulative), Shannon and Simpson diversity indices, number of alien species, number of ancient forest species and number of open habitat species, did not differ significantly. Our results show that low-intensity forest management has a marginal impact on the species composition in ravine forests. Species composition in ravine forests is shaped by natural disturbances and vascular plants are adapted to that condition. Low intensity forest management based on rare events of single tree cuttings emulate natural disturbance and do not change significantly the habitat conditions.

Dark diversity patterns in south Brazilian grasslands under habitat loss

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Recent results revealed that even moderate levels of habitat loss arising from land use conversion have reduced local plant species richness in south Brazilian grassland remnants. Yet, we do not know to what extent the biodiversity erosion has been caused by isolation of the grassland remnants or by associated local environmental conditions, such as grassland management changes linked to intensification. Here we apply the concept of species pool to analyze dark diversity patterns and their relations to grassland loss at landscape level and make inferences regarding this issue. We used data from a regional biodiversity survey of the south Brazilian grasslands, which sampled vegetation plots located in a stratified, nested design. This was defined by 30 landscape units of 2 x 2 km systematically located and representing the range of land use conversion levels within 10 mapped grassland ecosystem types. Within each 2 x 2 km unit, three homogeneous 70 x 70 m units representing mesic grasslands were selected, within which nine 1 m^2 plots were systematically described for the full species composition. Using species frequencies estimated after species incidence in the plots, we predicted, by Beals smoothing, the species richness (species pool size) for each 70 x 70 m unit; we then computed dark diversity as the predicted minus the observed species richness, and also the index of completeness of site diversity as the log ratio between observed and dark diversity. For each 2 x 2 km unit, we estimated the area of grassland remnants in the year 2009 and related it to the average index of completeness of site diversity. It was expected that grassland sites under similar environmental conditions should have the same species pool, irrespective of the level of conservation in the surrounding landscape. Thus, should the predominant mechanism of biodiversity erosion be fragmentation, a positive relation would be expected between percentage of grassland cover and completeness of site diversity. Indeed, a quadratic model revealing that percentage of grassland cover in the 2 x 2 km unit was a good predictor of completeness of site diversity ($y = 7.2E\text{-}05x^2 + 0.0013x - 0.75$, $R^2 = 0.43$, permutation $P = 0.0011$) indicating that this hypothesis is true.

Exploring the role of the species pool in driving species richness in temperate grasslands

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Grasslands are some of the most species-rich communities in the world at small-spatial scales, generating lots of interest in what enables large numbers of species to co-exist at scales where species interactions are expected to occur. Local species richness is influenced by the size of the regional species pool (i.e. the number of species that can potentially inhabit a site) and local abiotic and biotic factors. It is expected that the species pool is of greater importance in species-rich grasslands as these are relatively open to colonization, and high richness suggests local limitations are weak. We examined the relative importance of the species pool and local factors governing small-scale species richness and assembly patterns in temperate grasslands around the world. We sampled vegetation in 50 transects; transects were 10 m long and comprised of 100 contiguous 10 x 10 cm quadrats (total of 5000 quadrats). We calculated quadrat and transect-level richness and compared this among the study regions. We examined the relationship between transect richness (surrogate for species pool) and quadrat (small-scale) richness to determine if there is a positive linear relationship supporting the species pool hypothesis or if local communities were saturated suggesting local limitations. We further explored evidence for local limitations using a null model approach to compare several species richness measures to random expectations. We compared these tests among the regions to detect if community assembly is similar among temperate grasslands. Quadrat (10 x 10 cm) richness was high with a mean of 7.4 across all regions, and the highest richness (23 species) was found in the Spain-Morocco region. We found a positive curvilinear relationship between small-scale richness and transect richness indicating that communities are partially saturated at high richness. We found some evidence for local factors influencing assembly in most of the study regions but only at small-spatial scales. Local assembly patterns were similar, with few differences between the regions. We found evidence for both the species pool and local factors governing species richness patterns in ecologically similar but evolutionary distinct temperate grasslands. Most of the variation in small-scale richness is due to varying species pool size but there are still consistent, albeit, weak local limitations on community assembly.

Warming enhances growth of Arenaria tetraquetta in an alpine habitat but does not affect its facilitation effects

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Climate change is more pronounced in high-elevation habitats than elsewhere, potentially causing important disruptions in plant community composition and dynamics through changes in plant interactions. We tested the effect of warming and rainfall manipulations on growth and physiological status of *Arenaria tetraquetta*, a cushion plant species in the Sierra Nevada Mountains in Spain, and assessed the consequences of experimental manipulations on its facilitation effects. We increased temperature using acrylic open-top chambers (OTC) and increased or decreased runoff water, expecting that warming would increase physiological rates, leading to greater growth in plants with OTCs. We expected that temperature and rainfall manipulations would change cushion growth patterns and the relationships with beneficiary species, as larger growth would decrease cushion compactness, weakening facilitation effects measured in terms of species and individuals inside the *A. tetraquetta* canopy. Our rainfall treatments did not have significant effects, but warming increased daylight temperature, enhancing photosynthetic rate and respiration. Warming increased canopy growth and led to larger leaves although it did not change other plant traits nor the facilitation effects of cushions. We conclude that global warming may change the physiology of alpine plants, offsetting allocation patterns. It is unlikely, however, that warming will significantly affect interaction intensity between facilitator and beneficiary species, as expected temperature changes may not be enough to alter in substantial ways the *status quo* of current interactions.

Impact of anthropogenic disturbances on arbuscular mycorrhizal fungal communities

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The arbuscular mycorrhizal (AM) symbiosis is a key plant-microbe interaction in sustainable functioning ecosystems. AM fungi can directly benefit plant performance, and indirectly affect plant community structure by mediating biotic interactions. Furthermore, extra-radical hyphae production by mycorrhizal fungi influences soil physical characteristics, improving soil aggregate stability and resistance to soil erosion. Increasing anthropogenic disturbance poses a threat to AM fungal communities worldwide, but there is little empirical evidence about its potential negative consequences. In this global study we sequenced AM fungal DNA in soil samples collected from pairs of natural (undisturbed) and anthropogenic (disturbed) ecosystems. In the case of plant communities, it is usually believed that anthropogenic disturbances decrease diversity, although empirical results are sometimes multidirectional. We expected the negative impact on AM fungal diversity as well. However, disturbance increased alpha diversity at sites where natural diversity was low, and decreased diversity at sites where natural diversity was high. We conclude that anthropogenic disturbance does not have a consistent directional effect on AM fungal diversity; rather, disturbance equalizes levels of diversity at large-scales. In a complementary local scale study, we addressed the impact of forest clearcutting in Neotropical rain forest on AM fungal communities. There was no significant effect on local fungal diversity. However, clear-cut areas were characterized by more the frequent occurrence of specialist AM fungi, compared with mature forest areas. This result is counter-intuitive and suggests that certain AM fungi with narrow ecological niches have traits that allow them to exploit conditions of severe disturbance.

Responses to successional water deficit and recovery in four warm-temperate woody species

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In order to study the physiological and growth responses of plants to drought and subsequent rehydration, seedlings of two native (*Vitex negundo* L. var. *heterophylla* (Franch.) Rehder and *Quercus acutissima* (Carruth.) and two exotic species (*Robinia pseudoacacia* L. and *Amorpha fruticosa* L.) in China were selected to carry out greenhouse experiments. Parameters, such as gas exchange, stem hydraulic parameters, plant osmoprotectant contents and antioxidant activities, of seedlings subjected to sustained drought and rehydration (test group) were measured, and were compared with those of well-irrigated seedlings (control group). There exist substantial differences in responses to mild drought but similarity in responses to severe drought between the test group and control group. The two native species, *Q. acutissima* and *V. negundo* var. *heterophylla*, exhibited a greater degree of isohydry with drought, since they controlled stomatal opening timely from the onset of drought treatment. However, the two exotic species showed a more "water spender" strategy with *R. pseudoacacia* showing anisohydric and *A. fruticosa* showing isohydrodynamic responses to drought, respectively. Although *A. fruticosa* maintains stomatal opening for a long time, the water potential of *R. pseudoaccacia* fluctuated greatly and *A. fruticosa* maintained a stable water potential. Severe drought significantly decreased leaf gas exchange rates, shoot water potentials and stem hydraulic conductivity, whereas instantaneous water use efficiency and osmoprotectant contents increased remarkably. Most of the physiological parameters recovered rapidly after mild drought rehydration, but the water potential and/or supply of nonstructural carbohydrates did not recover after severe drought rehydration. The results demonstrate that the xylem hydraulic conductivity and shoot water potential jointly contribute to the recovery of the rejuvenation of woody plants; and demonstrate the linkages and tradeoffs between the traits and functions affecting plant water use, carbon assimilation, and synthetic in response of drought and rehydration. The experiments can provide evidence for the drought response of species to predict forest dynamics under the climate change.

Distribution, community characteristics and classification of Stipa tianschanica var. klemenzii steppe in China

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According to the Chinese national vegetation classification system, grassland vegetation dominated by *Stipa tianschanica* var. *klemenzii* is referred to as *Stipa tianschanica* var. *klemenzii* steppe at the formation level. It is a zonal vegetation type occurring in semi-arid regions of northern China and Mongolia. Using extensive field vegetation surveys during 2010 to 2016 and related published documents, we systematically studied the eco-geographic distribution patterns, community characteristics, and classification of *Stipa tianschanica* var. *klemenzii* steppe across China. This formation was found mainly on the Ulan Qab and western Xilin Gol Plateaus, across altitudes ranging from 581 to 4,601 m, with mean annual precipitation of 247 mm and mean annual temperature of 5.0 ℃. A total of165 plant species belonging to 85 genera and 29 families were recorded in 80 representative vegetation plots, in which rare species (those with constancy < 20%) accounted for 87% of the flora. Only four species had constancy greater than 50%, including *S. tianschanica* var. *klemenzii*, *Convolvulus ammannii*, *Cleistogenes songorica*, and *Allium tenuissimum.* Hemicryptophytes and therophytes were the dominant life forms, comprising 55% and 20% of the flora, respectively. Species were drought-adapted, with typical xerophytes accounting for the largest proportion of the flora (47%), followed by super-xerophytes (15%) and meso-xerophytes (15%). Representatives of ten geographic floristic elements were identified, among which Middle Asian and East-Palaearctic were the two most common ones, contributing 37% and 26% of species, respectively. The average height, cover, and aboveground biomass were 14 cm, 19%, and 60 g m-2, respectively, which were lower than those of most of the *Stipa* formations in China. Based on the life form and dominance of the plant species, we further classified the *Stipa tianschanica* var. *klemenzii* steppe formation in China into 6 association-groups and 29 associations.

Can the effects of intra-specific interactions mediate the outcome of inter-specific facilitation?

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Interspecific facilitation occurs when the presence of one species enhances the growth, reproduction and/or survival of another. The facilitative effects of cushion-forming plant species (compact, hemispherical species that create favorable microhabitats) on associated beneficiary species have been well documented, but studies have typically focused on direct and unidirectional interactions. However, beneficiary species could also affect each other, either positively or negatively or indirectly (i.e. through benefactor- or beneficiary-mediated interactions among beneficiary species). Where strong, these indirect interactions could potentially mediate the outcome of inter-specific interactions. The aim of this study was, therefore, to examine the impact of intra-specific interactions on the outcome of inter-specific interactions. We used the cushion-forming plant, *Azorella selago*, and a dominant perennial grass species that the cushion plant is known to facilitate, *Agrostis magellanica*, on sub-Antarctic Marion Island as a study system. We assessed the impact of intra-specific interactions (between *Agrostis* individuals) on the outcome of an inter-specific interaction (between *Azorella* and *Agrostis*) by testing if the cover and/or density of *Agrostis* mediates the impact of *Azorella* on *Agrostis*. Experimental data from two sites were complemented by observational data collected across altitudinal gradients. We found a significant decrease in *Agrostis* performance with conspecific density; however, experimentally reducing intra-specific *Agrostis* density had no effect on *Agrostis* performance. Additionally, the effect of *Azorella* on *Agrostis* was positive, with the grass performing best when growing on cushion plants or on the edges of cushion plants. Thus, the effect of inter-specific interactions (between *Azorella* and *Agrostis*) outweighs the influence of intra-specific interactions (between *Agrostis* conspecifics). This result therefore highlights the importance of positive plant-plant interactions and suggests that facilitation may matter more than intra-specific competition in this study system. Our results suggest that indirect interactions (i.e. benefactor- or beneficiary-mediated interactions among beneficiary species) may be relatively unimportant under strong facilitation in alpine systems.

Effect of environmental factors on plant species richness in semi-natural grasslands at various spatial scales

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Knowledge about spatial patterns of biodiversity is of key importance for the development of scientific theories and for nature conservation purposes. Relationships between plant species distribution and environmental gradients have been widely studied using a variety of approaches. The increasing availability of high accuracy data on plant species distribution and environmental variables stored in electronic databases facilitate the explanation of ecological patterns and processes. In our study, we used a vegetation-plot database containing information about species richness at fine-scale. We used 2,722 georeferenced vegetation-plot data from the *Polish Vegetation Database.* Selected data represented vegetation of semi-natural grassland communities in Lower Silesia (Poland, Central Europe). Due to the uneven spatial distribution of plots within the study area, we performed geographical stratification. Final data set for the analysis included 709 vegetation-plots. It has been previously emphasized that the relationships between species richness and environment vary across spatial scales. Therefore, we examined the effect of different environmental factors on species richness at four spatial scales. For each vegetation-plot, a buffer of a radius 0.05, 0.5, 2.5 and 5 km was established. For each buffer, we assigned five sets of environmental variables (climate, topography, soil, human pressure and landscape). We analyzed the explanatory value of different environmental factors using boosted regression tree method to find the most important determinants of plant species richness in grasslands. The variables representing human pressure (population density, income per capita) made the largest contributions to models at all scales. The relative influence of the sets of environmental variables varied depending on the scale. For each increase of the buffer size, the contribution of anthropogenic factors, climate and topography decreased while that of soil type and landscape structure increased. In the model incorporating all environmental variables, the 0.5 km radius buffer explained the highest fraction of deviation. The results improve our understanding of human influence on biodiversity and scale-depending relationship between species richness and environment. From a practical point of view, the results also enhance understanding of the ecology of semi-natural grasslands in Central Europe and help to preserve these communities.

Are wetlands of dune slacks actually novel ecosystems in New Zealand?

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The Manawatu coast of New Zealand houses an extensive and rapidly prograding dunefield of mobile parabolic dunes. The dune slacks (depressions inside the parabolas) host many small wetlands which are home to several rare and endangered plant species, many less than 2 cm tall, and turf-forming. These are only temporary communities, succeeding within 2-3 decades into taller restiad-based rushlands and shrublands. Therefore the habitat of the turf-forming species is lost unless infilled dune slacks deflate into wetlands again, or new dune slacks are formed in unvegetated sand closer to the coast. Despite being designated as examples of one of New Zealand's rare and threatened ecosystems, suspicion has arisen that they are in fact anthropogenic rather than natural. Here we briefly review the nature of the wetlands, and investigate the experimental and other evidence for them being novel, and anthropogenic rather than natural, ecosystems of the dunefields. National vegetation surveys show a lack of species' sorting along the wetlands' gradients, implying weak, if any, niche differentiation. Experiments on individual species under a range of environmental conditions also suggest their niche differentiation is poor. Given the known and possible histories of the wetlands, it seems that the species, also found in a range of other environments, have simply moved into a new, anthropogenic habitat as it became available. Nevertheless, the dune slacks currently provide a relatively pristine habitat for the rare species, newly formed via primary succession, and so alleviating threats to which they may be exposed in other habitats. Despite the anthropogenic origin of the wetlands, they still provide viable and potentially ongoing habitat. We reflect on the probable future persistence of the dune slack wetlands under various scenarios of change, such as stabilization of the dunes, cessation of coastal progradation, or retrogradation during periods of sea-level rise.

Pollen data reveals different pathways of mire vegetation development

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Sedimentary pollen provides valuable source of information about past vegetation development. In the majority of the pollen studies, the vegetation outside the sedimentary basin (lake or mire) is of main interest. However, in case of mires, pollen data also reflect changes on the site itself allowing to follow the pathways of mire development. In the present study, we compare the development of five mires on the island of Saaremaa, Estonia through their entire development since the mire sites emerged from the Baltic Sea after the last ice age 10 000 – 8000 years ago. At present, three of the mires are ombrotrophic bogs and two are minerotrophic fens. The pollen taxa and spores characteristic of dry areas are considered as background component and the analyses concentrate only on taxa which grow predominantly on the mires. Our preliminary results indicate that all three present-day bogs had a "fen phase" dominated by Cyperaceae in the beginning of their development lasting 3,000 – 6,000 years. In one of the present-day bogs, the *Sphagnum* peat began to accumulate as late as 2,000 years ago. Kanna site, presently a minerotrophic spring fen, has developed in the opposite direction – during the first thousand years (9,000 – 8,000 cal yr BP) it was as a small *Sphagnum*-dominated bog and the development of the fen began only after the mineral-rich surface water began to flow over the fen surface. Several species characteristic to present-day fens in Saaremaa – *Parnassia palustris*, *Myrica gale*, *Cladium mariscus* – can be seen in pollen records already from the beginning of the mire development indicating their good post-glacial spread. Our results highlight the potential of pollen data to describe the different development pathways of mires and to reveal the migration history of characteristic mire species.

Short-term dune community response to experimental climate change and Carpobrotus invasion

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Climate change and invasive alien species are two major causes of global biodiversity loss, but the interaction between both drivers is still under discussion. Plant coastal dune communities are one of the most sensitive habitats to global change factors such as increasing temperatures, more intense and frequent droughts, nitrogen deposition, and biological invasions. In a manipulative experiment in a permanent plot on a fixed grey dune in Galicia, NW Iberian Peninsula, we tested the short-term responsiveness of these communities to disturbances induced by the invasive species *Carpobrotus edulis* (L.) N.E.Br., and experimental changes in temperature and water availability, in terms of species richness and diversity, community composition, and biomass production. Inside the 252 m^2 fenced plot, we regularly demarcated subplots of 1.44 m^2 (1.2 x 1.2 m). The effect of species invasion was tested in 16 subplots, eight planted with *C. edulis*, a prominent invasive alien species in the area, and eight without it. The effect of predicted changes in the climate for the region, a 2.5 ºC increased temperature and a 30 % decrease in rainfall, was tested in 32 subplots with *Carpobrotus*, eight for each climatic scenario (control, increased temperature, reduced rainfall and the combination of increased temperature and reduced rainfall). We used Open Top Chambers and rainfall collectors to simulate the intended changes in climate. Species richness and diversity seem to be unaffected by any of the treatments, with no statistically significant values, but multivariate analyses showed a different species composition for each of them. One of the most affected species was the annual *Linaria arenaria*, a threatened species with a higher density in the control plots (no climate manipulation, no *Carpobrotus*). The results of our study suggest that community structure and function may be altered by the on-going environmental changes and provide useful insights for detecting rapid changes in vegetation in these fragile ecosystems. Dune communities can thus serve as early warning systems for anticipating the potential interaction effects between drivers of biodiversity loss, where severe and/or abrupt changes in climate and biological invasions are expected. This will provide knowledge for early action in conservation plans.

A comparison of distance-based and model-based ordinations

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Ordination has been a primary component of the analysis of vegetation for over half a century. The vast majority of ordination methods have employed matrices of pair-wise differences between samples based on calculations of geometric distance or indices of dissimilarity. These methods are now collectively called "distance-based" methods. Recently proponents of "model-based" methods have developed ordination techniques based on explicitly modeling individual species responses to underlying gradients to estimate sample locations along compositional gradients. I performed a rigorous comparison of distance-based ordination against model-based ordination on one simulated data set and four well-known data sets to determine the relative performance of the methods in identifying the effects of environmental variation on community composition and the ability of the methods to represent individual species response along gradients of community composition. Specifically, I tested distance-based Non-Metric Multidimensional Scaling (NMDS) and t-distributed Stochastic Neighbor Embedding (t-SNE) against model-based Bayesian Ordination (BORAL) and Random Effects Ordination (REO). Ordinations were calculated by each method on each of the five data sets, and analyzed by Generalized Additive Model (GAM) analyses of environmental variable explanatory power and multidimensional individual species response models. Where possible (NMDS, t-SNE, and BORAL) ordinations were calculated for both two-dimensional and three dimensional solutions; REO can only be calculated in two dimensions. For each environmental variable the ordination-specific models of environment were ranked by deviance explained and model AIC. Averaged across all five data sets, NMDS-3D achieved the best mean ranking for deviance explained (2.62), followed by t-SNE-3D (2.82) and t-SNE-2D (3.63). Rankings for minimum AIC were the same, indicating that the models were not over-fit. Distance-based models ranked 1, 2, 3, and 5.5; model-based methods ranked 4, 5.5, and 7. In general, except for t-SNE-2D, three dimensional models did better than two-dimensional models on all five data sets. For species, the abundances of all species that occurred at least five times in a data set were modeled by negative binomial GAM. Averaged across all species and data sets, t-SNE-3D ranked first (2.64), followed by NMDS-3D (2.74), and BORAL-3D (2.83). Distance-based methods ranked 1, 2, 4.5, and 6 and model-based methods ranked 3, 4.5, and 7. Model AICS were similar except that BORAL-3D ranked 2 and NMDS-3D ranked 3, suggesting that BORAL-3D achieved more parsimonious species response models. Across all tests distance-based methods were always best, generally achieving both the first and second best ranks for both environment and species models.

A comparative review of soil charcoal data: spatiotemporal patterns of origin and long-term dynamics of Western European nutrient-poor grasslands

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The nutrient-poor grasslands of Western Europe are of major conservation concern because land use changes threaten their high biodiversity. Studies assessing their characteristics show that their past and on-going dynamics are strongly related to human activities. Yet the initial development patterns of this specific ecosystem remain unclear. Here, we examine findings from previous palaeoecological investigations performed at local level on European grassland areas ranging from several hundred square meters to several square kilometers. Comparing data from these locally relevant studies at a regional scale, we investigate these grasslands' spatiotemporal patterns of origin and long-term dynamics. The study is based on taxonomic identification and radiocarbon AMS dating of charcoal pieces from soil / soil sediment archives of nutrient-poor grasslands in Mediterranean and temperate Western Europe (La Crau plain, Mont Lozère, Grands Causses, Vosges Mountains, Franconian Alb, and Upper-Normandy region). We address the following questions: (1) What are the key determinants of the establishment of these nutrient-poor grasslands? (2) What temporal synchronicities might there be? (3) What is the spatial scale of these grasslands' past dynamics? The nutrient-poor grasslands in temperate Western Europe are found to result from the first anthropogenic woodland clearings during the Late Neolithic, revealed by fire events in mesophilious mature forests. In contrast, the sites with Mediterranean affinities appear to have developed at earlier plant successional stages (pine forest, matorral), established before the first human impacts in the same period. However, no general pattern of establishment and dynamics of the nutrient-poor grasslands could be identified. Local mechanisms appear to be the key determinants of the dynamics of these ecosystems. Nevertheless, this phyto-historical synthesis provides insights into past climate or human impacts on present-day vegetation.

Assessment of the forest history of the Lorraine plateau in high spatial resolution for the identification of the ecological niche of beech versus oak trees

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The identification of relevant predictive scenarios needs to examine the past in order to gather insights about natural ecosystem trajectories, to identify mechanisms of changes and the responses of the ecosystems. It is a key issue to link knowledge from the past to predictions of the future. We seek here to do it for the forests of the Lorraine plateau, in North-Eastern France. In this area several ongoing issues such as socio-economic transition and climate change are challenging the sustainability of the forest resources for the future. Therefore, the current forest management is under question. However, the past natural forest dynamics and the mature stage of the forests of the Lorraine plateau are still unclear, especially at local scales regarding the mosaic of drained versus hydromorphic soils. Some hypotheses have been proposed based on historical written sources but there are still no direct biological insights about the forest stand history of the area. This gap is a key impediment to the identification of management strategies relevant at the local scale. Therefore, we investigated the forest ecological history of the Lorraine plateau from the stand scale to the regional scale, focusing on the history of local key forest trees species: the oak species (*Quercus robur* and *Quercus petraea*) and beech *(Fagus sylvatica*), in relation to soil characteristics (hydromorphic versus well-drained conditions). We sampled 18 forest plots (with two sampling locations per plot) on the Lorrain plateau, in well-draining soil conditions, to collect soil samples in order to obtain soil charcoal assemblages. These data, combine with soil description and radiocarbon dating, were used to (1) identify the direct evidence of the dominant tree species of the local forest stage in well-draining soils, (2) identify the chronology and determinism of the past changes of the dynamic trajectories of the forests, and (3) identify the natural ecological niche of beech, without the limitation of its distribution due to forest management. The results based on 2000 charcoal pieces show that *Quercus* is dominant (55% of the identified pieces). *Fagus* is almost identified in all sites with 300 pieces (15%). Various other genera, such as *Carpinus, Acer, Pinus*, etc., occurred with lower frequencies. The radiocarbon dates indicate that oaks and beech have been growing together for millennia in well-draining soil condition. We conclude that historical forest management has significantly influenced the current distribution of forest species of the Lorraine Plateau.

Assessing plant biodiversity in Mediterranean forests under different management options: traditional vs new indicators

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Indicators are fundamental tools for defining and promoting sustainable forest management (SFM), by providing relevant information for forest policy development and evaluation, national forest policies, plans and programs. The FutureForCoppiceS LIFE project (Life 14 ENV/IT/000514) aims to evaluate the effects of different management options based on some of the traditional SFM indicators and on new indicators that are proposed and tested by the project for the first time. Woody species are directly affected by management practices, e.g. by selective cutting; herbaceous species are indirectly affected. The aim of this specific study was to evaluate the effects of different management options on a traditional indicator, woody species, and on a new indicator, herbaceous species, in three European Forest Types: mountainous beech forests (MBF), deciduous thermophilous forests (DTF), evergreen broadleaved forests (EBF) of agamic origin. Two contrasting management options were compared: Pro-Active Conversion to high forest through selective thinning (PAC) vs. natural dynamics (NE), both practiced for at least 30 years. The random sampling design included 11 sites and 45 plots (100 m^2) located in Sardinia and Tuscany (Italy). Woody species included those with a trunk circumference greater than 30 cm. Herbaceous species richness was recorded in the main plots and in four nested subplots. Species-Area relationships (SARs) were fitted using the Arrhenius power model, $S = cA^z$ (S = number of species, A = subplot area, c = expected number of species in area unit, z = steepness of SAR). The c parameter was used as a measure of within-plot species richness, and the exponent z as a measure of within-plot beta-diversity. Overall, herbaceous species richness was significantly higher in PAC (33) than in NE (19) while management options did not affect woody species richness. Herbaceous and woody species richness across were positively correlated ($P < 0.001$) under both management options (NE $R^2 = 0.70$; PAC $R^2 = 0.42$). The c parameter was significantly higher ($P = 0.02$) in PAC (6.2) than in NE (4.5) and in DTF than in MBF and EFB. The z-values showed a more complex response, with no significant effects of management options. The greatest dissimilarity in herbaceous species composition between the two management options, tested with ANOSIM, was detected in the EBF ($R^2 = 0.42$; $P = 0.02$). The new indicator proposed by the FutureForCoppiceS project, herbaceous species, proved to be powerful in providing relevant information for assessing the effects of forest management options on plant biodiversity.

Windthrow in South Florida pine rocklands: pit-and-mound features and plant microhabitat associations following a hurricane

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Topographic heterogeneity can affect plant composition and diversity across scales from centimeters to kilometers. Topography can be created entirely by geologic forces, but more often is altered by biotic agents and/or natural disturbances. In this study, we examined the effect of pit-and-mound landforms created by hurricane-uprooted trees on spatial patterning in the pine forest understory. Following Hurricane Andrew (August 1992), we found that two areas - a wet site in Big Cypress National Preserve (BCNP) and a more xeric one in Everglades National Park (ENP) - differed markedly in morphology and substrate dynamics in the pit and mound environments. At BCNP, where pine roots occupied continuous marl soils, tip-up pits were shallow, wide, and filled in rapidly after the hurricane. At ENP, where trees were rooted in limestone bedrock, pits were deeper, and infilling with limestone fragments was irregular. The two sites also differed in the relative favorability of the two major tip-up habitats for plant establishment. Following a year of very high water conditions, species richness on BCNP mounds was about 60% higher than in pits. In contrast, pits in ENP were about twice as speciose as mounds. Pit and mound species composition (especially the former) were distinct from background vegetation during the immediate post-hurricane period. However, these relationships did not appear to persist; old tip-up features which were still recognizable in the rockland landscape did not differ from undisturbed terrain with respect to plant species composition. Spatial analyses indicated that pine forest understory vegetation was strongly structured at distances between 0.3 and 15 m. Within that range, units of relatively homogeneous vegetation of all sizes were present at both sites. Our results suggest that the uprooting of pine trees during periodic hurricanes creates ecologically significant substrate variation for early plant establishment on the rockland surface, and while succession and subsequent sedimentary processes erase some of this early vegetation patterning, the uprooting of trees contributes in an important way to the diversity of understory rockland assemblages.

Tree species identification errors in large inventory and monitoring programs

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The USDA Forest Service, Forest Inventory and Analysis program (FIA) conducts comprehensive inventories of forest resources across the US. Since the 1930s the program has moved from a narrowly defined mission of timber assessments to an inventory that not only addresses timber issues but broader forest ecosystem issues as well. This has created a need to both broaden the scope of and refine data collection protocols to fulfill the goals of this expanded mission. The correct identification of species is the cornerstone of any biological investigation; if a sample and subsequent estimates are applied to incorrectly identified species, then scientific conclusions are denigrated. Even though FIA has a QA/QC program there were indicators pointing to possible species identification problems by field crews. We designed a study to independently check species identification on previously measured plots. A total of 154 sample plots were randomly selected from a pool of 3,500 plots for identification verification by a contracting botanist. This resulted in a total of 4,499 live trees (≥2.54 cm DBH) being checked for verification in the study. The overall error rate was 8.6 percent. This extrapolated to approximately 8,009 trees identified incorrectly out of the 94,223 live trees sampled in the state chosen for study. However, the overall rate may be misleading in certain cases. This is because of the oligarchic distribution of trees sampled in large surveys where a few species account for 70 percent, or more, of the system importance value. For some species the error rates approached 100 percent. The conifers fared the best with a 1.6 percent error rate. The *Quercus* spp., another important genus, had an error rate of 7.8 percent. Some of the poorest error rates were in the *Acer*, *Ulmus*, and *Carya* genera. The study is important to reinforce the importance of quality work in large comprehensive surveys, often challenging because the field people come from varied backgrounds with different levels of experience. The study points out the importance of independent QA/QC, conducted by a botanist, and the need for periodic training of field people throughout the year. This is important to maintain the credibility of large inventory and monitoring programs. Species identification errors in the FIA data sets may lead to erroneous conclusions from a wide clientele of users, especially in studies emphasizing the importance of species distributions and shifts in range. Other studies involving community analysis and documentation will also be impacted by these errors.

Spatial structure in species composition within the Everglades ridge and slough landscape

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In a patterned landscape, large scale spatial patterns in plant species composition usually result from environmental processes acting at different spatial scales and their feedbacks on community assembly. In the Everglades, where hydrologic and soil-building processes are the basis for landscape patterning, ridge-slough (R&S) is a spatially structured landscape containing distinct linear features, i.e. sawgrass-dominated ridges separated by a network of sloughs with submerged and floating plant species. However, in a large part of the R&S landscape, the historical vegetation pattern appears to have been lost due to management-induced changes in hydrologic regimes. In this study our objective was to describe spatial structure within the R&S landscape based on species composition, and relate the derived structural measures to landscape condition. We sampled species composition in 62 5 x 2 km plots, namely PSUs (Probabilistic Sampling Units), distributed evenly throughout the historic R&S landscape. To model the spatial structure in species composition, we plotted Bray-Curtis dissimilarities against distance, also called "dissimmogram", and quantified spatial structure with nugget, sill and range, three commonly used parameters in semi-variance analysis. We reasoned that healthy R&S landscapes would exhibit strong anisotropy and a low nugget to sill ratio (nugget:sill). Our data showed a wide range in both the nugget effect and nugget:sill ratio, indicating differences in the size and magnitude of variation in community patches among PSUs. While the low nugget and high nugget:sill ratio for the majority of PSUs signified a homogeneous plant species composition - a sign of R&S degradation - a few PSUs displayed a higher nugget effect and low nugget:sill ratio, indicating relatively conserved R&S at the present sampling resolution. Long-term water depth in most of the well-preserved R&S areas ranged from 25-50 cm. The study indicated that more areas within the R&S landscape are in a degraded condition than are intact and in line with historical pattern. The current situation suggests that only an active and adaptive management targeting pre-development hydrologic regimes can restore the degraded R&S landscape.

Do the amount and synchronism of flowering of male and female trees change with age?

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Trees undergo mast flowering. However, given the long life of trees, the flowering interval may change with age from flowering initiation. Although masting has been reported in dioecious trees, little is known about the changes in the interval and synchronization of males and females with aging. Long-term research on flowering in trees can clarify changes due to internal factors, such as aging, and reveal external influences, such as climate change. Therefore, this study measured flowering in *Fraxinus platypoda*, a cold-temperate-zone deciduous tree, for 28 years from 1990 to 2017 in stands in a 90-year-old secondary forest and a more than 200-year-old natural forest in the Chichibu Mountains of central Japan. This study examined 26 female and 20 male trees in the natural forest, and 20 and 17, respectively, in the secondary forest. The number of flowering of female and male individuals was scored from 1 to 5 using binoculars: 1, no flowering at all; 5, a large amount of flowering. The data for the 28 years demonstrated clear flowering intervals for *F. platypoda* in both stands. In the secondary forest, the masting interval was 2–3 years, and the flowering in both sexes showed clear synchronization. The average flowering rank of all individuals was 3.02 for males and 3.11 for females, and did not differ. The coefficient of variation was 0.46 for females and 0.36 for males, and the difference was significant. In the natural forest, although the masting interval was 2–3 years, the interval changed over the 28 years. Since 2002, more males have flowered each year, while females retained an obvious interval. In addition, the flowering of the two sexes did not show clear synchronization. The average flowering rank of all individuals was 3.22 for females and 4.11 for males, and was significantly higher in males. The coefficient of variation was 0.48 for females and 0.28 for males, and was higher in females. The results revealed that the synchronicity of males and females was higher in the younger forest, while there was more male flowering in the older forest. The increase in flowering with age may be an internal phenomenon, while the flowering fluctuation after 2002 in both forests might have been affected by external factors, such as climate change.

California ultramafic landscapes: a geobotanical overview

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Ultramafic areas are very well represented throughout the Pacific Northwest of North America. The wide diversity of habitats found in ultramafic areas supports a very valuable biodiversity. California is an exceptional area within this broad region. Its varied climate and the proliferation of a massive local occurrence of ultramafics have created a true biodiversity hotspot. This natural patchiness requires a characterization of the different vegetation types, their specialized floristic composition, and vegetation series that are closely related with geobotanical features such as bioclimate diversity and biogeographical location. From sea level to the high mountain areas in Sierra Nevada or the Klamath-Siskiyou ultramafic landscapes, the biogeographical units recognized in California are always characterized by ultramafic vegetation. The focus of our research is to identify and characterize the main vegetation types such as mature stands of ultramafic vegetation, seral plant communities, and their dynamic patterns. We followed the standard phytosociological methods for vegetation sampling using the Braun-Blanquet scale for species cover abundances. The natural vegetation units on ultramafics were studied and contrasted by numerical analyses. A bioclimatic characterization and biogeographic framework were also compiled of selected places located in ultramafic areas throughout the state of California. The main phytosociological units covering ultramafic natural potential vegetation were forest plant communities framed in two classes: *Heteromelo arbutifoliae-Quercetea agrifoliae* Rivas-Martínez 1997 (sclerophyllous evergreen woodlands) and *Calocedro decurrentis-Pinetea jeffreyi* Rivas-Martínez & Sánchez-Mata 1997 (conifer forests and woodlands). Our overview includes a general survey of the main ultramafic vegetation types in California with some remarks on their updated syntaxonomical status. The phytosociological units are characterized by a typical floristic combination and are strictly related with bioclimatic and biogeographic features. The correspondences of these units with the updated *US National Vegetation Classification* (USNVC) are also given.

Vegetation structure and shrub dynamics relative to fire, prairie dogs, and large ungulates in a hierarchical exclusion experiment at the eastern terminus of the sagebrush steppe

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Alterations to vegetation structure and shrub communities have implications for wildlife conservation and livestock management, but the relative influences of multiple and interactive disturbances in semi-arid grasslands at the eastern terminus of the sagebrush steppe remains unclear. We assessed the individual and interactive effects of multiple disturbances on vegetation structure in a three-tiered, large-scale manipulative experiment in northeast Wyoming, USA. We used nested grazing exclosures to isolate the effects of herbivory from livestock, wild ungulates, or small mammals within areas affected by either historical wildfire, black-tailed prairie dog *Cynomys ludovicianus* colonies, or neither disturbance. We analyzed the interactive effects of disturbance history and contemporary herbivory by either small mammals alone, small mammals + native ungulates, or small mammals + native ungulates + livestock on vegetation structure by quantifying vegetation height, visual obstruction, shrub density, shrub canopy, and shrub leader growth. Exclusion of native ungulates and lightly-to-moderately stocked livestock for two years did not significantly affect herbaceous vegetation structure, shrub density, or shrub canopy cover. Maximum vegetation height, visual obstruction, and heights of grasses and forbs were ~50% lower on black-tailed prairie dog colonies than in undisturbed areas, and small mammal exclosures confirmed that these structural differences were caused by small mammal herbivory. Prairie dog colonies contained 71% lower shrub densities than undisturbed sites. Sites with wildfire or black-tailed prairie dogs had 89% lower canopy cover of shrubs and Wyoming big sagebrush (*Artemisia tridentata* ssp. *wyomingensis*), when compared to undisturbed sites. Shrub leaders experienced over 4.5 times more browsing on prairie dog colonies, when compared to undisturbed areas, which indicates that the relationship between black-tailed prairie dogs and shrubs is more than incidental due to selection of sites with low shrub densities. Generally, disturbance history did not modify the effects of contemporary herbivory on vegetation structure. However, shrubs on prairie dog colonies experienced significantly more leader browsing in the combined presence of livestock, native ungulates and small mammals than in treatments where livestock were excluded. These results have direct implications for ecology and management because short-term (1-2 yr) rest from large ungulate grazing may not substantially alter vegetation structure in this system. Instead, structural variation is strongly driven by black-tailed prairie dog colonization and historical wildfire. Understanding and managing multiple, potentially interacting disturbances is critical for maximizing wildlife conservation and livestock production in heterogeneous landscapes.

Classifying big sagebrush plant community composition across an ecological gradient in Colorado

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Big sagebrush (*Artemisia tridentata*) ecosystems are widespread in the United States and provide essential ecosystem services, including water and nutrient cycling, energy capture, and habitat for sagebrush obligate taxa. Notably, sagebrush ecosystems provide habitat for the greater sage grouse (*Centrocercus urophasianus*), which is a threatened species of high concern. Sagebrush habitat has experienced a 45% reduction in range and a large portion of intact habitat is at risk of loss from severe fire, cheatgrass (Bromus tectorum) invasion, and fragmentation due to human development. Thus, it is of high conservation significance to manage intact ecosystems to prevent loss and to restore degraded ecosystems. Sagebrush habitats form a broad array of plant community assemblages across the western United States; however, very little research has described these patterns in a quantitative framework. A detailed classification of plant community types within the big sagebrush ecotype would be beneficial for setting management and restoration goals. Therefore, we classified sagebrush habitat in Colorado and defined sagebrush communities using indicator species and elevation as diagnostics. We obtained vegetation data from 1,245 plots containing big sagebrush in Western Colorado from the United States Forest Service. We classified plots based on species cover similarity, and formed ten plant community groupings. MRPP and indicator species analyses revealed that these groupings had significant differences in species composition, associated indicator species, and functional group composition. Additionally, plot vegetation composition varied across Axis 1 of a CCA ordination and was strongly tied to an elevational gradient. Preliminary results suggest that sagebrush management goals and restoration methods should be informed by quantitative descriptions of plant functional communities.

Species area requirements shape species pool and richness on small islands

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Small islands are ideal model systems to study community assembly and local ecological processes that also characterize small and isolated habitat fragments in general. Due to more extreme environmental conditions on small islands compared to larger ones, environmental filtering is expected to preclude some species from successful colonization, potentially resulting in island-specific species pools. Knowledge about the area-dependency of species pools can provide new insight into community assembly processes and the elusive small-island effect (SIE), stating that on small islands, species richness varies independently of area or increases at a lower rate than on larger islands. We studied woody plants on sixty small islands with island area ranging from 3 m^2 to 11,806 m^2 in Raja Ampat, West Papua (Indonesia). Using the dark diversity concept and applying a novel method to calculate probabilistic island-specific species pools, we found that most species had significantly larger area requirements as expected from random colonization. Comparing a suite of alternative species-area models, we detected a SIE for the observed species richness and then tested if the SIE results from differences in species pool size. We found strong support that local limiting processes shape the SIE and that these processes have no impact on the species pool but rather control how much of the pool is realized on an island. Our findings are also relevant for understanding ecological processes in small fragmented and isolated habitats and with high relevance for nature conservation as many species have area requirements larger than remaining habitat fragments.

Can wet areas mapping (WAM) be used to predict invasive species in dry mixed grass prairie?

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Invasive species have been identified as one of the most serious threats to ecosystem health and to the conservation of biodiversity and endangered species. As such, the presence and abundance of invasive species is often used as a metric/indicator of ecosystem health and of critical habitat as defined under Endangered Species legislation. The rate of invasion of non-native species into ecosystems, however, often exceeds our ability to document their presence and, thus, protect vulnerable ecosystems. With less than 50% of Alberta's native grasslands remaining intact, their persistence, along with that of the high proportion of endangered species they contain, is of particular concern. Given the above, Wet Areas Mapping (a LiDAR based, digital elevation model of depth to water) has been proposed as a landscape-level tool for predicting patterns of invasion of non-native vascular plant species in grassland ecosystems of Alberta. In the summers of 2015 and 2016, transects were established in the Dry Mixed Grass prairie of southern Alberta in order to test its suitability for predicting invasive species occurrence, and for identifying both rare, and particularly vulnerable communities. We found that invasive species richness and abundance were both positively related to decreasing depth to water (as predicted by WAM) within our study area. The strongest explanatory model for both invasive abundance and richness included depth to water (WAM), along with proximity to oil & gas well sites, decreasing distance being positively related to increasing invasive species occurrence. Both these relationships were significant within the model. The second best model in each case included grazing as an additional predictor of invasive species. At a species level, Kentucky bluegrass (*Poa pratensis*), the most common invasive species in our study and a dominant species in 20% of our plots, was significantly positively related to decreasing depth to water values in the four top explanatory models of its presence. On the other hand, perennial sow thistle (*Sonchus arvensis*) was more consistently related to grazing in the four top models explaining its presence, while Canadian thistle (*Cirsium arvense*) was most consistently positively related to proximity to well sites in the four top models. Preliminary results indicate that plant communities also reflect the moisture gradient predicted by WAM, however the dominance of invasive species in some communities in our study area complicates the interpretation of local community data as a predictor of the presence of invasives. From a management perspective, WAM has the potential to become a useful and relatively cost-effective tool to predict hotspots of invasive species occurrence at a landscape scale, but promises to be more effective for some species than others.

Biodiversity gradients of woody plants along latitude and elevation: the role of functional group-specific cold tolerance

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Latitudinal and elevational diversity gradients (LEDGs) are major macroecological patterns relative to environmental factors including climate and geography. For woody plant species, environmental filtering linked with tropical climatic niche conservatism plays a critical role in generating LEDGs; species richness decreases under cold environments in higher latitude or elevation. Physiological studies suggest that cold tolerance operates species sorting along the gradient of freezing temperature. For example, plant tissues of tropical taxa are mostly damaged by freezing temperature at -2 °C. Most of evergreen broadleaved species suffer xylem embolism around -15 °C and cannot survive under such severe winter, while deciduous broadleaved species are in general killed at -30 °C. These species-specific cold tolerances predict that taxonomic (or functional) diversity change intermittently across a gradient of absolute minimum temperature (AMT) that is defined by the lowest historically recorded temperature. In this view, we investigated species abundance of woody plants (more than 2 m in height) in local communities (10 x 10 m plots, n = 745) across seven mountains (900-2,400 m) and twenty lowland forests along a latitudinal gradient on the East Asian islands. Using this dataset, we tested how AMTs, 0 °C, -15 °C, or -30 °C, are associated with taxonomic and functional diversity of woody plant species. Taxonomic and functional diversity showed monotonic decreasing/increasing and also unimodal patterns along gradients of latitude and elevation. In contrast to these various patterns with geography, AMT dependent diversity pattern was consistently bimodal that indicated peaks of woody plants diversity at -17 °C and -32 °C across seven mountains along a gradient of latitude. Notably, taxonomic and functional diversity changed dramatically across a gradient of AMT; diversity decreased sharply at 0 °C and also dropped in -10 °C, but substantially increased at -17 °C and -32 °C. These non-linear diversity shifts associated with AMT resulted from co-occurrence of deciduous, coniferous and evergreen broadleaved species or dominance of particular functional groups. Our findings supported the role of functional group-specific cold tolerance in shaping LEDGs of woody plants.

How did disjunct plant species distributions form during the Quaternary climate change in Northeast Asia? A case study of Betula davurica Pall. using a species distribution model

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Repeated periods of climate change over the glacial and interglacial periods during the Quaternary led to the migration of organisms. Such repeated migrations have caused disjunct distributions for many species. However, not so many studies have clarified the process that forms disjunct distributions in Northeast East Asia (NEA) under continental climate. In this study, we examined the distribution of *Betula davurica* Pall., which is a dominant canopy tree species in the cool temperate deciduous broad-leaved forests of the continental NEA with a disjunct distribution in the Japanese archipelago. We hypothesized that this disjunct distribution pattern was caused by climate change since the Last Glacial Maximum (LGM). To clarify how such distribution patterns were formed, we adopted a species distribution model (SDM) and examined a series of potential habitats in the LGM, mid-Holocene (mid-H), and the present. We adopted MaxEnt with the presence of *B. davurica* as the response variable and six bioclimatic variables as predictor variables. During the LGM, projected potential habitats were distributed around the Korean Peninsula, eastern China, and western Japan. The Japanese archipelago was re-connected to the continent several times throughout the glacial periods of Quaternary, allowing *B. davurica* to migrate across land bridges. In the mid-H, potential habitats retreated both from eastern China and western Japan, remained the same in the Korean Peninsula, and expanded to northern China, the Russian Far East, and northern Japan (Hokkaido). We indicated that the increase of annual mean temperature after the LGM is a factor in the formation of disjunct distribution, and the development of a humid oceanic climate could have caused *B. davurica* of Japan to decline. While, our results suggest that the Korean Peninsula and Central Honshu in Japan may be long-term refugia for *B. davurica*. Thus, due to rapid climate warming after the LGM, the distribution of *B. davurica* expanded to the north in the continental NEA, while it shrank in the Japanese archipelago and formed the current disjunct distribution due to the development of a humid oceanic climate.

Vegetation variability of the arctic vegetation of Alaska, USA and Yukon Territory, Canada using the Arctic vegetation archive (AVA)

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Vegetation classification has long been used by vegetation scientists, ecologists and nature conservationists to characterize and describe repeating patterns of vegetation in the landscape. A well-constructed classification is a crucial aid to land management decisions and inventory. With noticeable world-wide climate change, we can benefit from using classification as a tool to understand ecosystems and monitor their dynamics and qualitative changes in conjunction with satellite data. There is an ongoing need to monitor and manage important plant and wildlife population and their habitats that can be guided through recognition of vegetation and there environmental relationships. Following the Braun-Blanquet approach, botanists in Europe created sophisticated hierarchical system of units representing plant communities based on their floristic, ecological and structural criteria. Arctic regions of North America are missing a comprehensive overview of vegetation units that can be comparable with rest of the world. A compilation of vegetation data into an Arctic Vegetation Archive lead by the Alaska Geobotany Centre of University of Alaska Fairbanks and other institutions form the essential basis to building such a classification. The long-term ambition is to compile all relevant vegetation data with available axillary data from whole arctic biome. To explore an approach to building a biome-wide classification, an example set of data stored in Alaska Arctic Vegetation Archive (AAVA; ~3,000 relevés), and the Yukon portion of the Canadian Arctic Vegetation Archive (CAVA; ~1,360 relevés) were analyzed based on floristic composition and abundance using cluster analyses. Using the methods of crispness of classification, the best interpretable number of clusters were identified that lead to exploring the structure of the data. Results were interpreted through the use of diagnostic species, environmental gradients and biogeographical differences. Our next focus should be to create a useful classification system of arctic vegetation based on formal language that will be understandable and easy to use. Based on our preliminary results obtained by above mentioned methods together with finding the main gradients and drivers of vegetation variability in our dataset, we will be able to create a logical expert system comparable and combinable with recently used units such as the US National Vegetation Classification in the US, but also in other parts of the world.

Effect of non-native tree planting on diversity, invasion and homogenization processes in Central European forests

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Within European forests, non-native tree plantations cover 4.4 % (9.5 million ha), so their effect on forest vegetation diversity is extensive, but not yet studied enough to be fully understood. The most commonly planted non-native trees in Central European region are *Robinia pseudoacacia*, *Pinus nigra*, *Populus ×canadensis* and *Quercus rubra*. During vegetation seasons 2014 – 2017 we collected a unique dataset of paired relevés (twin plots) from plantations and adjacent native forests within Natura2000 habitats in the area of Slovakia, Hungary, Czech Republic, Poland, Ukraine and Romania. Each pair of relevés was selected using satellite image segmentation software (NaturaSeg) in plantation and adjacent native forest with less than 250 m distance among them, in the same environmental conditions (slope, orientation, soil type) to avoid the influence of local environmental conditions' variability on the forest undergrowth. Thus, the difference in species composition of the herb layer can be interpreted as an effect of alien trees. We hypothesize that (1) the effect of non-native tree planting on diversity of forest undergrowth differs among studied alien trees, (2) effect of planting on diversity of forest undergrowth depends also on vegetation unit of native forest that was replaced, (3) non-native tree plantations are more invaded by aliens than nearby native forests and thus plantations can act like a species pool for spreading of neophytes into surrounding native plant communities, and (4) diversity of diagnostic species typical for adjacent native forest species pool is always lower in plantations, so they have a homogenizing effect on forest undergrowth. We analyzed the dataset of 268 paired relevés of *Robinia pseudoacacia* plantations and native forests, 174 paired relevés of *Pinus nigra* plantations, 49 paired relevés of *Populus ×canadensis* plantations and 30 of *Quercus rubra* plantations, using paired tests, hierarchical clustering and ordination methods. The results show different effects of planted species; in general, plantations of *Robinia pseudoacacia*, *Pinus nigra* and *Populus ×canadensis* are more invaded than native forests. The effect of *Robinia pseudoacacia* has the biggest influence on undergrowth diversity when it is replacing floodplain forests, while the effect of replacing oak and oak-hornbeam forests is smaller but still important. All types of plantations are equally species rich as native forests, but they are more invaded and diversity of diagnostic species representing native forests species pool is lower in every type of plantations.

Drivers of bird-dispersed exotic plant invasions in the southeastern United States

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Exotic plant species degrade ecosystems that lack their natural predators and competitors. These invasives often have high growth rates and proliferate rapidly after colonizing habitat openings created by disturbances. Several species produce fleshy fruits and are spread by frugivorous birds, replacing native fruit in their dispersers' diets and forming mutualistic relationships with local frugivorous fauna. If fruit-feeders forage on multiple plants then these plants may indirectly affect the dispersal of fellow fruit-producers through contagious dispersal, allowing facilitative relationships to form between various native and exotic plant species. This study aims to answer two questions: (1) How do disturbance regimes impact the growth and spread of *Triadica sebifera*, a common exotic tree in the Southeast United States? (2) How do the composition of fruiting neighborhoods around focal plants impact the seed rain underneath that plant? The study sites are located in the Grand Bay National Estuarine Research Reserve (GBNERR) in coastal Mississippi and in the Weeks Bay National Estuarine Research Reserve (WBNERR) in coastal Alabama. At both sites, samples of *T. sebifera* were cut in order to determine the impacts of known disturbance events (wildfires and tropical storms) on the growth and recruitment of this tree through the study of its growth rings. Seed traps have been set up underneath specimens of *T. sebifera*, one fellow exotic fruit-producing species (*Cinnamomum camphora*), and three native fruit-producers (*Morella cerifera*, *Ilex vomitoria*, and *Persea borbonia*). The identification of the scarified seeds in these traps will reveal potential contagious dispersal between the focal species. Preliminary analyses indicate that recruitment of *T. sebifera* is most prevalent following severe tropical storm events (e.g. Hurricane Katrina). It also appears that the spread of native species is dominant in this ecosystem regardless of the plant species acting as a hub for contagious dispersal and the composition of the fruiting neighborhood.

Species nestedness and replacement effects on harmonizing forest inventories in subarctic Alaska, USA

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When two community ecology datasets come from different sampling designs (e.g. two different forest inventories), it is unclear how, or whether, to combine them for vegetation analysis. Ordination analyses, for example, should be sensitive to species pool differences arising from sampling different populations. With novel tools, we test the prediction that increasing beta-diversity components (nestedness and replacement) will decrease the exchangeability of two vegetation datasets. We introduce methods for comparing compositional variation among two datasets in nonmetric multidimensional scaling (NMDS) ordination. Bootstrapped NMDS establishes internal agreement (sampling variability) for each single dataset, and reciprocal NMDS determines external agreement (exchangeability) when two datasets are mutually exchanged. We first evaluate simulated datasets with specified beta-diversity differences, then compare real forest inventory datasets based on local vs. regional sampling designs in subarctic boreal forests of interior Alaska, USA. With increasing species replacement and nestedness in simulated vegetation data, internal agreement remained essentially constant, but external agreement (exchangeability) progressively declined. Species replacement (not nestedness) had the larger negative effect on external agreement. Among the real boreal forest data, internal and external agreement were qualitatively similar among the two forest inventories, suggesting moderate exchangeability, but the regional forest inventory exhibited better fit to environment. Species replacement (not nestedness) contributed the majority of beta-diversity differences among the two forest inventories. Findings suggest that species replacement alters ordination outcomes much more than species nestedness. Therefore, combining two vegetation datasets may not be advisable when species replacement prevails. Our method of assessing NMDS ordinations is tractable for comparing potentially incongruent datasets that may arise from different species pools. Understanding how beta-diversity differences influence multivariate models will strengthen large-scale synthesis and environmental monitoring efforts that draw together many disparate vegetation data sources.

Using artificial neural networks to develop a marsh vegetation community classification system in Louisiana coastal wetlands

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Though a diverse array of linear ordination and clustering methods have long existed for classifying ecological communities, their efficacy may be strained when applied to strongly nonlinear datasets that contain numerous outliers, rare species and missing data points. These characteristics are commonplace in species abundance datasets that are obtained across diverse landscapes. The self-organizing map (SOM), an unsupervised artificial neural network classification technique that has become increasingly popular in recent years, provides an alternative approach to linear ordination techniques. Making no prior distributional assumptions, SOMs provide a topology preserving nonlinear projection of the data set onto a two-dimensional plane, and thus constitute an approach for nonlinear ordination analysis. This two-dimensional plane is composed of discrete cells, or neurons, each described by a weight vector that approximates a region of the dataset's multidimensional space (i.e. species composition). Additionally, SOMs provide an intuitive graphical representation of similarity among samples and sample clusters. One further key distinction from traditional multivariate approaches is that once trained, new samples can be subsequently projected onto the SOM without altering the established ordination, making SOMs an ideal approach to developing community classification algorithms for *in situ* species abundance data collected as part of long-term ecological monitoring programs, and efficiently classifying new samples in real-time as they become available. In this study, an SOM was trained from *in situ* observations of emergent marsh vegetation species relative cover data from over 2500 samples collected over eight years at nearly 350 locations across coastal Louisiana. The approach was composed of two steps: first, an SOM was developed from the training data, and then traditional cluster analysis was applied to the SOM's weight vectors to delineate cluster boundaries across the SOM. Eleven distinct community types were obtained from the analysis. Clear gradients in hydrologic metrics (e.g. salinity, hydroperiod, tidal amplitude) were observed among community types. Species cover data obtained from Louisiana's Coastwide Reference Monitoring System (CRMS) were then projected onto the SOM to examine temporal dynamics in marsh vegetation species composition and how they may be influenced by restoration activities, climate variability, and disturbance.

Do rare herbs have large seeds? The seed mass – distribution range trade-off hypothesis

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We aimed to test the hypothesis that there is a negative association between the seed size and range size of herbaceous species due to the generally better dispersability of smaller seeds; i.e. that a trade-off exists between seed size and range size. In order to identify habitats where species have small range sizes and may be endangered, we also studied the relationships between environmental factors and seed size and range size. We collected data for seed mass, global range size and environmental factors for 1,600 herbaceous species of the Pannonian Ecoregion (Central Europe) from the literature, and we tested the relationships between seed mass, range size and environmental factors. We found that seed mass was negatively correlated to range size; thus, our results confirmed the trade-off between seed size and range size in the studied species. Seed mass increased with the increase of light availability and nutrient supply, but decreased with increasing soil moisture. Range size increased with increasing soil moisture and nutrient supply, but decreased with increasing light availability. Our results corroborate the former assumption that common species are mostly associated with nutrient-rich, degraded habitats, while rare species are mostly characteristic to less fertile and less degraded habitats. The results emphasize that, due to their heavier seeds and narrower range size, species of dry, infertile habitats, such as dry grasslands, could be more vulnerable to the negative effects of climate change and anthropogenic habitat changes than species of wet and fertile habitats. Although our results are based on a regional flora, due to the use of global distribution range and the remarkably high number of species, our study supports the understanding of global biogeographic patterns and may help in defining conservation priorities.

Wetland provisioning in agro-ecosystems: the role of cattle grazing, pasture management intensity and prescribed fire

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Wetlands provide considerable provisioning, regulating and cultural services to human societies worldwide. However, wetlands often are embedded within agriculture lands and thus face many changes and threats to their integrity. In Florida, many wetlands were drained and now are embedded in pastures managed for cattle ranching. The effects of such management practices on wetland provisioning services remain unclear, especially in subtropical systems. We assessed the separate and combined effects of pasture types (highly managed, improved pastures *vs.* semi-natural pastures), release from cattle grazing and prescribed fire on forage quantity, composition and quality in seasonal depressional wetlands embedded within pasture land. In 2006, we selected forty seasonal wetlands of similar size and shape (twenty in improved pastures, twenty in semi-natural pastures) at Archbold Biological Station's Buck Island Ranch, a fully operational cattle ranch and agro-ecology research center. Twenty wetlands were fenced in 2007, and twenty wetlands were burned every two years (starting in 2008) to complete a fully factorial design (pasture type X grazing X fire). Vegetation was harvested and sorted by species annually from 2006 to 2009 in five 0.25 m^2 quadrats selected in a stratified random design. We separated palatable from unpalatable species and analyzed relative abundance of each category in response to treatments using GLMM. Fenced wetlands had greater biomass and litter quantities (respectively +63.5% and +218%) than grazed wetlands. In grazed wetlands within improved pastures, biomass was dominated by the unpalatable species *Juncus effusus*, thus providing low plant diversity and low forage quality. In grazed semi-natural wetlands, biomass was composed of a mixture of palatable and unpalatable species with higher diversity and higher species turnover. Fencing wetlands resulted in higher forage quality in both improved and semi-natural wetlands due to lower abundance of *Juncus effusus* and increases in both native and non-native, highly-palatable grass species. However, fencing reduced the heterogeneity and the diversity of wetlands embedded within semi-natural pastures suggesting that in this system cattle grazing is beneficial to diversity. Burning fenced wetlands resulted in higher forage quality in wetlands within both semi-natural and improved pastures, and could be used to increase ecosystem provisioning. Based on these results, we propose that wetlands in improved pastures (where stocking densities are higher) should be carefully managed with rotational grazing to maintain low abundance of unpalatable plants such as *Juncus effusus*, and allow enough time for recovery and maintenance of palatable grasses.

Long-term response of vegetation of seasonal depressional wetlands to management intensity, cattle grazing, and prescribed fire in subtropical ranchland

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Wetlands are important but threatened ecosystems worldwide. In the Headwaters of the Everglades watershed many wetlands were lost or degraded following conversion of surrounding uplands to intensively managed pastures. The drainage of these wetlands and ensuing farming practices such as fertilization, liming, and planting of non-native species had negative impacts on wetland communities. Another common management practice of Florida ranchland is prescribed burning which occurs during the dry season (December-May). The impact of these management practices and their interactions on plant diversity have been studied in the past, but the results of these studies focused on short-term response of plant communities (1-4 years after setting up treatments). Here, we use a 10-year old experiment assessing the impact of pasture types (highly managed improved pastures *vs*. semi-natural pastures), cattle grazing (grazed *vs*. ungrazed) and prescribed fire (unburned *vs*. burned) on wetland supporting, regulating and provisioning services. For this particular study, we are focusing on how these management practices are affecting native and non-native plant richness, and species composition of seasonal depressional wetlands in the long-term. Forty seasonal wetlands of similar size and shape were selected (20 in improved pastures, 20 in semi-natural pastures) in 2006 at Archbold Biological Station's Buck Island Ranch, a fully operational cattle ranch and an agro-ecology research center. 20 wetlands were fenced in 2007 and 20 wetlands were burned every two year starting in 2008 to obtain a fully factorial design (pasture type X grazing X fire). Vegetation was surveyed each year since 2006 (last surveyed in 2016) using 15 stratified randomly located $1m^2$ quadrats in which the presence of all vascular species was recorded. We analyze shifts in species alpha and beta diversity in response to treatments using GLMM. We also use NMDS to study shift in species composition through time and in response to treatments. We expect a significant interaction between pasture type and both grazing and prescribed fire. Indeed, we expect, grazing and burning to increase species alpha and beta diversity only in semi-native pastures whereas in improved pastures we expect that there will be no difference in alpha and beta diversity among treatments but strong differences in composition due to more competitive conditions from non-native species and nutrient enrichment. We expect that fencing will increase tree and shrub encroachment in both pasture-types, a pattern that was not apparent in short-term studies.

History of USNVC and use of the "Eco-Veg approach" to classification of ecosystems in the United States

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In the United States, existing vegetation is at the core of nearly every conservation, restoration or management planning effort, activity or authorization a federal land management agency authorizes or performs. Unfortunately classification, mapping, and inventory of existing vegetation historically has lacked consistent standards and agencies and even units with agencies developed systems to meet their individual needs making data sharing difficult. Efforts to coordinate on collection of data, including vegetation data are long standing, but it wasn't until 1994 that the endeavor to build a standard method of classification that all federal agencies could use and share began in the United States. Federal agencies formed a partnership with the Ecological Society of American (ESA) and NatureServe, under the umbrella of the Federal Geographic Data Committee (FGDC) Vegetation Subcommittee, chaired by the US Forest Service. In 1997, a vegetation standard was adopted by FGDC, and a first version of the United States National Vegetation Classification (USNVC) was released in 1998. In response to issues related to mapping the hierarchy in that first standard, the FGDC Vegetation Subcommittee updated the hierarchy to include mid-level layers. In 2008, the current, dynamic standard was approved by the FGDC and a second version of the content of the classification was released in 2016. The scientific basis of the classification is the "Eco-Veg" approached outlined by Faber-Langendoen et al. in 2014 which aims to provide consistent, systematic and authoritative descriptions and classification of natural and cultural ecosystems. Content is dynamic and can be updated through a peer review process lead by the Ecological Society of America Panel on Vegetation Classification.

Leaf osmotic potential affects survival probability in response to inter-annual climatic variation in a semi-arid short-grass steppe in northern Colorado

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Global climate change increases the likelihood of extreme weather events and may exacerbate variability in inter-annual climate. This heightened variation in weather will likely affect biodiversity and ecosystem function, but we currently lack a general understanding for predicting how plant communities will respond to changing environmental conditions. Previous work has characterized broad relationships between plant traits and regional climate, but this work has ignored the population dynamics that lead to observable changes in community structure. The goal of our project is to quantify how plant functional traits mediate demographic responses to inter-annual variation in climate. We synthesized 15 years of demographic data from permanent plots, new measurements of functional traits, and records of annual climate variability in a short-grass steppe ecosystem in northern Colorado (COSGS). We have calculated the Standardized Precipitation Index (SPI) for each growing season as a measure of drought intensity. Here we focus on leaf osmotic potential, a measure of solute concentration in fully hydrated leaves that is highly correlated to turgor loss point, which is the water concentration at which a leaf begins to wilt. This trait is, in turn, highly predictive of drought sensitivity, such that plants with more negative leaf osmotic potential are more drought tolerant. We fit a Generalized Linear Model to determine whether leaf osmotic potential impacts the probability that a species will survive following dry years or excessively wet growing seasons. We found that survival was influenced by a significant interaction between leaf osmotic potential and SPI ($P = 0.018$). In dry years (low SPI values), individuals with low (more negative) leaf osmotic potential had higher survival rates, whereas in wet years (high SPI values), individuals with higher (less negative) leaf osmotic potential were more likely to survive to the next year. Our long term goal is to determine which multidimensional trait combinations optimize survival probability in dry years. By focusing on traits that can be measured across species, trait-based models allow us to discern relationships between traits and environmental conditions that can be generalized across ecosystems much more easily than species-based models. The relationships we quantify with our models will be more easily transferrable across ecosystems, allowing us to predict how climate change will affect ecosystem productivity and community biodiversity.

An experimental assessment of neighborhood interference on Everglades tree species growth and survival along a flooding gradient in constructed tree islands

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The competitive release hypothesis predicts that flood-tolerant plant species will occupy the wet end of a hydrologic gradient, but will be displaced by species with higher competitive ability at the upper end of the gradient. In this study, we tested this hypothesis in a meso-scale field experiment, examining species responses to flooding and neighbor size/proximity during years 3-8 after initial planting. In 2002 a landscape-scale physical model of the Everglades, the Loxahatchee Impoundment Landscape Assessment (LILA), was constructed at Loxahatchee National Wildlife Refuge. Control of hydrology and replication of landform structure at LILA allowed investigators to precisely assess ecosystem responses to important physical or biological drivers. One component of the landscape created at LILA was a set of forest patches (tree islands) that show a moisture-elevation gradient from drier center to wetter edges. Mean water depth was estimated at the location of each tree using elevation data from topographic surveys and water level data from nearby stage recorders. An interference index was used to characterize the competitive neighborhood of a target individual based on the proximity and size of neighbors. We applied a factorial regression analysis of survival and height growth of individuals as a function of hydrology and competition measured with the neighbor interference index. The growth response of most species decreased towards the wet end of the gradient indicating that waterlogging stress affected both flood-intolerant and flood-tolerant species. Neighborhood competition experienced by all species was stronger in the dry upper end of the gradient. However, during this early stage of stand development, higher neighborhood competition experienced by flood-tolerant species did not exclude them from more favorable elevated positions nor decrease their abundance relative to more waterlogged locations as predicted by the competitive release hypothesis.

The dimensionality of competition in plant communities

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Interactions are a defining characteristic of every species' "milieu" since no organism exists without participating in some sort of ecologically relevant interaction during its lifetime. In addition, interactions between species are regarded as a key driving force that determines species ability to thrive in different environments. They have even been described as "the architecture of biodiversity". In competitive communities, it is widely accepted that species must exploit a unique combination of resources and/or exhibit a unique set of functional traits if they are to minimize competition and thereby maximize their chances of coexisting. These ideas imply that competition is inherently a high-dimensional problem that needs high-dimensional solutions; that is, the majority of theories of competitive communities require that there are as many potential resources to exploit as species that successfully co-occur. In this talk, I will discuss new analyses of the competitive effects between plant species found in multiple locations around the world. In particular, I will show how the competitive interactions between these co-occurring plants give strong indications that competition is a decidedly "low-dimensional" phenomenon. Using data from some of the locations where the plants were subjected to experimental disturbance, I will explain why these low-dimensional systems can often and easily give the false impression that they are high dimensional. Finally, I will highlight the implications of these results for our understanding of coexistence in diverse communities and for competition theory in general.

Experimentally derived nitrogen critical loads for northern Great Plains grassland vegetation

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Deposition of anthropogenic reactive nitrogen (N) is documented through much of the world to cause declines in grassland plant diversity and shifts in vegetation composition, sometimes to undesirable invasive species. Despite strides made in reducing some emission sources, N emissions from agriculture and fossil-fuel combustion continue to rise in North America's northern Great Plains (NGP), an area of historically clean air. Because plant growth in NGP grasslands is commonly limited or co-limited by N, it is expected that these grasslands will be sensitive to elevated N. Accurate information on critical loads (levels of deposition below which there are no significant harmful effects) for sensitive ecosystem components is therefore needed by management agencies and policy makers to make informed decisions regarding acceptable emissions. Despite an abundance of N addition experiments in North American grasslands, currently suggested critical-load ranges for NGP grasslands are considered only "fairly reliable" or are based on data from outside the region. In a four-year field experiment at three NGP sites where current N deposition levels range from ~3 to 6kg N/ha/yr, we added 12 levels of N, from 2.5 to 100 kg N/ha/yr, to three natural vegetation types spanning a range of soil fertility and productivity. We measured the effects of N addition on soil and plant-tissue N concentration, as well as plant productivity, composition, and diversity. Highly variable results among years, as well as inconsistent responses to an increasing dose of N within sites, complicated the derivation of critical loads. A precautionary approach from the standpoint of managers trying to maintain current ecosystem processes and vegetation composition suggests a critical load of 6-10 kg N/ha/yr for the three vegetation types investigated. N addition at these levels increased plant tissue C:N ratios, biomass, litter loads, and/or the abundance of invasive annual grasses, depending on the vegetation type. A less precautionary approach to deriving critical loads yielded higher values of 10-38 kg N/ha/yr. The precautionary critical loads are lower than those previously proposed for this region (10-25 kg N/ha/yr) and well within the range of current or projected N deposition rates. Thus, anthropogenic N deposition may already be affecting NGP ecosystems.

In search of the "Piedmont prairies": multivariate analyses of extant heliophilic vegetation in the Piedmont of Virginia and the Carolinas, USA

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Heliophilic (light-demanding) vegetation cannot persist in closed-canopy forest and is currently rare in the eastern US Piedmont landscape. Historical evidence suggests that this landscape was once a mosaic of open and closed vegetation types, with heliophytes dominating open areas maintained by regular disturbances (e.g. fire). The open, heliophilic communities were given many names but most often referred to as “Piedmont prairies.” It is unclear if these communities represented a single vegetation type or a complex of structurally similar types. Their historical extent is currently uncertain, but heliophilic vegetation largely disappeared following European settlement and fire suppression. Extant heliophilic assemblages rely on anthropogenic disturbances (e.g. mowing or prescribed burning) to persist in the landscape. These communities host a diversity of rare species and require intensive and knowledgeable management to restore and maintain. Previous studies have done much to document and characterize the vegetation of specific sites, but a classification and characterization of Piedmont heliophilic communities is currently lacking. We used plot survey data from the Carolina Vegetation Survey and multivariate analyses to address the following objectives: (1) identify and characterize the major types of Piedmont, upland, heliophilic vegetation; (2) offer a definition and characterization of extant “Piedmont prairie” vegetation; and (3) discuss our findings in the context of regional and national vegetation classification efforts. To address these objectives, we analyzed a dataset of 222 plots representing upland, terrestrial, non-forest vegetation from the Piedmont of Virginia, North Carolina, and South Carolina. We computed a Bray-Curtis distance matrix for use with hierarchical clustering (flexible beta group linkage; $\beta = -0.25$). The R package optpart was used to identify optimal partitions. Environmental data (e.g. elevation, soil pH) were explored using nonmetric multidimensional scaling ordination. We also calculated species Indicator Values (following Dufrêne & Legendre 1997) and the number of “strong prairie indicator” species (*sensu* Davis et al. 2002). We identified and characterized 13 major types of heliophilic vegetation, including two distinctive clusters that contain all sites traditionally labeled “Piedmont prairie.” This suggests that “Piedmont prairie” is a somewhat coherent but heterogeneous vegetation type. A subset of these communities is characterized by the unique co-occurrence of Midwestern US prairie species and Southeastern US endemic heliophytes. Our results correspond somewhat to existing regional and national classifications, but differ because traditionally regionally separated communities may exhibit compositional similarities.

The role of environmental filtering and priority effects in natural regeneration processes following large-scale disturbances in the Tatra National Park, Poland

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Over the last 20 years forests of the Tatra National Park have been subjected to intense natural disturbances, windstorms and bark beetle outbreaks. These disturbances triggered large-scale regeneration of trees and accelerated the process of stand conversion. Secondary *Picea abies* forests, dominating in the area of the park over the last century, are now being replaced by a more mixed young generation of trees with several broadleaved species, mostly *Sorbus aucuparia*, *Acer pseudoplatanus* and *Fagus sylvatica*. On the basis of 630 sample plots distributed in regular spacing over the park area we compared the relative roles of the environmental filtering versus priority effects in natural regeneration processes. In the first set of analyses we related the density of seedlings and saplings to the basal area of live trees and the percent of basal area loss over the last two decades, that represented the relative changes in light availability. We also analyzed the relationship between the densities of seedlings and the environmental variables, like: elevation, relative illumination, topographic wetness index, type of bedrock, and soil type. In the second round of analyses, we related the numbers of seedlings and saplings in each research plot to the numbers of mature conspecific trees in that plot. The results showed a significant negative relationship between the density of saplings and basal area of canopy trees, and even stronger positive relationship between sapling densities and percent of basal area loss. The similar relationship for seedlings was insignificant. Both elevation and bedrock type affected the densities of seedlings and saplings: *Fagus sylvatica* and *Acer pseudoplatanus* were associated with lower elevations and limestone bedrock, while *Sorbus aucuparia* was associated with higher elevations and did not show any preferences to the bedrock type.

Climate change impact on potential habitats of buna (Fagus crenata) and a current migration process in the northernmost population in Japan

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Ongoing climate change impact on plant distributions were predicted in many studies, but the detection in ecosystems is still limited. Buna (*Fagus crenata*) is a dominant species in cool-temperate deciduous forests in Japan. While buna distributed along southern coasts in the Last Glacial Maximum (LGM) of about 20,000 years BP, it has migrated by 1,150 km northward after LGM, and arrived at the northern distribution front (NDF) in 1200 years BP (Tsukada 1982, Kito and Takimoto 1999). Migration speed was estimated 12 to 200 m/yr. In this study, we predict potential habitat (PH) changes of buna, using distribution models, and analyze the northernmost populations of buna in order to reveal the current migration process. Eight hypotheses on the cause of northern distribution limit of buna can be classified into two types, the climate determining one and the northward migrating one. According to two distribution models for buna forests and individuals in Japan, northern and upper limits of distribution, southern and lower limits, and its dominance were found to be respectively controlled by winter coldness, heat in the growing season, and snow accumulation. Northern and eastern regions of the northern island, Hokkaido, were predicted to be non-habitats both for buna forests due to winter coldness and a little snow, and for buna individuals due to winter coldness. Since the distribution models were developed using distribution data of whole Japan including Hokkaido, the models seem to underestimate PHs in Hokkaido. However, PHs covered coastal areas along the Sea of Japan in Hokkaido, reaching the northernmost region. These results support the northern migration hypothesis. The models predicted the expansion of PHs in Hokkaido under the future climate scenarios. Buna populations near NDF, which had increased in the past, were estimated to reproduce and expand in future, according to previous studies. The buna population found in Niseko Mountains in 2013 by an author, Tanaka, is located 12 km apart from NDF. This new northernmost population also showed reproduction since it consisted of individuals of various sizes with the oldest one of 131 years and many small ones. Because of this population established such many years ago and no other buna populations found by the survey in extensive areas, invasion of buna populations are very rare in the areas beyond NDF. Based on this population, the migration speed was estimated 12 m/yr, which is the same as the slowest speed previously estimated in Hokkaido.

Comparing US Forest Servicevegetation types to the US National Vegetation Classification

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The US Federal Geographic Data Committee's Vegetation Classification Standard requires federal agencies to assign vegetation plot data, and relate existing vegetation types and map units, to the lowest possible level of the United States National Vegetation Classification (US NVC). In the Intermountain Region of the Forest Service, existing vegetation is classified to dominance types based on the species with the plurality in the uppermost layer. Individual National Forests may subdivide regional forest dominance types into phases based on a second tree species. These types are similar in detail to US NVC Alliances, but based on different criteria. The Region's vegetation plot database currently contains 18,300 characterization plots with complete species lists, and 39,283 observations with partial species lists. This project was undertaken to develop methods for assigning vegetation plots to US NVC Macrogroup, Group, and Alliance using database queries. A list of all US NVC types occurring in the Intermountain Region was compiled using a spreadsheet with the entire US NCV and deleting types not occurring in the region by reading descriptions at http://usnvc.org. US NVC type descriptions were then used to develop database queries to assign plots to Macrogroups. US NVC type descriptions are generally qualitative in nature but database queries require quantitative values for terms such as dominant and codominant. The lack of quantitative descriptions required an alternate approach comparing the US NVC associations belonging to each alliance to our plots' assignment to Forest Service community types and associations based on potential natural vegetation (PNV). Entering the US NVC at the Alliance and Association levels was much easier that starting at the Class level and working down the hierarchy. Relationships between Forest Service dominance types and phases are generally many to many due to the differing criteria used by each system. Our dominance types are more numerous than US NVC Alliances (about 800 dominance types versus 300 Alliances). Forest Service dominance types are designed to describe existing vegetation for land managers at a forest wide or planning scale. Replacing Forest Service dominance types with US NVC Alliances can reduce the number of vegetation types managers think about, if the Alliances provide a similar level of detail for management decisions.

Identification of multi-diagnostic species in community ecology

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The common application of statistical fidelity measures (e.g. Phi- coefficient, u-value, Chi-square, IndVal, Fisher's Exact Test and others) based on a table of frequency data cross-classified using presence/absence data (species in plots/relevés) possess an important systematic weakness: those species which show concentration in more than one vegetation unit are systematically underestimated. Such species, which we call 'multi-diagnostic', are not considered by those fidelity measures as diagnostic, even though they clearly differentiate two or more vegetation units while being absent in others. The number of multi-diagnostics is surprisingly high and their absence in the diagnosis of a vegetation unit may penalize *a posteriori* identification of vegetation units. Here we propose a new method of identification of multi-diagnostic species in vegetation classifications. They can be determined by the application of any existing fidelity measure based on 2x2 contingency table. The fidelity calculation is applied within a vegetation table classified to at least three clusters on all possible combinations of merged individual clusters to one common target cluster. The species concentration within this target cluster is then compared with the rest of the dataset. The fidelity calculated for species distribution within the common target clusters may increase in situations when the relative species concentration within the target common cluster will be higher than within individual clusters and, at the same time, when the relative species concentration out of the target common cluster will be lower than the relative species concentration out of individual clusters. The newly introduced method of fidelity calculation has some indisputable advantages. Firstly, it may extend the number of species differentiating a vegetation unit, that may prove useful for instance in classification assignment of incomplete plots or in species-poor vegetation. Secondly, it can become a tool in the effective structuring of phytosociological tables.

Recovery of the species composition lags behind functional recovery in restored old-fields

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Semi-natural grasslands are decreasing in area all over the globe. Cessation of crop production in former arable fields, however, provides an opportunity to regain lost grassland territories. Recovery of grasslands can be left to spontaneous processes but can also be supported by active interventions. Considering target plant communities, landscape context, soil properties, etc., different methods can be advantageous. In this study we compared the effectiveness of three major restoration approaches: spontaneous recovery, sowing (dominant native graminoids) and perennial-crop-mediated (alfalfa) restoration, which were randomly applied after a mass abandonment of more than a thousand ha of cropland in Hungary two decades ago. All these old-fields have been mowed once a year since the cessation of ploughing and are embedded in landscapes rich in primary meadow steppes, which are in fact their target communities. We prepared a total of 300 4-m^2 relevés in the old-fields and 72 relevés in target meadow-steppes, and compared them according to functional and species composition. Based on nine plant traits, we found that all components of functional diversity (richness, evenness and divergence) recovered in spontaneous old-fields, indicating that these secondary grasslands occupy similar niche space and use resources with similar efficiency as their primary counterparts. The latter functional feature can also be told about the other two old-field types, although they tend to use a smaller section of the available niche space as their functional richness was lower. Regarding the recovery of species composition, sowing- and alfalfa-mediated old-field regeneration also lagged behind spontaneous recovery but primary meadow steppes had higher species richness than either old-field type. We conclude that spontaneous regeneration is more efficient than sowing- or alfalfa-mediated restoration in landscapes rich in primary grasslands, probably because the initially introduced, highly competitive species limit the establishment success of target species that would otherwise easily access the old-fields. We also conclude that the complete recovery of the species pool may need more time than the recovery of functional diversity. This means that similar ecological functionality is achieved in primary meadow steppes with more species, indicating higher functional redundancy, hence potentially higher resilience than in any of the studied late-phase old-fields.

Temporal patterns in functional change of vegetation validate both trait-neutrality and filtering effects

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There are several contrasting views of species assembly and the course of succession in the literature. Neutral theory of species assembly suggest that species assembly is rather a stochastic process and it is governed by dispersal processes and stochastic fluctuations in established populations. Another approach suggests that community assembly is strongly determined by functional trait filtering governed by more or less predictable abiotic and biotic filtering processes. We analyzed functional diversity patterns using vegetative and regenerative traits in four sites with 20, $4m^2$-sized permanent plots during the first 12 years of secondary succession after heavy goose grazing in an acidic sand area in Hungary. With trait-based analyses we addressed the following hypotheses: (1) in the first years we expected high fluctuations in the trait values, and later a divergent change in trait patterns of sites with different vertical position, (2) we expected different temporal patterns in functional diversity of regenerative and vegetative traits. We found that early vegetation development can partly be explained by the trait neutral theory, as high fluctuations and no clearly divergent vegetation development were detected for most of the traits. Most cases, this effect was diminished later on, or even a convergent change of some traits like clonal spreading or plant height were detected in sites with similar vertical but different topographical position. Our results weekly supported the second hypothesis; while there were some distinct patterns found for the functional richness of vegetative and regenerative traits. It should be noted that for both vegetative and regenerative trait groups an overall increase in functional divergence was detected. The increase in functional divergence, especially for those traits which are strongly related to competition, is generally considered as a signal of increased niche differentiation and increased rate of competition.

Soil seed bank and secondary succession dynamics in sand grassland ecosystems

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Spontaneous succession is increasingly involved in grassland restoration, because it offers a cost-effective solution. This topic is especially important nowadays, as large areas of marginal croplands are being abandoned on poor soils of Central and Eastern Europe, which offers a possibility for the spontaneous recovery of typical target grasslands. Studying the vegetation composition, aboveground biomass, and seed bank in old fields of different age and target calcareous sand grasslands using the chronosequence method, we answered the following questions: (1) Which species contribute to the seed banks of old fields and reference grasslands? (2) Does the direction of vegetation and seed bank succession trend toward the reference grasslands? (3) How are the vegetation changes in spontaneous succession reflected by the soil seed banks of old fields? In reference grasslands on the dune tops only sporadic seed banks were detected, while several hygrophytes had dense seed banks in reference grasslands on dune slacks. Similarity between the species composition of vegetation and seed banks was in general low. The development of vegetation and seed banks in old fields progressed toward that of target grasslands and the proportion of weedy species (e.g. indigenous weeds and invasive species) also decreased with time. Our results indicated that the role of persistent seed banks in the regeneration of calcareous sand grasslands from old fields is rather limited and promising vegetation changes are mostly driven by spatial dispersal. Our findings suggest that restoration of calcareous sand grasslands from old fields is weakly supported by the soil seed bank as persistent seeds of characteristic species are mostly lacking both in old-fields and in reference grasslands. Low similarities between vegetation and seed banks stress that promising vegetation changes are most likely driven by spatial dispersal. Landscape-scale patterns, such as availability and the spatial configuration of reference grasslands, should be evaluated and the support of spatial dispersal should be prioritized.

Fire regimes and the US National Vegetation Classification: a case study from pinyon and juniper woodlands of the interior western US

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The US National Vegetation Classification (USNVC) offers a consistent hierarchical solution for vegetation classification and management applications. With the adoption of the USNVC in North America by natural resource organizations efforts are underway to integrate the NVC into research and natural resource management solutions. Pinyon-juniper systems of the western US have been organized on a conceptual gradient among three woodland structure types – persistent woodlands, savannah, or mixed shrub-woodlands. For demonstration, we used pinyon-juniper ecosystems of the Southwest and assigned fire regimes to each of the three structure types, then applying USNVC classes at the level of Group to contrast current and historic regimes. By stratifying map data into state-classes, we were able to quantify current and historic conditions in terms of the USNVC units and provide an interpretation of fire ecology. Fire severity mapping, Monitoring Trends in Burn Severity (MTBS), was then used to corroborate our interpretation. Dynamics among USNVC Groups over time suggests both transitions from frequent to infrequent fire types and infrequent to frequent types, predominantly the former. With the shifting fire regimes there has been a shift in the relative abundance of USNVC Groups. The USNVC can provide a consistent and efficient means of integrating vegetation classification with applied science and the needs of managers and researchers.

Contamination-tolerant native plant communities in mining impacted areas of Butte, Montana: implications for restoration

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The Butte, MT area is home to one of the most prolific mining operations in North America. For over 100 years starting in the 1880s copper mining in Butte electrified the United States and powered the country through two world wars. The environmental cost, however, was severe. Much of the soil was removed, and most of the area was covered by tailings, waste rock, and deposition from smelting operations. Beginning in the 1980s the area was declared a Super Fund site and reclamation began by "capping" contaminated areas with approximately 18" of topsoil and planting a mix of non-native grasses. Recently, a movement has started to convert these novel ecosystems with native systems using ecological restoration techniques. Because the contaminated waste rests just below the surface, restoration efforts have not been as successful as desired. The objective of this study is to understand which native species can be successful in contaminated environments. We investigated ten unreclaimed sites around Butte. At each site, subjective random sampling and transects were performed using ten 1 x 1 m quadrats each for a total of 200 quadrats. In each quadrat all vascular plant species were assessed their percentage cover, and a 15 cm soil sample was taken. Each soil sample was analyzed for pH ($CaCl_2$), metals were analyzed using a portable x-ray fluorescence analyzer. Ten percent of the samples were verified by an accredited lab. Principal Component Analysis (PCA) was used for exploratory data analysis. Following the PCA, a permutation MANOVA test was performed to determine if there were significant dissimilarities between environmental variables, plant species, and plant coverage. In total, 28 native plants and 24 non-native species were observed. Our results show Pb, Cu, and Zn are the major limiting contaminants for native plants. However, some native species show significant tolerance to soil contaminants. *Deschampsia cespitosa* and *Leymus cinereus* show a positive relationship with Pb and Zn and a negative relationship with pH. *Oxytropis lagopus* has a positive correlation with Zn and a negative correlation with Cu and As. *Agrostis scabra* shows a positive relationship with Cu and a negative relationship with pH. *Mentzelia laevicaulis* shows a positive relationship with Pb and Zn. Our results are beginning to shed some light on the relationship between plant species and soil contaminants from mining operations in Butte. We have shown that many native plants can thrive in contaminated environments, these species should be prioritized for the restoration of contaminated sites.

Application of arbuscular mycorrhizal fungi in vegetation restoration: restoring the below-ground for above-ground diversity

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The loss and fragmentation of habitats is one of the main drivers of deteriorating ecosystem functioning and services. This has induced a growing need for conservation and increasingly more restoration. A central part of terrestrial ecosystems is soil biota with arbuscular mycorrhizal (AM) fungi being a key constituent. As ubiquitous plant symbionts, AM fungi have a global impact on carbon sequestration and nutrient cycling, soil formation, erosion and leaching processes, therefore influencing all spheres of earth. In soils where disturbance has led to the loss of soil cover or a drastic change in plant community composition, the absence of suitable AM fungal symbionts can lead to slow post-restoration recovery of plant communities, with negative implications on ecosystem functioning for decades. Consequently, the manipulation of soil AM fungal composition for restoring plant communities is a highly promising perspective. To test the applicability of this methodology, we have set up extensive field inoculation experiments in three vegetation restoration scenarios in Estonia: restoration of alvar grasslands, wooded meadows and depleted oil-shale quarries. Native soils and plant seeds were collected from target ecosystems and trap cultures were set up to obtain bulk fungal inocula. These inocula were applied together with native plant seeds to 18 vegetation restoration sites across Estonia. The sites are monitored for plant species richness and biomass through vegetation surveys, AM fungal diversity through molecular identification and the biomass of key soil organism groups through marker-fatty acid analyses. First year's results are indicating that the treatments are having an effect on plant species richness and biomass but site and habitat characteristics are important in predicting the outcome of inoculations. Existing plant species richness and connectivity to other sites before restoration play an important role in determining the possible added benefit of inoculations. In areas where the community-specific above- and below-ground species pool is small, inoculations could prove to have a higher positive effect. This is highlighted by the differences among restoration scenarios, for instance depleted quarry restoration sites having a more profound reaction to treatments than seminatural grasslands. This could be explained by strong biotic legacy effects of these former grasslands. The ongoing experiment is giving valuable insights into the practical implication of AM fungi for vegetation restoration and whether it is possible to increase plant species richness through below ground interactions.

A long-term vegetation sampling database and its possible applications

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Understanding how biodiversity contributes to maintain community stability, essential to the sustainability of ecosystem functions and services in the face of global change, has been a central goal in ecology for many decades. In this context, the establishment of permanent plots and collection of long-term vegetation surveys is of crucial importance, because such data can serve to establish vegetation-based indicators of ecosystems stability. Though there are networks as well as independent groups collecting long-term ecological data around the world, no major efforts have been made to unify and standardize these data to achieve a worldwide perspective. This talk will introduce our database, containing already ~80 datasets and more than 7,800 plots, each with vegetation surveys sampled for at least six years. This database includes datasets from different networks, as well as published and unpublished datasets from different authors, in a homogenized format. These datasets are compiled from North America, Europe, Asia, Africa and Australia, giving the opportunity to address critical ecological questions at a global scale. For instance, we will be able to (1) verify whether synchrony or asynchrony are widespread patterns in natural plant communities worldwide, (2) test to which extent measures of synchrony vary with species richness and community stability, (3) evaluate the dependence of temporal stability on species diversity across spatial scales, (4) assess the changes in community functional structure among years and their relation with community stability, resistance and resilience, and (5) evaluate whether synchrony and/or asynchrony patterns between species pairs is related to species pairwise trait differences. Preliminary results on these research questions will be discussed. At the same time, we will propose a new platform (long-term vegetation sampling) with our database and other contributions that will allow us to discuss the future development of these research questions and strengthen the collaboration between researchers.

A new aspect of plant dispersal: human-dispersed seeds can survive and disperse after the laundry cycle

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Due to increased human mobility, people play an important role as a seed dispersal vector. Cloth-dispersed seeds are transported over long distances, which would not have been bridged otherwise, that in some cases can lead to biological invasions. During human-mediated plant dispersal, seeds are exposed to physical and chemical factors that affect their germinability and establishment. Here we study a formerly overlooked component of human-mediated plant dispersal by assessing the effects of lavatory washing on the dispersed seeds. We asked the following questions: (1) Are human-dispersed seeds able to germinate after the laundry cycle? (2) What are the effects of washing on the fitness of germinated seedlings and on the temporal dynamics of germination? (3) Which plant traits are responsible for the specific responses of seeds to washing? We studied the germination of 13 species, which have morphological adaptations for epizoochory and are commonly dispersed by people. We tested six treatments (washing with water, washnut or detergent, at 30 °C or 60 °C) compared to an untreated control. Our results showed that washing temperature was the most significant factor affecting germination; and it is likely that seed shape, seed coat thickness and hydration status of seeds explained specific responses. Washing at 30 °C did not suppress germination of any of the studied species, but it increased the seedling number of *Geum urbanum*. Washing at 60 °C supported the germination of two species (*Agrimonia eupatoria* and *Tragus racemosus*), but suppressed six species. *Physocaulis nodosus* did not germinate at all after washing at 60 °C. The intensive washing treatments at 60 °C decreased significantly the synchrony of germination. Our measurements showed that more than 70% of attached seeds remain on our clothes for more than 8 hours and can enter to the laundry cycle. 64% of washed seeds fall down from clothes during drying, thus, they have a chance for establishment in an urban or rural environment. The remaining 36% of washed seeds can further disperse over a long distance. Our results showed that show that people are not purely transporting seeds from one location to another, but via the laundry cycle we also influence the fate of the transported seeds by affecting germination potential, seedling fitness and germination dynamics.

Unraveling the mechanisms and processes driving facilitative interactions: evidence from two contrasting ecosystems

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Our understanding of the ecological consequences of positive plant-plant interactions has rapidly developed over the last two decades, and the influence of facilitative interactions on populations and communities is widely recognized. However, the processes and mechanism underlying these interactions have yet to be addressed fully. In this study, we first suggest a clarification of the terminology regarding the biotic and abiotic mechanisms (amelioration of environmental stresses, trapping of seed, etc.) and processes (improved establishment, enhanced survival, etc.) driving positive plant-plant interactions. We then investigate a poorly studied potential facilitative process, by examining if the positive impact of benefactor species occurs via changes in the expression of functional traits in beneficiary species. While functional traits may be predominantly affected by abiotic conditions, these traits could also be influenced by plant-plant interactions. We used interactions between cushion-forming plant species (which typically facilitate other species) and their associated species as a model system. Research was conducted in two contrasting ecosystems using the same methodology: a species-poor sub-Antarctic tundra and a more species-rich southern African montane grassland. In the sub-Antarctic tundra, functional traits of a grass, *Agrostis magellanica*, associated with the cushion plant *Azorella selago* were measured, whereas in the montane grassland, the functional traits of seven species commonly co-occurring with the cushion plant *Euphorbia clavarioides* were studied. A paired sampling approach was used where leaf area, specific leaf area, leaf dry matter content, plant height, chlorophyll content, leaf toughness and leaf thickness were measured for paired conspecific individuals growing both within and away from cushion plants. Sampling was repeated across an altitudinal gradient in both systems. The influence of the cushion plant species on the seven leaf functional traits was negligible in both systems, despite the cushion plants having positive effects on species biomass, abundance and richness. Functional traits also showed limited responses to elevation, and the influence of cushion plants on other species functional traits did not vary with elevation, despite expectations that the net outcome of plant-plant interactions would be related to elevation. These results show that plant performance, as assessed by functional traits, has a limited response to the interaction with benefactor species. This research therefore demonstrates that the process through which facilitation occurs is not through shifting beneficiary species' expression of functional traits towards more resource-acquisitive states. Other processes, therefore, must be responsible for translating beneficial microhabitat modification by benefactor species into positive impacts on other species.

The US National Vegetation Classification in the context of the forest vegetation of the West Gulf Coastal Plain of Texas and Louisiana, USA

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In order to document late 20th Century and current natural forest vegetation of the West Gulf Coastal Plain (WGCP) of east Texas and Louisiana to serve as a benchmark for future vegetation, 16 old and new natural forest plot datasets from various local studies between 1994 and 2017 representing the full range of topographic and edaphic settings were combined and analyzed with ordination, classification, and Indicator Species Analysis. The resulting classification grouped the 700 WGCP samples into 18 general community types which were further subdivided on the basis of analyses of the subsets of plots representing each type. Results were consistent with a multi-factor ecological classification system (ECS) previously developed for the US Forest Service in the region. One phase of study was to cross-tabulate the WGCP vegetation types resulting from plot data analysis with the US National Vegetation Classification (USNVC). USNVC was searched for all geographically-relevant forest communities. All Alliances and Associations were then linked with the best-fitting WGCP type. Ninety-one NVC Associations were found to partially or fully correspond to communities identified by the WGCP study. Issues encountered included variable quality and detail-level of USNVC descriptions, circumscriptions of USNVC Associations varying from very broad to highly specific, and ambiguity in the geographic applicability of some USNVC types. The quality of USNVC Associations varied from those based on quantitative plot data to those apparently derived from qualitative descriptions of one-few stands. In general, USNVC descriptions of upland communities were of better apparent quality and were easier to relate to WGCP types than those of mesic communities. Several WGCP communities described from our dataset were apparently missing from USNVC including pure-stand T*axodium* swamps applicable to local settings (non-lake shore) and *Planera aquatica*-dominated swamps. Benefits of this study include an opportunity to evaluate and revise USNVC associations in light of additional plot data as well to use USNVC to target vegetation for sampling that is poorly represented by local plot data.

Climate impacts on flowering in mountain grassland plants over space and time

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Climate change impacts on plants are often inferred from studies investigating species' performance in response to climatic variability in space or in time, i.e. along spatial climatic gradients or in response to temporal climate fluctuations. The potential underlying drivers, and hence the interpretation of effects, differs depending on whether they are found along spatial climate gradients or in response to temporal climate fluctuations, however. For instance, spatial gradient studies reflect long-term outcomes of different climatic regimes, and are therefore best suited to assess evolutionary responses and ecological equilibria under different climates. In contrast, temporal gradient studies reflect short-term responses, and are hence best suited to assess ecological response rates and the underlying processes, and, in the case of longer time-series, directions of change and magnitude of lags. In studies applying either one of the two approaches, a lack of response in response to climate does therefore not necessarily indicate that the focal species or communities are not responding to climate, and will not be affected by climate change, but as the biota may be responding at different time-scales or through different mechanisms. Here, we present a ten-year study on plant community composition and reproductive performance carried out in 12 sites selected so that temperature and precipitation vary independently of each other, creating a climate grid with where three levels of temperature (spanning 4 °C in growing season temperature) is crossed with four levels of precipitation (2,200 mm in annual precipitation). In these sites, we assess the effects of both spatial and temporal climatic variation on flowering rates in 181 species of vascular plants in 120 permanently marked plots over 10 years. Across sites, we test the predictions that overall flower densities increase towards warmer and drier climates, whereas reproductive allocation increases towards colder and drier sites. Over time, we test the prediction that flowering rates are higher in warm and dry years. Further, we assess the extent of context-dependency, and find that plants in the colder and drier parts of the climate grid respond more strongly to inter-annual variation in climate. The combined results of the space and time approaches allowed us to not only detect climate control where a single approach would have overlooked them, but also to understand underlying drivers and provide a stronger basis for forecasting future impacts than single-approach studies.

Comparison of floristic and pollen diversities for the reconstruction of Holocene vegetation changes

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Palynological reconstruction of Holocene vegetation changes requires understanding of cross-scale relationships between floristic and pollen diversities. We explored the relationships in two regions differing in dominant vegetation and diversity patterns. The White Carpathians are a biodiversity hotspot of thermophilous vegetation comprising dry-mesic grasslands and broadleaved forests, while the Bohemian-Moravian Highland is dominated by species-poor coniferous forests, meadows and wetlands. In each region, 40 sites covering the major habitats were sampled for plant and pollen diversity. A detailed floristic survey in radii of 10 and 100 m and in two transects of 1,000 m was conducted at each site. Recent pollen diversity was sampled in a moss polster in the center of each site. Altogether, close to 1,500 plant species were recorded and more than 180 pollen taxa were identified. Interestingly, although the scaling of plant diversity was rather different in both regions, the total number of plant species was similar (approx. 800 species in the Bohemian-Moravian Highland and 900 species in the White Carpathians). Considering biases of pollen analysis, especially pollen productivity, we based our comparison of the floristic diversity to the pollen diversity on: (1) the standard pollen sum, (2) the sum modified by pollen productivities (PPEs) and (3) representation factors (RFs). We found that PPEs and RFs calculated from the same pollen-vegetation dataset did not improve the diversity relationship. In both regions, the main factor influencing the relationship of pollen-floristic diversity was the dispersal-deposition bias. Forested sites had a higher proportion of the regional pollen component (*Ambrosia*, *Artemisia*, *Chenopodiaceae* family) than open sites.

Fire-deficits have diminished forest resilience through greater stand occupancy and drought stress in dry conifer forests: tree-ring carbon isotope evidence from Central Oregon

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Many forests of the western United States have undergone fire-deficits since effective fire-suppression efforts were initiated during early- to mid-1900s, leading to progressively greater stand occupancy. Forests in this condition are putatively more competitive for resources and thereby less resistant and resilient to forest-health challenges such as drought and pests or pathogens that take advantage of drought-stressed trees. Here we demonstrate links between a century-long fire-deficit, increased stand occupancy and greater drought stress for a given drought severity. To do so we employ records of dated tree-ring growth, fire scars and tree-ring carbon isotope discrimination ($\Delta^{13}C$) across a dry mixed-conifer forest landscape of central Oregon. Since 1910, stand basal area has increased by two- to three-fold in most stands, corresponding to fire-return intervals that have increased from 20 to 25 years during the 1700s and 1800s to ~140 years more recently. From 1830 to 2014, inter-annual variation in tree-ring $\Delta^{13}C$ was strongly related to Palmer Drought Severity Index (PDSI). More importantly, depending on species, *Pinus ponderosa* Lawson & C. Lawson or *Abies grandis* Douglas ex D. Don, the strength of the relationship has more than doubled over the past century (i.e. 35-year moving window has shifted from of R^2 = 0.23 to 0.46 or R^2 = 0.20 to 0.54, respectively). Long-term trends in $\Delta^{13}C$ were not consistent among trees sampled; trees located in stands with an average basal area greater than 25 m^2 ha^{-1} in 1910 displayed declining trends, indicative of increasing drought stress. In contrast, trees located in stands where fires had resulted in low basal area prior to 1910 were buffered from drought stress over the past century. The average $\Delta^{13}C$ response of *Pinus ponderosa* since 1830 indicates photosynthetic assimilation rates and stomatal conductance have been ~10% and ~20% lower, respectively, compared to expected trends due to increasing CO_2 concentrations. Altogether, we conclude that progressively increasing fire-deficits across dry have reduced the resilience of mixed-conifer forests landscapes due to shifts in stand structure and drought stress that promote a greater likelihood of bark beetle outbreaks and/or catastrophic wildfires.

Alien plant invasions in European woodlands

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Theory depicts alien plant invasions as a hierarchical process. In order to establish, reproduce and spread in a new region, alien plants have to pass several environmental filters. Human activities have a key role during invasions, for instance by fostering species imports and increasing disturbance at the landscape and local scales. Although woodlands cover a third of Europe's territory, we have only a limited understanding of how they are affected by non-native plants at the continental scale. Furthermore, few studies have so far assessed the importance of individual filters for driving alien plant invasions. Our project aims to provide an overview of alien plant

invasions in European woodlands and seeks to disentangle how they are shaped by human disturbance and environmental factors. We launched our study by extracting 251,740 plots from the European Vegetation Archive (EVA). This dataset covered most regions of Europe, incl. the European part of Russia, Sweden, the UK, Greece and Portugal. Plots were linked to EUNIS woodland habitat types, the main habitat classification of the European Union. For every species, we assigned a status (alien, native) and for every alien a geographic origin (from within Europe, from outside Europe) by using existing databases (e.g. DAISIE, Euro+Med, GloNAF, USDA GRIN), literature and expert opinion. We filtered our dataset extensively, for instance by including only EUNIS types that were well represented in our dataset and limiting plots to those collected after the year of 1970. In total, our study found 386 alien plant species in European woodlands. Aliens originating from Europe and outside of Europe were equally represented in the species pool. Interestingly, the latter achieved a much higher frequency. *Impatiens parviflora*, an annual plant from Central Asia, and imported trees and shrubs were the most common non-native plants. Riparian woodlands showed the highest levels of invasion. In addition, we derived a spatially explicit subset of our EVA dataset, and linked it to data on human disturbance proxies (e.g. human population density, distance to roads) and environmental variables (climate, soil). By launching this analysis we aim to provide more insights into the importance of individual filters during non-native plant invasions in European woodlands.

Circumpolar arctic vegetation classification, mapping, and transects: a framework for Arctic change analysis

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A circumpolar framework of arctic tundra vegetation data is needed for a wide variety of purposes including studying and modeling past and future changes to arctic terrestrial ecosystems. Here we present an update on the classification, a new version of the Circumpolar Arctic Vegetation Map, and two arctic transects that traverse the full Arctic bioclimate gradient in North America and Eurasia. The new raster version of the map provides a much higher resolution map that will increase its application for modeling. The map is part of a hierarchy of maps centered on the Arctic LTER site. The Arctic Vegetation-plot Archive (AVA) and an Arctic Vegetation Classification (AVC) are modeled after the European Vegetation Archive and Classification. Approximately 30,000 vegetation plots from across the Arctic have been identified for inclusion in the AVA. The units of the classification are organized according to their associated habitat types, similar to the approach used in the European Vegetation Archive). A prototype AVA was produced for Alaska (the AVA-AK) and is publically accessible via a web-based portal, the Alaska Arctic Geobotanical Atlas and (http://alaskaaga.gina.alaska.edu). The next step will be to assemble similar archives for other regions of the Arctic. New data are currently being added from Canada and Russia. The archive, classification and hierarchy of maps provide a framework to examine change across the Arctic bioclimate gradient. Two transects in North America and Eurasia have been established. Similar studies are needed along the Arctic climate gradient in other parts of the Arctic, and across other gradients, such as toposequences, snow and glacial sequences, and a variety of substrates within each subzone. As sea ice retreats in the Arctic, it will be especially important to consider the consequences to the land-surface temperatures and vegetation. The current vegetation patterns will likely change in unpredictable ways, possibly eliminating the most northernmost subzone if summer sea ice totally vanishes. Difficult logistics in the Arctic limit the number of sampling locations and the quantity of data that can be collected, so it is important that standardized methods of data collection are developed and followed wherever possible. A longer-term goal is to use the AVA to develop a classification according to both the European Braun-Blanquet approach and the EcoVeg approach of the US National Vegetation Classification, with a cross-tabulation between the two approaches.

Are there rules for grasslands? Long-term data from a South African grassland

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The order of arrival of species, much of which is stochastic, may influence the establishment and development of communities due to niche pre-emption of key resources such as nutrients and light. These are known as priority effects. In warm, humid, eastern South Africa, there are two long-term experiments that have been running on the Ukulinga plateau since 1950/1951. One of these experiments has had continuous burning and mowing treatments and the other continuous fertilization treatments, providing us with a set of well-differentiated, large, replicated environmental settings that has resulted in well-described grass communities. We found that there are certain "rules" of this subtropical grassland in terms of ecosystem function that are consistent with results from temperate grasslands in the US and in Europe. This African grassland has been fertilized with two forms of nitrogen applied at four levels, phosphorus and lime in a crossed design in 96 plots. The burning and mowing experiment has 132 plots. In 1951, about 84% of plant cover consisted of *Themeda triandra*, *Tristachya leucothrix* and *Setaria nigrirostris*. Currently, the dominant species are *Panicum maximum*, *Setaria sphacelata* and *Eragrostis curvula*, making up 71% of total biomass. We found a significant (additive) interaction effect on ANPP of nitrogen and phosphorus, and a negative correlation between ANPP and species richness. There was also a significant negative effect of nitrogen amount and nitrogen form and a positive effect of lime on species richness and species diversity, much as has been found in temperate grasslands in Europe and the US Consistent with the results from the world's longest ecological experiment at Park Grass (England) and other long-term fertilization experiments of grasslands, we found a positive effect of soil pH and a negative effect of nitrogen amount on species richness, a more acutely negative effect on species richness of acidic ammonium sulfate fertilizer than limestone ammonium nitrate, a negative relationship between species richness and biomass, and a positive effect on species richness of lime interacting with nitrogen. A multivariate analysis showed that the effects of burning and mowing differed considerably from the effects of soil fertilization. Some of these differences are consistent with the expectations of the intermediate disturbance hypothesis, with few species dominating at either end of the fertilization/burning gradients. However, a classic "decreaser" species, *Themeda triandra* (decreases in abundance with heavy exploitation) increased in abundance under annual burning, suggesting that the status of decreaser/increaser species needs to be re-considered.

Novel ecosystems challenge traditional succession schemes in vegetation science; proposal for a way forward

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Changes in land use are affecting terrestrial ecosystems in many places. Moreover, the combination of climate change, nitrogen deposition, interferences in the water cycle and invasive species are leading to novel combinations of species and environmental conditions. This dynamic given is exciting but also challenging for scientists that aim to describe and classify communities and ecosystems. Phytosociologists that classify plant communities to a large extent base their syntaxonomical systems on vegetation recordings that were collected in the past. In this approach traditionally recordings from natural ecosystems are used to derive succession series under conditions not or only slightly influenced by anthropogenic processes. Such series are then compared to successional pathways under anthropogenic disturbance. These comparisons are used to predict how a community will potentially further develop and to define measures to conserve, facilitate or restore desired communities. However, it is questionable if such analogues are still useful for many of the current ecosystems in which new combinations of species and environmental conditions exist and in which the rate of change is fast. In this presentation we will analyze the development of several novel ecosystems that were recently created in the Netherlands. The insights obtained from these cases will be used to propose a framework for identifying alternative succession schemes in a rapidly changing world and add flexibility to the classification of terrestrial ecosystems along disturbance gradients based on species-environment interactions.

Root foraging precision across habitats

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Plant species differ in their root foraging precision, with only negligible traces of phylogeny signal. The trait has been previously linked to various other species traits. Here we aim to show the link between the root foraging precision and habitat of the species. We experimentally estimated the root foraging precision in ~50 plant species. All of the species were perennial and herbaceous. The species selection was further stratified according to species height and rarity. Most of the species were native to Central Europe, which allowed us to use Ellenberg Indicator Values (EIVs) and a similar index for disturbance intensity and frequency to describe their habitats, as well as direct habitat classification. Surprisingly, we found only a little evidence for a direct link between the root foraging precision and EIVs.

Ecological land surveys in the Alaskan Arctic: a 25+ year legacy vegetation dataset

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In an Ecological Land Survey (ELS), landscapes are viewed not as aggregations of independent biological and physical resources, but as ecological systems with functionally related parts. The goal of an ELS is to provide a consistent conceptual framework for sampling, modeling, analyzing, interpreting, and applying ecological knowledge. The first phase of an ELS is an ecological land inventory that involves field surveys and data analysis, including soils and general environmental data, describing and quantifying plant species composition, vegetation structure, and collecting plant voucher specimens. The ELS team at ABR, Inc.—Environmental Research & Services— has been performing ecological surveys in Arctic Alaska for over 25 years on over a dozen individual field studies. Vegetation classifications were prepared for many of these studies; for example, 24 plant associations were classified for the central Beaufort Coastal Plain from studies, and 43 plant associations were classified for the Brooks Range foothills and sandsheet regions west of the Colville River. However, the plant associations classified from these studies have not been peer-reviewed and are therefore considered provisional. Furthermore, a unified plant association classification has never been attempted because the data exist in multiple project databases. Recently we began to compile these data into a single PostgreSQL database to facilitate analysis and sharing of a harmonized dataset. These studies represent an important source of vegetation data (~3,500 field plots), spanning a broad swath of northern Alaska, for the ongoing Circumpolar Arctic Vegetation Classification and US National Vegetation Classification efforts. Here we present the ELS field methods and results of the provisional vegetation classifications, and discuss the data compilation process and anticipated outcomes.

Classification of dry coniferous forests and woodlands of the southern Appalachian Mountains

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Xeric to subxeric coniferous forests and woodlands of the southern Appalachian Mountains with a substantial component of yellow pines (*Pinus echinata*, *P. pungens*, *P. rigida*, and *P. virginiana*) have declined in area during recent decades because of fire suppression, drought, and outbreaks of southern pine beetle. Even prior to widespread decline of yellow pine communities, classification efforts were hampered by their dynamic nature and their tendency to intergrade with a variety of other communities. We have been exploring numerical classification of a data set consisting of over 1,000 permanent plot records extracted from the Carolina Vegetation Survey database, selected using criteria of location in the southern Appalachian region and having at least 10% combined cover of the four yellow pine species. Our current focus is on analysis of vegetation data from 333 permanent plots representing 14 US National Vegetation Classification (USNVC) Associations and the potential need to modify the existing classification structure. We report on the use of fuzzy clustering techniques to revise the a priori assignments of plots to Associations and to identify plots representing the core concept of each Association. Subsequent ordinations using nonmetric multidimensional scaling have identified a need to revise the placement of two Associations in the higher levels of the USNVC classification hierarchy. We also address classification of plots not fitting well into existing USNVC Associations.

Formal definition of associations using diagnostic species: a case study of European meadow steppes

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In 1910, the International Botanical Congress in Brussels defined the association as "plant community of definite floristic composition, uniform habitat conditions and uniform physiognomy". However, the question of what exactly is a "definite floristic composition" has puzzled vegetation scientists for almost a century. In recent decades, it has become clear that a floristic composition can only be considered "definite" if the membership of new plot records can be unambiguously determined on the basis of floristic assignment rules. In our case study, we aimed at establishing formal definitions for all associations of European meadow steppes, using a dataset of 34,173 plot records of dry and semi-dry grasslands of Central and Eastern Europe. Meadow steppes are semi-dry grasslands with a high portion of steppe species, i.e. of species with Siberian-Pontic-Pannonian distribution. In a first step, we classified the dataset into orders and alliances. As starting point, a TWINSPAN classification of the whole dataset was done and the diagnostic species of the main clusters were determined. The plots were re-assigned using formal definitions of the orders, and then the subset of the order *Brometalia erecti*, corresponding to all semi-dry grasslands of the study area, was again classified. On the basis of this second TWINSPAN classification, formal definitions of the alliances were established. Meadow steppes correspond to the alliance *Cirsio-Brachypodion pinnati*, which is distributed from Germany in the west to Russia in the East. Finally, we established formal definitions of all associations within this alliance. Associations were identified using (1) the TWINSPAN classification of the whole order, (2) TWINSPAN classifications of regionally restricted data sets (typically all *Brometalia* plots of one country) and (3) existing national classification schemes. All formal definitions were written in the expert system language of the JUICE program. Altogether, 6,742 plots were assigned to the *Cirsio-Brachypodion pinnati*. The expert system assigned 89% of these plots to one of 37 associations, while 11% of the plots remained unclassified. The formal definitions follow the logic of a determination key based on diagnostic species. Regional associations are particularly challenging since the constancy of geographical differential species is usually not high enough for them being present in all records of a region. Thus, a certain amount

of miss-classified plots seems to be unavoidable unless associations are merged into rather heterogeneous units with very large distribution area. On the other hand, we suggest that sympatric associations should be clearly different in habitat conditions.

Different biomes, different responses of alpine plant communities to climate change impacts: Mediterranean vs. temperate and boreal mountains

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Plant species respond to climate warming by moving their ranges to higher elevations or latitudes (Parmesan & Yohe 2003). As a consequence, the number of species on more than 300 temperate and boreal summits across Europe has increased considerably over the past 150 years and this increase has accelerated recently. This trend was linked to warming, while changes in precipitation or nitrogen input could not explain the increases (Steinbauer et al. 2018). However, these accelerated increases in summit biodiversity may be a temporary phenomenon, hiding a growing extinction debt as long-lived alpine plant species do not disappear immediately from increasingly unsuitable habitats (Dullinger et al. 2012). The decline and loss of suitable habitats (Engler et al. 2011, Hülber et al. 2016) may hit especially hard where the vertical extension of mountains is low and where climate warming is combined with decreased precipitation (McCain & Colwell 2011, Pauli et al. 2012). Velocity and magnitude of climate change-induced biodiversity losses can only be documented by long-term in situ monitoring. The GLORIA (Global Observation Research Initiative in Alpine Environments, www.gloria.ac.at) network provides a unique dataset of repeated surveys of alpine vegetation, recorded by using a standardized protocol in permanent plots on mountain summits (Pauli et al. 2015). Here, we compare species richness and abundance data from three GLORIA regions each in the Mediterranean, temperate and boreal biome from the years 2001, 2008 and 2015. Increasing biodiversity in the temperate and boreal biomes was linked to increasing temperatures. In contrast, on Mediterranean summits species richness declined between 2001 and 2008 and increased sharply between 2008 and 2015, a trend which was clearly correlated with changes in precipitation. In addition to climatic factors, we discuss the potential impact of other drivers of biodiversity changes such as anthropogenic land-use.

To test or not to test, that is the question: relating mean Ellenberg indicator values to ordination axes is an example of spurious correlation

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In 2012, together with André Schaffers, I published the "Too good to be true" paper in JVS. It described inflated Type I error rate in analyses testing the relationship of mean Ellenberg indicator values (mEIV) to sample scores on ordination axes (or other variables derived from a species composition, like species richness or assignment of samples into clusters). We suggested to either refrain from testing such relationship, or to use a permutation test with a modified permutation scheme, generating the null distribution of the test statistic by permuting species indicator values (before calculating mEIV) instead of samples. In the response paper, Wildi (2016) argued that testing such a relationship violates the requirement of the independence of tested variables and should not be used. Also, recent studies reporting inflated Type I error rate in community-weighted mean approach (CWM, e.g. Peres-Neto et al. 2017) stress that the solution, P_{max} test, does not apply to the situation when CWM is related to variables numerically derived from species composition (intrinsic variables). Note that mEIV is, in fact, CWM, so the problem with relating mEIV to ordination scores applies in general to relating any CWM to any intrinsic variable. The key question therefore is: can the relationship between mEIV (or CWM in general) and ordination scores (or other intrinsic variables) be tested or not? I argue here that this relationship can be tested, if one acknowledges that it falls into the category of "spurious correlations", i.e. a relationship between variables containing the same term. Mean EIV and ordination scores are both functions of a species composition matrix **L**, and can be rewritten as $f_1(\mathbf{e}, \mathbf{L})$ for mEIV (**e** is a vector of species Ellenberg indicator values) and $f_2(\mathbf{L})$ for ordination scores. In the relationship $f_1(\mathbf{e}, \mathbf{L})$ vs $f_2(\mathbf{L})$, the compositional matrix **L** occurs on both sides of the equation, in the same sense as in the spurious correlation of X/Y vs X, or X-Y vs X. Brett (2004) suggested testing spurious correlations by a permutation test acknowledging non-independence of variables. This solution is analogous to the modified permutation test suggested by my JVS paper, which changes the original null hypothesis of "no relationship between *mean* Ellenberg indicator values and ordination scores" into "no relationship between *species* Ellenberg indicator values and ordination scores". In this sense, the modified permutation test remains a valid tool for relating mEIV (or other CWM) to ordination scores (or other intrinsic variables).

A simple statistical model to integrate multiple environmental drivers to estimate distributions of various plant communities: a joint-probability-based modeling framework

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An important step in vegetation distribution modeling is to select an appropriate formulation for the statistical model. The formulation should consider both the shapes of vegetation response curves along environmental gradients, and adaptability of the selected model to considering new environmental drivers in the modeling. To satisfy requirements of the curve shapes and the model adaptability, formulations in commonly used statistical models (e.g. GLM) or modeling by non-parametric statistical methods (e.g. GAM, CART, etc.) have their own limits or disadvantages. Therefore, we proposed a new formulation based on a joint probability method. Our new model framework used the response curves directly fitting to vegetation survey data instead of making any assumption of the curve shapes, therefore different curve shapes (e.g. skewed) can be applied to the modeling. Moreover, our model framework had a high adaptability, because new environmental parameters can be added to the model without re-formulation and re-calibration. This joint-probability based model framework was compared with a multinomial regression based Bayesian model framework by using vegetation survey data of freshwater marsh communities in the Everglades, Florida. The environmental drivers included hydroperiod, water depth, and soil phosphorus and carbon contents. Our results showed that: (1) the joint-probability based model framework could simulate vegetation responses to spatial changes of the environmental drives, and (2) difference in the modeling accuracies between the two model frameworks was small. Therefore, this joint-probability based model framework has a great potential to estimate the vegetation responses to changes of important environmental drivers, and contributes to more informed conservation management.

Patterns and determinants of plant diversity in temperate mountain forests of northern China

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The spatial patterns of biodiversity and their underlying mechanisms have been an active area of research for a long time. In order to understand the mechanisms driving current diversity patterns, we conducted vegetation surveys for mountain forests, exploring the latitudinal and longitudinal patterns of species richness and compared the relative influence of geographical distance and environmental divergence on the β diversity in Shandong Province, China. A total of 457 plots (20m × 30m) were sampled in study areas. The sampling sites were chosen selectively in mature forests which were representative of typical vegetation types and away from slope crests and ravines, large rocky outcrops and stream gullies. All species observed in the plots were recorded. The location and elevation of each plot were recorded by global positioning system (GPS). Mean monthly temperature and precipitation at each plot were calculated using the WorldClim database. The results showed that species richness presented a monotonically decreasing pattern from low to high longitude. Species richness did not display a common monotonically decreasing pattern, but exhibited an inverted unimodal pattern along the latitudinal gradient in Shandong Province. Minimum species richness occurred at 36.5 degrees north latitude. This phenomenon was caused by special geographic position of Shandong Province. The majority of mountains above 36.5 degrees north latitude were located at the eastern of Shandong Province. The eastern Shandong Province is surrounded by the sea on two sides. The weather is often mild and moist, which is in favor for the survival of plants. In addition, the coastal areas of eastern Shandong Province was once linked with Liaodong Peninsula and Japan, then separated from them in the Quaternary period. Crustal movement had resulted in specification and diversification for plants. Therefore, current species diversity patterns were determined by both geological and historical processes. The similarity of species composition between two plant communities (β diversity) decreased as environmental divergence and geographic distance increased. Species turnover were significantly correlated with geographical and environmental distance. However, the effects of environmental divergence on species turnover were more significant than geographic distance. The results suggest that at the study scale, current spatial patterns of plants are structured by both environmental filtering and dispersal limitation. However, environmental filtering played a more important role in regulating community assembly in temperate mountain forests of northern China.

Reforestation on understory plant diversity: species traits and sampling scale matters

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The role of forest plantations in biodiversity conservation has gained more attention in recent years. However, most work on evaluating the diversity of forest plantations focuses only on one spatial scale; thus, we examined the effects of sampling scale on understory plant diversity in forest plantations. We designed a hierarchical sampling strategy to collect data on understory plant diversity in planted pine (*Pinus tabuliformis* Carr.), planted larch (*Larix principis-rupprechtii* Mayr.), and natural secondary deciduous broadleaf forests in a mountainous region of Beijing, China. Additive diversity partition analysis showed that, for annuals and biennials, compared to natural forests, the planted pine forests had a different understory plant diversity partitioning pattern at multi-scales, while the larch plantations did not show multi-scale diversity partitioning patterns that were obviously different from those in the natural secondary broadleaf forest. However, the additive diversity partition pattern did not show significant difference compare to the natural secondary broadleaf forest for herbaceous perennials. Compared to the natural secondary broadleaf forests, the effects of planted pine forests on understory plant diversity are dependent on the sampling scale selected for analysis. Diversity in the planted larch forest, however, was not significantly different from that in the natural forest. Our work demonstrated that the sampling scales selected and the plant life forms selected for data analysis alter the conclusions on the levels of diversity supported by plantations. Taking sampling scale and plant life form in consideration in the evaluation of the role of forest plantations on biodiversity conservation are highly suggested.

Connections between vegetation and soil bacteria in alpine ecosystems

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Plant phenotype results from a plant's interaction with the environment and its soil microbiome. The sensitivity and global distribution of alpine plant communities makes them practical indicators of human-driven environmental changes, such as climate change and nitrogen deposition. Therefore, the composition and resilience of alpine plant communities may be linked to microbial communities, but few studies have focused on alpine plants and their associated soil microbiome. To test hypothetical associations between soil microorganisms and alpine plant communities, and the rhizosphere and rhizoplane of particular alpine species, we resampled alpine plant survey sites, established approximately 10 years ago, on three mountains (Mineral Peak, Wolverine Peak, and Republic Peak; > 3000 m) within and near the northeast border of Yellowstone National Park. Abundance and cover estimates of vegetation were recorded along a 10 m transect in four sites (North-facing, South-facing, late snow-melt, and ridgetop) on each mountain to provide a reference point for microbial associations and temporal comparison of previous sampling campaigns. Rhizosphere and rhizoplane soil was collected from an abundant plant species (*Lupinus argenteus, Astragalus kentrophyta,* or *Carex albonigra*) at each site. A total of 16S amplicons derived from soil samples were sequenced via the Illumina MiSeq platform. Abundance and diversity of soil bacteria varied significantly between particular species independent of habitat type, but not between habitat types, or rhizoplane and rhizosphere soils. C:N was the only edaphic factor that was highly correlated with the spread of soil bacteria in NMDS ordinations. Distinguishing phyla identified through indicator species analysis included the Tectomicrobia for *Astragalus kentrophyta*, and Planctomycetes and Verrucomicrobia for *Lupinus argentus. Carex albonigra* lacked strong defining species, but generally shared more bacteria with *A. kentrophyta* than *L. argentus*. These results demonstrate the ubiquity of soil bacteria and support the premise that plant species differentially select for microbes via root exudates that may, in turn, assist in maintaining dominance in alpine ecosystems.

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