Frontiers of Vegetation Science—An Evolutionary Angle

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in collaboration with

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Abstracts of presentations at the 51st Annual Symposium of the International Association for Vegetation Science, Stellenbosch, South Africa, September 7-12, 2008

The editors have peer reviewed this compendium for scientific merit, technical format, and language.

Citation suggestions:

This book: **Mucina, L., Kalwij, J.M., Smith, V.R., Chytrý, M., White, P.S., Cilliers, S.S., Pillar, V.D., Zobel, M. & Sun, I.-F. (eds) 2008. *Frontiers of Vegetation Science—An Evolutionary Angle*. Keith Phillips Images, Somerset West.**

An abstract from this book: **Aguiar, F.C., Ferreira, T., Albuquerque, A. & Rodrígues-Gonzáles, P. 2008. Mahjonging key functional and taxonomic tiles in near-natural Mediterranean riparian woods (SW Iberia, Portugal). In: Mucina, L. et al. (eds), *Frontiers of Vegetation Science—An Evolutionary Angle*. p. 12. Keith Phillips Images, Somerset West.**

ISBN 978-0-9584766-9-0

Published by Keith Phillips Images, Somerset West on September 1, 2008

Cover design and layout: Keith Phillips Images, PO Box 5683, Helderberg, 7135 South Africa; images@iafrica.com

ISBN 978-0-9584766-9-0

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Word of Welcome

Dear Professor Peet, President of the International Association for Vegetation Science, dear Professor Mucina, Secretary-General of the IAVS and President of this meeting, dear botanists and ecologists, dear fellow scientists –

Welcome to the capital of the most beautiful flowers in the world – welcome to Stellenbosch, the heart of Capensis. Stellenbosch University, of which I have the honour to be Vice-Rector for Research, opens its arms to embrace the largest crowd of vegetation scientists ever to assemble in our country, or anywhere in Africa, for that matter.

The University is especially proud to host this, the 51st annual symposium of IAVS, which is one of the oldest and most respected ecological societies in the world. We trust that you will enjoy not only the fantastic flora of the Cape, but also our hospitality, and, of course, our wine.

The Cape is special – one of few places on this planet where an appreciation of beautiful plants and fascinating vegetation is not restricted only to professional botanists – as an engineer by training, I am a living proof of this.

Coming to the Cape, which is home to the most diverse of the planet's five floral kingdoms, is a dream of every botanist. Here is a kingdom blessed with unique flora and many floral superstars, such as proteas, pelargoniums, restios, hundreds of ericas, gladioli and many other bulbs – the complete list is much too long to mention here. I gather that most of you attended the pre-symposium excursions to our western and southern coasts, and especially to Namaqualand. At this time of the year these regions are floral wonders that we appreciate tremendously. The beauty of those landscapes is truly addictive.

In addition to its beauty, the Cape Floral Kingdom is an unsurpassed laboratory in which we can delve into the secrets of the evolution of plants and vegetation. It therefore is not surprising that the major focus of your meeting is evolution – or rather, bringing together the concepts of vegetation science and evolution. This is the sort of approach that is encouraged in the academic programmes of Stellenbosch University – we place a major emphasis on cutting-edge interdisciplinary and multidisciplinary research. We also encourage and foster international contacts. It is for these two reasons that the University is very pleased to host and support your meeting. I wish you success and relaxation. May you make many new friends and forge many new research partnerships. Simply put – have a good time and enjoy Stellenbosch!

Arnold van Zyl
Vice-Rector (Research), Stellenbosch University

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Oxford, United Kingdom

Springer
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NISC Digital & Print Publishing
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IAVS Comes to Stellenbosch

Ladislav Mucina

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The International Association for Vegetation Science (**IAVS; www.iavs.org**) is a bona fide scientific society supporting research in the field of vegetation science, one of the core scientific ecological disciplines. The IAVS is a very active scientific body, organizing usually one (rarely two) general annual meetings, publishing two international journals – ***Journal of Vegetation Science*** and ***Applied Vegetation Science*** – until 2008 in cooperation with Opulus Press, Uppsala, Sweden (**www.opuluspress.se**) and from 2009 onwards in cooperation with the renowned international publishing house Wiley-Blackwell, Oxford, UK (**www.blackwell.org**).

IAVS also supports several sub-units (regional sections) which pursue the aims of the IAVS on a regional level and in specialised working groups. After having held most of the past meetings in the Northern Hemisphere, the IAVS will hold its annual meeting for the first time in Africa.

Focus of the Symposium
http://sun.ac.za/iavs2008/

The main focus of the symposium is to seek links between vegetation science and evolutionary biology and the formation of platforms in cooperation between these major scientific fields. The title of our meeting – **"Frontiers of Vegetation Science—An Evolutionary Angle"**– alludes symbolically to the challenges that vegetation science as a discipline is currently facing. Technologically driven progress in evolutionary research is changing the face of many traditional biological sciences. Vegetation science, should (and to some extent already does) react to this new phase of evolutionary research by reaching out to ecological disciplines traditionally closer to evolutionary biology (population biology, palaeo-ecology) and implementing tools of evolutionary research in explaining structure and dynamics of vegetation. The field of interaction and cooperation is enormous and is ripe for exploration and discovery. The major aim of our meeting is to extend the interface and to deepen the cooperation between the evolutionary research and vegetation science.

The scientific programme features several major core topics, such as:

- Evolutionary Plant Community Ecology
- Linking Ecology, Physiology and Evolution: From Species to Functional Groups
- Linking Hierarchies: Populations, Communities, Landscapes

- Mechanism of Community Assembly: Ecological Filters and Assembly Rules
- Community Disassembly and Homogenization: Role of Alien Invasions
- Vegetation and the Global Change
- Surveying Biodiversity at High-Levels of Complexity
- Managing Vegetation: Conservation, Restoration, Reconstruction

Due to enormous interest and the high quality of suggested presentations, the LOC decided to run the symposium in three parallel sessions over three full days. Two Poster Sessions are also scheduled.

These core topics have served as the substrate for moulding the following sessions:

Monday, September 8, 2008:
Session A: EVOLUTIONARY COMMUNITY ECOLOGY 1
Session B: REGENERATION & RESTORATION
Session C: DIVERSITY PATTERNS IN VEGETATION 1
Session D: EVOLUTIONARY COMMUNITY ECOLOGY 2
Session E: VEGETATION MANAGEMENT 2
Session F: DIVERSITY PATTERNS IN VEGETATION 2
Poster Session 1

Tuesday, September 9, 2008
Session G: COMMUNITY ASSEMBLY 1
Session H: MODELLING SPECIES RESPONSE
Session I: VEGETATION SURVEYS 1
Session J: PLANT TRAITS IN COMMUNITY ASSEMBLY
Session K: VEGETATION & NUTRIENTS
Session L: VEGETATION PALEOPATTERNS
Poster Session 2

Thursday, September 11, 2008
Session M: PLANT FUNCTIONAL TYPES 1
Session N: VEGETATION SURVEYS 2
Session O: PLANT LIFE-HISTORIES
Session P: PLANT FUNCTIONAL TYPES 2
Session R: INVASIVE ALIENS & VEGETATION 1
Session S: INVASIVE ALIENS & VEGETATION 2

Wednesday, September 10, 2008 is reserved for five one-day excursions to Cape Point, Kirstenbosch National Botanical Gardens, West Coast National Park, De Hoop Nature Reserve and the Hermanus coast.

Venue

Stellenbosch University has the honour of organising the 51st IAVS Annual Symposium. This symposium is organised by the Regional Section for Southern Africa of the IAVS (Chair: Prof. Roy Lubke, Rhodes University, Grahamstown, South Africa) and Stellenbosch University. Stellenbosch (**www.tourismstellenbosch.co.za**) is the second oldest town in South Africa and lies about 50 km east of Cape Town. It has a very rich architectural heritage, with more than 100 declared monuments, and its streets are lined with oak (*Quercus*) trees – hence its colloquial name, Die Eikestad (Town of Oaks). It is the centre of the Winelands District of the Western Cape – a region renowned for its vineyards and mountains.

Stellenbosch has always had a significant involvement in the history of education in South Africa and Stellenbosch University is one of the oldest, and largest (about 22 000 students, on four campuses) universities in the country. Stellenbosch is truly a 'university town' – an intoxicating mixture of nature beauty, youth, and wine.

(Visit **www.exploresouthafrica.net/westerncape/Stellenbosch/history/** for information on the history of the town, and **www.sun.ac.za/university/history/** for information on the history of the university).

The symposium is held in the university's Music Conservatorium, on the corner of Victoria and Neethling Streets. The oldest university botanical garden in the southern hemisphere (**http://admin.sun.ac.za/botanicalgarden**) is a two minute walk from the Conservatorium and the town centre is a ten minute walk away.

The Conservatoire is situated on the Stellenbosch University Main Campus (corner of Neethling and Victoria Streets).

Welcome to Stellenbosch and feel at home!

51st IAVS Symposium inStellenbosch, South Africa:

Abstracts of Presentations

Space, time and environment: integrating ecological and evolutionary approaches to vegetation science

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The composition, structure and distribution of plant assemblages can be considered at many scales, from local communities to continental floras. Depending on the scale of analysis, a host of different processes may contribute to these patterns, including dispersal limitation, abiotic filtering, biotic interactions, demographic fluctuations, speciation and extinction. We face a great challenge in constructing a theoretical edifice and empirical methods that can span a range of scales and integrate ecological and evolutionary perspectives.

I will address three aspects of this challenge: (1) The need for a more explicit specification of the spatial and, especially, temporal bounds that define a plant assemblage, especially those defined by distinctive climatic conditions (e.g., Mediterranean-type climates). This creates a distinction between dispersal in space vs. time, and provides a common framework to understand the role of niche conservatism, adaptive change, and *in situ* radiation. (2) The role of space has long been emphasized, in the form of species-area relationships and more recently in the focus on community size in neutral theories. We need a corresponding focus on the structure and distribution of environments, providing a conceptual framework to address climate change and ecological opportunity. (3) Finally, I present a preliminary model that explicitly incorporates the distribution of environments, and its change through time, to examine the interaction of dispersal, adaptive evolution and speciation in the assembly of regional floras.

Mahjonging key functional and taxonomic tiles in near-natural Mediterranean riparian woods (SW Iberia, Portugal)

F.C. Aguiar, T. Ferreira, A. Albuquerque & P. Rodrígues-Gonzáles

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Studies on the ecology of riparian woody vegetation in Portugal are few in number and mostly small-scaled. This study aims to gain understanding of spatial distribution of the riparian woods using the analysis of congruence of taxonomy (species) and functional trait approaches.

Based on 175 surveys of river stretches with no or minor anthropogenic disturbances undertaken in 2004–2005, hierarchical classification was done to derive Taxonomic Species Groups (TSG) and Functional Trait Groups (FTG). The latter were defined after the identification of ecological meaningful Emergent Groups (EG). An Indicator Species Analysis was used to identify the key-woody species and the key-functional traits, respectively. Discriminant analyses were used to create predictive models. The contribution of FTG to the overall spatial variation of TSG was analysed.

Four TSG were identified, such as alder woodlands, ash woodlands, mountain shrublands and semi-arid shrublands. The ash and alder woodlands were widely distributed, in contrast to the shrubland formations. Thirty-one relevant plant traits were used to derive EG. Four FTG were defined, such as mixed woodlands dominated by waterlogging tolerators, mixed woodlands abundant in half-shade tolerators, evergreen anemochourous shrublands, and shrublands dominated by drought tolerants. The TSG and FTG approaches agreed closely in the extremes of the climatic gradient, with the semi-arid shrublands of small torrential rivers being congruent with the shrublands dominated by drought tolerants, and the mountain shrublands in small headwater permanent rivers with the evergreen anemochorous shrublands.

The TSG and FTG were primary driven by hydrological features, followed by broad geographical variables. TS-based approach wwas more strongly related with the environmental setting than was the FT-based approach. However the latter was able to highlight small local variations indirectly related to human disturbance. The two approaches used thus contributed synergistically to our understanding of the spatial variation of riparian woodlands and our ability to detect environmental and landscape changes.

Comparative plant functional forms in two thermo-mediterranean semiarid regions: SE Iberian Peninsula (Spain) and NW Baja California (Mexico)

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Morphological convergence in vascular plants on areas under similar climatic conditions is one of the premises of global bioclimatology. The Mediterranean Floristic Region and the Californian Floristic Region share similar climatic conditions and has been the subject of plant functional form studies. Nevertheless climatic conditions of both areas are very diverse (several vegetation belts), so we hypothesize that a better comparison should be based on more restricted bioclimatic zones and a more complete list of taxa.

In this paper we show the main comparative results of two areas: the SE Iberian Peninsula (Spain) and NW Baja California (Mexico) under thermo-mediterranean semiarid conditions. Only perennial plants (woody, suffrutescents and succulents) were considered, 165 taxa from Spanish and 123 taxa in the Mexican zone. The categories of characters analyzed were Life Form (habit), Leaf Traits (type, size, texture, pubescence, waxiness, aroma and division), Plan Traits (spinescence, phenology) and Fire Adaptations Traits (seedlings after fire and resprouting). Numerical analysis of data was performed with the R package, using a classification over the scores of a multiple correspondence analysis. In this analysis we separated the chaparral/maquis plants from sage-brush-succulent/tomillar.

The Spanish maquis is floristically poorer than Baja California chaparral, while the Spanish tomillar was floristically richer than Baja-Californian sage-brush. Adaptations to survive arid periods and leaf traits were different between regions. Aphyllous and climbing brush-wood plants were significantly more abundant in the Spanish than in the Baja California vegetation. Succulent plants were scarcely represented in Spain. In fact the Baja California coastal succulent scrub (matorral costero suculento) has no equivalent in SE Spain.

Conserving the matrix: identifying ecological core areas for The Nature Conservancy's large-scale conservation efforts in Vermont, USA

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The Nature Conservancy (TNC) was formed in the United States in 1951 as a not-for-profit organisation with the goal of protecting biodiversity. Over time, TNC's focus has gradually shifted from the protection of populations of rare species and small nature preserves to the protection of natural communities and larger areas of the landscape. Since 1996, TNC has placed much of its effort on large-scale, ecoregion-based conservation.

A map of ecoregions of the U.S. was created by TNC in 1999, based largely upon the previous work of Bailey (1994), and later modified to include Canada. The largest non-fragmented areas of land within each ecoregion, called 'priority matrix blocks,' are used as a coarse filter for conserving biological diversity. Blocks must contain large expanses of the ecological communities that dominate the landscape within the ecoregion and that form the primary natural land cover—the 'matrix' communities. Matrix blocks in the U.S. were identified using analysis of satellite imagery and other data layers in a GIS.

Conservation of a matrix block is premised upon achieving an effective and permanent management regime for the protection of biological diversity in a core area of the block that encompasses at least the minimum threshold area appropriate to the ecoregion. Conservation of core areas within blocks ensures that the largest scale natural communities are protected, along with small patch natural communities and source populations of many species. Vermont is contained within three ecoregions: the Northern Appalachian-Acadian (NAP) Ecoregion, the St. Lawrence-Lake Champlain Valley (STL) Ecoregion, and the Lower New England/Northern Piedmont (LNE) Ecoregion.

Minimum area thresholds for viable matrix blocks within these ecoregions were first developed for the NAP ecoregion following the approach by Anderson (Anderson 1999), and later developed for the other two ecoregions. These thresholds are designed to encompass four times the average large scale disturbance event for the ecoregion and to support at least 25 breeding pairs of area-sensitive species. In the NE United States, matrix blocks range in size from 4800 to 24,000 ha.

Minimum core area thresholds range from 4000 to 10,000 ha depending on the ecoregion.

The challenge in designing and delineating a core area is to include the maximum range of physical features as well as the best occurrences of the matrix community and the full complement of small patch communities and rare species that are found within the matrix block, while allowing for minimal interior fragmentation.

Of all the possible matrix blocks originally identified in Vermont, twenty were prioritized for further conservation planning based upon size, best representation of the ecoregion's matrix vegetation, and degree of anthropogenic disturbance: eleven in the NAP Ecoregion, five in the STL Ecoregion, and four in the LNE Ecoregion. One more block in the NAP Ecoregion was added because of an opportunity to partner with ongoing conservation efforts of another organisation.

Vermont has taken an approach to conducting preliminary inventories of each high priority matrix block that includes both GIS analysis and field work, with a focus on the matrix community or communities. The basic inventory methods include: (1) mapping the natural communities 'coarsely', (2) assessing the condition of the forest by community type, (3) determining whether and to what extent invasive species are present, (4) recommending a location for a core area (areas) and secondary conservation zones, and (5) recommending corridors for connectivity.

Field work combined with expert interviews and digital spatial analysis of environmental factors, political boundaries, conserved lands, occurrences of rare species and natural communities, and parcel data. Sociological information that informs current and potential future land use is also analysed, such as economic status of the communities, county or region-wide trends in jobs, population, income, education level, predominant job classes, predominant land uses, and current regional plans, town plans and zoning regulations. Various additional analyses are conducted, depending upon assessed need.

To date, preliminary inventory and core area delineation have been completed for eleven priority blocks in Vermont. Conservation efforts now focus on protecting lands within these core areas and in corridors that link them together.

Anderson, M.G. 1999. *Viability and spatial assessment of ecological communities in the Northern Appalachian Ecoregion.* Ph.D. thesis, University of New Hampshire, Durham, NH.

Bailey, R.G., Avers, P.E., King, T. & McNab, W.H. 1994. *Ecoregions and subregions of the United States (map 1:7,500,000).* U.S. Geological Survey, Washington DC.

Evolution of hydrological niches in Restionaceae: a project update

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Plants are in general exquisitely sensitive to differences in soil moisture availability, particularly when competing with each other. We have previously found that species segregate along soil moisture gradients in English wet meadows (Silvertown et al. 1999) and we now have good evidence from several sites in the Western Cape that the same phenomenon occurs in fynbos communities. Our discovery of plants segregating into hydrological niches, defined by their location along soil moisture gradients, in phylogenetically completely different communities in the northern and southern hemispheres suggests that this form of niche separation is very general indeed.

We are now using the Restionaceae family, one of the key components of fynbos vegetation, to test the hypothesis that the radiation of the Restionaceae clade in the Cape involved the occupation of novel niches in hydrological niche space. We have so far collected hydrological data on 39 species of Restionaceae from 6 sites and have a species-level phylogeny of the family (Hardy et al. 2008) which enabled us to estimate the rate of evolutionary change in hydrological niche parameters during the radiation of the group.

Hardy, C.R., Moline, P. & Linder, H.P. 2008. A phylogeny for the African Restionaceae, and new perspectives on morphology's role in generating complete species phylogenies for large clades. *Int. J. Plant Sci.* 169: 377–390.

Silvertown, J., Dodd, M.E., Gowing, D. & Mountford, O. 1999. Hydrologically-defined niches reveal a basis for species-richness in plant communities. *Nature* 400: 61–63.

Anomalous attributes of *Pinus canariensis*, a putative serotinous conifer

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Pinus canariensis is a dominant species of montane forests covering extensive areas on Tenerife. This species is commonly described as serotinous because cones are not shed when seeds are ripe and trees are capable of basal and epicormic sprouting following fire. We searched for other attributes of serotinous populations, sampling 22 stands on Tenerife in a wide diversity of habitats. We aged individuals by regressing diameter at breast height or number of branch whorls to tree ring numbers.

We found the following anomalies for a supposed serotinous conifer: 1) sexual maturity occurred at a relatively advanced age of 27–46 yr; 2) although cones did not fall immediately at the time of seed maturity, they did fall within the next 1–2 yr; 3) life span was long, often 300 yr (and capable of reaching > 700 yr in unique individuals; 4) stands were open, with large individuals capable of rapid growth (1–3 rings/cm); 5) seedling and sapling (ages 1–16 yr) densities were high, indicating that regeneration could occur any time, unrelated to time since the last fire; 6) trees in a population were distributed in a clumped pattern as often as random, indicating that establishment could have been due to gap dynamics as much as to fire; 7) mature trees grew rapidly in diameter (1–3 rings/cm) and could be massive; and 8) population age structures resembled those of climax-type populations not dependent upon episodic disturbance. Most stands, however, showed poor regeneration in the years 1980–1987.

Little is known about what the natural (pre-human) fire regime was - possibly fire return intervals were too long to play a role in the evolution of fire tolerance. One further anomaly is unrelated to fire: growth rate in trunk diameter was not significantly correlated with any environmental parameter, not to annual precipitation, mean annual temperature, geologic substrate, tree density, geographic or topographic position, nor to degree of exposure to the humid zone of trade wind clouds.

Assessing plant community assembly rules by dynamic neutral models: a comparative study

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There are well-established randomisation tests in vegetation science to reveal assembly rules as spatial non-randomness in biodiversity patterns. However, present static neutral models have serious limitations in that they underestimate the importance of constraints with cumulative temporal effects. Ecosystems are complex evolutionary systems with stochastic non-linear dynamics. Effective neutral models should be able to incorporate temporal and spatiotemporal aspects.

We propose a family of dynamic neutral models based on spatially explicit, individual-based simulations to effectively understand the dynamic consequences of spatial non-randomness. Using standard field sampling protocols, a comparative study has been performed to assess spatiotemporal organisation in various grasslands and semi-deserts. The study included North American tallgrass prairie, European grasslands developed on loess, sand, dolomite, and other alkaline substrates, and semi-desert shrublands in South Africa. Grasslands on natural loess and dolomite showed the highest fine-scale neighbourhood diversity and lowest overall spatial dependence. Semi-desert vegetation showed large between-year differences in spatial organisation. Dynamic neutral models suggest that niche differentiation is the dominant mechanism in loess and dolomite grasslands, while competition is the strongest organizing factors in semi-deserts. Disturbance has the greatest effect on the fine-scale spatial organisation in tallgrass prairie and soil heterogeneity in alkaline grasslands.

The genetics of a recent climate change driven range expansion

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Linum leonii (Linaceae) is a short-lived perennial growing in dry grasslands in France and Germany. Initial records of numerous German populations of *L. leonii* within the last decades indicate a recent shift of its range towards northern direction. We studied the genetics of 35 populations of *L. leonii* using AFLP markers. Six primer combinations resulted in 109 polymorphic bands indicating very low overall genetic variation within the species. The expected heterozygosity (HW = 0.036) and the mean number of polymorphic loci per population (5.1) were also low. In contrast the populations were strongly differentiated as indicated by a FST-value of 0.74. AMOVA, cluster analysis, and principal coordinate analysis revealed a high proportion of genetic variation among three sub-ranges of *L. leonii* located in South and Central France and in Germany.

Both, low genetic diversity within and high genetic differentiation between populations are in line with the predominantly selfing breeding system of *L. leonii* which in turn is indicated by a very low outcrossing rate (tm = 0.034). The number of private alleles per population strongly decreased from south to north which might cause by the direction of migration of the species. Large populations in Germany which apparently do just increase might also indicate a recent shift of the range northwards presumably due to climate change.

Distinguishing adaptive from non-adaptive genetic differentiation in *Carlina vulgaris* at different geographical scales

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Genetic variation is determined by four evolutionary processes: mutation, selection, random genetic drift, and gene flow. Patterns of genetic variation are often studied using selectively neutral molecular markers. However, the evolutionary ability of a species to respond to environmental changes depends on genetic variation in adaptive traits which are influenced by selection. Patterns of variation in these two types of traits may differ substantially.

We studied the within and among population-genetic variation in both quantitative traits and AFLP markers of the short-lived, monocarpic *Carlina vulgaris* at a European scale. *Carlina vulgaris* occurs in semi-natural grasslands throughout Europe, but has declined due to habitat deterioration and fragmentation in the last decades. We studied variation in several quantitative genetic traits in offspring from 74 populations of *C. vulgaris* from seven geographical regions (S Sweden, W Netherlands, C Germany, S Britain, NW Czech Republic, Luxemburg, and NW Switzerland). In addition, AFLP markers were studied in five randomly chosen populations from each of the seven regions.

The overall proportion of quantitative genetic variation that occurred among populations was 76%, with most of that variation (40%) among regions indicating strong population differentiation in quantitative traits. In the AFLP study, the overall proportion of genetic variation among populations was much lower (34%). Most of the genetic differentiation (AFLP patterns) was found among regions (28%), whereas the variation among populations within regions was small (6% of total variation).

The higher regional differentiation in quantitative traits suggests that at the large scale selective forces (Qst > Fst) which are closely related to geographical distances are most important for population differentiation. Furthermore, at the small scale genetic drift or environmental differences that are not related to geographical distances are also important. As conclusion we suggest that for generating tools for species conservation, both neutral molecular markers and of quantitative markers reflecting local adaptation should be considered.

Response of clonal growth to defoliation: a key of plant success in grazed pastures?

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Grazing is a complex biotic factor that influences vegetation structure and species composition through its direct and indirect impacts on plants. Tolerant plants, which are able to regrow and reproduce after defoliation, are expected to be more abundant under grazing conditions. Recurrent defoliation is likely to damage flowers, and thus to slow down sexual reproduction. However, most plant species in meadows are able to reproduce not only sexually but also asexually through the vegetative production of ramets (clonal growth). We tested the hypothesis that grazing pressure selects plants that enhance their clonal growth in response to defoliation, at the expense of sexual reproduction.

Species importance (percentage of vegetation cover) was determined in pastures that experienced three different grazing pressures. In addition, clonal growth under optimal conditions and responses to simulated defoliation was surveyed for the nine most abundant species of these pastures.

Clonal plants dominated the vegetation cover along the entire grazing gradient (87% on average), but grazing pressure influenced the abundance of six out of the nine studied species. Defoliation had no impact on clonal growth for seven species. It increased the number of ramets for only one species, which happened to be the dominant species in non-grazed conditions. Among the seven plant species that flowered during the experiment, six maintained flower production when defoliated, proving the ability to compensate for flower damage.

Contrary to our hypothesis, both clonal growth and sexual reproduction were maintained irrespective of the defoliation intensity. Thus, differences in species abundance along the grazing gradient can not be related to the enhancement of the vegetative production of ramets in response to defoliation. Future studies should take biomass allocations into account as some clonal growth modes could enable plants to compensate for biomass losses by the way of storage in clonal organs and resource reallocation after damage.

Scrophularia in riverine tall-herb nitrophilous communities along continentality and summer drought gradients in central-western Europe

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Muddy, sandy and stony deposits on the upper part of river beds are often colonized by hygro-nitrophilous communities dominated by *Epilobium hirsutum*. The river deposits are a perturbed habitat which remains flooded during heavy rain periods. The location of these habitats in the upper part of the river bed contributes to deposition of fine material as well as gravel and sand. Several perennial herbs adapted to these unstable areas grow there. Autumn floods destroy them, and the resultant organic matter rests there increasing the nitrification of the habitat. In summer, with the low water, these hygro-nitrophilous megaphorbs grow very fast and form communities characterised by high and dense canopy. These communities are often dominated by *Epilobium hirsutum* growing with other tall-herbs such as *Urtica dioica, Eupatorium cannabinum, Filipendula ulmaria, Mentha longifolia* and lianellas such as *Calystegia sepium* and *Solanum dulcamara*. Although there are some associations described from different regions of western-central Europe, the floristic composition appears quite similar all over this area. Intriguing is the occurrence of ecologically analogous *Scrophularia* species in the different associations and territories.

The aim of this work was to correlate the continentality gradient from western to central Europe and the summer drought gradient from central to southwest Europe with the changes in the floristic composition of these communities.

We have collected a data set with relevés available in the phytosociological bibliography and in some vegetation databases from Europe (SIVIM, BioVeg, Dutch National Vegetation Database, Czech National Phytosociological Database), first one in *Quercus* program by X. Font and the rest in Turboveg program by S.M. Hennekens. These vegetation data have been used for numerical analysis together with several environmental data, most of

them bioclimatic parameters and indices such as Ic (continentality index of Rivas-Martínez), P (annual average precipitacion), It (thermicity index of Rivas-Martínez) and Io and Ios3 (annual and estival ombrothermic index of Rivas-Martínez). We have also used as environmental data the rivers and basins where the relevés come from.

Up to now several analyses carried out with data from Iberian Peninsula show a positive correlation between the species composition of the relevés and the above mentioned environmental variables; this specially fits well with some ecologically analogous taxa of *Scrophularia* (*S. auriculata* subsp. *auriculata, S. auriculata* subsp. *pseudoauriculata, S. lyrata* and *S. nodosa*). A similar correlation at European level can be expected also in case of still another *Scrophularia—S. umbrosa*.

Acknowledgements: This work has been partly supported by the project CGL2006-13421-C04-04 of Ministerio de Educación y Ciencia (Spanish Government). We thank Stephan Hennekens (Wageningen, NL) and Milan Chytrý (Brno, CZ), who kindly provided some data from their vegetation database.

Does fire enhance flowering in Brazilian subtropical grasslands?

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Subtropical grasslands in southern Brazil are very rich in species; disturbance has an important role on the maintenance of plant diversity and grasslands physiognomy. Unfortunately, little is known about the effects of fire on vegetation regeneration and dynamics. We aimed to evaluate the effects of fire on flowering in this ecosystem. Studies were carried out in Porto Alegre (southern Brazil, 30°03' S, 51°07' W; 311 m alt.) in natural grasslands. Always in summer, flowering plants were identified in 30 plots (0.25 m^2, except for T1, 14 plots) randomly selected in each of three sites with different fire histories: 30 days (T30), 1 year (T1) and 3 (T3) years since last fire. Additionally, the number of flowering stems was counted for plots in T30 and T3. For further statistical analyses, species were classified into functional groups (graminoids, forbs and shrubs). We evaluated the differences in number of flowering species and flowering stems.

Our results show that forbs have a significant increase in number of flowering species for all the different fire histories ($p \leq 0.05$). Number of graminoids species increased only 1

year after fire ($p \leq 0.05$) but shrubs have shown no increase over this time period. Considering flowering stems for all groups, a higher number was observed at T30 ($p = 0.006$), but flowering stems of graminoids and shrubs showed no significant differences, only forbs ($p = 0.001$). Our results showed that fire has an important effect on plant phenology, mostly on forbs, enhancing flowering of many species (e.g. *Chaptalia runcinata*, *Macroptilium prostratum*, *Stylosanthes montevidensis*). Therefore, there would be a higher production of seeds, enhancing post-fire colonisation. In this sense, the absence of fire leads to a decrease in plant diversity in Brazilian subtropical grasslands by reducing diaspore release and, consequently, reducing the chance of seedling establishment.

Modelling spatial-dependent processes associated with the dynamics of forest-grassland mosaics in south Brazil

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The main factors and mechanisms allowing forest-grassland co-occurrence in south Brazil are still not well known. Besides the favouring of forests over grasslands under present climate conditions, a fundamental question is how spatial and temporal relations operate with the factors and mechanisms affecting establishment and survival of forest elements in campos grasslands.

Spatial-dependent processes such as seed dispersal and colonisation as well as fire behaviour were simulated using a cellular automaton model. Distance from seed sources, aggregation level, and arrangement of natural patches as well as other small-scale site heterogeneity (e.g. occurrence rock outcrops) compose attributes involved in the preferred routes taken by dispersers. In the model, these attributes are used to characterise landscape grid, and to define types and distribution of spatial tensions (axial, polar, diffuse) for dispersion. These tensions were used to calculate centrality values for each cell to be used in the evaluation of potential cellular growth, which further would compose the spatially distributed potential for forest expansion. Further, fire acts in preventing forest expansion in these mosaics. Attributes that characterise fire events (probability of ignition, intensity, frequency, and propagation) in part are also related to landscape spatial attributes such as fuel biomass, arrangement of vegetation types, slope and orientation of the terrain. A two-dimensional deterministic fire growth model was used to simulate fire behaviour. The interplay between all these spatial-dependent attributes was used to evaluate forest expansion under different disturbance and climate scenarios.

Plant functional types as predictors of nutrient status in mire vegetation

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We determined foliar concentrations of major nutrients (N, P, Mg and K) in 42 species growing at different habitats (hummock, scrub, lawn, fen meadow, hollow and marginal stream) in five mire sites in North Italy. These habitats spanned a wide range of environmental conditions as regards both depth to the water table and water chemistry.

The species were grouped into five major plant functional types (PFTs), currently used to analyse ecological gradients in mire vegetation: *Sphagnum* mosses, evergreen shrubs, deciduous shrubs, graminoids and forbs. Our objectives were to assess: *(i)* to what extent PFTs account for variations in foliar nutrient content; *(ii)* if and to what extent the observed patterns vary in relation to habitat.

Foliar concentrations of K showed the greatest range of variation, followed by Mg, P and N. PFTs differed strongly from each other in terms of foliar nutrient contents, with forbs exhibiting overall highest and *Sphagnum* overall lowest nutrient contents. Conversely, graminoids, deciduous shrubs and evergreen shrubs all showed differing patterns for individual nutrients. In particular, graminoids had high foliar N concentrations, similar to those of forbs, but lower foliar concentrations of P, Mg and K. Deciduous shrubs and evergreen shrubs had different foliar N concentrations but similar foliar concentrations of P, Mg and K.

The component of variance associated with PFTs together with the component of variance associated with species accounted for the majority of the total variance in foliar nutrient content. However, habitat was an important source of variation when the nutrients were analysed separately for individual PFTs. In particular, *Sphagnum* sp., graminoids and, to a lesser extent, deciduous shrubs revealed as reliable predictors of nutrient status in mire habitats. Conversely, in forbs and in a less extent in evergreen shrubs, a large component of variation was associated to species.

Using high-quality vegetation plot datasets to restore ecosystems: an example from the Coastal Plain of the Southeastern US

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The degree to which restoration efforts are deemed successful is typically based on the succession trajectory of a site to its predefined target condition. The processes by which the target condition is determined can vary, and restoration efforts may ultimately be hindered if the target is poorly described within the region of study. Reference sites of undisturbed, late-seral-stage ecosystems are needed to quantitatively define regional (less than one km^2) community types, which can then be used to successfully determine target conditions for restoration efforts. Over the past twenty years, the Carolina Vegetation Survey has acquired high-quality biotic and abiotic records from over 6,000 vegetation plots distributed across North and South Carolina, USA. Recently, we used the CVS database to assess the ability of an existing classification, the US National Vegetation Classification (NVC), to define target conditions for restoration. We focused on non-alluvial wetland community types in the southeastern Coastal Plain of the Carolinas, a region largely defined by its complex distribution of unique wetlands. Over half of the association-level vegetation units currently recognized by the NVC for the Coastal Plain of the Carolinas are wetlands. These systems vary considerably in terms of species richness, geomorphology, soil, hydrology, and disturbance history.

We classified 184 plots containing 601 species using hierarchical cluster analysis techniques and then used non-metric multidimensional scaling to define groups based on soils and geomorphology. Our analyses indicated a need for substantial revision of the NVC classification. Of the 56 associations recognised in the current study, 21 are newly described, 30 have complex relationships with one or more previously-described associations, and only 5 remain unchanged from their original NVC delineations. We were unable to assess 37 associations because we were lacking appropriate data. Ultimately, we designed a hierarchical framework to guide restoration efforts using the newly described classification units. Once defined, these classification units were mapped and identified to a biogeographic region. Regardless of seral-stage, restoration sites were delineated into specific classification units by identifying environmentally stable discriminants. Classification models were used to select the appropriate composition of species within a restoration site. Finally, monitoring plots were established to ensure that the succession trajectory of a restored site would reach its predefined target condition. This hierarchical framework provided a necessary platform to filter a rigorous community classification dataset into a usable structure that restoration managers could use to guide successful and ecologically meaningful restoration efforts.

The phytosociology of the afromontane fynbos communities on Platberg, Eastern Free State, South Africa

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Platberg (highest peak: 2394 m) towering about the town of Harrismith (eastern Free State, South Africa) is the largest and highest inselberg within the archipelago of more than 20 inselbergs north of the main massif of the Maloti/Drakensberg range. Within the Platberg area and the wider Drakensberg region, the shrinking natural resources and the threat posed to biodiversity are of concern to conservation management and require an understanding of long term ecological processes.

As part of an ecological survey to establish afromontane floristic links to the Drakensberg as well as for the sake of management of natural resources, we studied the remnant montane fynbos vegetation of Platberg. Using TWINSPAN classification in combination with the Braun-Blanquet table-sorting methodology, two major fynbos communities comprising four sub-communities and seven variants were recognised. Twenty two endemic or near endemic species to the Drakensberg Alpine Centre and 22 alien (partly invasive) species were recorded. Strong floristic links with the Cape flora fynbos vegetation and the grassland bioregions to the north and west of Platberg were established.

Using a broad scale vegetation map of Mountain Zebra National Park (South Africa) to assist with management decisions

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Mountain Zebra National Park (South Africa) has been expanded over the last couple of years from its original extent of 6536 ha (1960) to approximately 21,000 ha today. In

order to develop scientifically sound management programmes for conservation areas it is essential that an inventory of its natural resources is undertaken.

This poster reports on phytosociological surveys done to determine the nature of plant communities in these newly acquired areas of the Park. The detailed vegetation descriptions for the various new and old areas of the Park were combined into a synoptic table. The resulting broad-scale vegetation map is presented and divides the Park into 12 vegetation units that can be identified in the field. Habitat factors associated with differences in vegetation include topography, soil form and grazing. Descriptions of the plant communities include the dominant species as well as prominent and less conspicuous species of the tree, shrub and herbaceous layers. It is believed that this broad-scale vegetation map will assist Mountain Zebra National Park management in making science-based conservation decisions on the Park and its biota.

Physiological mechanisms for guild-based assembly rules in a lawn community

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The physiological mechanisms behind plant assembly rules are unknown. We investigated this in a lawn community where assembly rules have been convincingly demonstrated. We defined the functional niches of selected species in relation to their acquisition and use of light and responses to defoliation. We assessed leaf placement ability and sensitivity to light quality and quantity using novel photogrammetry techniques to record leaf movement, and conventional morphological measures including petiole lengths, leaf area, chlorophyll a/b ratio and biomass. As mowing is a major environmental component, the temporal niche of species during the defoliation/regrowth cycle was also investigated by examining changes in carbon: nitrogen ratio, stored carbohydrates, and root growth after clipping.

Species exhibited a range of responses and great plasticity, and some support for the assembly rule mechanisms was found.

Hot spots of plant species density on the plot scale

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Famous for high species richness are tropical forests at larger scales, while calcareous and subtropical grasslands and alpine vegetation at smaller scales. The Arctic hardly comes to one's mind when thinking about diversity hot spots. Our Greenland-based vegetation studies, however, revealed remarkably high values of species richness at small scales, a phenomenon regarded by some in category of a world record. Still, despite numerous diversity studies, no standards for richness exist to confirm this.

Therefore available published sources were screened for species-rich plot data collected in physiognomically homogeneous vegetation. In order to include as many different vegetation types as possible, the number of plots taken from each source was restricted to the four richest plots, not more than two of a community type, and only one of a community type and plot-size. Species-poor vegetation was omitted. Counted were vascular plants, bryophytes and lichens, and, in the rare cases when given, also algae.

The 500 richest plots from 225 sources, featuring more than 380 different communities, 38 countries on 6 continents were collated. The species richness of the 500 plots was plotted against plot size, both variables on log-scale.

With help of the lower and upper quartiles, preliminary ranks for richness are proposed. The lowest 25% are defined as moderately rich with 18–26*A and A = plot area in m^2 raised to the power 0.1, the middle 50% as rich with 27–41*A and finally the highest 25% as very rich with 42*A and more. Exceptionally rich at the large scale were the Costa Rican rain forests (233 species/100 m^2), followed by mediterranean shrub vegetation (119/64 m^2). At small scales the highest values were found in calcareous grasslands (100/25 m^2), Arctic tundra (95/25 m^2, 84/4 m^2, 71/0.25 m^2), savanna (84/4 m^2), limestone pavements (80/4 m^2), and in alpine vegetation (82/1 m^2).

Species were classified into morphologic-taxonomic-functional types following our experience with the Arctic vegetation as follows: woody, herbaceous, and graminoid species), bryophytes (acrocarpous and pleurocarpous mosses, hepatics) and lichens (crustose, foliose, fruticose).

In the majority of the plots herbaceous vascular plants contributed the most to richness, even in dry grasslands and in most forests. In the relevés from the Arctic, fruticose and

crustose lichens and acrocarpous mosses were most important. Our study shows, that cryptogam-rich arctic-alpine vegetation seems to hold the world-record of richness only at the small-scale (about 0.25–2 m^2), however at the larger scales (4–25 m^2) it is still comparable with communities famous for their high species richness. The high diversity of Arctic vegetation can only be appreciated, if cryptogams are taken into account.

Acknowledgements: The German Research Foundation funded my studies of the vegetation of Greenland.

Effects on vascular plant diversity and functional traits after coppicing disturbance in beech forests, Central Apennines, Italy

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In Central Italy, coppicing is still a traditional method of woodland management, in which young tree stems are cut to near ground level. In subsequent years after cutting, many new suckers emerge and start a regeneration process. In the Marche Region small stands (0.5–2 ha) of mountain beech (*Fagus sylvatica*) woodlands are cut in a cycle of 25–35 years.

We aimed to answer the following questions: *(i)* How does coppicing affect the beech forest plant diversity under different environmental conditions? *(ii)* What kind of changes in plant functional traits occur, in terms of Leaf Dry Matter Content (LDMC) and Specific Leaf Area (SLA), along the regeneration process after disturbance? A stratified random sampling was conducted according to 200 m elevation classes, bedrock types and stand age, to identify 61 sites. In this system, 80 sampling units of 20 x 20 m were assessed using phytosociological methods. Species were also grouped into phytocoenological groups. In a sub-set of 13 sites, a species sample was collected to measure the above-mentioned traits.

Our results suggest that high spatio-temporal variability of forest management and high landscape-scale heterogeneity maintain a relevant regional species pool. Time since coppicing explained the majority of observed diversity changes: about 40–60 years after coppicing, the contribution of the beech specialist species doubled, while non-forest species decreased. The beech specialist and forest generalist showed a progressive increment of SLA and a progressive decrement of LDMC over regeneration. The 'non-forest species'

did not show a clear adaptation trend along the forest regeneration process. We conclude that a prolongation of coppice rotation or abandonment would result in lower local species richness, but also in higher contribution of beech forest specialists, and complete regeneration of the compositional and functional diversity of beech forest understorey.

Pattern of plant traits in trampled vegetation along climatic gradient in Europe

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Trampling is an action exerting pressure on the soil surface by man and animals or by driving of vehicles. There are several consequences of trampling for vegetation, the main being mechanical damage of tillers, compression of soil reducing aeration and the water content in soil. In this paper we studied group of European thermophilous communities (dominated by plants characterised by C4 assimilation pathway) appearing in the late summer in trampled habitats. Here we attempt to find out which plant functional traits would reflect the diversity patterns within the studied communities.

A synoptic table from Čarni & Mucina (1998) was used as it represents a synthesis of trampled vegetation over a broad range of climates in Europe. It contains a matrix of 341 taxa x 21 syntaxa. A restricted set of plant traits (incl. life-form, Grime's strategies, chorotypes, and Ellenberg's indicator values) was selected as data for many traits were not readily available for all species in our dataset. The analysis based on plant functional traits corroborated the classification patterns revealed by the above-mentioned syntaxonomic classification. As the most important traits we identified chorotypes as being particularly informative; these correlate with temperature and to a certain degree with moisture.

Čarni, A. & Mucina, L. 1998. Vegetation of trampled soil dominated by C4 plants in Europe. *J. Veg. Sci.* 9: 45–56.

Acknowledgements: The research was carried out in the framework of the programme Fauna, Flora and Vegetation of Slovenia and Neighboring Regions (P1-0236) funded by the Slovenian Research Agency.

Dynamics, succession and species turnover on an accreting coastal sand dune system

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At present there is a worldwide tendency towards shoreline erosion with a consequent progressive retreat of backshore cliffs and dunes. The sand dunes from the littoral north of Portugal are a good example of a coast submitted to a severe inland displacement of the shoreline. Such erosion may be ascribed to the changes in the sediment budget (caused by anthropogenic activities). Jetty construction poses a barrier to sediment transport and promotes sediment deposition around the breakwaters in the northern sector. These changes are an important force capable of moving coastal sediments and altering landform shape. The beaches and sand dunes accretion in the northern sectors of jetties cause an important vegetation impact. The construction of the Aveiro jetties in 1951 provided a singular chance to study species turnover on a rapidly changing sea-shore. Moreover, there is evidence of succession correlated to strong dune accretion taking place along the São Jacinto Reserve (N Portugal). Permanent transects were used to compare 1989 and 2007 observations, in order to monitor changes in topography and vegetation in a rapid-changing substratum.

The objective of this study was to investigate community dynamics, diversity patterns and also individual species turnover patterns, using GIS and multivariate techniques. Data treatment is carried out by means of canonical correspondence analysis focusing on spatial and topographic features, modelled as a trend surface, as explanatory variables of turnover and diversity shifts. The results suggest that the main environmental controls of composition and diversity seem, in fact, to be associated with topography changes rather than any other factor. Results corroborate both radical changes on α- and β-diversities due to creation of new habitats. Examples of this are the promotion of large stretches of secondary dune allowing several chamaephyte-dominated vegetation types to exhibit greater dominance and mosaic diversity (c.f. β-diversity). Also a rise in α-diversity of chamaephytes was observed in the new secondary dune stretches. Moreover, both α- and β-diversities of annuals seem to have dropped in the secondary dune stretches. On the other hand, an inverse tendency, that of a rise in diversity of annuals on the new areas of primary and

embryonic dunes, is observed. Strong disturbance rates and rapid habitat changes also seem to facilitate the dominance of aggressive invaders such as *Carpobrotus edulis*, whereby strong local dominance leads to pitfall α-diversity drops.

Qualitative change in taxonomical and coenotical diversity is expected in rapid-growing dune systems and has to be taken into account for conservation issues.

Integrating hypotheses of invasion ecology into a single framework reduces theoretical redundancy and can guide research

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To understand how and why alien species can dominate and change the communities and ecosystems they invade, ecologists need to first understand the processes that enable and drive successful invasion. Invasion ecology includes myriad hypotheses. While empirical evidence suggests that most of these can explain the success of some invaders to some degree in some circumstances, the relative influence of different invasion processes and contending hypotheses is unknown.

A review of 29 leading hypotheses illustrates that invasion ecology is encumbered by theoretical redundancy that can be removed by integration. Structured around propagule pressure (P), abiotic characteristics (A) and biotic characteristics (B), with the additional influence of humans on P, A and B (hereon PAB), we show how these hypotheses fit into one paradigm. P is based on the size and frequency of introductions, A incorporates ecosystem invasibility based on physical conditions, and B includes the characteristics of invading species (invasiveness), the recipient community and their interactions. Having justified the PAB framework, we propose a way in which invasion research could progress. Using both holistic and incremental approaches, we show how the PAB framework can be used to quantify the relative importance of underlying invasion mechanisms. If the prime aim is to identify the main cause of invasion success, we contend that a top-down approach that focuses on PAB maximises research efficiency; it identifies the most influential factors first and narrows the number of potential causal mechanisms. Such an overarching framework helps to organize research and foster links among subfields of invasion ecology and ecol-

ogy more generally. By viewing invasion as a multifaceted process that can be partitioned into major drivers and broken down into a series of sequential steps, invasion theory can be rigorously tested, our understanding improved, and effective weed management techniques identified.

Acknowledgements: Funding for J.A.C.'s three-month period at Umeå University (Sweden) in 2006 was provided by CSIRO Land & Water, Cooperative Research Centre for Australian Weed Management and University of Melbourne. Meeting attendance was made possible by CSIRO.

Vegetation of the lowland tropical rainforests in Taiwan

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The lowland rainforests of Taiwan are situated at the northern edge of the Tropics, and were classified as the *Ficus–Machilus* forest zone of Taiwan. These forests are not only subjected to wind disturbance from typhoons and northeast monsoon, but they are also threatened by human activities. The aim of this study was to gain insight into structure of the remnants of these lowland rainforests. We used TWINSPAN to analyse existing vegetation datasets from 2202 historical plots and new field surveyed plots from Taiwan and two nearby islands (Orchid and Green Islands).

The studied forests were composed of 698 species of trees and shrubs, and were dominated by broad-leaved species from the families Moraceae, Lauraceae, Euphorbiaceae, Araliaceae, Myrtaceae, Guttiferae and Myrsinaceae. The first TWINSPAN division separated plots in the Orchid Island and Green Island from the main island, suggesting differences related to biogeography and the isolation of these small islands. There was a greater proportion of southern Malesian floristic element in the two offshore islands. Further subdivisions of the remaining Taiwan samples resulted in four major groups, including southern, northern, lowland, and foothill forest types. The results suggest that in the Taiwan main island forests are reflecting geographical and topographical differences in altitude and elevation. We also found that lowland rainforests of Taiwan differed markedly from those in tropical SE Asia, both in terms of physiognomy and floristic composition.

Spatial patterns of tree species in the Nanjenshan lowland rainforests in Taiwan: insights into monsoon wind effect

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Annual monsoon wind is one of the major disturbances of forest communities in southern Taiwan. To understand wind effects on tree distributions, four lowland rainforest plots, experiencing different intensities of monsoon winds in this area, were examined. Ripley's K function was employed to determine species spatial distribution patterns in wind-stressed and sheltered plots.

Wind-stressed plots accommodated significantly more aggregated species and less randomly distributed species than sheltered forests. When considering large trees only, the proportion of aggregation was reduced in each plot. No species displayed a regular distribution pattern in any size class. Different intensities of aggregation possessed by wind-stressed and sheltered plots implied that environmental factors, such as wind intensity, might be an important factor controlling species spatial patterns and, therefore, forest structure.

Species diversity and plant groups of vegetation along the altitudinal gradient in Lanyang River watershed, NE Taiwan

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We sampled 175 plots (500 m^2 each) and investigated a total of 1085 species in the Lanyan River watershed (Taiwan). These plots ranged from the sea level to altitudes around 3500 m. The patterns of species richness (S) along the altitudinal gradient were found to be

hump-shaped, with a peak near 1000 m of alt. within the ecotone spanning the lower montane and montane zones. Diversity (Hi) of woody species and of ground-layer herbs also showed a hump-shaped response along the altitudinal gradient. Evenness of both woody and herbaceous species was unimodal, but the evenness of woody species showed more pronounced hump-like response than that for the herbaceous species.

The number of species of Moraceae, Lauraceae, Fagaceae and gymnosperms were not markedly higher in particular altitude zones, but the basal area did vary with altitude. The basal area was the highest for Moraceae below 600 m, for Lauraceae and Fagaceae between 600 m and 2300 m, and for gymnosperms above 1800 m. Along the altitudinal gradient, herbs (incl. Poaceae, Cyperaceae, Rosaceae, Fabaceae, Orchidaceae, and pteridophytes) showed high species richness. However, the highest species numbers were in pteridophytes and Orchidaceae, mostly distributed between 600 and 2400 m, while Poaceae, Cyperaceae and Rosaceae were mostly distributed below 300 m and above 3500 m. The numbers of endemic species were highest between 900 and 1200 m, but the incidence of endemics increased with altitude. This pattern was found also in the other parts of Taiwan.

The analysis of beta diversity with the interval of 200 m showed that the highest turnover rates occurred between the coast/plain and subtropical lower mountains, and between the subalpine coniferous forest and the alpine belt.

The diversity patterns along the altitudinal gradient in the Lanyang River watershed did not support the Rapoport's Rule. We assume that the increased diversity in the mid-altitudes is mainly controlled by higher humidity and rainfall at those elevations.

Spatial determinants of plant species diversity in a Natura 2000 Network

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Assessing the effects of the spatial components on species diversity in a network of protected areas represents an important step for assessing its conservation 'capacity'. A clear evaluation on how α, β, and γ diversity are partitioned among and within spatial scales can help to drive management decisions and provide methods for monitoring species diversity. Moving from these concepts, a probabilistic sample of plant species composition was applied here for quantifying plant species diversity within the Sites of Community Importance (SCIs) of the Natura 2000 network in the Siena Province (Tuscany, Italy).

All analyses were performed separately for all species and those species defined as 'focal' (included in regional, national or continental 'red' lists).

The results indicate that species richness of the SCIs differed from one location to another, independently from sampling effort. Diversity partitioning indicated that most of the flora diversity within the network was generated by larger-scale β-diversity, i.e. the differences in species composition among the SCIs. Beta-diversity was then decomposed in two components: βArea (due to the differences in area among SCIs) and βReplacement (due to the compositional differences across SCIs). βArea was particularly important for all species, while βReplacement was the most important factor for focal species. The consequent implications for monitoring and nature conservation strategies are discussed.

Identifying environmental factors influencing tree species altitudinal distribution patterns along the latitude gradient in Taiwan

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The objectives of this study were to describe altitudinal distribution patterns of plant species along the latitudinal gradient in Taiwan, and identify the most influential environmental factor controlling these patterns. Three east-west oriented belts with similar altitudinal ranges (all up to 3500 m) were sampled on the north, centre, and south of the Central Mountain Range (CMR) stretching from the north to the south of Taiwan. Each belt was further divided into two regions (east-facing and west-facing slopes of the CMR). The species distribution data for each region were extracted from the dataset of a national vegetation mapping project in Taiwan.

The uppermost altitudinal limits of tree species shared in these six regions were markedly lower in the north-east and central-east regions, whereas uppermost limits of trees in the other four regions did not differ significantly. The direct contribution of the Massenerhe-

bung effect, which should result in a pattern that species distribute higher in the central of the CMR and lower in the north and south regardless of the aspect, to the altitudinal distribution pattern is disproved. The winter monsoon blows southeastward and brings the cold and moist air to Taiwan. The altitudinal distribution pattern in Taiwan is the consequence of weakening of the winter monsoon on the leeward side and in the southeast part of the CMR due to the topographic effect of the CMR on the winter monsoon.

Species richness of Euro-Siberian steppe and forest-steppe: effects of productivity, pH, climate and species pools

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Many high-latitude floras contain more calcicole than calcifuge vascular plant species. The evolutionary species pool hypothesis explains this pattern through historical abundance of high-pH soils in the Pleistocene and an associated opportunity for the evolutionary accumulation of calcicoles. However, high-pH soils are mainly linked to dry areas where calcium leaching from soils is limited and plant growth is limited too due to adverse effects of drought on productivity.

To obtain insights into the history of Central European species pools, we studied the relationships between species richness, pH, productivity and climate in cool and dry steppe and forest-steppe landscapes of southern Siberia which are the closest modern analogue of the Pleistocene environments of Central Europe. We sampled vegetation and environmental variables across long gradients of pH and precipitation in the Southern Urals, Altai and Western Sayan Mountains. We supported this hypothetical analogy by comparison of modern pollen deposition and mollusc communities from Siberia with fossil pollen and mollusc data from Central Europe.

In all studied areas species richness was strongly positively related to productivity, and productivity increased with moisture and temperature. At the same time, species richness was influenced by soil pH. Steppe grasslands occurring on base-rich bedrocks were usually richer in species than nearby grasslands on base-poor bedrocks, provided they did not significantly differ in available moisture. However, when moving towards drier areas on the same bedrock, soil pH generally increased (because of reduced leaching), but species richness decreased due to a negative effect of drought on productivity. Species richness of steppe was therefore negatively correlated with pH.

We suggest that in continental Euro-Siberian steppe, the largest species pools evolved or survived on soils with a pH of 6–7 because adverse effects of low pH and drought are balanced in such habitats.

Bioclimate and vegetation studies at Cape Verde Islands

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According to the bioclimatic classification system of the Earth proposed by Rivas-Martínez, the bioclimate of the Cape Verde Archipelago ranges from tropical desertic to tropical pluvioseasonal. When considering bioclimatic belts, thermotypes range from the upper infratropical to the upper thermotropical, and ombrotypes vary from the upper hyperarid to the low humid.

Field studies were made in last three years on Sal, Boavista, Maio, Santiago, Fogo, São Nicolau, São Vicente, and Santo Antão, on several plant communities, such as dunes, salt marshes, scrublands and woodlands. The vegetation is tropical and differs from that of Azores, Madeira and Canary Islands.

In this work we describe several new plant communities, classified within endemic classes such as the Zygophylletea waterlotii typical of the on dune habitat in low thermotropical hyperarid belt, and the Sarcocostemetea daltonii of woodlands and scrub. In the latter class we distinguished the Sarcostemetalia daltonni (scrub), and the Acaciatalia albidae (woodslands). The order of Sarcostemetalia comprises two alliances, such as the Sarcostemion daltonii (lowland vegetation of desertic to dry ombrotype belts), and the Artemision gorgonii (vegetation of hills and mountains of the subhumid to humid ombrotype belt). For the woodland we describe three alliances, such as the Sydroxylo marginatae–Acacion albidae, Phoenicion atlanticae, and Tamaracion senegalensis.

Short-term assemblages or co-evolved communities? An analysis based upon vicariance pattern

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Starting from the debate between superorganismic concept (Clements) and individualistic concept (Gleason) I ask whether present species combinations reflect palaeo-associations and whether one can study the evolution (symphylogeny) of communities. The degree of vicarism is used as an indicator for parallel evolution. If the cladogenesis resulted in species remaining in the ecological and sociological context of their ancestors, a supraspecific classification allows defining ecological niches of genera; it points out the co-evolution of the involved taxa, and it offers insight as to which habitats shelter primitive or derived taxa.

Synvicarism is a common phenomenon. Several types of vicarism can be distinguished, using examples ranging from the temperate climate to subtropical and tropical regions:

1. Zonal vegetation types and plant communities from not too extreme and not too isolated habitats are composed of common, vicariant, and unrelated species. Examples are the Mediterranean forests (Querco–Cedrea), scree communities (Heldreichietalia), and epiphytic bryophyte communities in tropical forests (Lejeuneo–Frullanea = Coeno–Plagiochiletea).
2. Under extreme environmental conditions such as in salt marshes and on coastal cliffs we observe a close correlation between phylogenetic and ecological groups (Puccinelliea, Spartinea, Cakilea, Crithmo–Staticetea) (taxon-habitat-coupling-hypothesis). Those habitats are often colonised by vicarious taxa, which give origin to monospecific or species-poor communities.
3. Another evolutionary trap is the rocky environment. Vicarious and primitive taxa are overrepresented. Rock-crevice communities are 'ancient' communities. A supraspecific classification allows the detection of historical and evolutionary patterns, for example the distribution range of the ancestor community. This is demonstrated by the communities colonizing halve-caves (stone overhangds) with dripping water in the Mediterranean area (Adiantetea), and by comparing succulent vegetation from SW Arabia and the Canary Islands (Kleinio–Euphorbiea and Crassulo–Aloea).

Many elements of present-day phytocoenoses have been associated for a long time. This is contradictory to a purely individualistic concept of biocoenoses. The reality lies in between 'co-evolved' and 'short-term'.

Evolution and adaptations of the 'matorral costero suculento' (coastal succulent scrub) in Baja California, Mexico

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The vegetation in the mediterranean-climate regions of the world is characterised by evergreen sclerophyllous trees and shrubs. In the mediterranean region of North America—California (USA) and Baja California (Mexico) —the chaparral and the coastal sage scrub form are the most abundant and dominant vegetation. However, in the northwest of the Peninsula Baja California, at latitudes spanning 30°00' and 32°30' N, unique and endemic community, so called 'matorral costero suculento' (coastal succulent scrub) occurs. The characteristic of this matorral is the abundance of succulent plants of the families (Cactaceae, Agavaceae, Crassulaceae and Euphorbiaceae) typically occurring in arid and semiarid regions.

We ask several questions about this matorral vegetation and its flora, in particular: (1) What is the origin of this flora? (2) Why do succulent plants occur in this Mediterranean region? and (3) Which climatic conditions control the establishment of this plant community?

We used bioclimatic data as well as floristic and biogeographic analyses to answer these questions.

Varying diversity patterns of different plant groups at different spatial scales in central European landscapes

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'Biodiversity' has been an important catchphrase both in science and in politics for some 15 years now. Well-funded research programs, countless publications, and even complete new journals have been devoted to the study of biodiversity, its patterns and causations as well as its decline and how this can be halted. Beside this enormous effort, some very basic pieces of knowledge are still missing, even in such well-studied regions as central Europe.

The question how species rich the central European landscape is on average can well be answered for scales from quadrants of topographic map sheets onwards (> 25 km^2) but not for scales below that. However, square metres or some dozens or hundreds of square metres are the scales at which different plant species directly interact with each other and at which studies on conservation or restoration of biodiversity are usually focussing. Yet, these studies are still lacking a well-founded benchmark to evaluate their results. Moreover, the few available studies/reviews with data of species densities on small scales usually provide only values for preconceived plant community types without actually knowing *(i)* how representative the used relevés are for the respective community and *(ii)* what proportions of a landscape are covered by the different types. Finally, most studies on plant diversity so far only deal with vascular plants and exclude bryophytes and lichens. Our aim therefore was to measure the average plant species richness for all plant groups and to characterise plant diversity pattern different spatial scales, using a new standardised approach.

For this purpose we selected two contrasting landscapes in the North German Lowlands, namely the area (126 km^2) of the topographic map sheet 2728 (Lüneburg) in Lower Saxony, NW Germany (ca. 35% forest, 10% grassland, 30% arable land, 25% settlement), and a sector of 6 km^2 of the topographic map sheet 3049 (Brodowin), Brandenburg, NE Germany (ca. 50% forest, 25% grassland, 20% arable land, 5% settlement). Within both investigation areas, we placed series of nested plots randomly and irrespectively of homogeneity with the help of a GPS (50 in Lower Saxony, 16 in Brandenburg). In each of these series, we recorded all species (shoot presence) of vascular plants, bryophytes, and lichens on plots of 0.0001 m^2, 0.0009 m^2, 0.01 m^2, 0.09 m^2, 1 m^2, 9 m^2, and 100 m^2 size. In each series, all plot sizes smaller than 100 m^2 were replicated four times in the four corners of the 100 m^2 plot.

In Lower Saxony, we found an average of 1–2 species on 1 cm^2, 8–9 species on 1 m^2, and 38–39 species on 100 m^2 (range: 2–137). The values for Brandenburg were consistently higher for all spatial scales (by 4%–29%). Non-vascular plants contributed a significant share to the overall plant diversity in both regions and at all spatial scales. On 100 m^2, for example, bryophytes constituted 15% and lichens 11% of average plant species richness. The most frequent plant species in both study areas and at all spatial scales besides the

smallest was the moss *Brachythecium rutabulum*, which occurred in more than 80% of all 100 m^2 plots. Also, the other most frequent species highly coincided between both regions, with the grasses *Lolium perenne* and *Elymus repens*, the forbs *Taraxacum* spp. and *Stellaria media*, the moss *Hypnum cupressiforme*, as well as the lichen *Lepraria incana* being present in more than 1/3 of randomly chosen 100 m^2 plots, each.

The species-area relationship was best described by a power law with a mean z value (increment) of 0.22 (fitted for log-transformed species richness). Beside substantial differences in the z values between individual plot series (range: 0.15–0.41), z values showed a general pattern of scale-dependency with a minimum between 0.0009 and 0.01 m^2. The observed increase towards larger plot sizes differs from published findings within homogeneous vegetation stands, where z values generally remain constant or even decrease with increasing plot size. We further analysed the species-area relationship separately for taxonomic groups and species of different floristic status (native, archaeophyte, neophyte, ornamental plant), and correlated diversity parameters to stand structure, landscape type, and site conditions.

We conclude that our flexible approach allows for objective comparison between differently structured landscapes and between various geographic regions. The approach is particularly promising in analysing biodiversity patterns simultaneously on multiple spatial scales and thus being capable of detecting relationships of diversity parameters to predictor variables that change direction with spatial scale.

The basiphilous semi-dry grasslands (Festuco–Brometea) in N and NE Europe: gradient analysis and large-scale classification

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The aim of our study was to develop a comprehensive and consistent classification of the basiphilous semi-dry grasslands (Festuco–Brometea) in the Nordic (Scandinavian) and

circum-Baltic regions. This area includes ten countries or parts of them, including Norway, Sweden, Finland, Russia, Estonia, Latvia, Lithuania, Poland, Germany, and Denmark. Further we aim to unravel gradients in species composition and species richness across the studied regions and reveal the role of relevant ecological factors structuring the complexity of the Festuco–Brometea.

For the purpose of this study, we made use of the phytosociological database of the 'Working Group on Dry Grasslands in the Nordic and Baltic Region', which is a joint project of colleagues from all ten listed countries. Ultimately, our aim was to include in the database all available relevés (both published and unpublished) of the dry grasslands and related vegetation types from the study area. As prerequisites for inclusion of the plots into the database we consider the size of the relevés not to lie outside 1 m^2 and 100 m^2 and presence of basic metainformation on the locality of a relevé. Presently, the database contains some 8000 of the ca. 20,000 suitable relevés we are aware of. For the present study, we attempted to enter at least all relevés showing obvious similarities to the Festuco–Brometea.

The first decisive step in any classification is to delimit the syntaxon in focus unambiguously throughout the studied dataset. It is evident that this delimitation can neither be based on the original assignment of the relevés nor on an à priori classification of all vegetation types of that area (as such a system is not available). Therefore we used generally accepted diagnostic taxa of relevant classes and assigned each relevé to the one class according to prevailing diagnostic species. The obtained sub-set of the Festuco–Brometea relevés was than subject to a series of classification analyses. We present the pros and cons of each approach used, and present here a new, robust phytosociological classification of the studied communities.

Vegetation/land cover dynamics in agricultural and urbanised landscape in Molise, Italy

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A GIS analysis of the transformation of the land cover in last fifty years using information from 1954–1955 (aerial photographs, cadastral maps) and 2005 (aerial photographs) was done and created maps adapting the CORINE land cover legend at a scale of 1:10,000. Our study area comprises six municipalities of the Italian Molise Region, covering an area of approx. 31,750 ha. This hilly region, spanning altitudes 200 m and 550 m, includes part

of the Molise coastline (approx. 23.5 km long) between the rivers Trigno and Biferno. It is an area which has undergone a great anthropogenic (agricultural) impact since the World War II. However, the area still has natural components that are worth preserving. In the area there are seven Sites of Community Interest (sensu 'Habitat Directive' 92/43/CE) which have humid, coastal, badlands and riverine habitat types.

The multi-temporal comparison of the obtained information allowed to define the developmental trends within the study area, and to quantify them using a series of landscape indicators (such as Class area, Number of Patches, Mean Patch Size, Largest Patch Index, Mean Shape Index, Mean Patch Fractal Dimension, Mean Nearest Neighbour Distance, Mean Proximity Index, Interspersion and Juxtaposition Index).

The PVN (potential natural vegetation) is represented by forests classified within the Quercetalia pubescenti–petraeae and the Quercetalia ilicis. The vegetation of the coastline is very peculiar and supports communities of the classes of Thero–Salicornietea, Cakiletea maritimae, Tuberarietea guttatae, Ammophiletea, Arthrocnemetea, Juncetea maritimae, Phragmito–Magnocariceta, Pegano–Salsoletea, and Ononido–Rosmarinetea.

We presume that our study will assist territorial-planning decisions (especially landscape planning) in fields such as management of water and coastal ecosystems, nature heritage and the like.

Assessing primary vegetation development on sea-born volcanic islands of the Mediterranean (Aegean Sea, Greece)

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Santorini (S Cyclades, Greece) is one of the active volcanoes of the South Aegean volcanic arc, with more than 12 major eruptions during the past 250,000 years. Our study focused on the oceanic volcanic islands Palea (PK) and Nea Kameni (NK), characterised by dif-

ferent ages and vegetation histories. Our research was based on a data set of 93 relevés and investigated the main patterns of vegetation differentiation on the two islands, and whether species niche segregation exists or whether species of dissimilar ecological preferences make up the species assemblages. Cluster analysis was used to distinguish different species assemblages, detrended correspondence analysis (DCA) was used to investigate the main ecological gradients, and Outlying Mean Index (OMI) analysis to explore species niche breadth and marginality, and thus species niche segregation. In the latter analysis, environmental factors such as altitude, ground inclination, total vegetation cover, relief, aspect, age of geological substrate, distance from the shore and Ellenberg Indicator Values (EIVs) were used.

The classification revealed the following seven plant communities (3 on PK and 4 on NK), which are briefly outlined in terms of species composition, ecology and distribution: *Limonium graecum* comm. (on aged coastal rock, crevices and ledges, heavily salt-sprayed), *Atriplex halimus–Lycium schweinfurthii* comm. (halo-nitrophilous scrub on aged coastal rocks and debris, salt-sprayed), *Pistacia lentiscus* comm. (the most prominent vegetation unit on the island's plateau on aged deep ashes and rocky debris); *Lupinus angustifolius–Helichrysum italicum* comm. (therophytic vegetation on young, deep, fine ashes), *Lupinus angustifolius–Hyparrhenia hirta* comm. (steppe-like vegetation on young shallow fine ashes), *Lupinus angustifolius–Umbilicus rupestris* comm. (on young coarse ashes rich in lava rocks with additional 'runoff' water from dew), *Lupinus angustifolius–Tolpis barbata* comm. (on young fine ashes; first stage of colonisation before perennials enter the competition). The main ecological patterns revealed by DCA concern the different floristic composition of the two islands which can be attributed to their different ages, the EIVs for nitrogen, and distance from the shore. The OMI analysis revealed significant species niche segregation on the basis of the environmental variables used in the analyses. Species niche segregation was also significant when OMI analysis was applied in data subsets representing each of the two islands.

Floristic, coenological, and biogeographical features of three coastal humid areas of Puglia region (southern Italy)

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This study was as part of an INTERREG project (III A Italy-Greece 2000–2006), in particular the Measure 3.1 aimed at the amelioration and management of some common ecosystems found on both sides of the Adriatic Sea. This project, covering western Greece and the Italian region of Puglia, involves the implementation of GIS allowing to acquire, process and analyse ecological data. These data were collected in three important coastal protected areas of the Puglia region, namely Torre Guaceto, Le Cesine, and Saline of Punta della Contessa. The importance of these humid areas is illustrated by the high number of Dir. 92/43 EEC habitats occurring here such as 1120 *Posidonia* beds; 2250 Coastal dunes with *Juniperus* sp. pl.; 1510 Mediterranean salt steppes; 2260 dune sclerophyllous scrubs; 9340 *Quercus ilex* forests; 1210 Annual vegetation of drift lines; 1410 Mediterranean salt meadows; 2110 Embryonic shifting dunes; 2120 Shifting dunes with *Ammophila arenaria*; 3170 temporary ponds; 1240 Vegetated sea cliff with endemic *Limonium* sp. pl.; 6420 Mediterranean tall humid grassland; 2130 Fixed dunes with herbaceous vegetation.

In order to preserve this fragile natural ecosystem from the wide range of anthropogenic factors that are currently threatening the Mediterranean retro-dune areas, a detailed phytosociological study of the small-scale plant community mosaic as well as of the potential vegetation types was conducted. The three Apulian humid sites differred from each other both floristically and coenologically. In addition to slight differences in their physical environments, the reciprocal floristic and vegetation diversity is likely to be related to biogeographical boundaries which cross the southern Apulia and which are expressed by the variation in the ecological behaviour of the main diagnostic species more than to the coincidence of their distribution areas limits.

Light quality, not quantity, segregates germination of grazing increasers from decreasers in Mediterranean grasslands

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Grassland plant species have traditionally been classified into two groups with respect to changes in their relative abundance in the presence or absence of grazing: increasers and decreasers. Underlying ecophysiological mechanisms of such a classification are still unclear.

An experiment was conducted with seeds of ten Mediterranean species of known grazing status under different conditions in order to test the hypothesis that herbivory selects species with light-dependent germination amongst grazing increasers. We established one treatment with two light quantity levels (Photosynthetically Active Radiation) and another with five light quality levels (Red:Far Red ratio; R:FR). Germination percentage related to viable seeds and number of days required to get 50% of germination (T50) were measured in the five replicates of each light treatment and species combination. There were no differences in response to light quantity between the two grazing status groups, and germination was inhibited in both groups at higher light intensities. However, increasers had lower germination percentages in low R:FR ratios, whereas decreasers were not affected by light quality. Germination speed (T50) was affected by light quality, regardless of grazing status, but not by light quantity. There was an increment in germination speed at the lowest R:FR ratio. Increaser seeds germinated faster than those of decreasers. These results reveal that light quality plays a key role in determining the species composition of Mediterranean grasslands affected by herbivores via its effect on germination.

The dynamics of natural mortality and tree structure in Oranienbaum Park in NW Russia

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We studied (during from 1981–2003) changes of in mortality of tree species in Oranienbaum Park (NW Russia, near St Petersburg), a woodland area of 161 ha. These woodlands are dominated by broad-leaved species such as lime (*Tilia*), oak (*Quercus*), and ash (*Fraxinus*). Our study used 13,256 sample trees and the following tree parameters were recorded: tree species identity, DBH, condition class, degree of crown shading, and tree age.

During the period 1981–2003, tree mortality rates in the Oranienbaum park varied between 1% to 3% annually for healthy (1st vitality class) and moderately healthy (2nd vitality class) trees, and between 3.9% and 9.3% for declining trees. Lowest mortality rates were observed for *Tilia cordata* and *Quercus robur* (0.8% and 1.0%, respectively), and the highest rate was recorded for *Betula pubescens* (2.7%). An analysis of the mortality rates in different age groups of different tree species showed that the greatest mortality for the majority of species was observed in young (< 40 years old) and old (>100 years old) age groups. Mortality rate of maple, lime and oak increased with age.

For maple, oak, linden and spruce significant differences ($p < 0.05$) between average diameters of the alive and dead trees were detected. Thus, in the younger and middle age groups diameter of dead trees less than the average diameter for the same age groups. Within the group of old trees (> 100 years), DBH of the trees died after 1981 were significantly higher compare with DBH of living trees.

The mortality rate of old and middle aged trees was higher mostly in open stands. We also found that for the young oak and maple trees mortality rate increased as higher the canopy closeness increased. For lime the relationship between mortality rate and canopy closeness appeared to be the opposite.

Grassland ecology along an urban-rural gradient using GIS techniques in Klerksdorp, South Africa

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Urban areas represent complex assemblages of unique vegetation communities. The multitude of influences on cities adds to this complexity rendering them an intriguing study object from an ecological point of view. Understanding the underlying patterns and processes operating in urban areas becomes increasingly important with large scale urbanisation, making urban areas potential conservation sites of the future. The urban-rural gradient approach often used to study these patterns and processes, aims to quantify the existing gradient allowing comparisons of vegetation at different locations, each with diverse human influences. However, accurately quantifying the urban areas became difficult with the realisation that gradients are non-linear and complex.

Previous studies were not truly comparative due to differences in measures used to quantify the gradient and a lack of a well-defined definition for urban areas. Our study in Klerksdorp (North-West Province, South Africa) focused on testing a model developed in Melbourne (Australia) in an attempt to contribute towards creating a standard set of measures to quantify the urban-rural gradient. The methods used in Melbourne aimed to set a general standard with which to globally compare urbanised areas taking into account the entire extent of the study area allowing multidimensional insights into the unknown gradients. At the heart of the approach is the main objective to observe if any global patterns emerge able to shed light on urbanisation influences.

In our study, SPOT5 HRV satellite imagery and GIS techniques were used to calculate measures representing demographic and physical variables, as well as landscape metrics. The accuracy of the demographic measures was constrained by the scale of the available census data and subsequently more information is needed.

Preliminary results show that road network density, landscape shape index, number of patches, and the largest patch index best quantified the observed gradient. Clear differences were observed in the extant vegetation composition of comparable grassland patches at different locations along the gradient, showing that urbanisation does influence vegetation composition and survival. Patterns and processes emerging from these studies could drastically influence planning and implementation actions concerning human development. In our study, potential changes in grassland ecology were identified with vegetation surveys studying both the extant vegetation and the soil seed bank, identifying possible unique vegetation combinations, and quantifying the influence of human impacts along the gradient.

Acknowledgements: This work was supported by a South African Student Travel Grant provided by the Regional Section for Southern Africa of the IAVS.

Vegetation ecology of phytogenic hillocks (nabkhas) in coastal habitats of Jal Az-Zor National Park, Kuwait

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The purpose of this study was to examine and describe ecology of the vegetation small phytogenic sandy hillocks (Arab. 'nabkha'). Nabkha is a mound-like accumulation of wind–driven sediments around vegetation. Nabkha is one of the most frequent aeolian deposits along the coastal plain of Kuwait. We investigated 42 nabkhas in a coastal habitat of Jal Az-Zor National Park, Kuwait.

Sixty-two species were recorded (47 annuals and 15 perennials) in the studied nabkhas. Four vegetation types were recognised after classifying the vegetation of the nabkhas by TWINSPAN, and named after their dominating species as follows: *Nitraria retusa* Com-

munity, *Zygophyllum qatarense* Community, *Haloxylon salicornicum* Community, and *Panicum turgidum* Community. Using ordination techniques such as detrended correspondence analysis and canonical correspondence analysis we assessed the relationships between the environmental gradients, floristic composition, species diversity, and geomorphology aspects in the studied habitats. The notable environmental variables affecting the distribution of the vegetation types in the study area were: geomorphology aspect, size of plant forming the core of the nabkha, moisture content, mineral contents, salinity, sand, silt, and pH.

Vicariant geographical types of open coniferous-birch hemiboreal forests in northern Asia: ecology, genesis of flora and classification

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Hemiboreal forests in northern Asia are an intermediate zonal type between true boreal forests and temperate steppes. The subject of this paper is to characterize the vicariant types of light mixed coniferous-birch forests widespread in western and eastern parts of the continent. Throughout the hemiboreal zone these forests show similar physiognomic features, such as an open canopy layer consisting of small-leaved and light-coniferous trees (*Betula*, *Larix*, *Pinus*), well-developed herb layer, and a sparse moss layer. We used the floristic classification of mixed small-leaved forests (classified following the Braun-Blanquet approach) to elucidate the links and similarities between the studied vegetation units, climatic factors and peculiarities of the genesis of the regional floras. The typical hemiboreal forests of the western (sub-Atlantic) geographical sector were grouped within the Brachypodio–Betuletea pendulae. Here European-Siberian and West-Palaearctic moderately thermophilous mesophytes predominated. Hemiboreal open-canopy coniferous-birch mixed forests of the Querco–Betuletea davuricae occurred in the eastern (sub-Pacific) geographical sector, which is characterized by a monsoon climate. The characteristic core of the latter class is represented by East Asian thermophilous xero-mesophytes. An ordination suggests that the amount of winter precipitation is the leading macro-ecological factor of formation of the hemiboreal forests bioclimatic types. Snow cover is the most important ecological factor controlling the patterning of the continental hemiboreal forests because hemicryptophytes and cryptophytes form approximately 85% of the floristic composition. Snow cover plays its controlling role in winter period and it also protects plants from sharp temperatures fluctuations in autumn and spring. Snow cover has less of an impact on the distribution of trees. That is why it is difficult to reveal the significance

of snow on the basis of physiognomic features. The vicarious classes defined on the basis of floristic criteria show outstanding macroecological and plant-geographical differences of the regional zonal forest types formed under the influence of different climatic regimes caused by Atlantic and Pacific Oceans.

Links between plant community composition, soil organic matter quality and microbial communities in contrasting tundra habitats

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Plant communities, soil organic matter and microbial communities are predicted to be interlinked and to exhibit concordant patterns along major environmental gradients. We investigated the relationships between plant functional type composition, soil organic matter quality and decomposer community composition, and how these are related to major environmental variation in soil pH, originally imposed by bedrock heterogeneity. We determined vegetation, organic matter and decomposer community compositions from five non-acidic and five acidic heath sites in an alpine tundra of northern Europe. We found strong linkages between vegetation, organic matter and decomposer system. Non-acidic heath sites with high soil pH were rich in forbs and soluble N in organic matter, had low C:N ratios and high nutrient availabilities, and supported higher proportion of bacteria in microbial communities than acidic heaths. In contrast, acidic heaths with low pH were dominated by dwarf shrubs, had phenol-rich organic matter with high C:N ratios and low nutrient availability, and were associated with higher proportion of fungi in decomposer system than non-acidic heaths. In multiple regression analyses, high forb: shrub ratio of vegetation was significantly positively associated with high soil pH, high concentration of labile N, low concentration of phenolics and low proportion of total C in organic matter, and high proportion of bacteria in microbial community. Our study shows that plant community composition, soil organic matter quality and microbial community composition are strongly interconnected, and that changes in one compartment are paralleled by predictable changes in others. These results indicate that variation in forbs-shrubs gradient of vegetation largely dictates variations in the chemical quality of organic matter and decomposer communities in tundra ecosystems. Soil pH amplifies the interactions between above and below ground systems and seems to function as an inherent environmental controller of the development of plant and microbial communities.

Long-term effects of the abandonment of grazing on calcareous herbaceous species in central Portugal

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The massif Calcário Estremenho is situated in the centre-west region of Portugal and had its origins in the Jurassic. Caves, screes and limestone pavements make this massif the biggest karstic landscape in the country. The vegetation predominantly comprises semi-deciduous forest (with *Quercus faginea* subsp. *broteroi* and sometimes with *Q. suber*), at the bottom of valleys, dry forest of *Q. rotundifolia*, and arborescent matorral of *Quercus coccifera* with *Q. x airensis* (a hybrid between *Q. coccifera* and *Q. rotundifolia*). The matorral form the first stage of forest replacement or represent mature communities in habitats where environmental conditions do not permit establishment of forest. The rocky habitats and pioneer vegetation are frequent in these landscapes. They comprise (1) calcareous rocky slopes with chasmophytic vegetation of the Asplenion glandulosi (Asplenetalia glandulosi, Asplenietea trichomanis) with *Asplenium ruta-muraria, Chaenorrhiunum origanifolium, Narcissus calcicola*, (2) rupicolous calcareous grasslands of the Calendulo lusitanicae–Antirrhinion linkiani (Phagnalo–Rumicetea indurati) with endemic taxa such as *Dianthus cintranus* subsp. *barbatus* and *Iberis procumbens* subsp. *microcarpa*, and (3) mediterranean pseudo-steppe with grasses and annuals of the Brachypodion distachyi (Helianthemetea guttati), supporting rich annual flora. Semi-natural dry grasslands occur here in mosaic with low scrub. The grasslands on calcareous substrates (Festuco–Brometea) are dominated by *Brachypodium phoenicoides* and contain rich orchid flora. The tomillar of the Rosmarinetea officinalis is dominated by *Thymus silvestris* and other heliophilous low scrubs. They correspond to very regressive replacement stages of mature forest.

In order to assess the influence of abandonment behind the use of land in the floristic composition through time, a comparison process was developed using relevés carried out in 25 permanent plots sampled in 1963 and 2008 in the same period of the year. Our analyses showed that despite of less important structural modification, floristic diversity in the sampled sites was higher 45 years ago. This reduction is attributed to the expansion of arborescent matorral, mainly due to the total absence of grazing during the last 20 years.

Gallery forest in Cuba: plant diversity, conservation state, and challenges for restoration actions

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In Cuba gallery forest is a plant formation with a historical process of degradation. The analysis of some aspects like plant diversity and conservation status must precede future efforts for those gallery forests that require restoration. Therefore the objectives of this work were: (1) to examine published literature about Cuban gallery forest from the perspective of the contribution to knowledge of this vegetation, (2) to discuss key findings about plant diversity and conservation of Cuban gallery forest, and (3) to identify main challenges for future restoration actions.

It was found that only few research projects was devoted exclusively to gallery forest and the most of the work on similar vegetation generally concerns watersheds. Plant diversity in these forests varies considerably according to soil characteristic, surrounding vegetation, and among flat and mountainous areas. A higher endemism was found on serpentine soils in the mountains. Conservation state of Cuban gallery forest depends of type and intensity of land uses of adjacent lands. Most of the invasive species found are non-exclusive elements of this vegetation. However, Syzygium jambos is typically found in degraded gallery forest. Have been developed Some projects targeting restoration or rehabilitation have been started with support of national legislation, however, in future these projects must include a major participation of human community and monitoring programs to evaluate the success of the implemented management.

What matters for vegetation regeneration—seedlings or resprouters? An example from Brazilian campos grasslands

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Subtropical grasslands in southern Brazil are very rich in species, maintained mostly by

grazing and fire. When disturbance is excluded, there is a decrease in plant diversity and shrub and forest species invade grasslands. Unfortunately, vegetation regeneration is not yet well studied. Hence, we aim to study regeneration after fire and mowing. A study was carried out in southern Brazil (Morro Santana, 30°03' S, 51°07' W; alt. 311 m) in two different areas: frequently burned and excluded from fire for a period of six years. Seven plots (2 x 2 m) were established in each area and for each treatment (fire and mowing, 28 plots). Six subplots (0.2 x 0.2 m/plot) were established for vegetation relevés. Prior to treatment, all species were identified and covers estimated. They were grouped in functional groups (graminoids, forbs, and shrubs) for statistical analyses. Experiments were performed during summer. Observations were carried out after 30 (T30) and 90 (T90) days. Seedling establishment was also followed after 360 days (T360).

More than 80% of all species showed the ability to resprout after aboveground biomass removal. More seedlings could be observed in burned plots (T30), (mostly forbs) and seedlings of shrubs (obligate seeders) were found at T360. Moreover, in burned plots there was a higher recruitment via seedlings of new species than in mowed plots. More species resprouted in mowed plots. However, they were usually the ones present before experiments (ca. 70%). We found a negative correlation between number of resprouters and temperature measured at soil level ($r = -0.78$, $p = 0.0023$).

Our results suggest that vegetation regeneration via resprouting is the most important strategy in Brazilian subtropical grasslands. Recruitment via seedlings occurs mostly in forb species just after fire experiments and for obligate seeder shrubs after one year. Thus conservation biologists should also consider vegetative regeneration for the management of subtropical grasslands in southern Brazil.

Bud bank and belowground systems: their importance for vegetation regeneration in Brazilian campos grasslands

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Subtropical grasslands in southern Brazil (also called 'campos') are often under influence

of disturbance, mainly fire and grazing. Vegetation recovering occurs mostly by vegetative regeneration, with the seed bank playing a secondary role. We aimed at analysing the importance of the bud bank and belowground organs for vegetation regeneration and maintenance of biodiversity in subtropical grasslands. Five areas under different disturbance regimes and histories were chosen: *(i)* grazing (EEA), *(ii)* frequently burned (MsFB), *(iii)* excluded from disturbance for six years (MsE6), *(v)* excluded for 15 years (APN15), and *(iv)* excluded for 30 years (ESA30). A total of 20 soil cores (20 x 20 x 15 cm) were sampled in each area, except for EEA (20 x 20 x 10 cm cores, 15 samples). Belowground biomass was sorted into different functional groups (graminoids, forbs and shrubs). Organs were classified into bulbs, rhizomes, xylopodia, tuberous roots and underground stems. Only viable buds were counted.

We found a significant decrease in bud bank density with an increase in intervals between fire events. Grazed areas showed the highest densities, mostly from graminoids, whilst excluded areas (APN15 and ESA30) had the smallest bud banks. Forbs showed the most drastic decreases ($p \leq 0.05$) in bud bank density in absence of fire. Xylopodia and tuberous root structures were typical for areas under influence of recurrent fires (MsFB and MsE6) and diversity of belowground systems also decreased with absence of fire. Xylopodia are not typical storage organs, but with high gemmiferous potential present in many species in campos grasslands and 'cerrado' in Brazil.

Our results show the importance of considering bud bank analyses in studies of vegetation regeneration and mechanisms of maintenance of biodiversity in subtropical grasslands. The long intervals between disturbances would lead to a loss of regeneration capacity of many species (mostly forbs). Consequently, there would be a loss of plant diversity in these areas and even if fire occurs, vegetation regeneration will not reach its full potential.

Patterns of alien plant distribution at multiple spatial scales in a large national park

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Biological invasions are among the most pressing issues facing conservation managers. In an effort to provide strategic direction to management interventions, much emphasis is placed on collecting spatial data, but often with little understanding of how the data is to be used. We used a unique data set from the Kruger National Park (KNP), South Africa, to assess the implications of spatial scale in developing an understanding of the distribution of invasive alien plants. Using 27,000 alien plant records collected over the entire area of the KNP (2 million ha), we assessed the impact of patterns of alien plant distribution at nine spatial scales, ranging from point data to presence/absence data at the resolution of quarter-degree cells. The influence of scale in evaluating alien plant distribution is underestimated, as visually evaluating maps at different spatial scales substantially alters the perceived patterns of invasion and would subsequently impact management planning. Scaling up from smaller to larger grid cells always distorts the abundance and distribution patterns. Scattered, patchy distribution patterns appear continuous, suggesting that the entire area is invaded. Data at a point-scale and up to a resolution of 500 m cells appear useful for relating species to environmental features. Data at a resolution coarser than 1 x 1 km cells looses too much detail to be particularly useful for determining environmental correlates as the habitats and local scale details are aggregated. Interestingly, data at the quarter-degree scale provides a highly distorted image of the real pattern of invasion, even when considered across an area of 2 million ha.

Linking genes to ecosystems: local genetic diversity drives production in species-rich limestone grassland

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Plant diversity has been shown to influence ecosystem functioning at both the species and genetic levels, but it remains unclear how these components of diversity interact to influence ecosystem properties in species-rich communities.

We created experimental microcosms using eight genotypes each of eight outbreeding plant species clonally propagated from a 10 x 10 m area of calcareous grassland in Derbyshire, England, and measured annual rates of aboveground biomass production over a three-year period. Despite all being derived from mature, proximate individuals in the field, genotypes of most species exhibited considerable differences in performance. Geno-

type performance depended strongly on neighbourhood composition, relating to both the specific and genetic identity of proximate individuals. Four-species communities were no more productive than monocultures of the dominant grass *Festuca ovina*, but *Festuca* communities planted with four genotypes were on average more productive than one- or four-species communities containing a single genotype.

Our results suggest that genetic diversity can influence ecosystem productivity by mediating interactions at the species level, and can alter dominance relationships between species. For communities dominated by perennial outbreeding plants where local genetic differentiation is often substantial, genetic diversity has the potential to significantly alter the way that plant species regulate ecosystem functioning.

Determinants of similarity of dry evergreen forests in Kenya to other forest regions of Africa and Asia

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The dry evergreen forests of Kenya (occurring close to Nairobi) are very unique on global scale. The main canopy species in these forests are *Brachylaena huillensis* (Compositae), *Elaeodendron buchananii* (Celastraceae), *Drypetes gerrardii* (Euphorbiaceae) and *Calodendrum capense* (Rutaceae). Many other plant taxa in these forests (e.g. including *Celtis, Diospyros, Ficus,* and *Olea*) are shared with similar forests of tropical and subtropical Asia. They occur at elevations of about 1700–1900 m. At higher elevation (around 2190 m) the species composition is similar to that of rainforests of lowland South Africa (200–600 m), as indicated by species such as *Apodytes dimidiata, Olea capensis, Ilex mitis, Brachylaena* sp., and *Psydrax* sp. In the forests at altitudes spanning 850–1460 m in South Africa, the common taxa include: *Cassipourea malosana, Drypetes qerrardi, Nuxia congesta, Ochna holstii, Rothmannia capensis* as well as species of the genera *Syzygium, Ficus* and *Croton*, etc. These forests characterise eastern Africa too. Miombo forest species are similar to those of savannas of western Africa, but there is no similarity in the dry evergreen forest or rainforest. This would have been caused by different climatic conditions and evolutionary history in western and eastern Africa. Some genera, especially *Syzygium*, *Psychotria, Rapanea, Ilex,* and *Shefflera*, are common in both East Africa and SE Asia.

Alteration of ecosystem processes by invasive plants in the South African Fynbos

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The Cape Floristic Region/Kingdom is the smallest of the world's six floral kingdoms and boasts one of the world's highest concentrations of plant species, of which about 69% are endemic. The predominant vegetation types in the biome are the fynbos shrublands which occur on nutrient-poor substrates. Thousands of hectares of natural fynbos have being invaded by alien tree and shrub species. Alien plant invasions can lead to changes in species composition and may change ecosystem functions such as nutrient cycling, water availability and fire regimes.

We compared the impact of three different invasive species from genera such as *Acacia, Eucalyptus* and *Pennisetum* on fynbos ecosystems. The objectives of our study were to investigate the impact of invasive alien species on indigenous above-ground vegetation, to determine whether invasion altered the native soil seed bank, and to examine the changes in physical and chemical soil properties. For each of the alien invaded sites we chose an intact reference community. Lower species richness and indigenous plant cover were observed in all alien invaded sites compared to the reference sites. However, a comparison of species richness in the soil seed bank showed no significant differences between sites. Higher levels of nitrogen, total phosphorus, and total organic matter were found in the *Acacia* thickets and the planted stands of *Eucalyptus,* while all micro-element concentrations in the *Eucalyptus* stands were from double up to four times higher than at in the reference site.

The results of this study have implications for restoration protocols for alien invaded sites. As a key step in restoring fynbos, it is recommended to investigate the optimal ground preparation treatments to implement prior to indigenous species re-introduction. Strategies of returning soils to pre-invasion levels of nitrogen are burning or the application of mulch. To reduce the phosphorus level by ploughing or the application of aluminium in form of aluminium sulphate (gypsum) are recommended.

Floristic heterogeneity of *Festuca airoides*-dominated grasslands in the Romanian Carpathians

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The Carpathian grasslands dominated by *Festuca airoides* (the Potentillo chrysocraspedae-Festucetum airoidis Boşcaiu 1971) are distributed from the upper montane belt (alt. 1700 m) to the alpine belt (alt. 2400 m). A collection of 211 published relevés was compiled by selecting only those samples where the tufted *Festuca airoides* appeared as dominant. The classification of relevés was performed using a non-hierarchical clustering method based on non-parametric density estimation. All relevés included in small size clusters (less than 10 members) were considered outliers and removed from subsequent analyses. The ecological interpretation of the clusters was assisted by indirect ordination (principal components analysis, PCA) and indicator species analysis.

Three clusters were distinguished and called as typical (83 relevés), closed (18 rels.), and open facies (12 rels.), respectively. The latter is characterised by a low vegetation cover and a high frequency of *Juncus trifidus*, suggesting disturbed stands or an early dynamic stage. The closed facies stands have high vegetation cover and dominance of *Festuca airoides*, which might represent either a post-disturbance phase or a late seral stage. The typical facies is somewhat intermediate and can be distinguished through the high frequency of *Agrostis rupestris*. The three facies are clearly separated along the first PCA axis, which is negatively correlated with the abundance of *Festuca airoides*. Only the typical facies is well spread along the second PCA axis, which is positively correlated with the abundance of *Potentilla aurea* subsp. *chrysocraspeda*, a Carpathian endemic typical of oligotrophic soils.

A large amount of residual floristic variation, due to unknown factors, is incorporated in the numerous outliers (98 relevés). In spite of the large altitudinal range, the floristic composition of these grasslands seems to be mainly influenced by disturbances and/or substrate conditions, including soil depth, water capacity, and rockiness.

Phylogenetic structure of local communities predicts the size of the regional species pool

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A major challenge in ecology is to explain species diversity in ecological communities. The species pool concept claims that large-scale processes like speciation, extinction, and dispersal processes in the regional flora or fauna; species are then further filtered to the species pool of local communities based on the species' ecological requirements. The regional species pool is thus a set of species available in a region and ecologically suitable for growing in the particular environment occupied by a local community.

As species pools are largely influenced by evolutionary processes such as the conservation of ecological niches within lineages we hypothesize that the size of the regional species pool increases with the variety of distinct phylogenetic lineages represented in a local community. We call this the Niche Conservatism Hypothesis of species pools. Alternatively, evolution may affect species pools by massive diversification of individual lineages in particular environments, thereby increasing the species pools in these environments. Local communities sampled from such species pools enriched by diversification will be characterised by a low phylogenetic distinctness of their constituent species. We call this the Diversification Hypothesis of species pools. Finally, the phylogenetic structure of a local community may be the idiosyncratic outcome of stochastic movement and local extinction of species across present-day communities, blurring any link to the size of the evolved species pool. This is our Null Hypothesis.

Analysing field-layer communities across a wide range of environments in Estonia (N Europe) we indeed found that local communities composed of phylogenetically highly distinct species recruit from larger species pools than communities of low phylogenetic distinctness. This confirms our Niche Conservatism Hypothesis. These results help us to understand how the species pool was assembled throughout evolution in different types of environments (immigration vs. *in situ* radiation of individual lineages).

Functional diversity, competition and community assembly during primary succession

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Trait-state diversity in co-occurring plant species can either show trait convergence, meaning that trait-states of these species are less variable compared to a randomly chosen community (e.g. from the species pool), or trait divergence, meaning that trait-states of coexisting species are more divergent. In order to quantify the relative importance of different functional traits for community assembly, it seems promising to analyse the changes in the diversity of trait-states during ongoing community assembly, i.e. primary succession, and relate it to changes in environmental factors and biotic interactions, especially competition.

In this study we tested the following three hypotheses: (1) traits not exposed to inter-specific competition show trait convergence; (2) functional traits that are related to inter-specific competition show trait divergence; and (3) trait-state diversity is positively related to competition intensity, i.e. vegetation cover.

The presented analysis is based on 1318 vegetation relevés of ten alpine glacier forelands of four different regions (Berner Alps, Rheinwald, Ötztaler Alps and Hohe Tauern). The glacier forelands were divided into three different succession stages, representing a natural gradient of competition intensity, i.e. vegetation cover.

The approx. 280 vascular plant species occurring in the vegetation relevés were characterised by 12 life-history traits (growth form, SLA, canopy height, clonality, flower class, flowering time, flower colour, buoyancy, epizoochory potential, terminal velocity, seed mass and seed surface). These plant traits differed in their sensitivity to inter-specific competition: e.g. traits related to insect pollination like 'flower-class' are exposed to (intensive) inter-specific competition for pollinators whereas 'terminal velocity of the seeds', a measure of wind dispersal potential, is not exposed to (direct) intense inter-specific competition. The traits were taken from own measurements and from trait-databases such as BIOPOP, DIASPORUS, and LEDA.

For each vegetation relevé and each trait we calculated trait-state diversity by calculating the standard deviation (for numerical traits) or the Simpson Index in its negative logarithm (for categorical traits) and compared it with trait-state diversity of a null model. We found no major differences between Da of numerical and categorical traits. The Diversity Index (DI) was calculated as the difference between the actually observed trait-state diversity (Da) and that of the null model (DA) divided by the standard deviation of the null model (SD (DA)). The standardisation with SD (DA) allowed a comparison between traits with different underlying variability.

DI = (Da - DA) / SD (DA)

whereby:

DI = Diversity Index,

Da = Trait-state diversity in species set a (standardised by mean),

DA = Trait-state diversity of the null model (here: mean of 20 randomly selected replicates from the entire species pool),

SD (DA) = Standard deviation of trait-state diversity of the null model.

We found trait convergence in all seed and dispersal related traits. Trait divergence was found in all traits related to inter-specific competition. These patterns can be explained if the diverging traits are strongly affected by competition for resources and if species with similar resource use strategies are less likely to coexist. In contrast, the converging traits may be mainly adaptations to non-consumable environmental factors (i.e. excluding competitive effects) and thus species with similar trait combination are filtered by the environment.

Remarkably, with increasing competition intensity (increasing vegetation cover), also traits for which no inter-specific competition was expected to shift towards trait divergence. These changes of trait-state diversity in these 'non competitive' traits can be explained by allometric effects and trade-offs (acting within one individual plant) with other functional traits that are affected by competition.

The presented patterns of trait-state diversity, which we observed during primary succession on glacier forelands, allow drawing conclusions that help for a better understanding of the functional basis of community assembly.

Detection of reed-bed decline and die-back at the Trasimeno Lake (central Italy)

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During the last decades the reed vegetation suffered a strong decline which can be referred to as die-back—still not well understood in the Mediterranean. Studies into this phenomenon in the peninsular Italy are still lacking. The shortage of data is perhaps the main

reason, why it is generally believed that the reed die-back is not an important issue in the (sub)mediterranean region.

This study targeted the reed beds of the Trasimeno Lake (central Italy), considered among the largest in Italy, and chosen because of the occurrence of symptoms of the reed decline. Each of 19 plots, located at 7 main sites, was monitored in 2006 and 2007. The analysis focused on population macro-morphologic, morpho-anatomic, and floristic-vegetation aspects. According to the available literature, a set of meaningful traits was selected, believed to point out the actual occurrence of the reed decline. These parameters included (1) macro-morphologic traits such as stem height, diameter, density and clumping, nodes number, flowering phenology, presence of dried apices, rhizomes diameter, lateral roots diameter and amount, and (2) morpho-anatomic traits measured on the adventitious roots, including central cylinder, aerenchyma, cortex and total diameter, the number of the external flattened layers of the cortex, and metaxylem ducts diameter. Floristic-vegetation tools such as using phytosociological relevés, number of species, vegetation cover, and the like were considered.

Several symptoms of decline have been identified. They can be referred to two main levels, such as autecological (mainly concerning growth rate and flowering phenology), and synecological (mainly related to the floristic-vegetation simplification and invasion of synanthropic species). The detection of some anomalous traits at least in part related to the die-back syndrome indicates that the reed bed at the Trasimeno Lake shows clear signs of decline and it is found in a seriously damaged general condition.

Effects of extreme events on the species composition and life history traits—the example river Elbe

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Plant species in European floodplain meadows are adapted to flood events in the spring time and drought in the summer/autumn time. The species zonation along the floodplain moisture gradient is very strongly correlated with the flooding tolerance of plant species and seems largely influenced by severe but rare flood events in the summer time. Furthermore, an extreme summer drought may cause basic changes in the composition of plant species. In 1998–1999, floodplain grasslands of the Elbe River with three different moisture levels (long, medium and short flooded areas) were investigated. In 2002, a sum-

mer flood took place which was untypical in time and intensity followed by an extreme summer drought in 2003. From 2003 to 2006 the same vegetation plots as in 1998–1999 were investigated with identical sampling methods.

The aim of the study was to investigate the effects of both extreme events on the plant species composition and life history traits of floodplain grasslands with different moisture levels.

The compositions of plant species in long flooded and short flooded areas were significantly different in 1998–1999 and 2003–2006. Theses differences were mainly caused by changes in the abundance of plant species, even though immigration and elimination of a few plant species could be demonstrated. In the short flooded areas, significantly lower mean covers of plant species from 2003-2006 compared to 1998–1999 were observed only for species with a low flooding tolerance. Hence, the summer flood seems to have an impact on the plant species composition in these areas. In the long flooded areas, moisture indicator species had a significantly lower mean cover in 2003–2006 compared to 1998–1999. It can be assumed that the extreme drought in 2003 had an effect on these low-competitive plant species.

Regeneration Ecology of *Erica arborea* in the Simen Mountains National Park, Ethiopia

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Erica arborea forests are endangered in the Simen Mountains National Park (SMNP) because of insufficient regeneration. As a basis for future management plans, stand structure and regeneration dynamics were studied at six permanent monitoring plots of 40 x 40 m covering the elevation from 3130 to 3590 m along a distance of 34 km. The plots were established to represent protected (exclosure from livestock), moderately and heavily degraded stands. The mean density of trees > 10 cm DBH was 838 individuals/ha while that of trees with a DBH of < 10 cm was 708 individuals/ha. Mean DBH was 15.3 cm, mean height 6.9 m, and mean basal area 18.3 m^2/ha^1. Deviations from the demographic model indicate insufficient recruitment. Seed banks, seed germination and establishment were studied in 1 x 1 m subplots. Experimental manipulations of micro-site conditions

included total protection by wire mesh, mowing of herbaceous vegetation, removal of topsoil and burning of woody litter. Bare mineral soil and thin moss layers proved to be suitable microsites as compared to thick moss layers and herbaceous vegetation. Burnt soil and charcoal in particular, were the best seedbeds for *Erica*. A soil seed bank of *Erica* was evident down to a depth of more than 5 cm. At the site of a recent wildfire a set of 104 random sample plots was used to study regeneration under varying fire intensity. There was abundant regeneration both from seeds and from re-sprouting of lignotubers and epicormical buds. Older trees were more frequently killed by fire than young trees, presumably due to higher fuel loads under bigger trees. From our studies and experiments we conclude that heavy grazing is the main cause of insufficient regeneration in the *E. arborea* forests of the SMNP. Heavy grazing by livestock affects regeneration directly by trampling and browsing, but even more so indirectly by the suppression of ground fires due to the removal of herbaceous fuel.

Invasive alien species slow down nutrient cycling in mediterranean-type ecosystems: a phylogenetic approach

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Invasive alien species alter a variety of terrestrial ecosystem processes, including nutrient cycling through leaf litter decomposition. However, there has not been consensus yet about whether leaf litter of invasive alien species slows down or accelerates the nutrient cycling processes. Interactions between habitat properties and leaf litter traits of invasive alien species may play an important role to determine the net effect. In mediterranean-type ecosystems this information is scarce, despite the fact that these ecosystems have suffered intensively and extensively from invasions by alien plant species.

In a 'common garden' experiment, leaf litter properties and decomposition rates of 21 invasive alien plants species were compared with native mediterranean congeners using phylogenetically independent contrasts to clarify whether changes in vegetation composition due to invasions may alter carbon (C) and nitrogen (N) cycles. Leaf litter of invasive and native species was collected from the main invaded habitats in the Iberian Peninsula,

i.e. riparian forests, disturbed areas and coastal shrublands.

Total decomposition rates varied greatly between species, ranging from 9% to 95% of the total litter mass during the approximately 300 days of the garden experiment. Loss rates of leaf litter mass was a function of growth form, being higher in herbaceous than woody species; and of status (alien or native). Contrary to expectation, alien-native comparison revealed no differences in important traits related to leaf litter decomposition such as specific leaf area, leaf litter C/N ratio or phosphorus concentration. However, leaf litter of invasive alien species decomposed slower than natives within each invasive-native pair, since the lignin content of invaders was higher.

In conclusion, vegetation changes in the Mediterranean vegetation composition due to biological invasion processes are likely to decrease rates of nutrient cycling, because invasive alien species on average produce less decomposable leaf litter due to their woody nature and their carbon structure.

Acknowledgements: Financial support was provided by the Spanish Ministry for Education and Science (grants RASINV, GL2004-04884-C02 02/BOS as part of the coordination project RINVE, and CGL2007-61873/BOS).

Phylogenetic dispersion of vascular plant communities differs along altitude and varies with scale

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Phylogenetic dispersion of species in a community may give valuable information about how communities assemble. The assemblage of species may be governed by different processes along an environmental gradient and with scale. We examine the ratio of mean number of species in a family for different communities to study the phylogenetic dispersion of vascular plant species at three different scales along 12 altitudinal gradients in Norway. The number of species per family is in all cases compared to an expectation from null models based on number of species in the sample and a defined species pool.

The results are both scale dependent and vary with elevation. Generally more species per family are observed than expected in the communities, i.e. phylogenetic clustering. Phylogenetic clustering is strongest when the species pool is defined as all the species found

on the mountain. When defining a more local species pool, the result is a weak, statistically non-significant trend pointing towards a trend of phylogenetic clustering. Trend in the species-to-family ratio with elevation shows that there are more species per family at higher altitudes than at low altitudes at the broadest sampling scale. The opposite pattern is observed for the smallest sampling scale, i.e. it is observed relatively higher number of species per family at low altitudes compared to high altitudes.

Influence of former cultivation on the endangered renosterveld in the Cape lowlands (South Africa) and implications for restoration management

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Renosterveld is a characteristic, once dominant vegetation type of the Cape Floristic Region, and highly threatened by conversion into agricultural areas and urbanisation. Therefore, attempts were made to restore renosterveld communities on former arable land, pastures and pine plantations. However, information is still lacking on potential long-term effects of practices like burning, mowing and cutting on species number and composition. Both, seed dispersal from adjacent pristine habitats and soil seed bank of the transformed habitat play a crucial part in species recolonisation. Especially information about soil seed bank in renosterveld vegetation is insufficient. Therefore, predictions about potential species composition after restoration in abandoned fields and on pine plantations are difficult. In this regard renosterveld restoration practices are still lacking a fundamental conception. Our ongoing study tackles this knowledge gap by comparing pristine renosterveld with and transformed renosterveld and cleared pine plantations at the Tygerberg Nature Reserve (Cape Town) by means of seed bank analysis and germination experiments. The used restoration technique was realised by pine cutting, removal of pine stems and burning of branch material on-site. Together with vegetation surveys and chemical soil analyses the ecosystem status of the area was assessed.

First results indicate that chemical soil properties of old fields differ from soils of adjacent renosterveld vegetation even after 40 years of abandonment. For example, higher concentrations of plant available phosphorus in old fields were measured and could favour

exotic grass species. On the other hand, chemical soil properties changed marginally with pine plantation land use of former renosterveld. Renosterveld and pine plantation sites were very different in species composition and richness, with larger number of species in standing vegetation than in soil seed bank. In contrast old fields are characterised by very few dominant exotic species and their potential species pool of soil seed bank is higher. Therefore we can conclude that indigenous species from the soil seed bank are not able to compete with dominant exotic grass species from old fields. Generally, renosterveld vegetation is characterised by a very high proportion of geophytes. However, old fields were lacking this component. In contrast a high proportion of geophytes were still viable under pine plantation land use and after pine clearing. Germination experiments indicated a positive effect of smoke primer treatment on the number of germinated species and seedlings in renosterveld and transformed vegetation. However this effect is low in contrast to the effect of smoke treatment in germination success of fynbos species. Further analyses revealed a persistent soil seed bank with a problematic number of exotic species (up to 50%) in all renosterveld land-use types.

Our preliminary results indicate that pine plantations on former renosterveld vegetation have the highest restoration potential compared to very slow recovering old fields, which are infested by exotic grasses. Therefore, the available area of pine plantations suitable for restoration should be pinpointed and further study sites examined. Due to the high number of exotic species in soil seed bank it will be necessary to monitor and control exotic species in all restoration approaches and land-use types.

Vegetation and soil-to-plant transfer of radionuclides in coastal black sand habitats in Mediterranean coast, Egypt

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Vegetation of the coastal black sands was investigated in two localities, such as Abu Khashaba and Baltim, both on the Mediterranean coast of Egypt. Field surveys of vegetation using line-intercept method and a greenhouse study on soil-to-plant transfer of radionuclides were carried out.

A total of 37 common species belonging to 17 families and 35 genera were recorded in habitats representing sand plains, sand dunes, sand mounds, and salt marshes. The vegetation was classified using TWINSPAN into six vegetation groups representing the habitat

types. A principal component analysis (PCA) demonstrated that soil factors, especially soil texture, chlorides and sulphates had significant effects on the distribution of species. The radionuclide content in soil of the study sites and in *Cakile maritima*, *Senecio glaucus*, and *Rumex pictus* were determined under greenhouse conditions. The thorium content in soil and in the plants was higher than the uranium content. The transfer of radio nuclides from the soil to plant is a complex process that is subject to many variables. The most important of these variables are the soil organic matter, clay content of soil, radio nuclides types, and the plant species identity. The high transfer of radio nuclides by some black-sand plants suggests the possibility of using such species for phytoremediation of soils contaminated with radioactive elements. The potential of *S. glaucus* as phytoremediator is greater than that of *R. pictus,* which, in turn, outweighs *C. maritima*.

Functional types of the endemic *Ebenus pinnata* Aiton: evolutionary strategy for survival

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Ebenus pinnata Aiton is a perennial herb, endemic to North Africa (spanning a broad region from Libya to Morocco). In Libya this species is confined to the coastal north-western arid regions, where it was recorded in only a few localities. The study site was located in the Msallata National Park, Libya at an elevation range of 200–300 m. Three functional types were distinguished in *E. pinnata*: ephemeral, modular, and coppiced life-forms indicating a possible shift from r- to K-selected strategy. Ephemeral life-form dominates in dry microhabitats, while the modular monocarpic life-form occurs under environmental conditions appearing more favourable for plant growth. The coppiced polycarpic life-form occurs in habitats where soil moisture remains within favourable range during the summer months.

The vegetative and reproductive traits of these three functional types studied. Population demography and phenology were analysed, and life-tables and fecundity schedules for the three functional types were compiled. The intra-population variations in the functional types were interpreted in terms of an evolutionary mechanism for survival and response to a wide range of environmental stress.

Ecophysiological and population biology characteristics of the aquatic resurrection plant *Chamaegigas intrepidus*

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In a number of cases poikilohydric cormophytes occurring in seasonal pools have been classified as annual r-selected species, adapted to their ephemeral habitats by their short life-span and fast response to changing environmental conditions. However, this set of traits does not apply to the aquatic resurrection plant *Chamaegigas intrepidus*, which grows in temporarily water-filled rock pools on granite outcrops in Central Namibia. These habitats are characterised by extremely variable conditions. The most important stress factors are (1) frequent and fast desiccation and rehydration, (2) long dry seasons, and (3) extreme nutrient shortage, especially nitrogen. This plant species must thus be adapted to the extremely short period of water availability, a high environmental instability and low predictability of site factors. It has a constitutive dehydration tolerance aided by, among others, the accumulation of abscisic acid, dehydrins and carbohydrates during desiccation. The high metabolic costs of these physiological processes, however, severely constrain growth and reproduction On the other hand, a conservative resource-use strategy seems to be an important mechanism for long-lasting persistence of existing genets in the seasonal pools. As with other long-lived perennials, *C. intrepidus* shows a high genetic diversity within sub-populations in a single pool. This is in accordance with the predominantly outcrossing behaviour of the species. There is a high gene flow between sub-populations from different pools on one inselberg, but populations on single inselbergs are genetically very highly isolated.

The duration of favourable periods in the rock pools, which are the only habitat of *C. intrepidus*, may be too short to complete a therophytic life cycle. Therefore, the species survives the dramatic environmental stochasticity, with its low predictability of the occurrence and duration of favourable periods within a mostly hostile year-round season, by being a slowly growing, long-lived poikilohydric stress tolerator.

Effect of human population density on plant genetic diversity in fragmented grasslands

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Genetic diversity is required for plant populations to adapt to changes in environmental conditions. In plant communities, formation of genetic diversity depends on several historical and evolutionary processes like different dispersal patterns and accumulation of mutations. Semi-natural grassland communities have developed and persisted due to long-lasting habitat management. Many grassland species have adapted with moderate anthropogenic pressure. Consequently plant populations in semi-natural communities are now dependent on habitat management and human-mediated dispersal. Nowadays, many semi-natural communities are facing negative human impact due to the dramatic changes in land use. Here, we explore the effect of historical and current anthropogenic pressure on the current genetic diversity of habitat specialist species in semi-natural communities. Human population density was considered to be a proxy for all human-mediated processes.

We studied the impact of past and present human population density and landscape structure on the current genetic diversity of grass *Briza media*, a habitat specialist species in fragmented calcareous grassland patches situated on the Estonian islands of Muhu and Saaremaa (with total area of islands 2900 km^2). Current habitat patches varied in area size from 1 to 150 hectares. Altogether we collected 719 plant samples from 34 grassland patches. Nine enzymes were analysed from each sample by using isozyme electrophoresis. We used the percentage of polymorphic loci (P) as a measure of genetic diversity. As the studied habitat patches have suffered great area loss during the past century, both current and historical habitat configuration (area and connectivity) had to be taken into account. By fitting a general linear model we related current genetic diversity to current and historical (in 1922) human population density and to current and historical (1930s) landscape structure. We applied backward stepwise selection to obtain the best-fit model.

Our analysis revealed that historical human population density has had a positive effect on the current genetic diversity of *B. media*. In 1922 land use was mainly extensive and management regime supported the survival and dispersal of seeds in semi-natural communities, thus facilitating the formation of higher genetic diversity. Current human population density showed a negative relationship with plant genetic diversity. In addition, current habitat connectivity (an index showing how many similar habitats are in surrounding in present) had significant positive influence on genetic diversity of *B. media*, showing the

importance of improvement of the current landscape connectivity through restoration of disappearing communities.

In summary, we demonstrated that the development of high genetic diversity in fragmented semi-natural grasslands is supported by historical human activities, but nowadays this diversity may be threatened by negative human influence.

Interpreting large-scale patterns in phytosociological data using Gaussian extension of quasi-neutral models

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The data in phytosociological databases contain a lot of information on large-scale patterns in ecology. Ideally, this information should be analysed by comparing patterns of the database data to patterns produced by independent community models based on simple but yet conceivable community dynamics. In order to minimise difficulties due to the large number of unknown parameters, general models with as low-as-possible number of parameters should be used. This is well served by a family of quasi-neutral models that capture essential elements in the plant community assembly and dynamics while requiring a rather low number of key parameters. In particular, a Gaussian gradient extension of the neutral framework is used.

Here we are using stratified and hierarchically structured data set from the Czech National Phytosociological Database to extract major large-scale patterns in a such as mean alpha and beta diversities and species abundance distributions for different subsets in the hierarchy. These are compared with patterns generated with Gaussian gradient extension of the neutral model with the following parameters being examined: total gradient length, 'speciation' rate, relative role of migration, and total community size. Fit of these database and simulated data is used to determine whether patterns of large sets of phytosociological relevés do match those generated by the model and to infer values of the key parameters.

Arctotheca calendula (Asteraceae): a South African invasive plant in the Iberian Peninsula

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Arctotheca calendula (Asteraceae) is a highly invasive plant that was introduced originally as ornamental in many countries of the world (Australia, New Zealand, Western USA, Japan, Chile, SW Europe). In some regions this species is considered a pest because it is an aggressive competitor for water and space and threatens native plant communities. In the Iberian Peninsula, it was first cited in Portugal in the XVIII century (Brotero 1804).

In this paper we concentrate on the current distribution of *A. calendula* in the Iberian Peninsula and the main invaded habitats. Some of these habitats, especially the coastal dunes, are included in the European Community Habitats Directive (92/43) with a priority category.

Arctotheca calendula is today widespread mainly along the coasts of Portugal and Spain, in regions characterised by thermo-temperate and thermo-mediterranean climatic regime, and it also occurs in some inland localities of Portugal. This species usually grows in sandy habitats, such as natural coastal dunes (supporting the Ammophiletalia and Crucianelletalia) and in disturbed sites (the Sisymbrietalia), which can be quickly invaded by opportunist species. Its dispersion is very effective by woolly seeds which tend to adhere to nearly any surface or are carried by the wind; it can also spread vegetatively by means of stolons. These reproductive features and the disturbance obviously determine the strong invasive ability of *A. calendula*.

In order to define the main bioclimatic parameters that could explain the Iberian distribution of this plant, we used available data from the Climatic Digital Atlas of the Iberian Peninsula (Ninyerola et al. 2005). In the locations where *A. calendula* occurs we have calculated the following climatic indices (Rivas-Martínez 2007): It (thermicity index), Ic (continentality index), Io (ombrothermic index), and considered data on the rainfall in winter, spring, summer and autumn.

Our results revealed that spring rainfall is the main climatic factor correlated with the current distribution of *A. calendula*.

Brotero, F.A. 1804. *Flora Lusitanica. Pars I.* Typographia Regia, Olissipone.

Ninyerola, M., Pons, X. & Roure, J.M. 2005. *Atlas climático digital de la Península Ibérica. Metodología y aplicaciones en bioclimatología y geobotánica.* Universitat Autònoma de Barcelona, Bellaterra.

Rivas-Martínez, S. 2007. Mapa de series, geoseries y geopermaseries de vegetación de España. *Itin. Geobot.* 17: 5–436.

Acknowledgements: This work has been partly supported by the project IT-247-07 of the Basque Government.

Using old phytosociological relevés to study long-term vegetation dynamics

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Predicted effects of changes in climate and land-use and their interaction have initiated a major interest in finding ways to predict how environmental changes will affect biodiversity. Knowledge about vegetation dynamics at relevant time scales is very limited, due to the lack of high-quality long-term data sets. Therefore, there is a need of alternative approaches to be used to study long-term vegetation dynamics.

There has been a strong tradition of plant sociology in Europe, providing numerous carefully sampled data-sets collected from the beginning of the 20th century up to recent time from many different vegetation types and regions. Such data provide a unique starting point for detecting changes in vegetation over decadal time scales even though there are no permanent plots. We have developed an approach that can utilise the vast amount of old phytosociological data, not dependent on permanent plots. The approach focuses on the relative displacement of species optima along important environmental gradients using weighted averages to estimate the realised optima of species in different time periods. We used this method successfully on a study of alpine vegetation. The study area is situated in Rondane National Park in central Norway. This study is based on relevés sampled by the late Eilif Dahl in the 1950s, which were re-sampled in 2004.

Of the 21 analysed species, nine showed a significant change of realised optimum along at least one environmental gradient. Only two species had significant changes in species optimum that could be correlated to climatic changes. Most of the significant changes in species optimum were found along soil chemistry gradients. Our results are in accordance

with the changes in the observed environmental factors in the area, climatic factors (temperature and precipitation), and land-use changes only slightly while soil pH experienced a major decrease.

Our approach successfully identifies easily interpretable changes and recognisable patterns that have been revealed by other studies of vegetation change in this area. We therefore conclude that if permanent plots are unavailable, our method is a viable approach for detecting vegetation changes over several decades.

The effect of environmental factors and plant community properties on species-area relationships in wet meadows (Železné hory Mts., Czech Republic)

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In last decades quantifying biodiversity has become one of the hottest topics among vegetation ecologists and conservation biologists. A commonly used measure of biodiversity in ecology is species richness. Using species-area curves for describing species richness on spatial scale appeared more appropriate than using single number (e.g., number of species, Shannon-Wiener index). The most widely used types of functions used by botanists are the exponential curve ($S = z \ln(A) + c$) and the power curve ($\ln(S) = z \ln(A) + c$). The values of the constant 'z' are usually in range 0.1–0.4, thus we can observe that the increasing of number of species per area is at decreasing rate with rising area. Response of species richness is usually not linear along environmental gradients (e.g., humped-back curve or describing changes of species richness along a nutrient availability gradient).

We studied the species richness of 22 wet meadows of the Molinion, Calthion, Caricion fuscae, Sphagno recurvi–Caricion canescentis and Caricion gracilis alliances characterised by different production, species composition, and environmental characteristics in highland region of the Železné hory Mts. (Czech Republic). The relationships between area, number of species, productivity, and environmental characteristic were analysed by two types of species-area curves, such as the Arrhenius' power function $S = cAz$ ($\log S = \log C + z^*\log A$), and the Gleason's exponential function $S = C + z^*\log A$.

Using the former equation, the exponent 'z' was positively correlated with productivity and negatively correlated with equitability. On the other hand, using the latter equation, the exponent 'z' was positively correlated with equitability and negatively with total soil nitrogen. The intercept 'C (log C)' was positively correlated with equitability in both equations. The groundwater level, total soil phosphorus and soil reaction (pH) was neither related to 'z' nor 'C (logC)'. The use of both types of species-area equations for studying plant communities and their relationships with environmental factors is discussed.

Constraints for geospatial modelling of distribution for invasive species in their secondary distribution area

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Dozens of studies were conducted in the field of spatial distribution prediction of invasive species. Their methodology covers a wide complexity and various spatial scales. There is a lot of spatial data available as predictors with high precision. It should be very easy on the base of the ecological niche theory to determine the spatial pattern of invasion processes. How precise are these models and why do they not allow product more exact results?

The biology of invasion has to be considered as it shows many reasons for modelling scepticism: The ecological niche can be changed during the invasion process and thus the niche based on secondary distribution area dataset can provide more precise results. However, during the invasion process not all suitable habitats have to be colonised in the time we collect data about realised niche in secondary area. An invasion process is driven by chance while random long-distance movements accelerate the spreading rate over the prediction based on simple model of local spreading which consider only the life history data of modelled species.

We lost the part of the accuracy during datasets processing: Historical data often have a low level of spatial accuracy which push the datasets to the coarser scale, and thus precise environmental predictors become average out the values and part of fault predicted sites grows up. Scientists have to deal with all these constraints and they should clearly explain all sources of inaccuracy in their work and each model has to contain the rate of inaccuracy. This is the reason why often only probabilities of distribution are presented as results.

Bryophyte communities of East Texas, USA

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Despite including the second largest group of plants (mosses), bryophytes are often neglected in ecological studies and until now little effort has been made to describe east Texas bryophyte communities. A recently-revised ecological classification system (ECS) describes a range of ecological types based on soils, topography, and vascular plant communities for the Texas Pineywoods. Using ECS as a framework, we revisited a subset of the sample sites that provided the basis for ECS and examined bryophyte diversity and species composition. These sites, from Angelina, Sabine, and SFA Experimental Forests, represented the principal east Texas ecotypes.

Eighty-four species (sixty-one mosses, twenty two liverworts and one hornwort) were encountered. Ordination and classification of the species-by-samples data matrix enabled the description of eight bryophyte communities which differed across floodplain, mesic, upland, and dry sandy sites. While the occurrence of these communities was strongly related to the corresponding vascular plant community on a site and responded to similar soil and topographic gradients as for vascular plants, bryophyte communities appeared to respond to these factors at a finer spatial scale and were also strongly influenced by the types of substrates available in each site.

Vegetation on flat rocky outcrops of the Bonin (Ogasawara) Islands, Japan

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The Bonin (Ogasawara) Islands are oceanic islands located in the NW Pacific Ocean (26-28° N lat.; 142° E long), about 1000 km south from Tokyo. The islands rose out of the sea floor more than 1 mya. The climate of the Islands is subtropical (MAT: 22.9° C; MAP: 1255 mm) and the flora of the islands is characterised by many endemic plants (161 of total 447 native species).

Especially Chichi-jima Island (alt. 318 m; 24.0 km^2) and its neighbouring islands possess

many flat andesite rocky outcrops exposed to high surface temperature and aridity. Several endemic (also endemic-rich) plant communities supported by these habitats have been described. One of them is a prostrate scrub community (the Osteomeleo lanatae–Zanthoxyletum beecheyani), while the other communities are grasslands (incl. the Aristidetum boninensis, Sedetum boninensis, *Ischaemum ischaemoides–Rhynchospora boninensis* community and *Fimbristylis longispica* var. *boninensis–Digitaria platycarpha* community).

The character, differential or dominant species of these communities support polydemic vicarious species also found in wetlands and on coastal cliffs in SW Japan, Ryukyu, Taiwan, Mariana and continental Asia. It has, therefore, been suggested that the rocky-outcrop vegetation of the Bonin Islands might have been derived from the flora of wetlands and/or coastal grasslands. As Shimizu (1989) proposed, the rocky outcrops grasslands originated probably from the cloud-band vegetation during the last glacial period, when sea level was lower and the relative elevation of islands was higher.

Shimizu, Y. 1989. Ecological character of forest vegetation on oceanic islands in the Ogasawara Islands. In: Miyawaki, A. et al. (eds.), *Vegetation of Japan. Vol. 10, Okinawa and Ogasawara*. pp. 159–203. Shibundo, Tokyo. (in Japanese)

Drivers of plant diversity in forest patches among contrasted agricultural landscapes: a hierarchy

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Although most recent studies recognise the importance of both local (e.g. spatial heterogeneity, resource fluctuation, disturbance) and landscape (e.g. landscape structure, species pool) factors on species assemblages, the relative importance of these factors is still uncertain since they act at different temporal and spatial scales. As some of these scales are difficult to manipulate, empirical analyses of patterns are needed.

In this study we aim at identifying the controls on the patterns of vascular plant diversity among forest patches that are scattered among contrasted agricultural landscapes, and at searching for the relative importance of local vs. landscape factors. For this purpose we surveyed the vascular plant species composition of 243 forest patches that were distributed among six landscape windows of 5 x 5 km in size, ranging from a bocage (i.e., small forest patches connected by a dense hedgerow network) to an open field agricultural

landscape (i.e., small patches isolated in intensively cultivated fields) in the Picardy region of northern France. For each patch we also recorded local (incl. soil types, forest vertical structure, relief, management-associated disturbances, patch size) and landscape (incl. climate, hedgerow density, surrounding land uses) environmental factors. Species pool (γ diversity) was determined for each window as the cumulated species list of patches. The relative importance of environmental factors on species composition at both scales were investigated using canonical correspondence analysis. We then reduced the collinearity among variables within the two sets (local vs. landscape) using principal component analysis (PCA) and introduced the synthetic variables (PCA axes) into structural equation models, using successively woody species richness, forest herb richness and total species richness as response variables.

The carbohydrate economy of dicots and graminoids: the key to understanding plant coexistence on traditionally managed European meadows?

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Regularly-mown oligotrophic meadows in Central Europe contain species-rich plant communities dominated by graminoids (grasses and sedges) that usually coexist with a substantial number of dicots. Although many studies show that the graminoid growth traits, contribute to their success in these communities (e.g. height or biomass production), plants do not invest resources into growth alone. Theoretical works (e.g. Chapin et al. 1990) suggest that the trade-off between growth and formation of reserves is important and the decision how to invest resources between them depends on the probability of catastrophic events.

We studied carbohydrate reserves in storage organs of 10 graminoids and 31 dicots on two meadows in Czech Republic to ascertain whether graminoids and dicots differ in their storage strategies. The two meadows differed in their water availability but showed the same graminoid versus dicot contrast in carbohydrate economy. Dicots had a higher concentration of non-structural carbohydrates in storage organs, and showed smaller increase in those concentrations during the season, than did graminoids.

We suggest that graminoids and dicots differ in their strategy. Graminoids invest more into

growth than dicots, which are usually subordinate, and maintain relatively high amount of carbohydrate reserves during whole vegetation season. The difference in carbohydrate economy can contribute to coexistence of dicots and graminoids on traditionally managed meadows in Central Europe.

Chapin, F.S., Schulze, E.D. & Mooney, H.A. 1990. The ecology and economics of storage in plants. *Annu. Rev. Ecol. Syst.* 21: 423–447.

Shape of species responses: Huisman-Olff-Fresco models revisited

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The shapes of species responses along ecological gradients are not only of theoretical interest but also have important implications for numerical analysis. Most analytical models in community ecology still assume that species responses are unimodal and symmetric. Oksanen & Minchin (2002) recommended the use of hierarchical Huisman-Olff-Fresco models (HOF; Huisman et al. 1993) to evaluate the interactions between species and environmental gradients. The original HOF models are a set of five response models including no trend (Model I), increasing or decreasing (II), increasing or decreasing bounded below the maximum response value (III), symmetrical Gaussian response (IV), and skewed but unimodal response (V). The selection between the models can be done by statistical criteria like Akaike's Information Criterion (AIC).

I analysed species response shapes in a dataset containing pH-measurements (N = 1000) and in a dataset containing mean Ellenberg indicator values (N = 50,000) to see what the determining factors for species response shapes are, and if rules about the frequency of the five HOF models can be establish. It turned out that the size of the dataset, the length of the observed gradient, and the used statistical model discriminator were the strong determinants of the frequency distribution of the five models.

Furthermore species attributes such as the frequency of occurrence, Ellenberg indicator values, and strategy types also differ between estimated model types. In the pH sub-set, containing mostly arable land with pH values from 3.5 to 7.5 (pH-CaCl), I found (using AIC as the selection criterion) at least 20% of species with no response to pH, Model II and Model V responses were increasing with increasing dataset size, Model III was decreasing and Model IV had a more or less constant frequency of not more than 15%. Most notably the latter value is remarkable because it is still a canonised view in vegetation ecology that

species have symmetric, unimodal responses to ecological gradients and commonly used methods such as correspondence analysis (and its derivatives) assume unimodal model as the underlying species response. These results support use of more robust ordination methods, such as non-metric multidimensional scaling. On the other hand the HOF models can be a helpful instrument to interpret species responses as well as the datasets if we know the dependencies of response shapes. For example a high frequency of Model I species can be a sign for a gradient too small at both ends; a high frequency of Model II and Model III species can be a sign for a gradient too small at one end of the gradient.

Huisman, J., Olff, H. & Fresco, L.F.M. 1993. A hierarchical set of models for species response analysis. *J. Veg. Sci.* 4: 37–46.

Oksanen, J. & Minchin, P.R. 2002. Continuum theory revisited: what shape are species responses along ecological gradients? *Ecol. Model.* 157: 119–129.

Plant biodiversity patterns on the Helan Mountain, China

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A case study was conducted to mountainous ecosystems in the east side of the Helan Mountain, located in the transitional zone between the steppe and desert biomes of China, aiming to reveal the influences of four environmental factors on features of plant biodiversity and spatial pattern of vegetation types. The field data were analysed using canonical correspondence analysis and species diversity was estimated using Shannon-Weiner index for alpha diversity, while Sørensen index was used to calculate beta diversity.

The preliminary results suggest that: (1) Ranked in terms of their impacts on spatial patterns of plant biodiversity, the four most important controlling environmental factors are (in order of importance): elevation, location, slope, and aspect. (2) The variation of alpha diversity along the altitudinal gradient is similar to that of species amount within altitudinal belts spanning 200 m each. This suggests a unimodal relationship between the species richness and the environmental condition with regards to altitudinal factors. Both species diversity and the species richness within each altitudinal belt reach their maximum at the altitudinal range spanning 1700–2200 m. (3) The altitudinal belt showing the highest alpha diversity is identical to the range where the deciduous broad-leaved forest, temperate evergreen coniferous and deciduous broad-leaved mixed forest are found. The altitudinal span 1700–2200 m delimits the belt with both high level of species richness and diversified vegetation types. (4) The variation of beta diversity along the altitude is consistent

with the vegetation vertical zones. According to the Sørensen index between each pair of altitudinal belts, the transition of vegetation spectrum from one zone to another, as from the base horizontal zone, the desert steppe, to the first vertical zone, the mountain open forest and steppe zone, to the mountain coniferous forest zone, and last to the alpine shrub and meadow zone, could be recognised through floristic evidence. (5) The diversity of vegetation types and the spatial variation of alpha diversity of plant communities might be the simple but effective indicators predicting the general species richness and beta biodiversity patterns especially in regions that lack complete list of flora.

Vegetation ecology and history as keys for sustainable nature conservation

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In the old mining region Erzgebirge (Germany) there is a historic man-made water system consisting of ponds, ditches, and subterraneous trenches. Initiated in the early 16th century to store water for the operation of mining machines, it is still used today for drinking-water, industrial water supply, fishery, and for recreational purposes. This water system is also protected as a historic monument.

Beside these outstanding features, the ponds are of European importance for nature conservation. They commonly provide habitats for vegetation of the Littorelletalia and Isoeto–Nanojuncetea; vegetation types that are rarely found elsewhere. Littorelletalia species like *Littorella uniflora* occur close to shores on submerged and exposed sand. Isoeto–Nanojuncetea species, which include the endangered and protected *Coleanthus subtilis*, develop only on moist mud and within short time when ponds are drained. Thus two habitat types and one species protected according to the European Habitats Directive occur in these ponds, for which management plans have to be designed.

The history and the continuous specific use of the water system with its extreme water level fluctuations had been the basis for the colonisation by those species and the persistence of these populations over such a long time. Until now, however, this has not been taken into consideration in nature conservation measures. Furthermore, little is known about the species' dispersal mechanisms and their ecological requirements. Important questions are therefore: When and where did the species first colonise ponds? Why are species absent from ponds that are not connected to the water system? Therefore, is hydrochoric seed dispersal via the ditches and trenches more important than dispersal by migrating wetland birds? Why is the area in which *L. uniflora* occurs declining? What are the consequences

of future management changes for this unique vegetation?

Vegetation ecological and historical approaches are keys to elaborate foundations for the sustainable protection of this unique vegetation and will be used to design a water system management scheme in which different use forms are coordinated with each other and with the requirements of nature conservation.

Fire effects on forest regeneration in Alaskan boreal forests: from patches to landscapes

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Biologically important wildfires in the boreal forest occur at scales of tens to thousands of hectares. Consequently, scientists and managers seek to understand and predict fire effects at these large, landscape scales. However, experiments can rarely be carried out on whole landscapes and we must rely on small scale experiments to test hypotheses related to fire effects. As ecologists, we are challenged to reconcile the gap of scales to generate meaningful interpretations and predictions of landscape responses to fire disturbance.

To understand fire effects on succession trajectories in Alaskan boreal forests, we have developed a hierarchy of studies that span from small-scale patches (m^2) to forest stands (ha) and landscapes (km^2). Experimental manipulations of patch-level fire effects provide information on population responses of individual species to post-fire conditions. Responses to these small-scale experiments then form the basis for interpreting stand-level responses to natural variations in fire consumption within a single large wildfire. Most recently, we have used observations following widespread fires in 2004 to assess interacting fire effects on vegetation recovery across large, heterogeneous landscapes of interior Alaska. This large-scale study highlights interactive effects between fire and site conditions that only emerge at landscape scales. However, an understanding of small-scale processes has been critical in allowing us to develop models that have a strong mechanistic basis and can tease out the sensitivity of forest landscapes to changes in fire regime. Here we present the results of our landscape study using structural equation models that are firmly based in

the results of previous, smaller scale research.

We conclude that learning about fire effects in boreal forests requires a multi-scale approach where experiments and observations both contribute to interpretation and prediction of vegetation responses.

Upward shift of alpine plants increases floristic similarity of mountain summits

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Plant species might shift their ranges as a response to climate warming. Mountain summits provide an ideal natural observatory for range shifts on a relatively small scale. Baseline data reaching back in history are rather scarce but where they are available, they show upward shifts of species ranges.

Based on a data set from a previous study of summits in the Bernina region of the Swiss Alps, that in part dates back to 1907 (relevés were made by Rübel), we expanded the analysis from a pure species-richness approach to beta-diversity and spatial heterogeneity analysis. We hypothesised that the upward shift of species, induced by climate change, leads to homogenisation of Alpine summit vegetation. We compared the species composition on mountain summits between1907, 1980, and 2003 using a two-component heterogeneity concept, including the mean and the variance of Sørensen similarities between the summits. Non-metric multidimensional scaling was used to explore the changes on individual summits in detail.

Both heterogeneity components (mean dissimilarity and variance) decreased over time, indicating a trend towards a more homogeneous vegetation among Alpine summits. However, the development on single summits was not strictly unidirectional. The upward shift of plant species has led to homogenisation of alpine summit regions. Increasing alpha-diversity is thus accompanied by decreasing beta-diversity. Beta-diversity detects changes that cannot be described using species richness or other coefficients of alpha-diversity alone and deserves greater attention from scientists and nature conservationists.

The establishment of *Pulsatilla patens* in dry boreal heath after experimental manipulations with scarification, charcoal addition and fire

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This study reports the effects of experimental burning and wildfire emulation by charcoal addition and vegetation removal on germination and growth of *Pulsatilla patens* (Ranunculaceae), a rapidly declining and endangered boreal herb. The decline of *Pulsatilla* is presumably related to changes in land use, especially in forestry practices where efficient wildfire prevention and termination of cattle grazing has led to the formation of continuous moss layer, or strongly grass-dominated vegetation that severely hinders the regeneration of the species. The positive effect of forest wildfire on germination and establishment of several boreal species is due to the reduced competition and increased light and nutrient availability. Also, charcoal produced by wildfire is capable to adsorb secondary metabolites of ericaceous species that have been shown to retard the germination and establishment of other plants.

The sowing experiment had a balanced factorial design. Experimental burning of 2 x 2 m experimental plots was carried out towards the wind. Experimentally burnt plots and plots where vegetation removal (+/-) and charcoal addition (+/-) were applied as treatments, resulted altogether in 30 experimental plots in five different treatment variants. At each 15 x 15 cm sowing spot 30 fresh *Pulsatilla* seeds where sown. The germination of *Pulsatilla* was significantly lower in experimentally burnt plots compared to unburnt plots. The highest germination rate was recorded in those treatment variants where the surrounding vegetation was left intact. However, there was a positive effect of charcoal addition to the germination of *Pulsatilla*; germination rate was significantly higher in treatments with standing vegetation removed and charcoal added. The positive effect of charcoal on seedling establishment was not detectable in the second year of the experiment due to the high mortality of seedlings, probably caused by extremely dry weather conditions in three consecutive years.

Allelopathic potential, a neglected plant trait, and its role in post-grassland succession

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Chemically-mediated interactions among plants should be considered as one of the factor determining resource competition. Allelopathic potential, measured by simple bioassay tests, could be a good predictor of allelopathic activity in the rhizosphere. Positive tests could be used as surrogate for complex allelopathic interactions and help us to understand the phenomena such as monodominant stands or other unusual, repeating, spatial vegetation patterns.

Laserpitium siler and *Grafia golaka* (both umbelliferous tall herbs) tend to form monodominant stands in the montane belt of the North Adriatic Karst (Slovenia) after abandonment. They were chosen to test the hypothesis that umbellifers act as nurse plants that facilitate the establishment of shade-tolerant species, and hence lead to natural reforestation. The antithesis is that the umbellifers, as strong competitors, slow down the succession by self-promotion and inhibition of the establishment of other plants through allelopathy.

Bioassays for allelopathy showed significant inhibition of germination and development of test plants after treatment with extracts from roots, leaves, stems and fruits of both umbellifers. Reconstruction of the site's vegetation history from aerial photographs over the last 50 years, showed only moderate forest progression after abandonment. The tree invader of umbelliferous stands is *Pinus sylvestris*, which is uncommon in the montane Karst area.

Bioassays for allelopathy demonstrated that *P. sylvestris* germination was negatively affected by the extracts, but seedling development was not retarded. An explanation could be that the same essential oils (limonene, pinene) are present in umbellifers and in *P. sylvestris*.

To test the generalisation that large umbellifers exert allelopathic activity, the allelopathic potential of 40 randomly chosen umbellifers was determined. No clear correlation was found between allelopathic potential and plant height, and between SLA and carbon component. Allelopathic potential thus seems to be related more closely with phylogenetic patterns than plant architecture, which mostly determine the role of plants within the community.

Secondary succession on abandoned agricultural terraces: from the landscape level to plant traits

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The outflow of the Dragonja River (Slovenia) has sharply decreased in recent decades. The explanation rests in vegetation change after agricultural abandonment. A comparison of cadastres of 1830 with vegetation mapping of 2007 revealed an increase of forests from 39% to 68%. Grasslands and arable land declined from 33% to 11% and from 2% to 11%, respectively. This secondary succession drives overall landscape change. The water loss, registered in decreased outflow, resulted from an increased vegetation development and evapotranspiration.

Since most of the arable land was vineyards, we have studied the succession on terraced vineyards with the chronosequence method using Braun-Blanquet cover estimations. Six groups of relevés were defined with TWINSPAN classification. The PCA analyses of 190 species using 34 plant traits delineated two main groups. High SLA, annuals, overwintering leaves, seed-propagated species were found in the first group and perennials with high LDMC and vegetative propagation in the second. In order to identify the most variable plant traits along the temporal gradient, the matrix of 190 species x 54 relevés was multiplied by the matrix of 34 traits x 190 species. The matrix 54 relevés x 34 traits was subjected to DCA. The DCA ordination of relevés along the first and second axis delineated three main groups. The first and second groups showed active vineyards and early succession stages, the third DCA group was composed by post-ruderal grasslands and scrub/woodland formation. Earlier stages had significantly lower percentages of perennials, phanerophytes, tussock growth-species and scleromorphic leaves. The C-S-R components showed the R component declining during succession and the C component increasing. The S component did not show any clear trends.

We conclude that the species turnover during the succession revealed roughly the same patterns when using floristic or functional approach. The post-ruderal (grassland/scrub) phase appears to be much more homogenous when analysed by functional approach.

Long-term effects of artificial water supply on tree dynamics in the savanna ecosystem of Chobe (Botswana)

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The free-dwelling elephant population in northern Botswana-Zimbabwe-Namibia is the largest in the world and has doubled since 1991. The provision of water by means of artificial waterpoints allows these elephants and other water-dependent animals to persist in otherwise water-limited habitats. However the long-term effects of such management intervention on vegetation dynamics and landscape processes are still poorly understood. Here, we studied the response of the woody vegetation to the introduction of artificial waterpoints in the Nogatsaa area of Chobe National Park, an unfenced elephant-dominated area in northern Botswana.

We hypothesized that the utilisation of the vegetation zone around artificial waterpoints has extended in space and increased over time since artificial water supply commenced in 1996, resulting in a decrease in the average tree density, tree height and canopy volume. To test this hypothesis we identified and measured the height and canopy dimensions of all woody plants in 50 x 2 m plots for small trees (0.2–3.0 m high) and 50 x 20 m plots for large trees (> 3.0 m). A total number of 30,740 trees were measured in 172 plots. Plots were located at 100, 500, 1000, and 2000 m distances around eight permanent artificial and two seasonal waterpoints in the four cardinal directions and sampled between 1997 and 2000, and again in 2008. Where distance between waterpoints allowed, additional plots were located at 5000 m from waterpoints. A Repeated Measures ANOVA showed that tree density had increased over time at each distance category, especially in plots around the two seasonal pans. The observed increase in tree height and canopy volume was mainly due to an increase in less-preferred species, such as *Baikiaea plurijuga* (Fabaceae) and *Croton gratissimus* (Euphorbiaceae). In spite of twelve years of artificial water supply and a growing elephant population in the region we found no evidence of a decrease in vegetation density or change in vegetation composition that would suggest that the current management intervention of artificial water supply has a negative effect on the vegetation biomass or composition of this study area.

Acknowledgements: This work was supported by a South African Student Travel Grant provided by the Regional Section for Southern Africa of the IAVS, and by a US Fish & Wildlife Service grant from the African Elephant Conservation Fund (Grant AfE-0390/7-G322).

Plant functional traits and their role in meadow abandonment

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Hay meadows suffer from successive and serious species loss when being abandoned. We studied functional traits that might explain the extinction, and also the prevalence, of some plant species along a gradient of abandonment (1 cut/year, 0.5 cut/year, 0 cut/year; effects measured for 8 years). The traits were: shape, number, position and timing of leaves and shoots; leaf life span and overwintering; shoot life span and function (vegetative and generative enrichment, innovation, spatial exploration, competitive exclusion).

Leaf life span turned out to be very short in species from nutrient rich meadows (1 month). Surprisingly, the individuals that where not cut for several years showed even lower leaf life spans than individuals from the treatments cut every year or every second year. Competitive effects may enforce leaf turnover on abandonmend treatments compared to cutting treatments. Leaf life spans generally are higher for species from nutrient poor meadows whereas most grassy wet meadow plants show very long lived leaves (≥ 1 year). Legumes show rather high leaf turnover rates almost irrespective of the site and management conditions. In nutrient poor and dry meadows we found on average medium leave life spans but with high variation. Several species adapt to dry conditions by producing long-lived leaves that decompose only slowly. In nutrient-poor dry meadows we found only a few plants with only one growth period for their leaves (e.g. grass *Brachypodium pinnatum*). Many herbs and most grasses produce two-phase shoots; they develop a stout innovation shoot with basal rosette leaves in one year and, by elongating the apical meristems of the innovation shoots, produce new flowering stems in the subsequent year. This kind of shoot innovation seems to be advantageous under cutting, as many species that show it quickly disappear after meadow abandonment.

How equalising processes affect size hierarchy of plants on two species-rich meadows with contrasting water supply?

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Mowing of meadows is an example of an equalising process. This process reduces difference between species because it represents a regular disturbance. All plants are affected equally by removing all aboveground biomass at approx. 5 cm above ground level. Mowing prevents elimination of weak competitors and thus allows the coexistence of numerous species that differ in height.

Here we aim to test two alternative non-equilibrium hypotheses: (1) tall competitive species lose proportionally more leaf canopy than small species and therefore size hierarchy in mown plots is a function of plant size, and (2) disturbance favours fast-growing plants that invest relatively little in height growth. This prevents overtopping of such plants by slow-growing species that invest more into height growth, so size hierarchy in mown plots is a function of biomass investments into height growth.

We tested these hypotheses on two oligotrophic species-rich meadows that differed in water availability. The first hypothesis was only partly supported, and only after exclusion of phenologically late species such as *Betonica officinalis*, *Molinia arundinacea* and *Molinia caerulea*. In the wet meadow, the second hypothesis was supported, and we also showed that graminoids with small investments to height growth were favoured over dicots by mowing.

We conclude that size hierarchy of plants on meadows in the second half of the season is not merely a function of plant size in first half of the season or biomass investment into height growth, but is also influenced by phenology and stress tolerance.

Plant functional type diversity and functional redundancy in South Africa's Cape lowlands: implications for fragment stability

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The Cape lowlands of South Africa with a predominantly mediterranean-type climate are dominated by high-diversity, fire-prone ecosystems characterised by fine-leaved, sclerophyllous and evergreen shrubs with fynbos, renosterveld and strandveld as the main vegetation types. These lowlands have been severely transformed by agriculture, urbanisation, mining and invasion by mostly woody alien species, leading to the drastic reduction of once contiguous habitats into tiny fragments embedded in novel land use types. The precise implications for biodiversity conservation in these lowlands are largely unknown because the few studies that have investigated the impact of habitat fragmentation in the region have shown weak and/or inconsistent fragmentation effects, especially with respect to species richness and abundance relative to fragment size. This has left conservationists wondering whether these fragments are worth conserving and if so, how best to manage them. It is therefore vital to know and predict how plant communities in such fragmented, mosaic like landscapes will respond to recurrent and new disturbances, particularly in the context of changes that affect land use patterns.

There is now ample evidence that such predictors do exist in the form of sets co-occurring plant traits (i.e. trait syndromes) or plant functional types (PFTs), though there is continuing debate as to whether all plant species or just a few representatives of each general functional type are required at any time to maintain major ecosystem processes.

We investigated the effect of fragmentation on plant community composition by comparing plant functional type diversity in the 'mainland' and three different-sized fragments and all three fragments combined at four different scales (0.1, 1, 50, and 100 m^2) sampled within Modified Whittaker plots in three Cape lowland vegetation types (i.e. Atlantis Sand Fynbos, Swartland Shale Renosterveld and Langebaan Dune Strandveld). Traits were selected based on their relevance to plant response to fragmentation. PFTs were derived both objectively using classification tree analysis (eight PFTs) and subjectively (19 PFTs). Sample-based PFT accumulation curves, a maximum likelikehood (ML) Chi-square test and different diversity indices were used to compare PFT diversity among the different sites for the various sampling scales. Preliminary results as well as implications for fragment stability will be presented.

Formation of Northern Asian vegetation complexes in the Holocene

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This paper focuses on the problem of indication of climatic changes by vegetation complexes at local and regional scales within subarctic, boreal and temperate vegetation zones in Northern Asia. It is based on the analysis of floristic, phytosociological (over 6000 relevés) and climatic (2200 climatic stations) data. The regional bioclimates were described by 22 climatic indices, of which Kira's warmth and coldness indices, continentality index, ombro-evapotranspiration index, and winter precipitation best explained geographical pattern of modern vegetation. A concept of zonal site was employed to find the relationships between climatic variables and the core association in each vegetation complex. Analysis of floristic groups combined with available fossil data allowed reconstruction of probable development of modern vegetation cover.

Fluctuating humidity and balancing of continentality-oceanicity were the major factors affecting vegetation changes in the Holocene. At the time of late Pleistocene aridification the climate favoured intensive migration of Central Asian steppic elements which make up a significant component of the modern flora of Siberia; they also characterise the Lathyro–Laricetalia, the driest order of the Vaccinio–Piceetea. Aridification in the temperate zone led to distinctive separation of insular and mainland vegetation complexes in Northern Asia with a retreat of thermophilous species especially on the mainland. The increase in temperatures and humidity caused a rapid expansion of larch forests up to the Arctic coast in the period 10,000–5000 yrs BP and the formation of the Ledo-Laricetalia characterised by wetland vascular species and bryophytes with circumboreal distribution. Forest retreat at about 3500 yrs BP led to the formation of extensive thickets dominated by shrubby birches, willows and larch woodlands. One of the most important refugia for the humidity-dependent vegetation in the Pleistocene was the NW coast of the Pacific Ocean, which still supports many Tertiary relics. All zonal vegetation types of Northern Asia show strong floristic relationships to Beringia and northern Pacific Islands.

Acknowledgements: This study was supported by the Russian Foundation for Basic Research (grants 07-04-00654, 08-04-08288).

Arctic-boreal system of homologous regions – humidity and the position of treelines

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Bioclimatic regionality of boreal environments has been evaluated on the basis of phenological observations, biotemperature, daily temperature range, and seasonal humidity. I have used long-term climatic records and excluded positive midwinter values (December–February) from biotemperature. Subzones of equal size were determined. Phenology in S Finland has showed that the threshold average temperature for actual growth is generally 7–9°C. When a higher threshold is applied the growth period settles to May-September in most continental parts of the boreal zone. The benefit from a longer period is mainly restricted to the better part of the hemiboreal subzone.

In a humidity analysis, a combination of summer rainfall, evapotranspiration, and biotemperature was used. In continental areas the two first ones are strongly correlated and zones and humidity provinces often coincide or run parallel. Large part of northern Eurasia is rather uniformly humid. The very moist Amur region forms an exception and its flora has acquired competitive water-regulating capabilities. Larger water bodies cause marked drying and cooling. Permafrost is considered beneficial to water balance in the dry interiors.

The regionality of tree lines observed from satellite images was determined. Boundaries of formations appear far from homologous. Individual treeline species show different responses to humidity but often low humidity is an asset for growth in a cold environment. In the more continental parts of Siberia *Larix* species extend into the middle part of the Arctic zone. *Picea* and *Betula* species are hardiest in wet and cold conditions. In Tierra del Fuego deciduous mountain forests grow in the coolest summer temperatures on Earth. Away from the poles treelines shift towards zonally warmer conditions and the tolerance of low average temperatures disappears.

The origins and character of treelessness are diverse. In S Finland spring growth started in treeless areas several days earlier than in wooded environment indicating that open areas are markedly warmer (at least 1° C) and drier. Dry timberlines thus form stable ecotones. Excess late summer humidity is evident in many oceanic and Arctic areas which situation is relieved by a woodland stand type. Western Europe lacks a dominant tree that is evergreen and tolerates microthermal temperature range. Consequently the communities generally have a common European rather than sectorial affinity.

The balance between speciation and dispersal in forming local species pools: an example from the Canary Islands

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A species pool is the potential set of species available for a particular habitat conditions. In theory, species pools have two main drivers: historical migration and ecological filtering. The species pool concept claims that more species will be found in habitats that have been historically more widespread since these habitats have had more chances both to speciation and migration.

Oceanic islands have been model objects in ecology and vegetation science for more than a hundred years, but data from them have not explicitly been linked to the species pool concept. We checked the premises of the species pool concept by using a unique data set from Canary Islands. Altitudinal diversity in the Canary Islands has resulted in distinct zonal habitats that have a high percentage of endemic species. Using the local flora of Canary Islands, we evaluated for each species their affiliation to habitat types and their geographical spread over seven main islands. Thus, we can form local species pools for each habitat type in each island. We linked local species pool sizes to the historical area of respective habitats in each island using subsets of endemic species (the aspect of speciation) and native non-endemic species (the aspect of dispersal).

Both subsets showed strong positive correlations. Our results indicate that local species pools of coastal habitats consist mainly of species that have immigrated to the islands during the last 1–20 myrs. On the contrary, the local species pools of higher altitude habitats contain mainly speciation-driven endemic species. These results indicate that evolution of species pool and historical migration for different habitat types within an archipelago is strongly related to community area. Diversity of some habitats is mainly dispersal-driven, but in some habitats rely more on speciation. In conclusion, the data from the Canary Islands supports the main expectations of the species pool concept well.

Effect of mowing on phenology of plants with different shoot architecture: a comparison of two contrasted meadows

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Coexistence of plants on species-rich meadows is enabled by the fact that large plant are more affected by mowing as they loose a larger proportion of biomass than small plants. However, the cost of biomass loss further depends on the organ that was affected and the phenology of the plant. With the aim to evaluate those factors we studied growth and flowering of 22 perennial species occurring in a dry meadow and 18 perennial species in a wet meadow throughout one growing season. We assessed the effect of mowing (versus abandonment), shoot architecture, and the presence of bud pre-formation on plant growth and flowering.

Growth dynamics of species was strongly influenced by mowing in the dry meadow but not in the wet meadow. Our classification of species into three groups according to their shoot architecture (semi-rosettes, rosettes, and erosulates) showed that mainly erosulates were suppressed by mowing.

In the dry meadow the flowering phenology of species was depended on the group whereby the rosette group was least influenced by mowing as other groups. This was probably a consequence of the different shoot cyclicity between the groups. No apparent difference between groups for flowering phenology was found in the wet meadow probably because of strong competition among species occurring there.

By using the method of phylogenetic contrasts, we could demonstrate that organ pre-formation in buds was not correlated with species responses to mowing (those were calculated for both growth and flowering data) in both dry and wet meadows. This indicates that bud pre-formation is an idiosyncratic trait and relates on species. Our results support the idea that shoot architectures differ in response to mowing due to different phenological development.

Reaction of plant species composition to hydrological changes in reference to the nutrient cycle in a shallow lake

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The response of plant species composition in the littoral zone to disturbances in water fluctuations was analysed in a shallow, polymictic lake (Lake Niepruszewskie, W Poland) during the growing seasons 1999-2001 and 2005-2006. In 2002, water level in the lake was reduced on average 0.6 m, and the mean annual amplitude of water level fluctuation decreased from 0.8 m to 0.3 m. Nutrient cycling was also compared along a moist gradient in the littoral zone spanning four vegetation types, such as: Caricetum acutiformis, Glyceretum maximae and Phragmitetum (all seasonally-flooded), and periodically-flooded Typhetum angustifoliae and Phragmitetum. Eight permanent transects, perpendicular to the shoreline, were chosen in an area of abundant vegetation. Each transect had two sampling sites: one located at 1/3 and the other at 2/3 of the width of the littoral zone (seasonally and periodically flooded, respectively). The biomass production and nutrient concentrations in the dominant species and sediments were measured at the time of maximal shoot growth in August of each year. The species abundances and cover were estimated according to the Braun-Blanquet approach.

The reduction of water level fluctuation had a negative influence on nutrient uptake by plants from sediments as well as their cycle and seasonal decrease from the water and sediment in the lake. Stronger decreases in above-ground biomass production were observed at sites that were less affected by drainage and where water was present throughout the year. In drawdown areas, plant growth was also diminished. However, species such as *Phragmites australis* and *Carex acutiformis* coped better with less amplitude in water fluctuations than did *Typha angustifolia*. *Calystegia sepium* made a significant contribution to the Phragmitetum, which dominated in this lake. The results showed that disturbance in fluctuations can be a significant driving force in lake ecosystems and it can control the above-ground biomass of emergent plants and species composition in the littoral zone.

Acknowledgments: This research was funded by the University of Life Sciences in Poznań, Poland.

Changes in forest plant communities with recent climate warming in Jura Mountains (France and Switzerland)

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Mountains provide an ideal environment for detecting vegetation changes in response to

climate warming because of steep climatic gradients across elevation. Numerous observations at the subalpine/alpine and the alpine/nival ecotones have already substantiated an influence of climate warming on the coldest margin of plant species distribution. However, observations for vegetation changes in response to recent climate warming are truly lacking at lower elevations, below the subalpine-alpine ecotone.

In 2007 (current period of warmer conditions), we re-sampled 211 vegetation plots first sampled in 1989 (previous period of cooler conditions), below the subalpine vegetation belt in silver fir forests of the Jura mountain range (NE France and W Switzerland). We used both even-aged and uneven-aged stands to test the effect of fluctuations in stand characteristics over time that might mask changes of primary interest, namely recent warming conditions in the studied permanent plots.

The correspondence analysis that used plots sampled in 1989 as active variables and plots sampled in 2007 as supplementary variables depicted a change in plot position between periods along the first two axes related to elevation and water availability respectively. A significant shift of the plots towards lower elevations along the first axis, and a significant shift of the plots towards lower water availability along the second axis indicate a change in community composition towards warmer and dryer conditions during the past 18 years.

The use of Landolt's mean indicator values showed a significant shift towards higher temperature values between 1989 and 2007, which confirms a significant change in community composition towards warmer conditions implying the coming of thermophilous species and/or the loss of species due to non-tolerant to warm conditions. An additional change of mean light values was detected for even-aged stands only. By keeping equilibrium in stand structure characteristics over time, uneven-aged stands management allowed us to highlight climatic trends regardless of natural ageing trends. Among frequent species, present with more than 40 occurrences in the dataset, lowland species displaying more than 5% of change in frequency between 1989 and 2007 (9 out of 31) mostly increased in frequency (8 out of 9 species) between periods whereas high-altitude species displaying more than 5% of change in frequency between 1989 and 2007 (5 out of 29 species) mostly decreased in frequency (4 out of 5 species). The high-altitude species also showed a significant decline at the lower limit of their altitudinal distribution leading to a rise of 18 m of this limit.

Our study shows that climate change also affects the community assemblage in mountainous temperate forests, regardless of stands age and forest management, in addition to the upward or poleward shifts of species distribution limits already observed in extremes ecosystems.

Response of a meadow community to mowing, fertilisation and dominant removal: the role of species traits

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The results of a 14-years manipulative experiment in an oligotrophic species-rich meadow in South Bohemia, Czech Republic are presented. The experiment had a factorial design with three factors (mowing, fertilisation and removal of dominant grass *Molinia caerulea*), and three replicates for each of the eight factor combinations.

In the course of the experiment, species composition, composition of species functional groups and prevailing species traits, total species richness, total productivity, and seedling recruitment all changed, depending on the treatment. Overall, mowing had a positive and fertilisation a negative effect on species richness and seedling recruitment. Effect of removal of *Molinia caerulea* was also positive, but differed according to the combination of mowing and fertilisation. Responses of individual species can be predicted by (combinations of) species traits, with potential species height being the most successful predictor (potentially tall plants are favoured by fertilisation and absence of mowing). Other predictors include characteristics of clonal growth. *Molinia caerulea* maintained highest dominance in unmown unfertilised plots. When removed, it is not replaced by species from the same functional group, but mostly by various tall dicots. The weighted averages of trait values in individual plots change due to (1) change in species composition or (2) species plasticity. For the change in the species composition, mowing is more important, whereas for the plastic response, fertilisation is much more important. The dominant species *Molinia caerulea* plays a unique role in the community, which is determined by its life history. Its presence affects the amount of litter, seedling recruitment and phenology of the whole community, and the constancy of biomass production over the years.

Rapid altitudinal range expansion and the formation of no-analog communities in response to warming

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Species ranges are predicted to expand along their cooler boundaries in response to the rising temperatures associated with current global changes in climate. Indeed, this has been well documented for the poleward extension of latitudinal ranges in the northern hemisphere. However, few studies have demonstrated upslope altitudinal range expansion and none have yet documented the response of a complete vascular flora to warming. In consequence, current rates of range expansion and the proportion of species shifting upslope have been estimated from subsets of local floras.

Here we examine patterns of altitudinal range change in the entire indigenous vascular flora (22 species) of sub-Antarctic Marion Island (South Africa). We demonstrate a significant mean upslope expansion in the flora since 1965 (Wilcoxon matched pairs test: $T = 48.5$, $p = 0.035$), in response to warming of 1.2° C on the island. The 3.4 ± 0.8 m/yr (species with expanding ranges; mean ± SE) upslope expansion rate documented is amongst the highest estimates from partial floras. However, less than half of the species (43%) in the flora were responsible for the expansion trend, demonstrating that the biological responses to climate change may be driven by a highly responsive subset of the species pool. Individual range expansion rates varied greatly (coefficient of variation in changes upper altitudinal boundary = 197%), with range changes varying between a 388 m upslope expansion and 146 m downslope contraction of species upper altitudinal boundaries. Species-specific niche requirements explained some of this variation, with slower range expansion in species associated with seabird manuring (0.8 ± 0.5 m/yr) and range contractions in the two halophytic species (0.5 ± 0.1 m/yr). As a result of the idiosyncratic expansion rates, the altitudinal pattern of community composition changed considerably, leading to the formation of no-analog communities (i.e. novel combinations of species) at higher altitudes. Altitudinal patterns in species richness were also affected by changes in species upper altitudinal limits, with, for example, an increase from one to seven species occurring at altitudes exceeding 600 m. Therefore, both species-level and community-level changes occurred in the flora of Marion Island over a relatively short period of rapid warming, demonstrating the sensitivity of high latitude communities to climate change over the last 40 years. Patterns of change within this flora illustrate the range of variation in species responses to climate change and the consequences thereof for species distributions and community reorganisation.

High species richness in the warm-temperate zone of Taiwan: a result of mid-domain effect or evolution?

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In Taiwan, the highest species richness along the elevation gradient is in the warm-temperate zone, located approximately at altitudes between 1000 and 2000 m, which is close to the middle of the elevation gradient spanning almost 4000 m (0–3952 m). One possible interpretation of this pattern is the mid-domain effect. However our previous study based on regression models revealed that apart from the mid-domain effect, other explanations might include the presence of the cloud, and the interaction between area and landscape heterogeneity in each elevation zone. We therefore propose an evolutionary explanation for the mid-elevation peak in species richness as an alternative to the mid-domain effect. We hypothesize that the long-term stability of habitats within the warm-temperate (altitudinal) zone led to evolutionary accumulation of species.

The concept of generalists and specialists was employed for this purpose. We assumed that specialists are more sensitive to habitat conditions, and that the number of specialists in a given habitat can be therefore used as an indicator of its past environmental changes. Fridley et al. (2007) proposed the idea of calculating the degree to which a species is a specialist or generalist based on the co-occurrence data from phytosociological databases. We used a modified algorithm accounting for the size of the species pool and calculated the degree of species habitat specialisation of Taiwanese plants using an extensive vegetation dataset.

Projection of species optima on the elevation gradient showed that specialists were concentrated between 1000 m and 2000 m, while generalists were evenly distributed across the whole elevation gradient. This result is in contrast with the predictions of the mid-domain effect theory which expects high proportion of generalists at the middle elevations. How-

ever it supports our hypothesis that stable environment (at evolutionary time scale) may be the main reason for the highest species richness in the warm-temperate zone of Taiwan.

Fridley, J.D., Vandermast, D.B., Kuppinger, D.M., Manthey, M. & Peet, R.K. 2007. Co-occurrence based assessment of habitat generalists and specialists: a new approach for the measurement of niche width. *J. Ecol.* 95: 707–722.

The constant part of vegetation—Is that an assembly rule?

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From the point of view redundancy in vegetation structure, the composition and diversity of plant functional groups can be the major filtering rule for community assembly. Studies of biogeography have shown that in relatively similar ecological conditions around the globe one can meet the repeating pattern of plant traits, without any constraint for overlap in taxonomical levels. Probably it is quite easy to accept the conclusion that there exists a common structural base rule for those communities: i.e. the constant part of the structure along the geographical gradient. The next step would be considering plant communities on a wide gradient of environmental conditions, and questioning that can one still detect any constant base of those communities? For instance, can we detect something common in the conditions of habitat disturbance and fragmentation?

We assumed that analysing pooled data of very contrasting communities or landscapes should reveal a base structure for their assembly. Using a field layer data we intended to detect common patterns. Field layer has been sampled along the wide gradient range of light availability and disturbance intensity in European agricultural landscapes. In the analysis, we excluded the most evident pattern of functional groups correlated to environmental conditions to reveal the more fundamental structural trends in herb layer communities. This was done by analyzing composition of functional groups beyond the first two axes of ordination.

The results show that beyond disturbance related traits the communities are structured by life-span, plant strategies and species performance in the landscape.

The applicability of revealed structural rules in ecosystem evaluation and biodiversity indication will be discussed. Most of all, we would like to suggest to look beyond the most revealing patterns in community structure, which can hide the more essential rules for assembly of plant species, particularly in conditions of species loss due to anthropogenic disturbances.

Differentiation of vegetation along latitudinal and altitudinal gradients in Taiwan

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Latitude or some environmental factors associated with latitude, may influence the distribution of vegetation types in Taiwan. The effects of latitude have never been identified in previous studies because the effect of altitude is overwhelmingly profound. The purpose of this study was to identify whether there are latitudinal effects on vegetation altitudinal distribution despite the great effect of altitude. Data of 3564 plots collected for the National Vegetation Diversity Inventory and Mapping Project, and 2015 plots collected from literature sources across Taiwan were used.

In the first-stage analysis, aimed at identifying the effect of altitude, plots in all 33 watersheds of Taiwan were divided into groups at intervals of 500 m along an altitudinal gra-

dient. Cluster analysis showed that latitudinal distribution patterns of vegetations were similar among altitudinal bands. Watersheds with similar species composition and distribution pattern were grouped. Three vegetation regions along the latitudinal gradient were identified: North, Central and South.

In the second-stage analysis, plots of the 33 watersheds were grouped into three groups according to the vegetation regions, and the vegetation altitudinal distributions for each region were examined. Six vegetation types were identified for all three regions. The *Ficus–Machilus* belt occurs in all but the North region. In the ascending order of altitude, these vegetation types were: the *Ficus–Machilus, Machilus–Castanopsis, Quercus, Tsuga–Chamaecyparis, Abies–Tsuga and Abies–Juniperus* belt. Our results showed that three vegetation belts at low to mid altitudes (the *Machilus–Castanopsis, Quercus, Tsuga–Chamaecyparis* belts), were found at higher altitudes in the Central than in the North and South regions. The winter monsoon is considered as the most important factor influencing vegetation at lower altitudes of in the North and South regions. This factor is also considered as the main cause of differentiation of the vegetation types along the latitudinal gradient.

The effects of species dominance on species distribution modelling

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It has been reported that the performance of species distribution models (SDMs) is related to data properties (such as location error and sample size) and species traits (such as growth rate, altitudinal distribution range and maximum altitude). The dominance of species in habitats is a measure of population success and thereby it may be associated with the probability of species occurrence. Habitats with low dominance of a species may represent a noise for modelling, which may reduce the accuracy of SDMs. Here we address two questions: Does removal of low dominance species records increase the accuracy of SDMs? Is species dominance an influential factor for SDMs?

Tsuga chinensis var. *formosensis* in Taiwan was selected for the modelling. The percentage basal area of *Tsuga* in each plot was used as the dominance index. Plots with presence of *Tsuga* were divided into nine groups according to *Tsuga* dominance on a nine-degree scale. It was found there were no plots in the first two degrees. Data were put into models in order to remove plots with low ad high dominance. Performances of two distribution modelling

methods, maximum entropy (MaxEnt) and generalised additive models (GAMs) were examined.

Although the performance of the two models differed significantly amongst datasets with different dominance assemblages, the performance was affected by the number of sampling plots rather than by dominance of data. Removal of low or high dominance data did not increase or decrease the accuracy of the prediction of the two models. Our results indicated that species dominance of data has no significant effects on the performances of either model.

European heathland vegetation: a biogeographical approach

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Heathlands are physiognomically well-defined vegetation type, particularly common in the Atlantic coastal regions of Europe. It consists of shrubby heathers (*Calluna, Erica* and other Ericaceae), woody legumes (such as gorses *Ulex europaeus, U. gallii, U. minor*), *Stauracanthus boivinii, Pterospartum tridentatum,* several *Genista* species (*G. anglica, G. micrantha, G. pilosa, G. tridens* etc.) and grasses including *Agrostis curtisii, Pseudarrhenatherum longifolium, Avenula sulcata* etc. This vegetation type has been traditionally included in the class of Calluno–Ulicetea. Climate with high rainfall and a strong oceanic character is the main environmental condition involved, together with acidic substrata. Atlantic coasts of Europe have suffered several dramatic advances and retreats during the Pleistocene. Large areas have been sea-free during cold maximums and they were flooded in warm periods such as during the Holocene. The fingerprints of these climatic waves are, to a certain extent, recorded in the modern distribution of the species and assemblages of heaths.

The purpose of this paper was to study the biogeographical signals and patterns in the European heathlands. The main assumption was that the floristic spectrum of the different plant communities of a given vegetation type in a particular area partially summarizes the historical events and the climatic conditions when compared to other regions supporting the same vegetation type. We have used floristic relevés (collected using the Braun-Blanquet approach) available in the literature about heathlands classified syntaxonomically as the Calluno–Ulicetea. The study area included the Atlantic seaboards of Europe, spanning Norway and Iberian Peninsula as well as a small region in northern Morocco. The total

area has been arbitrarily divided into 24 sectors using geographical and heathland species distribution criteria. Those sectors are intended to have a comparable size in order to assure an even partition of the whole area. Climatic indices (incl. Rivas-Martínez's thermicity, continentality and ombrothermic indexes) calculated on basis of climatic data collected in the meteorological stations located in the selected areas have been used.

Canonical correspondence analysis revealed correlations between the species richness and the thermicity and ombrothermic indexes. The distribution of the sectors in the ordination showed a similar pattern in analyses which used only the Calluno–Ulicetea species or only the rest of the species. The sectors with the highest richness of both the Calluno–Ulicetea species and the companion species were located in the north-western part of the Iberian Peninsula, while the species-poorest ones were found in northern European regions characterised by overall lower temperatures. The southernmost sectors (SW Iberian Peninsula and northern Morocco) support a high proportion of endemics and the heathlands are accompanied by a large number of mediterranean plant elements; the diversity of the true (characteristic) Calluno–Ulicetea taxa is lower.

These results suggest that the European Atlantic heathlands are, in their origin, thermophilic and strongly oceanic and ombrophilous western European vegetation type which during the last glaciation was restricted to the shores of the Bay of Biscay. Temperature increase in Holocene has allowed the expansion of these heathlands northwards as far as Norway and Scotland, where they mix with heathers of boreal distribution. The southern distribution limits of these heathlands are severely limited by low rainfall; they are restricted to the mountainous areas where orographic precipitation permits its survival. However, the south Iberian and Moroccan heathlands do support some endemic taxa which fact is suggestive of an ancient origin of this vegetation type, perhaps being a witness of periods when climatic drought was not so severe as today.

JUICE-based, robust floristic classification of indigenous forests of Mpumalanga Province, South Africa

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Most of the indigenous forests in Mpumalanga Province (South Africa) are classified as Mpumalanga Mistbelt Forest with no previous attempts to subdivide forest into sub-types. The Mpumalanga forests are considered by many as complex and difficult to interpret. This study attempts to do so for the first time. Indigenous forests of Mpumalanga were surveyed using over 698 species collected in 506 forest relevés across the Province, and in three of the adjacent provinces. Species richness for each plot ranged from 18 to 101 species with an average of 44–45 species per 400 m^2 relevé.

We classified the plot data using various cluster analyses embedded within JUICE 6.5 software, which links seamlessly to PCORD 5. In order to select the best combination of cluster analysis settings, OPTIMCLASS procedure was used to test the efficacy of the different settings by highlighting those settings which resulted in the highest cumulative number of diagnostic species occurrences (based on fidelity values).

A range of fidelity values were ultimately used in the OPTIMCLASS procedure and those settings which consistently produced the highest number of diagnostic species were selected for further testing to determine best technique. A total of 21 different combinations involving various cluster analytical procedures (settings) were used for comparisons and also compared to the once popular TWINSPAN classification method (using the Modified TWINSPAN procedure available in JUICE 6.5). The performance of each setting (as well as Modified TWINSPAN) was calculated and expressed as a percentage of the highest performing value (the highest number of diagnostic species occurrences for that particular fidelity value). Thus for each setting and each fidelity value, a value out of 100 was obtained. These values were then averaged across all fidelity values, and then ranked from highest to lowest. The performance of the top three ranked distance measures were then further tested for robustness and compared to select the best method to apply to the data set. These tests were based on the classification of 10 groups. Four tests were conducted, such as (1) measure of beta diversity within each cluster (averaging Sørensen resemblance within each cluster), (2) averaging the number of positive fidelity values (using u-value fidelity measure), (3) crispness, and (4) uniqueness of classification.

Averaging the OPTIMCLASS values across fidelity values identified the best method and settings as the Jaccard similarity with floating cut level by species data value transformation and beta-flexible (-0.25) group linkage method. The modified TWINSPAN procedure performed poorly and ranked only 19 out of 22. The top three distance measures were again tested for robustness of choice. Jaccard similarity outperformed the other distance measures as it had the lowest averaged dissimilarity score within groups (groups were therefore more homogenous); it also had the highest pooled number of positive fidelity values, the highest averaged uniqueness value, but also the lowest crispness values.

We conclude that JUICE 6.5 provides a suite of procedures suitable for ensuring a robust

analysis and the users of its classification routines are advised to engage in careful testing of its options (in conjecture with the data structure) prior to embarking on classification of the data.

Acknowledgements: This work was supported by a South African Student Travel Grant provided by the Regional Section for Southern Africa of the IAVS.

The ecological factors controlling high plant diversity in Raifa (Tatarstan, Russia)

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A species pool is shaped under certain environmental conditions by filtering from a regional species pool, eventually leading to a restricted number of observed species in a target community. Using the species pool concept we aim to explain the local plant community assembly in a very heterogeneous region of Raifa (Tatarstan, Russia).

We considered the species pool of a target community as a set of species filtered by ecological sieves including biotic and abiotic interactions of different quality. We assumed that the total regional species pool is affected by long-term historical processes such as migration, speciation, geological stability and the like. At the same time the observed regional pool is an outcome of restricted species dispersal ability. This way differences between species richness of local target communities can be explained by ecological limitations in the sense of eco-topological distinctions in spatial distribution.

We were seeking for evidence in which environmental gradients in the species pool would provide a better explanation in the observed variations in species richness within a landscape. Ellenberg indicator values were used to estimate the environmental suitability of the communities. Simultaneously similar coenotic assemblages, i.e. resembling target community types, were determined by phytosociological means. An accurate identification and quantification of the size of the species pool makes it possible to determine the relative importance of mechanisms of community assembly, such as environmental limitations, coenotic preferences, and stochastic events.

Contrasting plastic responses to light in two closely related *Agrimonia* (Rosaceae) species

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Phenotypic plasticity is often considered a trait that is positively related to fitness in heterogeneous environments. However, in homogeneous and predictable environments the maintenance of mechanisms for plastic responses may become an unnecessary burden for an individual, thus lowering its relative fitness.

We hypothesised that species-specific response patterns to light availability exist in Estonian populations of two closely related, morphologically and ecologically similar congeneric species: *Agrimonia eupatoria* (Rosaceae) and *A. pilosa*. There were two reasons to expect a higher degree of active plasticity to light in *A. eupatoria* when compared to *A. pilosa*: (1) Since differentiation the two species have encountered different light conditions – *A. eupatoria* has inhabited European mosaic landscapes, while the distribution centre of *A. pilosa* has been in ecologically more homogeneous steppe and forested steppe regions of Russia; (2) Estonian populations of *A. pilosa* are at the edge of their distributional range and thus isolated from core populations. This allows us to expect a relatively high degree of homozygosity, shown to retard the ability of plastic responsiveness.

In total 120 individuals from four populations of *A. eupatoria* and five populations of *A. pilosa* were randomly chosen and collected. We measured the following shoot morphological characteristics: shoot biomass, stem length, inflorescence length, the number of leaves, leaf area, and specific leaf area. In the rooting point of each plant the penetration of light through tree canopy (Site Factor) and through herbaceous canopy was measured using hemispherical photographs and light meter with a linear sensor.

The results confirmed our working hypothesis: *A. eupatoria* demonstrated active plastic responses to light in several functionally important shoot traits while *A. pilosa* showed hardly any active plasticity, most of its variability in morphology being explained through differences in plant size.

Complexity of application of association concept for Irano-Turanian montane vegetation

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The Irano-Turanian Floristic Region is a phytochorion belonging to the Holarctic Floristic Kingdom. This is a vast area spanning regions from northern Syria, Central Anatolia, the entire Iranian Plateau and covers large areas of Central Asia up to Gobi Desert. A large number of montane and alpine lineages has their centre of diversity in this area. The biodiversity patterns and vegetation of this area has been insufficiently investigated.

In our study we have focused on the vegetation and biodiversity patterns in the Tuchal Mountains, part of the Central Alborz, northern Iran (from 1800 to 3000 m of alt.). A total number of 340 species was recorded, most of them being Irano-Turanian elements. The hemicryptophytic life form is the dominant one in the majority of plant communities. A phytosociological study was carried out from the foothills up to 3000 m. More than 300 relevés with a standard size of 25 m^2 were recorded according to Braun-Blanquet method of cover estimation. A multivariate analysis resulted in classifying the vegetation of the area into five major vegetation units. The plant communities are differentiated along altitudinal gradient and habitat characterisation. In this area some vegetation types such as alpine, hygrophilous and cliff communities are well separated from each other. But in montane and steppic vegetation we have encountered great problems in distinguishing of plant communities at the association level.

We argue that a combination of long-term land use (e.g. grazing), small scale niche compartmenting, genetic diversity among many actively evolving plant groups, and climatic fluctuation are the main reasons for such complex pattern. Therefore we need to develop an improved procedure for description of plant associations. Furthermore we found that many mixed associations arise from niche compartmenting, habitat heterogeneity, and introgression which introduces the need for the new concept—'hybrid association'.

Succession of wood-inhabiting fungi during decomposition of the dead wood

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Wood decaying polypore species are key components of the forest biodiversity and they also have functional role in the nutrient cycling. Many polypore species are threatened as a result of intensive forest management and decline of amount of dead wood in forests.

However, effects of biodiversity loss on rate of decomposition are not known and differences in the succession of the polypore species in the decomposing substrate in managed and unmanaged forests is not quantified. In this study we analyse the succession of deadwood decaying species and its relation to the decomposition of dead wood. This study test the hypothesis that the species diversity peaks at the decay stage, when rate of decomposition is highest and resource is easily available.

Modelling of probability of fruit body occurrence (spore production) of polypore fungi are based on extensive species-habitat survey data that comprise observations from 125,000 deadwood objects. In addition, wood decaying species are identified directly from a smaller number of decaying logs with amplification and sequencing of DNA and RNA. Besides identified species, this technique allows estimation of total species richness of all active fungi species. The time since death of tree is measured with dendrochronological methods and the phase of decomposition is measured as a mass loss of logs. The changes in the C/N-ratio of the decaying substrate and the proportions of different chemical fractions (hemicellulose, cellulose, and lignin like substrates) are used for development of a dynamic decomposition model that is linked to a stand level simulation model.

The highest number of species was observed in mid-decay phases where the rate of decay is highest. To use the information on succession of wood-decaying fungi in practice, developed species models are linked to dynamic dead-wood decomposition model that is implemented into forest ecosystem model. The model simulations show how dead wood continuum (amount and quality of dead wood) is affected by different management practices (natural and managed forest) and how species diversity is maintained with different management options. The results of this study improve the understanding of the functional role of biodiversity on decomposition process and they can be used in forest conservation and restoration plans.

Ecotypes of wild rooibos (*Aspalathus linearis*) require sustainable management regimes to ensure their survival

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Rooibos tea is produced by harvesting and fermenting the leaves and branches of cultivated and wild growing *Aspalathus linearis* (Fabaceae). This fynbos shrub is endemic to the Cape Floristic Region of South Africa. The natural distribution of *A. linearis* is limited to the

western interior of South Africa along the winter rainfall zone. It is well adapted to nutrient poor and acidic soils, and does not occur naturally anywhere else in the world.

Sustainable harvesting and management regimes for a resprouting *A. linearis* ecotype have been recommended based on scientific evidence and local knowledge. Further scientific studies on five morphologically distinct rooibos types suggest that: (a) genotypic differences correspond the variation in morphology of plants in the wild at the population level, (b) the distribution of different wild rooibos ecotypes is linked to the structure and composition of plant communities where they occur, and (c) that specific harvest and management regimes are crucial to the conservation of wild rooibos ecotypes.

A scientific study is being proposed, hypothesising that intraspecific classification of wild rooibos is warranted, and that morphologically distinct types require specific management regimes to ensure their sustainability. The need for such a study is rooted in the growing concerns of the negative impact that indiscriminate harvesting practices, overgrazing, alien plant invasion and unprecedented changes in land-use practices have on the genetic stock and health of wild rooibos ecotypes. The research will focus on the following issue: re-examination of the intraspecific classification of *A. linearis*, investigation based on genetics and morphology, investigation into the plant community structure of sites where significant populations of wild rooibos occur, elucidation of harvest practices that will ensure sustainable use of the different ecotypes, and on an evaluation of the extent to which wild rooibos is valued by land-users in the local context.

Species packing under different disturbance levels

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Classical niche theory predicts decreasing realised niche widths with increasing interspecific competition. Provided that interspecific competition is not prevented by other factors, the increasing density of species' optima in a community should, on average, lead to narrower niche ranges—a phenomenon that is commonly called species packing.

We analysed the relationship between niche widths and the density of plant species optima with a large vegetation database from NE Germany. We hypothesised that with decreasing disturbance level the relationship between niche widths and optima density should become stronger, i.e. a high disturbance level should effectively prevent interspecific competition,

whereas the absence of disturbance should allow strong competition. We used weed vegetation (2822 plots) as an example of a highly disturbed habitat type, managed grassland vegetation (2562 plots) as an example of intermediate disturbance level, and natural open peatland vegetation (3172 plots) representing a relatively low disturbance level.

To estimate the niche widths of species we used a recently published method that is based on co-occurrence data (Fridley et al. 2007). For the estimation of density of species optima we used species scores of a detrended correspondence analysis. As density measure we applied the mean of the Euclidean distances in the four-dimensional solution to the neighbouring species (one third of the total species pool of the respective data set). Additionally, we weighted these mean Euclidean distances by the average frequencies of the neighbouring species, reasoning that only a present species can impose competition.

Contrary to our hypothesis we did not find any relationship between realised niche widths and the density of species optima within the three data sets. When measured as presence-absence data with a co-occurrence based approach, niches widths of plants from the observed habitats are obviously independent from the packing intensity of species optima.

Fridley, J.D., Vandermast, D.B., Kuppinger, D.M., Manthey, M. & Peet, R.K. 2007. Co-occurrence based assessment of habitat generalists and specialists: a new approach for the measurement of niche width. *J. Ecol.* 95: 707–722.

Seed banks and fire—their role in north European heathlands

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Dormant seeds in the soil serve a dual function in plant populations. They are memories of populations and communities past, but also a potential for future persistence and survival. Habitat loss and degradation as a result of land use changes are great threats to biodiversity on a global scale. In Scandinavia traditional coastal farming has resulted in a high diversity of semi-natural habitats. Heathlands are dynamic systems where management history in many cases is known; they lend themselves to investigations on spatial and temporal processes.

We analysed succession change in standing vegetation and seed bank in burnt heath (mature to degraded phase) of varying age (0–24 years since last fire), using a chronosequence

approach, in heathlands of western Norway. Soil seed banks were germinated and compared with standing vegetation. A total of 75 taxa were identified, 54 species were found to germinate from the seed bank, while 60 species occurred in the standing vegetation displaying a 68% similarity. Species richness of the vegetation was higher than the corresponding seed banks at all sites. The 10 most abundant species in the seed bank constituted 98% of the germinated seeds. The most abundant was *Calluna vulgaris* constituting 49% (12,018 seeds/m^2). *Erica tetralix* was the second largest; 34% (8414 seeds/m^2).

Calluna showed significantly higher germination rates in the two first years following prescribed burning, a response possibly triggered by germination ques related to smoke, ash and temperature. We have initiated two experiments based on these findings. These intend to tease apart the mechanisms contributing to higher germination rates as seen in *Calluna* right after fire.

Overall seed density, richness, and composition showed only weak relationships to the time since burning. The species found in the seed bank were largely related to the localised vegetation composition and did not change markedly during the course of the post-fire succession. Hence, seed banking may be a crucial asset in post-fire recovery. These findings confirm rotational heather burning to be a viable management measure and an important factor in order to maintain northern heathlands.

Arbuscular mycorrhizal fungal communities in east Texas

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This study investigates arbuscular mycorrhizal fungal (AMF) communities from the roots of three widespread native plants across a range of east Texas (USA) habitats using a DNA fingerprinting technique. Denaturing gradient gel electrophoresis (DGGE) was used to separate AMF PCR products of 18S rDNA amplified from DNA extracted from root samples of *Callicarpa americana*, *Chasmanthium sessiliflorum* and *Toxicodendron radicans* to obtain AMF community 'fingerprints'. Samples were taken from the full range of far-east Texas ecotypes including pine-dominated uplands, mesic slopes, minor stream bottoms, and river floodplains. 137 fingerprints from 29 sample sites were obtained. The resulting samples-by-DGGE bands data matrix was subject to multivariate analysis. Samples from

each of the three hosts occupied overlapping but partially distinct regions of a canonical correspondence analysis (CCA)—indicating a degree of host preference among AMF. CCA followed by a permutation test for AMF samples from *C. americana* showed soil phosphorus, potassium, magnesium, percentage clay as well as the topographic position of the sample sites and the first two axes of a detrended correspondence ordination based on vascular plant species to be significant constraints. For *T. radicans*, soil pH, nitrogen, phosphorus, sulphur, and the first axis of the vascular plant ordination were significant constraints while for *C. sessiliflorum*, only potassium was significant. Nitrogen, potassium, magnesium, and the second axis of the vascular plant ordination were significant constraints for an ordination of the samples from all three hosts. Analysis of a UPGMA dendrogram of the AMF samples using the 'Treeclimber' software indicated that the branch-structure was non-random with respect to nitrogen, phosphorus, magnesium, and the second axis of the vegetation ordination. AMF community composition in eastern Texas thus corresponds to both the host plant with which the fungi associate and the larger habitat in which they occur.

Serpentine flora and vegetation of the SW Santa Clara region, Central Cuba

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Floristic inventory and vegetation study of a 27 ha plot were pursued to describe the serpentine flora and vegetation of the SW Santa Clara, Cuba. Data were collected during more than 50 expeditions to this area during 2001–2008; historical herbarium collections in ULV were also surveyed.

We found in total 155 species of phanerogams in the area, representing 35.7% of the plants listed for the entire serpentine region, although the studied territory was actually 2700-times smaller than the total extent of the serpentines. The level of endemism was 38 %, with a high number of local endemics (7); the local endemism and the endemism of the ancient province of Las Villas represent together 50 % of the district endemism. The following plant formations were identified and characterized: xeromorphic thorny thickets on ultramaphic soils, secondary grassland with elements of xeromorphic thorny thickets, and secondary riparian grassland.

The extraordinary scientific value, small size and proximity to the city, makes this region of extraordinary importance for conservation and an ideal object for the development of environmental education programs involving the local population.

Species richness in European steppes: role of productivity, soil depth and pH

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Productivity and soil pH are commonly recognised as influential determinants of grassland vegetation diversity. So far, little is known about factors influencing local richness in steppe grasslands of subcontinental and continental areas of Europe. We sampled steppe vegetation in two regions: *(i)* in the southern Urals, situated within the Euro-Siberian steppe zone, and *(ii)* in the Czech Republic, situated at the margin of the forest-steppe zone. By simultaneously studying these contrasting regions we aimed to identify the major patterns in species richness and how these patterns relate to productivity, soil depth and pH.

Steppe vegetation types varying in soil depth, pH and productivity were represented in both data sets. Vascular plant species richness was determined for 100 m^2 plots. Aboveground non-woody biomass was collected from 0.25 m^2 subplots and used as an estimate of site productivity. Soil depth was measured in three places of each plot and averaged. Similarly, soil pH was measured from a mixed soil sample taken from three places in each plot.

Species richness increased with productivity in both the Czech and the Uralian steppes. Due to their general dryness, productivity of most steppe vegetation types is relatively low. In addition, strong moisture fluctuations in steppe soils make it difficult for competitive species to become dominant in the stands. Competitive exclusion is probably not a major force. Therefore we did not observe the typical unimodal or even decreasing response of species richness to productivity, commonly reported from grasslands with a higher and more balanced water supply.

Productivity was strongly related to soil depth. Interestingly, in the Uralian steppes soil depth is a markedly better predictor of species richness than productivity, while in the Czech steppes the effect of both predictors is comparable. This implies that soil depth does not only affect species richness through its effect on productivity, but also by other means.

Species richness increased along the pH gradient in both regions. However, in the Uralian steppes, there is a peak at pH 6.8 followed by a decrease towards the highest-pH soils. In the Czech steppes, such indication of unimodality also appeared once soil depth was included in the model. Low species richness at low-pH soils corresponded to a relatively small species pool of acidic substrates. The decrease in number of species at high pH may be due to severe site dryness, often connected with these high-pH soils.

To conclude, in European steppes most species occur at deep, productive soils with a pH between 6 and 7.5. Soil depth and pH together can explain about half of the variation in species richness in both the Uralian and Czech steppes.

On the evolution of the 'alpine meadows' of the Tibet Plateau

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High-latitude 'alpine meadows' cover humid south-eastern regions of the Tibetan Plateau forming 2–3 cm short mats reminding of golf-course lawns. The turfs of the endemic *Kobresia pygmaea* constitute the most important rangelands for the Tibetan yak pastoralists. Their distribution ranges between 38°N and 28°N, with a latitudinal expansion of 1400 km, and span the upper limit of alpine mats and 800 m in the forest belt. They are widely believed to be natural, despite the overall presence of livestock. We challenge this assumption.

The most elucidating feature of these mats is that the dominating species keeps its main above-surface phytomass beyond the grazing reach of large herbivores. The dominance of the low-grown graminoids is apparently grazing-induced. Results from grazing exclosures in the southern and north-eastern highlands maintained since 1997 and 2002, respectively, revealed that taller grasses emerging from a bud bank overgrow the Cyperaceae mats. Experiments in the Haibei Alpine Meadow Research Station (Qinghai) revealed that the relatively tall *Kobresia humilis–Festuca* grassland is replaced by *Kobresia pygmaea* and accompanying rosette plants under increased grazing pressure. Controlled (low) stocking rates resulted in the recovery of tall-grown forage plants, while rosette-forming and cush-

ion plants (grazing weeds) disappear.

Charcoal and pollen-analyses support the hypothesis that early pastoralists burned forests in favour of pastures within the forest belt. It is however not clear whether forests were directly replaced by the mat-forming *Kobresia pygmaea*. First ^{14}C dating of topsoils supporting *Kobresia pygmaea* and macro-remains and pollen extracted from the turfs, give evidence of a Late Holocene turf genesis. The turfs resulted from the transformation of pre-existing topsoils by secondary penetration and accumulation of roots. Consequently, the *Kobresia* pastures must be regarded as a synanthropic pseudoclimax, in most areas replacing former tall-grown grasslands and even forests.

Restoration of a sahelian savanna: 27 years monitoring in grazing exclosures in N Senegal

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Desertification research is in need of long-term data on vegetation dynamics, including reference plots which would allow distinguishing between climate-driven and human-induced vegetation dynamics processes. We present the results of 27 years of monitoring of a grazing experiment set up by the GTZ (Deutsche Gesellschaft für Technische Zusammenarbeit) on 25 permanent plots of 1 ha in the sandy Ferlo region of N Senegal (15°59' N, 15°19' W; 300 mm of MAP). The experiment provides data on vegetation changes under three different grazing regimes, such as controlled pasture on fenced plots, free communal pasture, and not-grazed regeneration plots. Daily rainfall and standing crop of the herb layer were determined every year; the composition of the herb layer was studied annually since 1992 (line intercept method), before in intervals of 4–5 years (Braun-Blanquet relevés). Trees and shrubs were subject of inventories every 4 to 5 years, while saplings were counted annually. Spot checks of topsoil nutrients were also performed in 2006.

Two pronounced droughts during the observation period (1982–1984 and 1990–1992), had clear effects on all variants of the trial. The woody vegetation contracted and regenerated best in depressions. Formerly dominant south-sahelian tree species *Sclerocarya birrea* and *Combretum glutinosum* were largely replaced by thorny *Acacia* species and *Balanites aegyptiaca*. The exclosure plots, however, proved that without grazing, the savanna would still have a considerably less arid physiognomy due to larger proportions of non-thorny trees and shrubs that can regenerate when protected from grazing. These include *Sclero-*

carya birrea and the baobab (*Adansonia digitata*), both species prone to extinction on the communal pasture.

The herb layer in the study area consisted almost entirely of annual species and showed a high inter-annual variability in production and grass/herb ratio, generally depending on the rainfall dynamics. These short-term and medium-term precipitation fluctuations were superimposed on long-term succession trends that could only be traced in such a long observation period. After 10 years, the herb layer of the ungrazed plots started to deviate markedly from those of the grazed variants. Time series regressions on species frequencies within ecological groups revealed that aridity-indicating plants were largely replaced by humidity-demanding ones, with a significant increase in the magnitude of forbs ($p < 0.01$). Most of these belonged to a species group with high grazing value and high productivity (especially legumes), the frequency of which increased significantly as well ($p < 0.001$). Accordingly, the standing crop of the exclosure plots increased significantly ($p < 0.05$) over the entire period, parallel with the precipitation ($p < 0.001$). In contrast, the grazed herb layer did obviously not recover completely after the drought 1990–1992. Over the whole period the regression showed a significant ($p < 0.001$) decline of the standing crop, paralleling an equally significant augmentation in aridity-indicating species, which contrasted the increase of precipitation. With regard to productivity (expressed as Rain Use Efficiency) the grazed herb layer showed significant decline as well, whereas there were insignificant trends in the exclosures.

Comparative analyses of topsoil nutrients in the two extreme variants (exclosure and communal pasture) showed higher contents of total C, N, P, K and high cation-exchange capacity in the regeneration plots. Even though the number of samples did not permit any profound statistical scrutiny of these differences, they indicate either a possible restoration of the soil conditions in the absence of grazing, or a silent degradation of the communal pastures, or a combination of both processes (no data from the beginning of the trial are available).

The documented secondary, progressive plant succession in the ungrazed savanna documents that the present sahelian climate allows the persistence of a vegetation type of a considerably higher mesic character than it is suggested by the grazed ecosystems. They also indicate that pastoralism contributed to a much greater extent to long-term aridification trends than it was traceable so far. Non-equilibrium concepts of ecosystem dynamics should therefore be applied with caution to the central Sahel.

We suggest that there may be two different conservation strategies depending on the favoured objective: (1) If the focus was on the maintenance and amelioration of rangelands, a temporal reduction or short-term exclusion of the grazing pressure is more beneficial for pasture regeneration than a long-term total protection. (2) If the focus was on

the restoration or reconstruction of less disturbed, quasi-natural vegetation types and an augmentation of biodiversity, the complete long-term exclusion of livestock, combined with fire-protection, is much more effective. The length of the required protection period depends on the conservation target and the environmental conditions.

Assessing floristic disturbance in the camping sites of Taman Negara National Park, Merapoh, Pahang, Peninsular Malaysia

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Disturbance on the vegetation of six camping grounds at different elevations in Taman Negara National Park, Merapoh, Pahang, Peninsular Malaysia were studied. Visitors at this national park are mostly climbers targeting the highest mountain in Peninsular Malaysia, i.e. Gunung Tahan (alt. 2187 m). On each camping site, a plot of 20 x 20 m was set up. To compare the vegetation composition and density, a control plot (undisturbed vegetation) for each study plot with the same size was also made. All plant species, except mosses, were recorded and counted individually.

Results show that disturbance in the camping site at higher elevation is more severe in terms of species diversity and density than at the lower altitude. This is because tropical montane vegetation is more sensitive to disturbance and shows slower regeneration rates. The direct effect of the disturbance is the enlargement of the area at the camping sites. Number of steps should be taken to (1) avoid the enlargement of the area by reducing the number of the visitors annually in order to minimize the impact, and (2) to establish new camping grounds and using these alternately to allow recovery of the disturbed areas.

Impact of climber trails on the mountain vegetation in Peninsular Malaysia

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Mountain hiking and climbing has recently becoming a popular activity in Malaysia. In particular the mountain of Gunung Tahan (2187 m), located in the state of Pahang and being the highest mountain in Peninsular Malaysia became major destination. The tropical mountain regions support many endemic and highly sensitive species. To asses the effect of the climbing activities on the montane vegetation of the Gunung Tahan, six study plots (each 40 m^2) were established and studied.

Initial results show that the diversity of flora along the trails is lower when compared to the control, non-disturbed sites. Tree densities are also significantly lower when compared to the control sites. In order to avoid the loss of species diversity and to reduce the damage to the plants along the trails, intensive rehabilitation programme should be developed and implemented. Other actions, such as solidifying the soils surface in the affected sites, and building of board-walks for climbers could improve and conserve the floristic composition on the mountain forest.

Impact of clonal traits on plant performances: a modelling approach

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Most herbaceous species can reproduce either by seeds or by cloning (production of ramets connected to each other either above or below ground). Each individual is constituted as a network that colonises space and through which resources can be shared and/or stored. Understanding clonal strategies is particularly important to explain patterns of species coexistence. We aimed (1) to detect which properties in clonal growth (plant architecture, resource sharing, and storage) were the most important in determining plant performance, and (2) to identify the combination of clonal traits that promotes plant performance with and without competition.

We developed an Individual-Based Model to simulate plant growth individually and in mixtures. Plant growth is simulated using rules linked with the metabolic process (carbohydrate production, ramet and connection costs in terms of primary production), the plant architecture (ramification, elongation) and the resource strategy (resource sharing and storage). Extensive simulations were made using volunteer computing (http://vcsc.cs.uh.edu/virtual-prairie/). Volunteer computing consists of using the spare time of individual

PCs of volunteers for calculations. It gives free access to millions of simulations in a short time period. This approach allows the objective testing of all combinations of parameters, assimilated to plant traits.

Trade-offs were found between the indicators of performances (biomass production, number of ramets). The ratio cost/production for connections and ramets and the inter-ramet distance were determinants of plant performance. Resource strategy and architecture parameters were dependent on the indicator of performance considered. Best performance was achieved by plants with different trait combinations (i.e. different strategies) rather than by plants with a single trait (one strategy).

This modelling approach, especially the use of volunteer computing, enabled us to proceed to large-scale virtual experiments that go past the examining of only biological constraints of plant growth. It is a key tool for understanding processes determining plant performances and identifying optimal clonal plant strategies. This study is part of a wider project of simulation of a whole multi-species prairie.

Germination cues in Mediterranean Basin flora

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The role of fire as a germination cue in plants of the Mediterranean Basin is still unclear. Heat is known to stimulate germination especially in Cistaceae and Fabaceae, but smoke is thought to play a more limited role in cueing post-fire germination than in other mediterranean-type ecosystems. Nevertheless, smoke experiments are rare in this region. Moreover, there is evidence that germination response may depend on resprouting ability as this persistence mechanism may reduce the evolutionary pressure to acquire post-fire seeding traits.

In this framework we aim to evaluate the role of heat and smoke in the post-fire germination response, and to test whether this response differs between resprouting abilities. To this aim, we performed a germination experiment with seven heat and two smoke treatments on 31 mediterranean shrub species, including both facultative (with resprouting ability) and obligate seeders (without).

The results show that twelve species were stimulated by heat alone, two by smoke alone, and six by both heat and smoke. The results also show that obligate seeders have seeds with higher dormancy and higher heat resistance, and their germination is more stimulated by either of the fire cues (heat and smoke); the inhibition by heat is also lower in obligate seeders, as compared to facultative species.

In conclusion, our results suggest that both heat and smoke are important germination cues for mediterranean species. They also support the hypothesis that there are differential evolutionary pressures on post-fire seeding depending on the resprouting ability. These results may have implications in the post-fire community assembly.

Phytosociological classification of the savannas of the Kruger National Park, South Africa

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The vegetation of the Kruger National Park has been the focus of several postgraduate studies, but until now no integrated phytosociological overview has been established. In a first attempt at such a syntaxonomic synthesis all available data have been compiled in a Turboveg database, comprising more than 3000 relevés. The resulting classification comprises seven formations and twelve vegetation classes. Of these, the three savanna classes are the subject of the present paper.

The savanna ecosystem constitutes the most widespread biome in Africa, covering large parts of the tropics and subtropics. Driving macro-ecological factors include a thermal regime of high mean temperatures and the (almost) absence of frost, as well as the alternation of wet summer and dry winter periods. In the northern part of the Kruger National Park, the Colophospermetea mopane (1 order, 1 alliance, 6 associations) is the prevailing vegetation class. The mopane veld, dominated by the name-giving species Colophospermum mopane, is endemic to southern subtropical Africa with its main distribution in Botswana and the adjacent areas. This vegetation class is associated with severely dry winters and severe periodic physiological water-stress within the vegetation layer. Such water-stresses may be induced by high water retention characteristics of clayey soils in areas with moderate rainfall, or by extremely low rainfall on sandy soils. The Combretetea apiculati

(3 orders, 4 alliances, 13 associations) are predominantly associated with well-drained, sandy soils. These habitats include sandy planes and plateaus, undulating landscapes and coarse-grained gravel slopes associated with a wide range of geomorphological types. Soils are generally leached and nutrient-poor due to their position along the catena and due the low nutrient status of the mother material from which they originate. The third class, the Acacietea tortilis–nigrescentis (3 orders, 3 alliances, 13 associations) is restricted to soils with relatively high nutrient content, low levels of nutrient leaching and frequent physiological water-stress in the associated vegetation. This class may range from clay-rich soils in the moderate to high rainfall areas, to poorly leached sandy soils in the low rainfall areas. Soils are derived from a wide range of different geological origins.

This syntaxonomic classification and its underlying data will form the basis for SynBioSys Kruger, an information system for the planning, evaluation and support of biodiversity management among plant species, vegetation types and landscapes in the Kruger National Park.

Soil seed bank and its relationship with the current vegetation at forest-grassland ecotone areas in southern Brazil

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Natural grassland-forest mosaics characterise vegetation in southern Brazil and some studies have shown that forests are expanding into grasslands, since climatic conditions allow the forest development. Fire and grazing are both factors that prevent such expansion, maintaining sharp edges as well as species-rich grasslands.

This study was carried out on ecotone areas where borders between forest and grassland have been remarkably stable due to frequent fire. Soil seed banks (SSB) were collected in two soil depths (surface: 0–5 cm; deeper layer: 5–10 cm) and current vegetation was examined in six transects along forest-grassland gradients representing distinct grassland physiognomies.

The SSB of forest samples had an average of 1409 seeds/m^2 while grassland ones had 3477 seeds/m^2, considering surface samples. Deeper soil samples had significantly less

seeds and richness, and distinct species composition. Sharp borders in forest-grassland were as well observed in the SSB. While samples within forests were relatively similar, composition changed rapidly at the border, followed by a gradual increase in similarity between grassland units. Within the grassland, the SSB was diverse, probably because of high spatial heterogeneity of grassland composition. Indeed, inside the forest a very low similarity between SSB and vegetation was observed, corroborating with low disturbed ecosystems; high floristic similarity suggests that most of species present in the SSB were induced to germinate, usually due to disturbances. On the other hand, the grassland SSB was more similar to current vegetation, as it should be in high-disturbed ecosystems, but still low (Sørensen index = 0.37); moreover, dominant species in SSB were totally distinct from those of vegetation. Current vegetation is mainly characterised by perennial grasses while SSB was composed especially of annual and ruderal herbs that did not occur above-ground. Thus, the SSB does not appear to be an important source for seedling recruitment after disturbance in these forest-grassland ecotones under actual fire regime; the ability to quickly sprout after any disturbance event is probably the main strategy of grassland plants and the forest expansion over them is almost exclusively dependent on seed rain and establishments in the intervals between fire events.

Patterns of woody species seedling regeneration in relation to environmental gradients in a semi-deciduous African tropical rainforest

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Seedling regeneration patterns (diversity, density, and spatial distribution) in relation to environmental factors, and historical management practices (HMPs) were studied using 32 plots (0.5 ha each) situated along topographic gradient transects in the Budongo Forest Reserve (BFR), Uganda. We compared seedling species diversity, composition, and distribution patterns among *(i)* topographic gradients, *(ii)* HMPs, and *(iii)* forest community types; and tested whether environmental factors contributed to the variations in seedling abundances among species.

We recorded 85,624 seedlings in 237 species and 46 families, with *Cynometra alexandri* and *Lasiodiscus mildbraedii* as most abundant and among the most widely distributed

species. Of the 237 species, about 30% were rare (2–10 plants), while 12% were very rare (one plant each). The species-richest family was Euphorbiaceae, followed by Fabaceae, Rubiaceae, Meliaceae, Moraceae and Rutaceae. Only total seedling density was significantly different between the HMP areas; the highest was found in the logged areas only, the lowest was in the nature reserve, and the intermediate in areas with combined logging and application of arboricide. Seedling composition differed significantly between transects, but not between topographic positions or HMPs. Both Chao-Jaccard and Chao-Sørensen abundance-based similarity estimators were relatively high at the plot, forest community, and HMP levels. Environmental factors significantly explained 59.4% of the variance in seedling species distributions, with soil organic matter, total soil titanium, and leaf area index (LAI) being the most important variables. Total seedling density was significantly correlated with LAI. Differences in the diversity of >2.0 cm stem diameter plants also explained significant variations in seedling species diversity.

Patterns of seedling regeneration in BFR are a reflection not only of the site conditions as shown by the edaphic and abiotic factors, but also of the HMPs. Hence, the important mechanisms influencing seedling regeneration in BFR operate through both edaphic and canopy vegetation characteristics. The wide distribution of seedlings for a variety of species suggests continuous regeneration in BFR.

Beta-diversity of the woody flora of a managed semi-deciduous African tropical rainforest

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We determined and described patterns of woody plant beta-diversity (measured by Whittaker's beta-diversity Index and modified Morisita-Horn Index of similarity) at the scale of plot, transect, historical management practice (HMPs) type, and total forest. We employed separately stem diameter *greater than or equal to* 2.0 cm (further SD≥2) and *greater than or equal to* 10.0 cm (further SD≥10) data from 32 plots (0.5 ha each) at various topographic positions in the Budongo Forest Reserve (BFR), Uganda. We tested for variation in community species composition at the various scales using the ANOSIM permutation tests and explored the relationship between beta-diversity and environmental factors (soil

nutrients, light availability, HMPs type) using canonical correspondence analysis.

Mid-slope, upper-slope, and crest plot groups were found to be significantly different (RANOSIM>0.2; $p < 0.05$) from the lower-slope (swampy) plots in terms of species composition. Both Whittaker's beta-diversity and Morisita-Horn Index values were higher along transects for SD≥10 than for SD≥2 woody plants. At the HMPs scale, higher beta-diversity for logged and arboricide treated areas were detected, followed by logged only area, and nature reserves. Beta-diversity was relatively high at the total-forest scale, when compared to other scales. Generally beta-diversity was low, but higher for SD≥10 than for the SD≥2 data.

Environmental factors significantly explained 66.5% and 61.9% of the variance in species composition for SD≥2 and SD≥10 data, respectively. Spatial variability in community species composition was higher for SD≥10 compared to SD≥2 data across the forest.

We conclude that the use of SD≥2 cut-off would be more appropriate in assessing beta-diversity in semi-deciduous forests of conservation value as it captures most of the species richness and variation in species composition of sites. Variation in woody species composition in BFR is characterised by significant spatial patterns. The patterns in beta-diversity are to a great extent associated with environmental heterogeneity.

The mathematical models simulating populations, plant communities, vegetation of landscape dynamics and evolution in the changing environment

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Evolution of vegetation (phylocoenogenesis) is the genesis of new types of plant communities (syntaxa). It includes three interacting components, such as evolution of species (phylogenesis), evolution of flora (florogenesis), and evolution of environment (ecotopogenesis). Phylocoenogenesis is manifested by vegetation succession, hence a mathematical theory of plant succession is cardinal to understanding the phylocoenogenesis.

The system of mathematical models that simulates plant populations, plant communities, vegetation dynamics and evolution at the landscape scale in a changing environment includes the following three models:

MSC: a model simulating competition between plant populations in the plant community under a changing environment. The model is based on a modified Lotka-Volterra system of differential equations, where the coefficients of competition, mortality and generation are interpreted as Ramensky-Grime plant species strategies and the capacity of environment is estimated using Ramensky's' ecological scales.

LAPONA-2: a model consisting of differential equations simulating growth of tree stands, the flows of organic matter, nitrogen and water, soil temperature and light penetration through the canopy. LAPONA-2 uses the submodel ROMUL (by Chertov, Komarov) that simulates rough organic matter decomposition. One of the main input parameters of the model is the granulometric composition of soil, which determines (with rough organic matter and humus) the water capacity of the ecosystem, soil temperature and phytomass production.

LVD: a model using a Markov chain non-stationary process that simulates landscape vegetation dynamics and evolution under the influence of climate and disturbances such as forest fires, volcanic eruptions, wind fall, invasions of animals and new plant species. The syngenesis (*sensu* V. Sukachev) on the disturbed areas in LVD depends on the composition of the plant cover at each step of simulation. The changing transitional probabilities are estimated using the rates of succession obtained in LAPONA-2.

The models were verified for the boreal zone using data and soils obtained from 55 permanent sample plots and 2000 relevés. The model experiments allowed the estimation of the role of climate, water regime, forest fires, and atmospheric pollution.

The main conclusions of the simulations are: (1) The Cladonio–Vaccinietalia forests are maintained on sandy soils by a cold climate and forest fires, (2) drainage of peatlands leads to the appearance of forests, floristically similar to forests on naturally-drained mineral soils, and (3) intensive atmospheric pollution and urbanisation leads to the genesis of new types of plant communities.

Acknowledgements: This study was supported by the Ministry of Education and Science of Russia and Northern boreal forests Interreg-TACIS programme.

Influence of Holocene volcanic activities on the vegetation dynamics and evolution of the Kamchatka Peninsula

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The Kamchatka Peninsula situated north of the Russian Far East region is notable for its 30 active volcanoes, geysers, and numerous hot springs. Volcanic eruptions, with the ejection of 1–10 million m^3 of igneous rock, are registered almost every year. Volcanic eruptions of high magnitude (ejection more than 1 km^3 of igneous rock) occur almost every 400 years causing regional catastrophes. Gigantic catastrophic eruptions with a volume of 10–100 km^3 damage the plant cover over an area of 10-100,000 km^2.

Detailed tephrochronological studies showed 24 Holocene key-marker tephra layers to be related with the largest explosive eruptions from 11 volcanoes in Kamchatka. Each layer was characterised by its stratigraphic position, radiocarbon (^{14}C) age, and area of dispersal. The dated tephra layers provided a record of 24 Holocene voluminous explosive eruptions that destroyed natural vegetation over an area more than 100,000 km^2. Volcanic eruptions lead to the rise of new specific environments, which vary by the type of substrata, chemical and mineral composition, extent of water permeability and other characteristics. New specific volcanogenic types of plant communities formed in these environments include for example: poplar (*Populus suaveolens*) open-forests at the upper forest limit, steppe-tundra dominated by *Kobresia myosuroides* at the southern slopes of dry scoria cones in the mountain-tundra belt, and lichen-rich larch (*Larix cajanderi*) open-forests at the deposits of dry river deltas flowing down from volcanoes.

Permanent volcanogenic influence causes an irreversible plant succession processes. As a result of the Holocene volcanic activities, the seral plant communities and secondary permanent communities prevail in Central Kamchatka. These communities include birch forests with *Betula platyphylla* forests and larch forests with *Larix cajanderi* which replaced the virgin primeval spruce (*Picea ajanensis*) and stone-birch (*Betula ermani*) forests. The persistence of forest and tundra communities depends on the community age. The old-growth forests and old-aged tundra are more resistant to the periodical volcanic ash-falls than younger ones. The recovery of vegetation after volcanic-induced damage begins with the invasion of pioneer bryophytes and lichens and the reforestation begins with the settling of tree saplings and shrubs. The herb and grass layer needs a longer period for the rehabilitation. Plant succession pathways on bare lava flows are very slow, while those on tephra deposits are more rapid. The duration of post-eruptive plant succession varies from a few centuries to a few millennia. On basalt lavas the primary plant succession lasts nearly 3000–5000 years while at least 500–1000 years on ash and scoria fields. The rate of secondary successions after the disturbance of previous vegetation by ash-falls varies from a few decades to several hundreds years after the eruption.

We conclude that the initial vegetation cover of the Kamchatka Peninsula was essentially

transformed during the Holocene by the repeated volcanic catastrophes. The modern vegetation of the Peninsula is mainly formed by serial and secondary permanent plant communities.

Impacts of fog and dew on soil moisture, respiration and nutrients recycling

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Dew and fog have been viewed as an important source of moisture in many ecosystems and are also likely to influence soil nutrient availability. Variation in soil surface wetting by dew and fog at a landscape scale is likely to result in variation in soil water and nutrient supply to plants roots. The frequency, variability and spatial extent of fog and dew are poorly documented in the Succulent Karoo biome (South Africa).

In this project, seasonal changes of soil respiration (CO_2 efflux) rates and physical and chemical properties were measured in vegetated and non-vegetated areas on quartz and shale-covered substrates in ambient environments and in those artificially manipulated with open top warming and fog exclusion chambers in the Knersvlakte (Western Cape) for twelve consecutive months. Soil CO_2 measurements were made using an Infrared gas analyzer, and while soil moisture was determined gravimetrically and by using leaf wetness sensors.

Results show that intermittent increases in soil water content closely correspond to fog but no dewfall in winter and summer months. Soil CO_2 efflux rates were consistently higher in vegetated areas than on bare ground, and also higher on shale than on quartz substrates. The differences were greater at higher soil water contents. Soil respiration was positively correlated with soil water content but negatively correlated with soil nitrogen and phosphorus content. However, reduced soil respiration rates in the fog exclusion chambers located in the shale substrates tended to correspond with decreased nitrogen content.

Increased soil respiration in response to increased soil water content supports results of previous studies that soil moisture is a key driver of soil respiration. The positive correlation of volumetric soil water content and occult precipitation suggest that fog and dew have got a controlling influence on the soil water content. This means that occult precipitation may

consequently be having a dominant impact on soil respiration. Reduced soil respiration in the fog exclusion chambers located in the shale substrates alongside decreased Nitrogen levels suggests that occult precipitation could be a source of nitrogen for the soil microbes and roots which are a key in CO_2 flux.

Scaling laws at vegetation boundaries: implications for detecting vegetation shifts

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Almost every natural vegetation boundary is a complicated geometric object, consisting of bays, peninsulas, and islands. It is not trivial how to define the position of a boundary, for example, of a tree-line along a hillside. This task calls for a solution when we wish to monitor a boundary shift due to climate change, or when we seek to compare tree-line positions between geographic regions. An additional challenge is the dynamic nature of most boundaries: considerable fluctuations may occur due to stochastic, fine-scale colonisation and extinction processes. Peninsulas and islands appear and disappear, merge and split, and stochastic fluctuations need to be distinguished from a systematic shift.

We apply the theory of critical phase transitions for studying dynamic boundaries along environmental gradients. Space is represented by a square lattice, and the vegetation type under study can spread by a contact process. The uniform contact process (i.e. without any gradient) is relatively well understood, but there is little previous work on gradient contact processes, even in physics. We study this gradient system by varying the rules for colonisation and extinction in space.

Our results confirm the earlier hypothesis based on the uniform contact process that, under dispersal limitation, sharp boundaries can emerge even along smooth environmental gradients. This would seemingly suggest that the position of the borderline should be defined as the point where the vegetation density approaches zero (i.e. at the extinction point). Further results show, however, a difficulty in this method. As the extinction point is approached, the variance-to-mean ratio of the density in finite samples increases rapidly, increasing the necessary sampling effort. We propose an alternative: instead of focusing

on the transition between survival and extinction, we suggest to focus on the transition between connected and fragmented vegetation. The method is based on selecting the largest percolation cluster, and delineating its hull edge. Along the gradient, the position of the boundary is defined as the mean position of the hull edge. An advantage of choosing the hull edge is that it has some universal features. It is a fractal with dimension 7/4, which does not depend on the slope, and is insensitive to the local details of colonisation and extinction. Therefore, the method is expected to be applicable in a broad range of situations (vegetation types and environmental conditions). Further simulations have shown that the fractal dimension does not depend on the distance by which connectivity is detected. Considering those organisms for which the actual vegetation type provides a habitat, this result implies that species with different dispersal distances are likely to perceive similar habitat geometry at the boundary between connected and fragmented vegetation, in spite of the fact that the positions of the boundaries differ.

Acknowledgements: Our research was supported by the SFI International Programme and OTKA K61534 (to B.O.).

Distribution pattern of *Larix kaempferi* and succession constraint factors in an avalanche disturbed area of Mt. Fuji, Japan

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Avalanches are most important disturbance affecting the vegetation structure and dynamics in alpine and subalpine zones of Japan. There are a lot of avalanche disturbed scars in the subalpine zone on the flank of Mt. Fuji. It might take a long time for the rehabilitation of vegetation. In one of these areas, a primary succession phase was found with patchy distribution of *Larix kaempferi*. This area was estimated to be more than five decades old based on the examination of a 1962 aerial photograph. Several factors have been identified as the cause of unsuccessful *L. kaempferi* establishment. These factors included, amongst others, frequency and intensity of avalanches, size and movement of ground cover gravels, and relief. We studied distribution pattern of a pioneer tree species *L. kaempferi* and its revelant vegetation and soil conditions.

We selected two avalanche disturbed sites, A and B. The vegetation of the first site was in a seral stage, while the site B was a newly disturbed area without any trees. We also selected one undisturbed site for comparison purposes. A topographic survey was carried out on

both disturbed sites to explain the relief formed by avalanche. We then selected our study plots by dividing the sites into microsites: 9 plots in site A, and 10 plots in site B. These microsites were distinguished by topographic features (concave, convex or flat), existence of rocks or fallen trees and so on. In the plots, age estimation and distribution of *L. kaempferi*, soil condition and bacterial flora were recorded.

One-year-old *Larix kaempferi* seedlings were found in new avalanche paths, but older seedlings (> 3 years) were found only in areas with higher nutrient and water availability. Bacterial floras differed between the study plots. We suggest that bacterial composition during succession would change with soil maturation, and would influence the distribution pattern of *L. kaempferi* seedlings .

Effects of the overabundance of native Sika deer (*Cervus nippon*) on plant communities in Okutama, central Japan

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Large herbivores can have a large impact on plant community structure, composition, and dynamics. Overabundance of deer is becoming a serious problem in ecosystems in temperate and boreal regions worldwide. In Japan, the native Sika deer (*Cervus nippon*) population has increased over the last few decades, causing serious impact on vegetation especially in wildlife conservation areas.

In Okutama region, the northwest part of the Tokyo metropolis, population of Sika deer had drastically increased in the late 1990s. Our aim was to assess the impact of the high-density populations of Sika deer on plants and plant communities. A deer survey in Okutama region was started on 1987, and followed up in 1992–1993, 1998–1999, 2001, and 2004. In each survey, presence/absence of Sika deer was recorded in 1 km x 1 km grid. At the same time population density of Sika deer was surveyed by the block count method in several sites in Okutama region. We created the distribution map of population density of Sika deer from these data by a spatial interpolation technique using GIS software, and compared the spatial distribution of deer density between years 1987 and 2004.

These distribution maps revealed that population density of Sika deer had increased mainly

in high-altitude areas (over 1000 m). We assessed the change of plant species composition by monitoring plots which were surveyed using phytosociological method in 1979–1985. A second survey was conducted in 1999–2006. The vegetation data for 139 plots were collected. A significant change of the floristic composition was observed in the region in which Sika deer population is high (> 5 deer/km^2). Shrubs (< 2 m) and herbs, especially medium-sized herbs (30–100 cm) and large-sized herbs (> 100 cm), showed a significant response to the population density of Sika deer.

Land use dynamics and impacts on conservation of Dakatcha and Marafa coastal forests in Malindi, Kenya (with special reference to *Warburgia stuhlmannii)*

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The vast coastal forests of Kenya are experiencing rapid environmental degradation due to climate change and population growth. Dakatcha woodlands and Marafa forests have been documented as Critical Ecosystem Biodiversity Hotspots. These sites have no formal protection status and are highly threatened by anthropogenic factors. A study was carried out using LANDSAT images over the past 25 years, and baseline data were collected to understand impacts of land cover changes on biodiversity. Data was obtained from LANDSAT thematic time series images (1975, 1987, and 2000). IDRISI, GEOVIS and ArcView 3.3 were used to process the raw data and in calculation of rate of change in the identified land use/land cover classes using the arithmetic model builder overlay process. Ecological and social studies were also conducted to establish the global conservation status of *Warburgia stuhlmannii*, which was found to be vulnerable (VU) based on the IUCN assessment criteria. Spatial data analyses conducted between 1975 and 2000 indicate an extensive depletion of the dense forest cover resource from 82% to 34% giving way to degraded woodland class and settlement mainly influenced by both human and climatic factors. Results from the social studies identified human interferences such as farming (51%), charcoal burning and timber logging (11%), and settlement (4%) among others as the major causes of land cover loss. Recommendations have been highlighted for the development of innovative solutions for long-term conservation of rapidly declining coastal biodiversity and development of a framework for decision makers who can promote conservation of such threatened and unprotected habitats.

Acknowledgements: This work was supported by a South African Student Travel Grant provided by the Regional Section for Southern Africa of the IAVS.

Host specificity and bird dispersal in the parasitic mistletoe, *Tapinanthus natalitius* (Loranthaceae)

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Host specificity has been observed in some species of mistletoe from different localities. However, there have been few studies quantifying these levels of host specificity. This poster addresses the mistletoe *Tapinanthus natalitius* (Loranthaceae) and its relationships to host communities at Hela Hela (Umkomaas Valley) and in the Weenen area (KwaZulu-Natal, South Africa).

Although a single phenotype of this mistletoe species has been reported, we have recorded this mistletoe on four different *Acacia* host species. Many factors may have an effect on host specificity. Most importantly, we examined the effects of variation in ingestion rate and gut passage rate of some selected frugivorous birds feeding on mistletoe fruits. In laboratory experiments, none of the four bird species consumed mistletoe fruits although field observations confirmed that these birds are dispersers of this species. Interestingly, in reciprocal transplant studies, *T. natalitius* mistletoes from *Acacia caffra* germinated better on *A. karroo* than on *A. caffra.* This may indicate that host specificity is not present in this mistletoe species, unlike other mistletoe species from the Middle East, Australia and New Zealand.

Alpine communities respond differently to nutrient additions: initial production and dominance structure do matter

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Two main types of community response to nutrient (especially nitrogen) additions are known for alpine and arctic communities: 1) graminoid biomass increases while dwarf shrubs, mosses, and lichens decline; 2) herbaceous species are replaced by taller woody plants. But it is not yet known how universal these types of response are, and how they depend on different nutrient and water limitation regimes.

Our primary objectives were to determine: 1) which soil resources limited production of four alpine communities with different productivity and dominance structure, 2) which plant functional groups react positively or negatively to different resources; 3) whether the reaction of alpine plant community depends on initial dominance structure.

We investigated four alpine communities: alpine lichen heaths (ALH), *Festuca varia* grasslands (FVG), *Geranium–Hedysarum* meadows (GHM) and snow bed communities (SBC). The study was conducted during a 5-year period and included controls and five treatments: Ca, P, N and, NP additions and irrigation. Above-ground biomass was sampled in the fourth and fifth year of the experiment.

The production of studied alpine communities differed in resource limitation type. For ALH and GHM, N was the principal and P the secondary limiting nutrient; FVG responded to N alone but it did not respond to P either alone or together with N. SBC aboveground biomass increased equally in NP or Ca treatment. Relative biomass increase in NP treatment was negatively related to biomass in control plots across communities: more productive communities (FVG and GHM) responded less than low productive ALH and SBC. Grasses often reacted more vigorously to fertilisation with P, but sedges to N alone. Dominant species (*Geranium gymnocaulon*) of productive meadows tended to increase their share after NP addition. We classified the increase of dominant forb species as a third type of cold-biome community response to NP addition.

Sharpening the focus of community patterns by adjusting phylogenetic scale

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Scale is an important issue in community ecology because community patterns differ according to the scale of observation. Spatial scale determines which taxa are captured and

which spatial phenomenon are highlighted in community analysis. If community-environment relationships are the phenomenon of interest, the influence of ecological interactions at a small spatial grain (sample unit size) or species dispersal limitation at a large spatial extent (sampled area size) could be considered noise. Here I consider the possibility that these types of noise can be reduced by adjusting the phylogenetic scale of analysis. Phylogenetic scale can be defined in a manner similar to spatial scale, defining extent as the phylogenetic scope of a community study (e.g., vascular plants) and grain as the phylogenetic resolution of community units (e.g., species). Focus, another spatial scale concept referring to sample unit averaging, translates to phylogenetic lumping. Lumping of phylogenetically-related taxa may be appropriate if the taxa exhibit phylogenetic niche conservatism and thus respond to environmental gradients in similar ways. Under these conditions the effectively coarser phylogenetic grain of lumped taxa could sharpen community-environment patterns under the constraints of a given spatial scale. This raises the question: How to identify such an 'optimal' phylogenetic grain given, that patterns of niche conservatism may differ in different lineages and on different environmental gradients?

I suggest a solution that entails exploratory analysis of association patterns among taxa at multiple levels of a phylogenetic hierarchy, leading to identification of clusters of strongly-associated taxa of variable phylogenetic resolution. This approach follows the logic of indirect gradient analysis by using community patterns to infer environmental influences while also reducing potential noise arising from a fixed community taxonomic level. I present a preliminary application of this approach using data from the Carolina Vegetation Survey.

Phytosociology of vegetation in the valley of the Jinsha River (upper reaches of the Yangtze River), Yunnan Province, China

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The Jinsha River constitutes the upper reaches of the Yangtze River. In the middle reaches of the Jinsha, in Yunnan and Sichuan Provinces of China having subtropical climate. This region is characterised by landforms such as high mountains and deep valleys affecting wind patterns. These geographic set up creates an environment which is both dry and hot, and which supports peculiar vegetation patterns.

Phytosociological methods (247 relevés in total) were used to study vegetation of the dry and hot valleys. A classification system including orders, alliances and associations was

created and character-species of these syntaxa were identified. This syntaxonomic system includes one class (Phyllantho emblicae–Heteropogonetea contorti), one order (Dodonaeo viscosae–Heteropogonetalia contorti, three alliances (Tephrosio purpureae–Heteropogonion contorti, Barlerio cristatae–Heterogonion contorti and Laggero alatae–Heteropogonion contorti) comprising 30 associations.

The vegetation existed for past hundred years is the arid type. The vegetation constitutes what we may call semi-natural savanna, showing some connection to the savannas of Africa and India, The structure and species composition of the vegetation are simple, and seasonality change is obvious. Human disturbance is one of the major factors impacting the vegetation. The composition of the flora in this valley savanna is characterised by *Dodonaea viscosa*, *Heteropogon contortus*, *Calotropis gigantea*, *Cymbopogon distans*, *Phyllanthis emblica* etc. These floral components have a putative connection with the flora of the ancient Mediterranean and show links to the Tertiary.

Because of its physical position and its salubrious climate, the Jinsha River valley area has been inhabited by humans for a very long time. The landscapes in the valley area in fact remind desert to an extent. One of the reasons for the desertification tendencies is the seasonal lack of soil water: the climate of the area is sharply contrasted into a rainy and a dry season and the drought is usually very serious. The other is the long history of human disturbance; the natural vegetation degenerated gradually over a very long period, and some of the vegetation types had been destroyed totally.

Community assembly from species pools: the effects of functional traits

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Efficient conservation and restoration of plant diversity requires a predictive ecology based on general principles of the assembly of plant communities (so-called 'assembly rules'). Theories on the processes that shape local plant communities can be grouped into three broad views according to the main processes involved: niche-based processes, dispersal-based processes and trait-neutral, abundance-driven processes. We search for generalities in the assembly of plant communities across habitats by using the large vegetation database of the Netherlands. Our premise is that differences in functional traits between abstract

metacommunities (i.e. the pool of possible species in a given habitat type) and the local species composition in small plots can give clues for the processes at work in assembling plant communities. The use of plots differing in environmental conditions as well as in spatial configuration will allow the identification of general patterns of community assembly, i.e. those combinations of functional traits that are overrepresented in local communities of a certain habitat type and those that are rarely encountered relative to random sampling.

Although species were found to clearly sort along environmental gradients (niche-based processes), our results indicate that for most species the availability of seeds is a major limiting factor. This 'seed limitation' has two components: the limited availability of seed sources (trait-neutral, abundance-driven processes) and the limited transport of the available seeds (dispersal-based processes). This presentation shows the impact of 'seed limitation' across several levels of organisation (species, community, landscape). The presentation will focus on the effect of changing land-use on dispersal processes.

From plant traits to community assembly processes in fire-prone ecosystems

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Fire has strong destructive effects on vegetation, but in frequently burned ecosystems, this disturbance acts as a strong evolutionary pressure. The variability in fire regimes in Mediterranean communities makes them an excellent framework to test community assembly theories. In such fire-prone communities, traits that enable quick and efficient post-fire regeneration, such as resprouting capacity and post-fire seeding, are fundamental for the success and regeneration of plant populations. Thus we expect a different representation of regeneration traits (phenotypes) in communities under different fire regime. Furthermore, as plant persistent and regeneration traits are phylogenetically conserved, we also expect different phylogenetical structure of plant communities under different fire regimes.

In this review we test these predictions at different scales in Mediterranean environments: at a biogeographical scale between different Mediterranean-type ecosystems; at a regional scale between sites under different climates; and, at a local scale in relation to different bedrock types. Different evolutionary histories, climatic conditions and bedrock types generate different fire regimes that in turn determine the set of species entering the communities. The results suggest that fire is a strong driving force in assembling Mediterranean

plant communities and support the role of recurrent disturbances as filter driving phylogenetic and phenotypic clustering of plant communities.

Macroecological approach in vegetation science: distinguishing the effects of ecological and evolutionary processes in plant communities

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Recent evidence shows that the character of local ecological relationships may be determined both by local ecological and regional evolutionary processes. Ecological processes include species' relationship to environment (autecological relationships, e.g. physiological tolerance), and positive and negative biotic interactions between taxa (synecological relationships, e.g. assembly rules). Evolutionary processes determine how sets of species with particular characteristics (species pools) have developed in particular regions with particular environmental conditions. Here I promote the macroecological approach to distinguish ecological and evolutionary effects in plant communities. This approach implies study of global patterns of ecological relationships (hence meta-relationships) by using geographical regions with different evolutionary history. We can also simultaneously vary environment (e.g., address the latitudinal gradient from tropics to temperate regions) or keep the environment similar (e.g., address environmentally similar temperate regions in northern and southern hemispheres). Divergence of ecological relationships across evolutionarily contrasting regions supports the significant role of evolutionary processes, while convergence indicates the crucial role of ecological processes. This issue can be addressed by conducting meta-studies using data from literature, but many regions lack comparable data. In addition to observations, I strongly encourage global cooperation for conducting parallel descriptions and experimental studies (meta-experiments) in evolutionarily different regions. In vegetation science, we should start with most principal relationships among key parameters like diversity, biomass, soil chemistry, life-form spectra or invasibility. I shall provide examples how some ecological relationships in grasslands have converged and how some of them have diverged.

I maintain that a macroecological approach in vegetation science is a promising prospect to understand ecology of plant communities, especially when assisted by global scientific organisations like IAVS.

Biodiversity, chorotypes and sigmeta of the Torricchio Natural Reserve (Italy)

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The Montagna di Torricchio Natural Reserve is located in the Central Apennines (Italy) at altitudes between 800 and 1400 m. From the point of view of phytogeography, this region is part of the Central European Bioregion. The vascular flora of the Reserve is composed of 707 taxa, representing the following chorotypes: Mediterranean (30.0%), Euro-Asiatic (19.0%), European (15.0%), Paleotemperate (9.9%), Euro-Caucasian (9.1%), Circumboreal (5.5%), Endemic (5.0%), Cosmopolitan (3.0%), Atlantic (1.7%), Tropical (0.8%), Naturalised (0.7%), Arctic-alpine (0.4%), and Pontic (0.3%).

The vegetation of the Reserve was classified into the following syntaxa (total number of vascular species encountered in each community and the proportion of the dominant chorotype are given within the brackets): the Brometalia, incl. four associations (353; Mediterranean: 33.4%), the Scutellario–Ostryetum (152; Mediterranean: 24.2%), the Polysticho–Fagetum (136; Euro-Asiatic: 24.3%), several segetal and ruderal associations (105; Mediterranean: 29.5%), the Arrhenatheretalia with one association (103; Euro-Asiatic: 25.2%), the Prunetalia, incl. two associations (95; Euro-Asiatic: 27.4%), several pioneer associations on colluvia and rock walls (30; Mediterranean: 46.4%). The highest floristic diversity was found in the dry grasslands of the Brometalia.

Two sigmeta occur in the Torricchio Reserve, such as the Scutellario–Ostryeto sigmetum and Polysticho–Fageto sigmetum. The latter is the most wide-spread one and it is composed of different community types that are dominated generally by the Euro-Asiatic chorotype. These include segetal associations (Mediterranean: 33.8%), ruderal communities (Euro-Asiatic: 25.5%), the Brometalia grasslands (Mediterranean: 33.4%), the Arrhenatheretalia grasslands (Euro-Asiatic: 27.4%), the Prunetalia scrub (Euro-Asiatic: 27.4%), and the Polysticho–Fagetum forests (Euro-Asiatic: 24.3%).

Ecoinformatics, large-scale surveys, and the future of vegetation science

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Community ecology is undergoing a dramatic transformation made possible by the emergence of ecoinformatics. The availability of massive quantities of co-occurrence data is creating new directions and allowing critical new synthesis in ecology. For the first time we have simultaneous access to detailed, spatially-extensive information about places, databases of attributes of taxa including phylogeny and geographic distribution, and archives with thousands of plots representing records of taxon co-occurrence. The intersection of these data types is allowing ecologists to resolve broad-scale patterns and processes while simultaneously acknowledging that local community structure depends on contingencies of place and history. However, discovery and merging of large quantities of distributed and heterogeneous data poses challenges. For ecoinformatics to realise its potential, ecologists need to develop and conform to standard data structures, metadata standards, exchange formats, and data registration and archiving practices. An obvious role for IAVS is to establish international data standards to facilitate the rapid development of ecoinformatics.

The emerging US National Vegetation Classification (US-NVC) represents one example of integration of ecoinformatics and classical vegetation science. The Ecological Society of America and its partners are building the information infrastructure to support the US-NVC. Plot data used in the classification will be archived in VegBank, a public archive where the contents will be openly available for future research, reanalysis, and vegetation documentation. Proposals for changes in the US-NVC will be prepared, submitted, and processed using web-based peer review. The results of the peer review process will be published in online Proceedings. The full classification will be available through a web portal with click-through access to plots in VegBank.

Acknowledgements: This work derives from several long-term collaborations including the Ecological Society of America Panel on Vegetation Classification, the U.S. National Evolutionary Synthesis Center (NCEAS) Working Group for 'An Information Infrastructure for Vegetation Science,' the U.S. Federal Geographic Data Committee Vegetation Subcommittee, the SEEK project, and the IAVS Working Group for Ecoinformatics. Among the many persons involved, I would like to thank in particular Michael Jennings, Don Faber-Langendoen, Michael Lee, and Matthew Jones. Funding was provided by the U.S. National Science Foundation (DBI-9905838, DBI-0213794, ITR-0225635) and NCEAS.

Diversity in Portuguese riparian woodlands in relation to hydrogeomorphological conditions and chemical characteristics of flowing water

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The goal of this study was to characterise and discuss the relationships among the floristic diversity of riparian Portuguese forests and some physicochemical variables like the composition of river water, lithological and geomorphological characteristics of the river basin and the hydrological regime (quantity and dynamics of flow).

The analyses of water chemical parameters have confirmed syntaxonomical distinction of the Osmundo–Alnion communities (Mediterranean poor sandy or siliceous rock soils on river beds with running oligotrophic waters) and the Populion albae communities (Mediterranean rich soils with slow flowing eutrophic water), the former presenting lower values of pH, phosphorous, nitrates, nitrides, water hardness, conductance and suspended solids in comparison with the latter.

The Osmundo–Alnion communities inhabit mostly upland rivers and streams (marginal lowlands to uplands) with a medium to high kinetic energy level and with a river basin dominated by rocks of predominantly acid composition.

In Portugal, Populion albae communities predominantly occupy the river's lower altitudes, with low energy level, usually on alluvial plains with marl-clay materials (lowlands). These areas are the most sought after for intensive agriculture and animal production as well as for building urban agglomerations. This fact therefore explains the increase of nutrient concentration in the water and the increase of floristic richness in these riparian communities. The nature of the dominant substrate on the drainage basin allows to segregate between calcicolous (Estremenho Limestone Massif and Algarvian Barrocal) and acidophilous communities (flood plains of Guadiana, Sado and Mira drainage basin).

Trait-convergence, trait-divergence and phylogenetically structured assembly patterns in ecological community gradients

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Community assembly apparently involves two paradoxical trends. Species in a community tend to be similar in ecological requirements and traits, leading to trait convergence, but species coexistence may be restricted by their trait similarity, leading to trait divergence. Limiting similarity is a kind of assembly rule, a pattern arising from the interactions controlling how species associate, while trait convergence is a pattern arising from environmental filters. We adopt the terms trait-convergence assembly pattern (TCAP) and trait-divergence assembly pattern (TDAP), since both refer to the patterns resulting from different processes of community assembling from a regional species pool. The problem is that species traits are more or less independent from the species' phylogeny and thus phylogenetically structured assembly patterns (PSAP) may arise.

Here we examine how TCAP, TDAP and PSAP relate to ecological community gradients, which may reveal links of assembly patterns to community processes. We offer a method to analyse trait-based data sets aiming at scaling the information on functional traits to the community level in order to sort out TCAP and TDAP in ecological community gradients. The correlation between trait-based described communities and ecological gradients is evaluated and the fractions reflecting TCAP and TDAP are separated by partial correlation. The method uses species as community components after fuzzy weighting by the traits. The measured correlation for TDAP and TCAP is tested by permutation against a null model assuming random assembling.

We offer an analogous procedure to reveal PSAP and their links to ecological gradients: By scaling the phylogenetic information from the species to the community level, we define species as community components that are fuzzy-weighted by their phylogeny. Then the correlation between phylogeny-based described communities and ecological gradients is evaluated and, by using partial correlation, the fractions reflecting TCAP and TDAP removing the effect of phylogeny are revealed and tested against the null model.

We applied the method to trait-based data from south Brazil, which are from sapling communities colonising *Araucaria* forest patches of increasing size in a forest-grassland mosaic. For some traits, such as fruit type (drupe) and fruit colour (yellow, violet, black), TDAP was correlated ($p = 0.078$) to forest patch size, while the same traits revealed low level of correlation for TCAP along the same gradient. For other traits, such as diaspore type (drupe, arillate seed) and colour (black), however, strong evidence of TCAP related to forest patch size was observed ($p = 0.031$). The species occurring in these communities show PSAP unrelated to forest patch size. Furthermore, both TCAP and TDAP revealed by these traits were still significant ($p = 0.057$ and $p = 0.099$) after the removal of PSAP.

Modelling actual and potential distribution of tree species of temperate Chilean forests associated to the climatic change

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The aim of this work was to model the distribution of tree species in the Chilean temperate forests, and to predict changes in their distribution as a consequence of increasing temperatures in the 21st century. The ecological responses of *Araucaria araucana* and the most frequent *Nothofagus* species were characterised according to climatic factors using logistic regression models. We used presence/absence information for each tree species from the Chilean National Forest Survey (CONAMA-CONAF 1999), coupled with climatic data. Observed climatic data for 1971–2000 were used with GIS to map monthly mean temperatures and precipitation values for this 30-year period at 1 km^2 resolution. Climatic variables were extracted for more than 100,000 plots of the Chilean Forest Survey and coupled with species presence/absence in order to achieve the environmental distribution models. These models were introduced in the GIS with future climate values (for the 2071–2100 period) to delineate future habitats of the tree species over the whole territory of Chile. Climatic scenarios based on the Intergovernmental Panel on Climate Change (IPCC) scenarios were generated by two general circulation models–PRECIS (Providing Regional Climates for Impact Studies) and HADCM3 (Hadley Center Climate Model, version 3) (CONAMA 2006).

The predicted potential habitat of the mountainous species decreased under the future climate scenarios, leading to an extinction risk of an endemic species, while the simulated potential habitats of other species expanded. Besides a better understanding of tree species behaviour in the poorly known ecosystems of South America, this study allowed us to predict the impact of climatic changes on patterns of tree species diversity in temperate Chilean forests. The results provide an important tool to adapt forest management to future changes.

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A new method for the measurement of habitat filtering effects

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As an alternative to the convex hull approach, a new measure—the index of trait segregation—is suggested for measuring the effect of habitat filtering based on functional traits.

Range difference between the two species assemblages is calculated for each functional variable separately, and then a composite index is constructed with a resulting value falling into the range of (0, 1). In addition to having definite lower and upper bounds, the measure has the following advantages: (1) compatibility with mixed data types, including data sets containing nominal, ordinal and interval scale variables simultaneously, (2) tolerance to missing scores in the data, (3) no limitations as to the number and orthogonality of traits, (4) species and trait contributions are determined easily, and (5) fast computations even for very large data sets.

Of great importance is the fact that the index is sensitive only to those changes in the trait space that are attributable to the environment, while the convex hull volume changes are not necessarily proportional to the changes of functional traits. Advantages retained from the convex hull approach include (1) versatility of standardisation of each trait (global, local or related to information for any regional geographic scale), and (2) independence of whether the shape of the point cloud is triangular or not in the trait space.

The species pool concept: like a real light bulb—useful and shining

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To explain species coexistence many theoretical concepts were stressed such as the resource-ratio hypothesis or niche differentiation (Tilman 1982, 1988), the carousel model (van der Maarel & Sykes 1993), the species pool-concept (Zobel 1997), the neutral theory (Hubbell 2001) or the most recent metacommunity concept (Leibold et al. 2004). Not any of these concepts is able to explain all patterns of species coexistence but every concept may be true in specific cases. However, most concepts remain theoretical and experiments are rare. Some years ago, Wilson & Anderson (2001) bashed the species pool concept and

stated 'that it is probably operationally impossible to test. Like a wooden light bulb, it is beautiful and interesting, but of little use'. Surprisingly, many papers still claim the species pool concept as useful although there was never an answer to Wilson & Anderson. We do that and present an experiment where we could show that species pools of two spatial scales, actual and local/regional, are related to each other and that species composition of the actual species pool depends on the local and regional dispersal infrastructure.

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Dynamic biomes: phylogeographic reconstruction of plant histories in the Little Karoo

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The Little Karoo (South Africa) is a region of complex topography, climate, and soils, of unusually high plant species richness, and it is home to more than 3000 species. Such richness can, in part, be attributed to the geographic position of the Little Karoo on the boundary between summer- and winter-rainfall regimes. Biomes associated with the two climatic systems co-occur within the region, with occurrences ranging from large, continuous biome sections to patchy mosaics. Boundaries associated with these are likely to be quite sensitive to small climate shifts and are likely to have oscillated as a result of past climate change. This makes the Little Karoo ideal for testing hypotheses on histories of

antagonistic biomes such as the summer-rainfall dependent subtropical thicket and the winter-rainfall dependent succulent karoo shrublands.

This study investigates the history of subtropical thicket and succulent karoo shrublands within the Little Karoo through detailed population-level analyses of DNA polymorphism data from three representative plant species (*Berkheya cuneata* from succulent karoo and *Pappea capensis* and *Nymania capensis* from subtropical thicket). It is assumed that these typical species are reliable proxies for the biomes in which they occur.

The three species show strong phylogeographic structure within the Little Karoo, revealing a strong break dividing the region into eastern and western populations. Coalescent methods are used to establish the following for each of the species: the effective and ancestral population size, migration rates between populations, and the timing of population divergence. These phylogeographic results will be discussed in the context of the evolution of the targeted biomes within the Little Karoo.

Acknowledgements: This work was supported by a South African Student Travel Grant provided by the Regional Section for Southern Africa of the IAVS.

Managing the renosterveld of the Fynbos Biome: the effect of fire and grazing on multiple vegetation states

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The renosterveld vegetation, characteristic of the shale soils in the lowlands of the Fynbos Biome (South Africa), has multiple structural faces. Most common are the asteraceous-dominated shrubland state, but tussock grassland, lawn grassland, and bulb-rich herbland are also recognised. Controversy exists on whether this vegetation type was historically (before European settlement) shrub or grass dominated and what might have caused the presumed change to the current shrub dominated state. Settled agriculture accompanied by fixed burning cycles and overgrazing by livestock has been blamed by most, but the removal of indigenous large herbivores and their associated disturbance effects has also been implicated as possible reasons for the presumed state change.

Here we present the results of a two year study that closely monitored the reaction of multiple renosterveld states (shrubland, tussock grassland, and lawn grassland) exposed to combinations of fire and herbivory by a number of indigenous herbivores (eland, bontebok and ostrich).

Our results revealed that ungulates exerted minor effects on the vegetation states in the absence of fire, but their presence or absence immediately following a fire could change the trajectory of the system among alternative states. We hypothesise, that competition between germinating shrub seedlings and resprouting lawn or tussock grasses can be identified as a key factor altering the state trajectories. We also formulate several recommendations on how to manage renosterveld towards a more grassy state.

Acknowledgements: The study has been supported by National Research Foundation of South Africa (a focus area grant to L. Mucina) within the framework of PhD study of F. Radloff. We thank CapeNature for research permits and logistic support.

Influence of natural and anthropogenic factors on biodiversity of forest landscape

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Homogenous forested landscapes situated in western Poland on outwash plains originating from last glaciation were primarily supporting deciduous acidophilous oak forests of the Calamagrostio–Quercetum, with some admixture of other forest types such as oak-hornbeam forests of the Galio–Carpinetum, thermophilous oak forests of the Potentillo albae–Quercetum as well as of pine forests of the Leucobryo–Pinetum. This vegetation has been strongly modified by forest management and transformed into pine plantations, leaving natural forests limited to only small patches. These interventions resulted in serious unification of the contemporary vegetation. This uniform forest formation is intersected by two striking linear forms, including natural series of small depressions which emerged in places of melting dead-ice and following NW-SE direction, and by an international motorway passing from west to east and accompanied by a broad belt of non-forest vegetation.

The aim of study was to determine the diversity of flora and vegetation connected with

the natural habitat differentiation and that resulting from human activities (incl. forest management and presence of road system). Studies were conducted at the levels of species, phytocoenoses, complexes of plant communities, and the entire vegetation landscape. The biodiversity has been estimated on the basis of richness of species, syntaxa, and spatial units of different ranks, as well as using the share of native versus alien, common vs. rare species and of units distinguished on structural basis.

The results show that both natural and anthropogenic linear elements contribute to the increase of biodiversity expressed as richness of vegetation units at all targeted levels of hierarchic complexity. Distinct differences occur, however, when qualitative traits are taken into account. Natural linear elements enrich the landscape in rare, native and endangered elements. Anthropogenic linear structures bring about not only drastic changes to landscape physiognomy fostering introduction of synanthropic elements into flora and vegetation, but also aid creation of habitats for rare sward species and communities, and for semi-natural vegetation.

Ecology and mapping of post-fire recovery of *Pinus brutia* forests: a case study in the island of Karpathos, Greece

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A large wildland fire which occurred in 1983 on the island of Karpathos (Greece) burned, according to the Hellenic Forest Service, ca. 32,000 ha of forest and forested land covered mainly by *Pinus halepensis* subsp. *brutia*. This case study aims at assessing and mapping changes in the vegetation patterns after 25 years of natural regeneration and succession under different management practices. The pre-fire vegetation mapping was achieved by an extensive sampling survey that took place before the 1983 fire. The current vegetation status, after 25 years of natural vegetation development and human management, was assessed by a sampling survey assisted by the use of satellite remote sensing technology. Landsat Thematic and Enhanced Thematic Mapper data, acquired in 1987 and 2000, respectively, were co-processed along with field data collected by an extensive sampling survey in the summer of 2007. Other auxiliary information such as human management practices, digital elevation model, geological, and soil maps were involved in our study of the ecosystem restoration and assessing changes with respect to pre-fire situation.

We analysed the ecosystem recovery by considering various parameters supposed to influence ecosystem regeneration and development, incl. restoration management practices, abiotic conditions, etc. The restoration of the fire scar in the study area presented various patterns depending on the characteristics of micro-environment and the human management practices. The restoration measures applied in the study area were implemented by: (a) planting of small trees without further treatment, (b) planting trees in terraces supported by mechanical means, and (c) sowing a mixture of species randomly. Some stands (as control) were left out to recover by means of natural regeneration.

The anthropogenic and environmental impact on the forest structure were lower where management restoration practice implied plantation of trees without mechanical treatment. However, patterning was evident because of the equally-spaced position of the planted trees. Plantation of trees in terraces by mechanical treatment created a similar pattern in the structure of the recovered forest caused by the gradients between the stripes. In this case the management restoration practice resulted in a situation where patterning in forest structure became the most evident. Sowing management practices resulted in denser and more random plant spacing and cover. The mixture of species and the lack of patterning in the structure of recovered forest are the most important characteristics of this kind of management restoration practice. Finally, the recovered forest in naturally regenerating patches seems to have the most natural physiognomy, since there was no evidence of any type of patterning. The recovered forest in this case approximated the characteristics of the forest in the pre-fire situation.

Plants in man-made landscapes: land use affects the genetic variation of plant populations in Europe

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Centuries of anthropogenic land use has transformed the natural landscapes of Europe. Today these man-made landscapes consist of a multitude of different and strongly fragmented habitats that are subjected to a variety of land use types. These habitats differ to a high degree from each other with regard to ecological factors such as disturbance regime, nutrients, light, or water availability.

Many species occur in different habitat types and are, therefore, subjected to varying environmental conditions. Abiotic and biotic factors within a specific habitat have a strong

impact on processes such as flowering or fruiting. These processes are in turn of crucial relevance for the reproduction of plant species and affect genetic variation via the exchange of pollen and seeds or the establishment of seedlings. Genetic variation of plants depends, therefore, indirectly on land use. In addition, genetic variation within and between plant populations is affected by landscape structure. The degree of landscape fragmentation and the availability of habitats have a strong influence on gene flow between populations. Since variation both within and between populations depends on the balance of gene flow and drift, landscape structure indirectly affects the genetic structure of plant populations.

Using common garden experiments and molecular methods such as AFLPs or RAPDs, the influence of land use on genetic variation could recently be demonstrated for a set of species in central Europe. In a study on the annual *Saxifraga tridactylites* it could be shown, that populations from natural and anthropogenic habitats are genetically different from each other, since populations from rocks were clearly separated from populations located along railways. An investigation on the perennial grassland plant *Scabiosa columbaria* revealed that mowing and grazing of calcareous grasslands resulted in the development of seasonal land use ecotypes. Furthermore, in a study on the grass *Sesleria albicans*, phenological and morphological adaptation to ecologically differing habitats could be demonstrated. Finally, a recent analysis of the clonal species *Ficaria verna* revealed that levels of clonal genetic variation can depend on land use, since much stronger variation was detected in meadows compared to forests.

Many species that are typical of the open central European landscapes, such as *Taraxacum*, are even thought to have passed through an adaptive radiation, which has been generated by environmental differences between different habitats. Land use is, therefore, an important factor for evolution in man-made landscapes.

Major riparian plant communities of northwest Baja California (Mexico)

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Baja California is an interesting zone where Neotropical and Holartic vegetation meets. Major terrestrial plant communities of Baja California (Mexico) have been studied from a phytosociological point of view, as almost no information has been published on riparian

communities in the region.

Results of our study on the riparian vegetation of the NW Baja California Peninsula are based on almost 200 relevés from both mediterranean (thermo- and mesomediterranean) and tropical (thermo- and mesotropical) zones. Among the forest riparian vegetation we can recognise 3 associations (Platano racemosae–Populetum fremontii Rivas-Martínez, Sánchez-Mata & Costa 1999, Salicetum laevigato–lasiolepidis ass. nova & Baccharido salicifoliae–Washingtonietum robustae ass. nova). We have also distinguished two shrubland communities, such as the Isocomo menziesii–Plucheetum sericeae ass. nova and the Prosopidetum torreyanae Peinado et al. 1995. The syntaxa of the meadow vegetation comprise: the Eleocharido geniculatae–Schoenoplectetum pungentis ass. nova, Eustomo exaltati–Juncetum leiopoldii ass. nova, Eustomo exaltati–Juncetum mexicani ass. nova, Junco xiphioides–Schoenoplectetum californici ass. nova, and Typho domingensis–Schoenoplectetum americani ass. nova.

From north to south, we have observed a progressive substitution on forest and woodlands dominated by Salicaceae by shrubland communities with abundant Compositae and Arecaceae; the Holartic communities became gradually replaced by Neotropical ones.

The biogeography and habitat selection of Ajax daffodils (*Narcissus* L. subgenus *Ajax* Spach, Amaryllidaceae) in the Iberian Peninsula

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In the genus *Narcissus* (Amarallidaceae), the Subgenus *Ajax* comprises ca. 65 taxa, thus 30% of the species, subspecies and varieties included within the genus. The Iberian Peninsula is the centre of diversity of *Narcissus* subgenus *Ajax*; 30–40 taxa have been described from this area. The aim of this study was to indicate the biogeographical distribution and habitat type selection of 48 taxa of the subgenus *Ajax* of the genus *Narcissus*.

When considering the biogeographical provinces recognised by Rivas-Martínez et al. (2002), there are five relevant zones accounting for 6 or more taxa. The Cevennean-Pyrenean Province seems to be the richest in number of taxa, with three sections and four

of the seven series in which the genus is divided. The Baetic Province presents two endemic exclusive series, such as *Nevadensis* and *Longispathis*.

Amongst the 48 taxa analyzed, 28 are restricted to a single habitat type. The remaining 20 taxa grow in two or more different types of habitats. The widest ecological plasticity is shown by *N. alpestris* and *N. pallidiflorus*. Both deciduous forests (18 taxa) and wet grasslands (26 taxa) are the most common habitats for species of the subgenus *Ajax*. Thickets with 11 taxa and grasslands with 9 taxa are also favourable habitats for daffodils. In the Mediterranean region, wet grasslands seem to have more prevalence as habitat for daffodils than forests or any other habitat type.

In relations to altitudinal ranges and bioclimatic belts, the occurrence of the daffodils range from 100 m in the Portuguese coast to above 2400 m in the Pyrenees. Most taxa grow in intermediate environments at altitudes 600–1800 m, under subhumid or humid climates of the supra-mediterranean or montane belts.

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Imprints of postglacial history in recent vegetation: example of Central European subcontinental oak forests and subcontinental semi-dry grasslands

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It becomes widely recognised that species composition of recent vegetation is not determined solely by local, small-scale fluctuating environmental factors such as light avail-

ability, soil moisture, or soil nutrient content, but also by large-scale spatial and temporal factors including local/regional evolutionary processes (speciation, migration, refugial history etc.).

Central European subcontinental oak forests and subcontinental semi-dry grasslands are species-rich communities with rather peculiar species composition that has been traditionally attributed to specific site conditions (oligotrophic, intermittently wet soils). Using comparison of large data sets of vegetation plots we show that species composition of these two vegetation types exhibits remarkable similarities to Siberian hemiboreal forests dominated by Scotch pine, white birch, and Siberian larch. We hypothesise that common postglacial history may be a relevant explanation of this similarity.

Shady broad-leaved forests composed of nemoral species and nutrient-rich grasslands composed of competitive heliophilous species recently prevail in mesic sites of temperate Central Europe. Their species composition is much different from subcontinental forests and grasslands, as well as from the Siberian hemiboreal forests, though they occur in similar sites. We propose that the Siberian hemiboreal forests may be considered as relics of Early Holocene Eurasian pine-birch(-larch) forests in the region where extremely cold winters prevented competitive replacement of pine, birch, and larch by broad-leaved tree species during postglacial forest expansion. Using the same logic, subcontinental oak forests and subcontinental semi-dry grasslands may be considered as relics of Early Holocene heliophilous vegetation of mesic sites in Central Europe. Indicators of heliophilous vegetation continuity, including the occurrence of relic heliophilous species, were identified to test our hypothesis.

Disentangling the complexity of invasive alien plant management in the Cape Floristic Region

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The spread of invasive alien plant species (IAPS) is currently threatening the biological

diversity of the Cape Floristic Region (CFR). Despite considerable progress in managing invasions, there is an urgent need to improve the efficiency of management operations. Integrated frameworks that incorporate distribution data and spread dynamics, coupled with a complete understanding of the factors influencing the management decision, are required. We are, thus, currently developing an innovative and integrated decision-making tool for managing IAPS in three representative regions of the CFR. The study will focus on the most invasive plant species in the region, mostly species of *Acacia, Hakea* and *Pinus*. The suitability of overall management strategies will be assessed using a spatial-temporal explicit model simulating the spread of these target species, which will take into account both ecological and economic aspects.

However, we first need to understand how managers prioritise areas for alien clearing by applying methods that help us to understand complex problems. One of these techniques is the Analytical Hierarchical Process, which is a multiple criteria decision-making process that is useful in determining the relative importance of factors by comparing one choice with another. The results of this particular exercise show us that the most important factor determining the management of invaded areas is the window opportunity that wildfires create. Then, however, alien management should prioritize those areas of the landscape where the density of IAPS is below 25% and the potential for spread into neighbouring areas is high. Although the importance of the species present in each stand has a relatively low score in prioritising the stands for clearing, the availability of an effective biocontrol agent and the importance of fire for the growth of the species appeared as the most relevant factors in deciding which species to clear first based on its invasive potential.

Climate relations of South African vegetation and its components

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The relationship between vegetation and climate remains a fundamental pillar of insight and understanding in vegetation science. Here we present a review of key climatic relationships of South African biomes, bioregions and various groupings of vegetation types at lower hierarchical levels.

A brief history of vegetation-climate relations reveals an earlier dominance of regionally-specific initiatives, progressing through important geospatial advances in data develop-

ment and modelling, to recent analyses using decision trees within the national domain. We expand vegetation-climate analyses to explore new patterns of climatic association. These include investigation of: a wider range of important climatic parameters to include those such as rainfall seasonality; local modifiers of climatic effects including fog, wind and special habitats; plant growth form profiling with critical thresholds in relation to putative climatic determinants; species endemism at the vegetation type scale in relation to climatic range, climatic variability and other parameters.

The challenge for improving our understanding of vegetation-climate relations in South Africa is to move beyond the associative and correlative to the causal and to considerations of the relative dynamic sensitivities of vegetation components to climatic and other environmental changes. The development of a reliable predictive understanding of vegetation change is urgently required in view of the ever-diminishing areas of vegetation available to test and verify expected outcomes.

Effect of climate warming, soil N enrichment and an alien-invasive grass on post-fire recruitment in a fynbos ecosystem

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Elevated soil nitrogen levels, due to increased use of fertilisers, coupled with global warming and alien invasive species are likely to negatively affect the recruitment and growth of indigenous species in mediterranean-climate ecosystems following disturbance by fire. We tested this hypothesis by exposing soils containing viable reproductive propagules collected after a late autumn fire from the Cape of Good Hope Nature Reserve (a section of the Table Mountain National Park) to naturally and artificially elevated soil N levels and to naturally and artificially elevated soil temperatures (3° C increase above ambient, consistent with global warming scenarios), in 16 microcosms (4 replicates of each N and temperature combination treatment). A split-plot design was adopted in which one half of each replicated microcosm contained equivalent numbers of individuals of the invasive grass *Lolium multiflorum* sown from seed with the other half of each microcosm containing no *L. multiflorum*. Recruitment, photosynthetic performance and growth of both indig-

enous (germinating propagules) and sown invasive grasses were monitored over a 9-month period. Also, soil temperature and volumetric water contents were recorded hourly in each microcosm during this period with Decagon TE sensors interfaced with data loggers.

Preliminary results indicate that *L. multiflorum* grew more rapidly and attained reproductive maturity much earlier in the experimentally warmed microcosms with this effect exacerbated under elevated soil nitrogen levels. Recruitment and growth of indigenous species were stimulated in the experimentally warmed chambers but severely inhibited by the presence of invasive grass. This inhibition was not a consequence of a greater demand for soil water resources by *L. multiflorum* as soil moisture contents were unaffected under ambient temperature conditions by the presence of this species and even significantly increased in its presence in the experimentally warmed microcosms.

Acknowledgements: This work was supported by a South African Student Travel Grant provided by the Regional Section for Southern Africa of the IAVS.

Resource manipulation for control of alien invasive grasses in lowland vegetation of the Cape Floristic Region

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Over 95% of vegetation in the lowlands of the Cape Floristic Region (CFR) has been transformed by agriculture and invasive alien species, and restoration of ex-arable lands invaded by alien grasses is therefore vital. Restoration efforts may be aided by the artificial reduction of soil N and P levels which are known to promote the growth of many invasive alien species. This is in contrast of indigenous fynbos species that are adapted to nutrient impoverished soils. Sugar and gypsum additions are proposed methods for immobilising plant-available N and P levels in soils thereby increasing the competitive success of native species. This premise was tested both under field and greenhouse conditions by applying systemic (roundup) and contact (paraquat) herbicides to reduce the large alien invasive grass biomass. Subsequently sugar was added to reduce N, or gypsum to reduce P, or sugar and gypsum to reduce both N and P.

Seeds of nine indigenous species were sown into the soils in late autumn while seedlings of an additional nine target species were subsequently introduced in mid winter. Recruitment, physiological performance, soil physical and chemical properties, growth and survival of both target and resident indigenous and alien species were monitored in each treatment over a 12-month period spanning early winter to late autumn. Our results showed that indigenous species grow and survive better where herbicides were applied to remove invasive grasses, a result explained by absence of competition. Reduction in N and P affected both invasive and native species growth and survival, a situation that leads us to conclude that microbial activity could be converting nutrients into forms that are unavailable for plants. Results suggest that the addition of sugar and gypsum as a tool in the restoration of indigenous fynbos species in the lowlands of CFR provides no significant benefit over a one-year period.

Acknowledgements: This work was supported by a South African Student Travel Grant provided by the Regional Section for Southern Africa of the IAVS.

Analysis of hygrophilous flora and vegetation in Andalusia (southern Spain)

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Hygrophilous flora and vegetation are important topics in plant conservation, due to the fragility and current scarcity of wetlands and rivers in the Mediterranean region. This fact has a wider dimension in Andalusia (Iberian Peninsula, southern Spain) where many wetland and aquatic threatened species are included in the Andalusian Red List of Vascular Flora (Cabezudo et al. 2005). Furthermore, much of this vegetation is protected by the European Habitats Directive (Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora).

The main objective of this study was to catalogue and analyse the hygrophilous flora and vegetation developing in rivers, streams and wetlands of Andalusia. Between 2004 and 2008 we have located, sampled, and identified nearly 800 plant species and 215 vegetation types in the main rivers and wetlands of Andalusia (Guadalquivir Basin, Andalusian Mediterranean Basin and Andalusian Atlantic Basin). The studied region shows a great ecologic and landscape diversity covering a total amount of 26 districts belonging to 13 sectors and

5 main biogeographic provinces of the Western Mediterranean Sub-region. From a geo-symphytosociologic point of view, 18 edapho-hygrophilous dynamic units appear to be represented in the area, including 12 vegetation geoseries and 4 vegetation microgeoseries, comprising 33 vegetation series, 3 sub-series, and 7 faciations (Salazar & Valle 2004).

The collected data were analysed from taxonomic, syntaxonomic, chorologic, biotypic, ecologic, and synecologic points of view. Abundance, known distribution, and conservation status of species and of vegetation types protected by environmental laws and/or included in red lists were evaluated.

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Acknowledgements: This work has been financed by a research contract between the University of Jaén and 'Empresa de Gestión Medioambiental' (EGMASA), Reference NET 200855.

Using multivariate analysis for classification of high Andean peatlands vegetation

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In the puna ecosystem of the high Andes, situated above alt. of 3500 m and poorly drained, swamps/peatlands occur called 'oconales' by the local people. These 'oconales' are considered a good pasture land especially for alpacas (*Lama pacos*) and are used by locals as refuge areas for grazing during the dry season.

The objective of this study was to differentiate types of the peatlands vegetation in the Central Andes of Peru. In the Lauricocha River basin (Huánuco, Peru) over a period spanning 2002–2004 we made vegetation relevés using phytosociological methods. We analyzed the data using multivariate analysis (NMDS and K-means clustering). We used the software package VEGAN and MASS package (from R) for ordinations and the modules GINKGO and QUERCUS from the VEGANA program package for classifications.

After combining both approaches, we propose two new associations (with several sub-

associations) and two communities. The Carici humahuacaensis–Plantaginetum tubulosae (caespitose vegetation on flat geomorphology) typically occurs at altitudes of 3800–4500 m; within this association a new subassociation rorippetosum nanae is restricted to altitudes above 4000 m. The Cuatrecasasiello isernii–Distichieteum muscoides (cushions on convex geomorphology), occurs in swamp habitats above 4000 m; the subassociation plantaginetosum rigidae is limited to upper altitudes (>4500 m). Furthermore we identified two peatland communities dominated by cushion-forming *Oreobolus ecuadorensis* and *Phylloscirpus deserticola* (both above 4000 m of alt.).

Relationships of geographical floral elements and environmental site factors in fluvial landscape at Yatsugatake Volcano, Japan

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Central regions of the Honshu Island (Japan) are interesting from phytogeographical and vegetation-ecological points of view because of their geographical location at the centre of Japan Archipelago. However, the relationship between the geographic and local distribution of the floristic composition of plant communities has not been studied yet.

We chose the semi-natural forest in fluvial landscape (remnant of eroded fan) at the foot of Yatsugatake Volcano as our study area. Based on the similarity of their distribution pattern in Northeast and East Asia, we assigned all species to two major categories (Japanese endemic and Continental elements) and five subcategories based on their geographical affinities. We analysed the distribution of these geographical floral elements with regard to topographic and soil factors by comparing the distribution of elements among five ecological site units (mounds and depressions with developed andisol, rocky outcrops, steep slopes, and valley floors with sandy soil).

The frequency of the Japanese endemics was the highest on the well-drained sites such as rock outcrops, steep slopes, and valley floors, whilst the frequency of the Continental species was relatively constant across the landscape, with slightly higher frequencies in depressions and on valley floors. In general, the Japanese endemic species characteristic of the southern part of the Japan Archipelago were absent on developed andisols. These results suggest that groups of plants defined on basis of their geographical distribution patterns tend to have similar affinity for site conditions in the studied landscape.

Two-phase functional redundancy in plant communities along a grazing gradient in Mongolian rangelands

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The potential effects of biodiversity loss on ecosystem functioning and services have been one of the primary concerns of ecologists during the last decade. The concept of functional redundancy is at the core of theory relating changes in ecosystem functioning to species loss. At its heart, there is the assumption that some species perform similar roles in communities and ecosystems, and redundant species can therefore be lost with minimal impact on ecosystem processes. Determining the relationships between species and functional diversity has thus important implications for predicting the consequences of disturbance or management regimes on the functioning of a given ecosystem. However, our knowledge of the strength and the form of the relationship between species and functional diversity (i.e., the presence of functional redundancy in ecological communities) is limited to a few studies. In particular, we know little about how local extinctions in real assembling communities might impact functional diversity. Here we present the relationship between species and functional diversity in plant communities along a grazing gradient across Mongolian rangeland ecosystems. We found significant sigmoid logistic relationship between species richness and functional diversity, indicating high functional redundancy at low levels of species richness followed by rapid increase at intermediate levels, until functional diversity asymptotes at high levels. This two-phase functional redundancy suggests that functional traits are abruptly lost from a community below a certain level of species richness, and subsequently a community shifts into a contrasting state that has few limited functional groups characterized by disturbance-resistant traits. This study will permit a major step forward in predicting the consequences of livestock grazing on the functioning of Mongolian rangeland ecosystems.

SynBioSys Kruger for storing, integrating and managing the ecological data of the Kruger National Park

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SynBioSys Kruger, a cooperative project between University of Pretoria, South African National Parks and Alterra Wageningen University Research Centre, is aiming at the development of a biological information system, which may operate as a tool for supporting the evaluation and management of biodiversity in Kruger National Park. By bringing together existing data at the levels of species, ecosystems and landscapes, the system contributes to further integration and dissemination of vegetation and wildlife knowledge. Until recently, data such as species distribution, population demography, migrations, ecosystem composition and dynamics, plant-herbivore interactions, predator-prey relationships and landscape changes were stored, managed and analysed as separate entities. At the species level, the South African plant species checklist is used as a basis. This list is also incorporated in the computer software package Turboveg, a user-friendly management system for input, import, selection, and export of vegetation data, nowadays the standard in worldwide vegetation data handling. The vegetation data of Kruger National Park, more than 3000 relevés which are stored in an overall Turboveg database, form the basis for the overview of plant communities on the ecosystem level. On the landscape level, a hierarchic Ecozone map of Kruger National Park is used as a basis, which will be linked to the recently published vegetation map of South Africa by Ladislav Mucina and Michael Rutherford. SynBioSys Kruger, that will be developed step by step, incorporates a GIS platform for the visualisation and spatial analysis of layers of information on the different levels. The entire system is data driven and an open-ended system. The system will benefit from experiences gained in Europe, where similar expert systems have been developed or are under development (SynBioSys Netherlands, SynBioSys Europe).

Walnut-fruit forests of southern Kyrgyzstan: human-environmental interactions over the last 2000 years

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The walnut-fruit forests of southern Kyrgyzstan are the most extensive walnut forests worldwide and of global significance for biodiversity conservation. Until recently, these

walnut stands were considered an impoverished relic of forests of the Tertiary period. However, pollen analyses from the sediments of a sedge fen provide new data to infer the forest history of the last 2000 years in the Arslanbob region of the Fergana range. The results suggest that the walnut stands are only about 1000 years old. Walnut forests obviously developed in the presence of grazing domestic animals (grazing indicators). Only around 1500 AD did they reach their approximate present distribution. The results point to an anthropogenic origin of the walnut stands. The establishment of walnut forests under grazing pressure suggests that *Juglans* was specifically promoted by man.

The intimate interaction with human activities continues until today. Walnut forests are of considerable importance for sustaining the livelihoods of more than 100,000 people living in the forest area. A wide range of valuable resources has caused intensive forest use, in particular after the collapse of the Soviet Union. Forests are adversely affected by the high amount of firewood and nuts collected, and by livestock grazing in spring and autumn. Present institutional settings, external demands on specific products and the economic constraints of the local population lead to reinforced exploitation.

Detailed vegetation analyses along utilisation gradients revealed massive human impacts. Classification resulted in four forest communities, differentiated primarily by form and intensity of forest use. Ordination analyses showed that anthropogenic site factors exert a greater influence on variation in vegetation patterns compared to natural site factors. Impoverished stand structures, regressive successions, and almost complete failure of seed-produced regeneration point to considerable changes in the walnut-fruit forests and to their uncertain future.

Population dynamics on quartz fields in South Africa – climate change effects on conservation efforts

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Climate change scenarios for southern Africa predict decreased annual rainfall and increased annual temperatures for the Knersvlakte in the Succulent Karoo Biome of South Africa. Despite having only a 150 mm annual precipitation, this region is renowned for its high species richness and endemism. The diversity is attributed to habitat mosaics and

climatic conditions, i.e. mild temperatures during the growing season and reliable fog and dew precipitation. Quartz fields, covered by quartz gravel and dominated by leaf-succulent dwarf shrubs, are a common habitat type that contains habitat-specialised, local endemics. However, dwarf plants are exposed to extreme temperatures at the soil surface, which make them likely to be particularly sensitive to climate change effects. The newly established nature reserve in the Knersvlakte could thus be strongly affected by climate change. With our study, we aim at *(i)* characterising trends in the regional climate of the Knersvlakte during the last decades; *(ii)* at describing trends and fluctuations in vegetation composition of the quartz fields and of populations of individual species; *(iii)* at analysing whether the latter can be related to the first and what consequences of these findings are for biodiversity conservation.

We analysed the trends of climatic variables for two weather stations in the Knersvlakte, namely Vanrhynsdorp (1922–2005; only precipitation) and Vredendal (1959–2005; precipitation and temperature). Changes of species composition and abundance were monitored on eight permanent plots from 1993 to 2005. These plots (5 m x 5 m) were established in order to represent the variety of near-natural vegetation types of the quartz fields in the Knersvlakte. The number of individuals of all vascular plants occurring on these plots was counted in the years 1993, 1995, 1996, 1997, 1998, 1999, 2000, and 2005.

Annual mean and maximum temperature significantly increased during the last 45 years (+1.2° C and +1.7° C, respectively), while annual minimum temperature and annual temperature amplitude did not change. Annual precipitation showed no significant trend over the last 83 years, but the inter-annual variability of rainfall more than doubled during this period. During the permanent-plot study period, the years 1993, 1995–1997 and 2001–2002 received precipitation above average, and the years 1994, 1998–2000, as well as 2003–2005 below average.

In total, we recorded 67 vascular plant taxa (51 chamaephytes, 10 therophytes, 6 geophytes), mostly belonging to the families Aizoaceae and Crassulaceae. Vascular plant species richness per plot and year ranged from 4 to 38 taxa. The total number of plant individuals on 25 m^2 (abundance sum) varied considerably between plots and years with a minimum of 49 and a maximum of approx. 13,000 plants. Of the tested biodiversity parameters, log-transformed abundance sum and species richness showed a significant general pattern among the plots, while abundance-based species diversity and evenness varied independently on the individual plots. Specifically, log-transformed abundance sum was significantly above long-term average in 1997 and 2000, but below in 1993 and 1995. Species richness exceeded average in 1996 and 1997, and deviated negatively in 1999. The relative changes in species composition (plot-wise extinctions and re-establishments as well as net change) differed significantly between years but not among plots. The inter-annual fluctuations in population size were lowest for chamaephytes, intermediate for geophytes,

and highest for therophytes. For all species combined, log-transformed relative abundance showed a positive trend over the 12-year study period, which however explained only a small proportion of the total variance ($p = 0.0003$; $r^2 = 0.010$). When looking separately at the life forms, the positive overall trend was more pronounced for chamaephytes and geophytes, while therophytes showed significantly decreasing abundances.

We conclude that anthropogenic climate change has already altered some relevant climatic parameters in the Knersvlakte, but this did not yet affect species richness of quartz fields or the population dynamics of their endemic species negatively. However, another study with an experimental approach has shown that stronger temperature increases may have lethal effects on quartz field plants. Thus, despite our present results, conservationists should remain cautious about future population trends of quartz field plants, and our monitoring scheme should be continued accordingly.

Plant diversity studies in threatened sourveld grassland close to rural settlement

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Conservation planners are required to identify high conservation value grasslands. For example legislation requires that they set conservation targets for vegetation types at national and provincial scales. Tools to do this include land-cover maps. These are however not accurate enough to use on their own because of the difficulty in detecting old lands, degraded rangeland and areas that have lost species as a result of utilisation and disturbance. In terms of land-cover maps rural dwelling is a defined entity with a boundary. Given the higher density of people and their livestock in this zone relative to the surrounding rangeland we posed the question: How does plant diversity differ with increasing distance from rural dwelling?

Sample sites were located distances of 100 m to 2000 m from rural dwellings in unfenced rangeland. Sampling was restricted to natural grassland in the vegetation types Midlands Mistbelt Grassland, KwaZulu-Natal Sandstone Sourveld and Ngongoni Veld. Plots were selected that were comparable based on attributes such as soil type, soil depth, slope, and fire frequency. Plant species diversity (Shannon-Wiener Index) on each site was calculated. Using benchmark data from monitoring plots in grassland little or unaffected by anthropogenic disturbances associated with such rural dwellings, a measure of diversity loss was

derived on a percentage scale (a depletion score). The relationship between distance from rural dwellings and plant diversity was quantified.

Distance from rural dwellings was correlated with plant diversity. Sites 600 m from rural dwellings showed declines in plant diversity of 65%. Sites 100 m to 500 m from rural dwellings showed declines of 60%–100%. A 70% loss of plant diversity is regarded as critically low when evaluating a grassland site for its ability to maintain biodiversity. These findings will be used to set exclusion buffers around rural dwellings in the new 2005 landcover map of KwaZulu-Natal to systematically define a type of degraded grassland. Provincial scale conservation targets for applicable vegetation types may exclude such areas.

How useful is a Veld Condition Assessment to measure plant diversity?

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Protected area managers, extension officers, rangeland ecologists and environmental consultants are often compelled to make assumptions about grassland plant diversity (or ecosystem health) based on Veld Condition Assessment (VCA) scores given the paucity of local information on other measures, (notwithstanding that this was never the purpose of the VCA system). We posed the question: What precisely can VCA scores tell us about diversity based on forb species richness and evenness?

VCA's were done in a selection of permanent monitoring plots for which non-graminoid species richness and species diversity scores were known. Sampling was restricted to natural grassland of KwaZulu-Natal Province (South Africa) in the vegetation types Midlands Mistbelt Grassland (MMG), KwaZulu-Natal Sandstone Sourveld (KSS) and Ngongoni Veld (NV) and plots were selected that were comparable based on attributes such as soil type, soil depth, slope, and fire frequency. The geographical range of the sampling area was from Qudeni (east of Dundee) in the north to Highflats and Mzimkulu in the south. 85 plots were selected and they represented each of the five VCA classes (critical, poor, average, good, excellent) in more or less equal proportions. The relationships between VCA score and species richness, Shannon-Wiener species diversity index, % cover of *Themeda* and *Aristida* were investigated. The grazing value weighted veld condition scoring method was used.

In MMG, species richness (number of species/100 m^2) declined ($p < 0.001$) with decreasing Veld Condition Index (VCI), from 35–40 species in good- to excellent-condition grassland (VC>60%) to fewer than 10 species in grassland considered to be in critical condition (VCI < 20%). Evenness (distribution of abundance among species) was unaffected by veld condition but the overall Shannon-Wiener diversity index (H'), which was constantly high in average- through excellent-condition grassland (VCI: 40%–100%), declined markedly ($p < 0.001$) below a VCI of about 30% to consistently low levels below a VCI of 10%. Both species richness and diversity in KSS and NV changed in a similar sigmoidal fashion ($p < 0.001$) along the veld condition gradient, with consistently high diversity (~50 species/100 m^2) in good condition grassland (VCI > 60%) and a sharp, step-like decline in diversity below a VCI of approximately 50%, to reach a constant low below a VCI of about 30%, where as few as 10 species per plot were found.

In MMG, KSS and NV diversity was at its lowest when the proportion of grass *Aristida junciformis* (a key indicator of degraded grassland) was high, and generally high when grass *Themeda triandra* (a key indicator of good condition grassland) was abundant, but diversity indices, and species richness in particular, were highly variable when the converse was true.

The implications of this are that, in the context of flagging conservation-worthy areas for plants such as those often used in environmental impact assessments, VCA scores have limited usefulness. They do however indicate diversity at the upper and lower extremes of the VCA scale. Only veld in critical condition (< 20%) may be regarded as not conservation-worthy for plant conservation. The two key species *Themeda triandra* and *Aristida junciformis* alone are not sufficiently good indicators of diversity.

Foraging for space by plant roots: a comparative study of grasses from contrasting habitats

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The availability of belowground space and presence of impenetrable obstructions in the soil can strongly affect root growth and plant performance, even when nutrients, water and oxygen are not limiting. Under natural conditions, roots can encounter obstructions in a

variety of sizes and densities. Such obstructions reduce space for root growth and deployment, and hamper root access to resources, leading to a reduction in resource acquisition efficiency. Plants could therefore benefit from being able to forage for usable space, avoiding substrate with a high density of obstructions in favour of substrate that their roots can explore and exploit more fully. However, there have been no studies to assess the ability of roots to avoid obstructions, to determine how widespread any such ability might be, or to explore the attributes that might confer this ability.

The aim of this study was to investigate the ability of roots to avoid obstructions and forage for usable space, and to reveal the mechanism involved. Eight grass species from four genera were examined. Each genus included species characteristic of habitats with high and low nutrient availability. The ability to limit root mass and to adjust morphology within substrate containing obstructions in the form of gravel was investigated. A treatment with activated carbon, which adsorbs organic compounds, was used to examine the possible involvement of root exudates in responses to obstructions.

Root morphological responses to obstructions were different from those shown in response to low nutrient availability or compacted soil. Species from nutrient-poor habitats were more effective than those from nutrient-rich habitats in limiting root mass placement in patches containing obstructions. The ability to avoid obstructions was apparently mediated by the sensitivity of roots to their own exudates accumulating in the vicinity of obstructions. This mechanism may ensure efficient root placement in obstructed substrate before resource uptake becomes directly affected by the aggregation of roots in limited space.

Using the deductive approach to characterise natural forest vegetation of South Nechernozemje, Russia

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Sudost-Desna watershed is a large territory in the broad-leaved forests zone of South Nechernozemye of Russia. The natural vegetation in this region and that of the originally forested landscapes of Central Russia were highly transformed by human activity. As a result, the zonal broad-leaved forests cover less than 5% of the region today. These secondary forests are found at various stages of succession, and are difficult to classify.

We used the deductive Kopecký-Heiný's approach to syntaxonomic classification.

A number of basal and derivative communities of the Sudost-Desna watershed broad-leaved, coniferous, and mixed (coniferous/broad-leaved) forests, xerothermic shrub communities at the river valleys, disturbed flood-plains, continental meadows as well as synantropic and neophytic vegetation types were studied. Based on a five-year study and using 1000 relevés, I described 25 associations, 13 subassociations (classified into 12 alliances, 9 orders, 6 classes) as well as 10 basal and derivative communities.

Basal communities dominated by the Acer platanoides, Betula pendula and Populus tremula are of secondary nature. They have a high similarity with the zonal oak, lime-tree-oak, and spruce-oak forests. Some rare derivative communities are formed by tree species, which are represented outside of their natural geographical distribution (as in the case of the Urtica dioica–Alnus incana [Fagetalia sylvaticae] community).

Phylogeny-minded management of invasive alien species: an emerging perspective

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Determining which species will be invasive among thousands of immigrants is a challenge for invasion ecologists and evolutionary biologists alike. To address this, an emerging research theme is that of phylogenetic pattern of biological invasions, including phylogenetic clustering and overdispersion among native and non-native species. Studies focusing on the species and community invasibility concepts may not be sufficient enough to rationalize invasiveness and to build up a predictive framework for future invasion management. What is needed now is a more comprehensive and synthetic approach, one that would be able to integrate the key concepts and contributions of previous models from diverse research fields and that would provide a more realistic conceptual framework. We propose such an approach by attempting to merge the concepts of phylogeny, functional richness, and species richness at different spatial scales with the ultimate aim, of generating a frame work for invasive species management across the globe.

We constructed a hypothetical tree or cladogram representing phylogenetic relatedness among the species (natives and non-natives) in a community to illustrate how functional diversity/ functional richness can be related to the phylogeny of the species. For example, functional characters (T) of species (S) in a community can be related to each other on the

basis of closest functional characters (characteristics of an organism that are considered relevant to its response to the environment and/or its effects on ecosystem functioning. Examples of functional traits are leaf size, toughness and longevity, seed size and dispersal mode, canopy height and structure, ability to resprout, and capacity for symbiotic fixation of nitrogen). This can be said otherwise as S set of species (native and non-native) related to each other on the basis of closest functional characters. In a hypothetical phylogenetic tree derived from the set of characters (T) for a number of species (S), selected non-native species show close relatedness to the native species and share some common features (functional characters) to those of native species. Previous research highlights that if species richness is high, there is a higher probability of phylogenetic relatedness, and regions rich in species are often more susceptible to invasive species. If the related species (in a species rich environment) share similar characters and habitat requirements with the invaders, this could explain the success of invaders in diverse habitats.

We suggest that phylogenetic relatedness should be considered when anticipating management of plant invaders in highly diverse environments. Highly diverse habitats are sometimes less penetrable to invasion, and while the invader might display high phylogenetic relatedness, their success might be minimised due to competitive exclusion at the local scale. In contrast, when the species richness is low, the success of an invader depends more on the availability of empty niches, rather than on the phylogenetic relatedness as such. We review the existing literature in the light of the above conceptual debate, and propose a comprehensive model that could possibly lead us to construct a framework towards the phylogeny-minded management of invasive species.

Plant invasion of the Southern Ocean Islands: homogenisation or differentiation?

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Alien species commonly homogenize biotic communities. We examined the flora of the Southern Ocean Islands (SOI), a region typified by low temperatures, low human population and extreme isolation. The SOI represent the only ice-free terrestrial environment at high latitudes in the southern hemisphere. Despite a large dispersal barrier (isolation), alien plants have reached the SOI. Across the SOI alien plant richness covaries with avail-

able energy (i.e. mean temperature) and human visitation frequency. Over 470 indigenous plant species have been recorded for the SOI and another 350 have been identified as alien. Plant invasion far outweighs plant extinctions. We determined how alien plants impact the flora of the SOI. Homogenisation processes were investigated at different spatial scales. We examined smaller islands groups, based on regional proximity (Southern Indian Ocean, Southern Pacific, etc). Homogenisation and differentiation were calculated as a change in percentage of Jaccard's index of island floras, resulting from invasion.

At the biogeographic scale we found that alien plant species have differentiated the flora of the SOI (-1.86%). Previous studies found that indigenous plants of the SOI showed significant nestedness. Supporting this, we found that homogenisation of island floras increased with distance between islands, due to the decreasing similarity of indigenous plants with island distance.

Homogenisation processes varied between island groups (or archipelagos). Due to plant invasion, the flora of the Southern Indian Ocean group has been highly differentiated (-22.95%) while Southern Atlantic group flora became homogenised (0.733%). These results highlight that homogenisation is driven by the initial similarity of biota.

The most widespread SOI aliens have a taxonomic affinity with globally widespread aliens. Many common alien plant species across the SOI are also common in very climatically different ecosystems. Our results highlight the impacts of aliens at a biogeographic scale, and how they influence biodiversity.

Acknowledgements: This work was supported by a South African Student Travel Grant provided by the Regional Section for Southern Africa of the IAVS.

Will a decreasing winter rainfall cause a shift in Succulent Karoo boundaries? Evidence from competition and vegetation-change analyses

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The ecotone between the Namaqualand shrublands (Succulent Karoo biome) and Bushmanland Arid Grassland (Nama-Karoo biome) is characterised by transitional (ecotonal) physiognomy (grassland-shrubland mosaic, and grass and shrubs intermingling in arid communities). We discuss findings from studies of vegetation distribution patterns and processes at the ecotone, in the context of climate change and ecotone dynamic.

A reciprocal seedling transplant field experiment revealed that established grass vegetation competitively prevents the establishment of succulent shrub seedlings in grass communities. In communities where grass and succulent shrubs co-occur, a nearest-neighbour analysis technique revealed a stronger competitive impact from grass on the succulent shrubs. Higher competitive pressure from grasses on the succulent shrubs is important to grass-shrubs dynamics at the ecotone, particularly given the observed and predicted decline in winter rainfall, to which the succulents in Namaqualand are well adapted. It is inferred that the stronger competition from grass on the succulent shrubs reflects a reduction in water availability in the upper soil layer, where most of the root mass for succulent shrubs is concentrated. Furthermore, multi-temporal analyses of LANDSAT data between 1986 and 2006 revealed areas showing persistent signs of increasing grass cover, but not signs of a persistent increase in shrub cover.

We propose that changes brought about by a shift in seasonality of rainfall may already be manifest in the vegetation, as indicated from evidence of increasing grassiness. Such changes may be ascribed to competition for water and interactions between the different root morphologies at the ecotone.

Acknowledgements: This work was supported by a South African Student Travel Grant provided by the Regional Section for Southern Africa of the IAVS.

Changes in plant form and function across altitudinal and wetness gradients in wetlands of the Maloti-Drakensberg, South Africa

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A survey of 93 wetlands in six catchments (alt. span: 1000–3200 m) across the Maloti-Drakensberg Mountains was done to assess the distribution of plant functional types across altitudinal and wetness gradients. Within each catchment, the wetlands have been selected to cover the ranges in altitudes and wetland types. In each of the selected wetlands, vegetation was sampled in 3 x 3 meter quadrates covering the entire range of habitats, from temporarily wet to permanently inundated soils.

Eleven plant functional types were recognised in vegetation plots in the wetlands of the Maloti-Drakensberg area. The proportion of the vegetation occupied by each functional group was assessed by adding the species occurrences. Canonical correspondence analysis showed that 'wetness' clearly had the highest impact on the distribution of growth forms. The most important plant functional types in wetlands were grasses and sedges, however at higher altitudes, forbs (especially rosette plants) and bulbous plants become a more prominent feature in the wetlands. The total amount of graminoids gradually decreases with altitude. Sedges tend to increase with increasing wetness and C_3 plants (grasses and sedges) increase with increasing altitude, but these effects are not independent. The distributions of C_4 sedges and C_4 grasses along an altitudinal gradient were quite different, and C_4 grasses manage to grow abundantly at much higher altitudes than C_4 sedges. C_4 sedges occur only marginally in the area, whereas C_3 grasses are also occurring in the permanently wet parts of the wetlands, especially at higher altitudes (usually occupied by sedges). Shrubs are rare in the wetlands and tend to be an indication of disturbance. A previous paper by Kotze & O'Connor (2000) focused on the distribution of grasses and sedges at the lower altitudes in KwaZulu-Natal, and established that C_4 sedges are much more prominent at lower altitudes (< 1000 m) where forbs and rosette plants are largely absent. This supports an idea that C_4 as an adaptation to hotter and warmer climates might be less favourable photosynthetic pathway in wet areas. At high altitudes, rosette plants and bulbous plants become more competitive in wetlands, probably because grasses and sedges present at these altitudes generally grow smaller.

Kotze, D.C. & O'Connor, T.G. 2000. Vegetation variation within and among palustrine wetlands along an altitudinal gradient in Kwazulu-Natal, South Africa. *Plant Ecol.* 146: 77–96.

Long term effects of thinning on floristic composition and regeneration of Atlantic oak woods in NW Spain

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We studied the effect of several thinning levels on the floristic composition and oak regeneration in oak woods (*Quercus robur*) in the NW of Spain. In 1999 experimental plots were established in two forest types (the Rusco aculeati–Quercetum roboris and the Myrtillo–Quercetum roboris). The thinning levels were: *(i)* 0% or no cut, *(ii)* 15%, *(iii)* 35%, and *(iv)* 55% of basal area reduction, with three replications for each treatment.

After nine years since the beginning of the trial, we found small changes in floristic composition, mainly affecting species of the class of Calluno–Ulicetea. However, new species appeared only in small proportions, not in all plots, and independent from treatments. The species diversity was calculated and indicated a small increase in diversity in the last year of observations, but this index did not differ between the two forests. Oak regeneration increased in the plots with a higher thinning level, mainly as trunk sprouts.

The thinning treatments, which are directly related to the amount of light reaching forest soils, significantly increased plant diversity, with a direct relationship between thinning levels and species diversity. Species such as *Pteridium aquilinum*, *Rubus* spp., *Frangula alnus*, and graminoids increased in cover during several years after thinning, however this increase was not always significant. For species such as *Castanea sativa* and *Erica arborea*, thinning treatments had a negative and significant effect on their plant cover.

Community genetics: Are genetic diversity and plant species diversity correlated? A test in the Park Grass Experiment

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In grassland communities plant species diversity is negatively correlated with nutrient supply (particularly N). In contrast, genetic diversity is strongly correlated with mating system and its direct relationship (if any) with ecological variables is unclear. We used the Park Grass Experiment (PGE), begun in 1856, to test two hypotheses about the relationship between genetic diversity in populations of the grass *Anthoxanthum odoratum*, resource supply, soil pH and the species diversity of plant communities. They were: H1. The coexistence hypothesis: Genetic diversity within species favours coexistence among species and therefore species and genetic diversity are positively correlated; H2. The niche breadth hypothesis: Interspecific competition constrains the niche breadth of individual species, thereby limiting genetic variation. Species diversity and genetic diversity should therefore be negatively correlated. We used AFLP markers to measure the genetic diversity of populations of *A. odoratum* growing in 10 plots that lie along nutrient and soil pH gradients in the PGE. Species diversity was negatively correlated with nutrients along this gradient and was severely reduced by values of soil pH < 4.5. We found that genetic diversity in *A. odoratum* was significantly ($p < 0.0001$) correlated with the number of nutrients added (ranging from nil to three) to a plot but not with species diversity, soil pH or biomass of *A. odoratum*.

Variability of the forest communities of the Dilj Mountain (Croatia) along environmental gradients

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This paper deals with the forest vegetation of Dilj, situated on the southern edge of the Pannonian Basin in NE Croatia. Ten plant communities of the Querco–Fagetea were found and their ecology was analyzed in detail. This study provides the data on the vegetation and environmental factors and discusses the significance of factors for the plant species composition; it characterizes the most important environmental gradients and the differences between plant communities are presented. Surface soil layer was analyzed in all sampled plots. Other ecological characteristics, such as microclimate, geomorphology, and Ellenberg indicator values, were also considered and tested for possible correlations. The forest vegetation was classified by means of cluster analysis, while vegetation-site relationships were examined by using methods of direct gradient analysis. The studied communities were found to occur in relatively restricted space, where the ecological factors control formation of a mosaic of vegetation patches with spatially unclear boundaries. Soil reaction and exposition was identified as the most significant environmental factors explaining the variation of the studied vegetation.

Determinants of community assembly and phylogenetic structure of *Tetraria* communities: traits, gradients and scale

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Co-occurrence of species in the fynbos sedge genus *Tetraria* at fine spatial scales is non-random with respect to phylogeny (Slingsby & Verboom 2006). This pattern may arise because the functional traits that determine habitat preference and interspecific interactions are phylogenetically structured. Whilst previous work has demonstrated that the evolution of a number of traits within the genus *Tetraria* are phylogenetically conserved, neither the utility of the traits, nor their association with specific environmental variables, were established. No direct link between ecological process and community structure could thus be inferred.

We report the results of a study in which we investigated, within a phylogenetic framework, the utility and relationships with environmental variables of a range of morphological and physiological traits in the genus *Tetraria*. We use this information, along with species co-occurrence data and a phylogeny for the group, to infer which functional traits and ecological processes determine the structure and assembly of *Tetraria* communities. The investigation was conducted at fine (2 x 2.5 m and 5 x 10 m plots) and broad spatial scales (occurrence in quarter degree squares across the Cape Floristic Region) to establish if the dominant ecological process determining species occurrence changes with spatial scale.

Slingsby, J.A. & Verboom, G.A. 2006. Phylogenetic relatedness limits co-occurrence at fine spatial scales: Evidence from the schoenoid sedges (Cyperaceae: Schoeneae) of the Cape Floristic Region, South Africa. *Amer. Nat.* 168: 14–27.

Acknowledgements: This work was supported by a South African Student Travel Grant provided by the Regional Section for Southern Africa of the IAVS.

Whole-island estimate of production and nutrient cycling on a sub-Antarctic island: are plant guilds the way to go?

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Sub-Antarctic Marion Island (47° S, 38° E; 290 km^2), although situated at a relatively low latitude, supports almost the entire range of vegetation types that occur in northern hemisphere tundra, ranging from dwarf shrub tundra, tussock tundra, wet meadows and bogs, to fellfield and polar desert. The exception is forest tundra. Trees do not occur anywhere in the sub-Antarctic. A long-term goal of the research program on the island is to construct whole-island budgets for plant biomass, primary production and nutrient cycling. Primary production and nutrient cycling have so far been measured for 8 of the island's 41 plant communities. This involved analyses of the seasonal changes in plant biomass and chemical composition, changes the sizes of soil nutrient pools, and studies of plant litter decomposition, soil carbon efflux and nutrient inputs to the communities by abiotic and biotic processes. The biomass, production and decomposition studies were carried out on a per-species basis and took nearly 20 years. At the end of that period we still seemed to be a long way from being able to quantify primary production and nutrient cycling, or to construct biomass and nutrient budgets, for the whole island.

Canonical ordination and clustering analyses of vegetation and soil chemistry information obtained during these (and other) studies classified the island's terrestrial ecosystem into 21 habitats. For this habitat classification, the ordination was repeated several times, with the plant species being successively grouped into increasingly broader guilds. The guilds were based mainly on plant-growth form but in some cases on taxonomic characteristics, or combinations of taxonomic and ecological characteristics. The groupings tested first were those previously shown to be useful in multivariate analyses of tundra vegetation types. Thereafter, other groupings were created based on similarities in the canonical axes weightings. The result was a set of 15 plant guilds which yielded a clear separation of habitats in the ordination space, in a pattern which could be readily interpreted in terms of the environmental and ecological forcing variables that are most important at the island. These are: soil moisture and hydrology, exposure to wind, soil type (mineral volcanic ash to highly organic peat), wind-blown salt spray and manuring and trampling by seals and seabirds. These same factors are also cardinal determinants of ecological function processes, such as photosynthesis rate, decomposition, soil microbial activity and nutrient cycling, so it was predicted that the habitat classification would emphasize the between-habitat variation in ecosystem function. In fact, the production, decomposition and nutrient cycling values for the eight communities studied (each represents a different habitat) are located in the multidimensional space of the ordination gradients that defined the habitat classification in a pattern that is wholly congruent with the interpretations of those gradients.

This suggests that the plant guilds of the habitat classification are analogues of plant functional types that can be used to economically estimate biomass, primary production and nutrient cycling for the remaining habitats, and thus attain the goal of these parameters on a whole-island basis. The viability of this approach is discussed and some early results of its implementation presented.

Inhibition of nitrification in matgrass swards: the effect of the vegetation

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There are clear differences in nitrification characteristics within the Dutch grassland slopes in southern Limburg. Compared to the acid top and lower calcareous zones of the vegetation gradient (i.e. the Thero–Airion and Mesobromion erecti, respectively), potential nitrification rates are repressed in the middle, matgrass sward zone (Nardo–Galion saxatilis). In contrast to the differences in potential nitrification activities, no differences in dominant ammonia-oxidising bacterial species (ß-Proteobacteria) were observed. A feasible explanation for the observed repression of potential nitrification in the matgrass swards is the mechanism of repression by allelopathic compounds from the vegetation.

In order to investigate the effect of characteristic plant species on nitrification activity, a greenhouse experiment was designed. Soil from the upper 10 cm of a matgrass sward, classified as the Nardo–Galion, and from a calcareous grassland of the Mesobromion was collected in the Bemelerberg Nature Reserve (the Netherlands) at the end of October 2007. Four characteristic plant species of the Nardo–Galion and four of the Mesobromion were cultivated from seeds collected from the wild. Young seedlings were planted into soil of both the matgrass sward and calcareous grassland. Potential nitrification activities, plant growth, and soil chemistry were measured at the start and at the end of the four months-lasting experiment. First results show that the plant species of the Nardo–Galion have a negative effect on nitrification activity, whereas some plant species of the Mesobromion seem to stimulate nitrification activity.

SynBioSys Rooibos—an information system on wild rooibos (*Aspalathus linearis*, Fabaceae) and its occurrence in the Fynbos Biome of South Africa

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Wild rooibos (*Aspalathus linearis*) is an ericoid shrub of the Fabaceae family found in fynbos of the Cape Floristic Region. The species is well-known as source for the South African iconic herbal tea. Initiated by the Dutch Embassy in Pretoria, a multidisciplinary project has been initiated to address the sustainable harvesting and production of wild rooibos, with special reference to the effects of the harvesting on fynbos ecosystems.

Within this project, a user-friendly information system (called SynBioSys Rooibos) is under development. This system will bring together available data on the ecology, geography, and sustainable use of rooibos at species, vegetation and landscape levels. The system will also entail a GIS interface for the visualisation and analysis of information layers on the different levels. It will also incorporate new data resulting from the current project, including the data on floristic composition of sites supporting wild rooibos, and the effects of natural fires and human-induced burning on its populations. Samples of rooibos plants (showing with various growth-forms) will be analysed for genetic differences using chloroplast DNA markers. In *Aspalathus linearis* so far five different 'ecotypes' have been distinguished: rankies, bossie, langbeen, tree, and cultivated type. In cooperation with the University of Cape Town and a local nursery in the Suid Bokkeveld, germination trails were set up to investigate the germination biology of these different ecotypes, including the cultivated rooibos.

Responses of succulent Karoo rangeland vegetation to rest from grazing

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Northern Cape (South Africa), where most of the area of the Succulent Karoo biodiversity hotspot is situated, has the third highest veld degradation index in South Africa, largely due to livestock grazing threatening ecosystem integrity by changing the composition and cover of plant communities. Traditional succession models for arid and semi-arid rangelands are criticized, as exclusion of livestock for long periods can have little effect on species diversity. It appears that non-equilibrium models represent arid vegetation dynamics more accurately.

Changes in species richness, seedling recruitment and cover following livestock removal were measured within the Paulshoek communal rangeland. Furthermore, two palatable (*Hirpicium alienatum* and *Ruschia robusta*) and one non-palatable (*Galenia africana*) species were selected to serve as indicators of veld condition, with abundances and biomass of these species being measured.

Our study showed few significant differences between the rested and grazed areas. Increases of species richness and abundances of palatable growth forms in the grazed areas suggest a slight grazing effect. Seedlings showed a significant increase in species richness in the grazed area, mainly due to the increase in perennial herb species richness and abundance in the grazed areas. These plants are generally non-palatable, benefiting from selective grazing of more palatable seedlings. Cover of leaf succulents showed a significant decrease in the grazed area, due to preferential grazing. *H. alienatum* showed highly significant increases of abundances and biomass in the ungrazed area. Such palatable species could thus be used as indicators of veld condition. An analysis of various environmental variables showed that these factors were more important determinants of community dynamics than grazing alone. This suggests that traditional succession models based on equilibrium dynamics are unsuitable for application in this semi-arid rangeland. Management decisions should thus be based on non-equilibrium models, in order to maximize biodiversity conservation while still supporting the livelihoods of the local human communities.

Understorey vegetation does not always hinder seedling establishment

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It has been shown repeatedly that seedling density, species richness, growth and survival are negatively correlated with the abundance of understorey vegetation. However, understorey vegetation in previous studies was characterised by large-fronded species, such as palms or tree ferns. We would like therefore to ask the following question: Does understorey species with smaller frond play similar role in seedling establishment as do the large-fronded species?

We assessed the influence of understorey vegetation on seedling survival in an Australian subtropical rainforest. The understorey vegetation of this forest was dominated by fern *Lastreopsis decomposita* having fronds less than 90 cm long and having canopy only 30–40 cm high. Seedling survival was monitored for two years in a 0.5 m wide and 200 m long transect. In this forest, most of the seedling mortality was caused by smothering (litter cover) and by physical damage (vertebrate foraging activity). In addition to light transmittance, amount of litter cover, and frequency of vertebrate disturbance in habitats with and without fern understorey were measured. Mean diffuse transmittance was significantly lower beneath the fern canopy than in its absence. The amount of litter cover and frequency of vertebrate disturbance were also significantly lower where the fern understorey was present. Seedling survival was greater in habitats with a high fern cover. In terms of the role of influence of understorey vegetation on seedling establishment, our results suggest that the negative effects of lower light availability are outweighed by the positive effects associated with lower stress associated with lower litter cover and lower vertebrate disturbance. Seedling survival hence is facilitated due to the presence of understorey plants. This study shows that the roles of understorey vegetation in seedling establishment depend on their influence on both the physical environment of seedlings and the patterns of animal activity.

How critical is the number of species for the identification of community assembly patterns?

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In this contribution we aim to identify if the number of species we have sampled in two areas of forest vegetation in northeast of the state of São Paulo, Brazil, are suitable to recognize community assembly patterns. Based on a recent method to sort out trait-convergence (TCAP) and divergence (TDAP) assembly patterns in ecological community gradients (Pillar et. al., in press), we used bootstrap re-sampling to evaluate how these parameters describing TCAP and TDAP evolved with increasing sample size. The method to identify TCAP and TDAP and evaluate the correlation between trait-based described communities and ecological gradients required three input data matrices. To describe the species by traits (matrix B) and performance (basal area) in the community (matrix W), we chose 17 quantitative morpho-physiological traits witch were used to evaluated 214 individuals (59 species) in 8 plots (4 in lower Atlantic Forest–AF, and 4 in Restinga Forest–RF, closest to the sea).

The total plant species richness in each plot defined the third matrix (E), which varied from 43 to 96 species. By multiplying the traits matrix (B) and performance matrix (W) we defined matrix T (T= B'W) with the averages of a trait in each community. The species similarities in terms of the traits defined matrix U with degrees of belonging of the species to fuzzy sets defined by each species. By matrix multiplication X = U'W will contain the composition of the communities in terms of these fuzzy types (each row in X will refer to a species). Both T and X can be related to E by matrix correlation, in this way measuring how the patterns in T and X are associated to the richness gradient in E. For relating T to E, a proper distance matrix of communities (DT) is computed using T and another distance matrix of the community sites (DE) is computed using E. Then matrix correlation σ(TE) = σ(DT;DE) would measure the level of congruence between variation in traits and the species richness at the plot level. By using a recursive method, at each iteration another trait subset is chosen in B defining a new matrix T and correlations σ(TE), allowing at the end to find the subset of traits maximizing TCAP related to species richness. Similarly, matrix correlation σ(XE) = σ(DX;DE) between X and E is defined, and the same recursive algorithm was used to find the subset of traits maximizing σ(XE). A large σ(XE) will indicate that either or both TCAP and TDAP are related to E. The trait convergence component is then removed from σ(XE) by using partial matrix (Mantel) correlation σ(XE.T), revealing how TDAP is related to species richness. In order to check for statistical significance, the observed partial correlation σ(XE.T) for TDAP is tested by permutation against a null model. We evaluated σ(XE.T) and the corresponding permutation probabilities for our complete data set and then re-sampled the species by extracting bootstrap samples with up to 55 species. We used in all simulations the same subset of traits which were optimized with the whole set of species (59).

Our results showed that the probabilities of the test against the null model decreased with the inclusion of more species in the sample; the null model was not rejected in 35% of the samples with 40 species, and in 5% of the samples with 55 species. Our results suggest that community assembly patterns could be assessed with a subset of species instead of the whole community.

Pillar, V.D., Duarte, L.DaS., Sosinski Jr, E.E. & Joner, F. in press. Sorting out trait-convergence and trait-divergence assembly patterns in ecological community gradients. *J. Veg. Sci.*

Acknowledgements: E.E.S. is a holder of a post-doctoral bursary FAPESP (Processo 05/59168-1).

Species-specific responses of understorey tree density and species richness to overstorey species in a seasonal semideciduous forest

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Despite the recognized importance of plant-plant interactions in community assembly, knowledge about the associations between overstorey and understorey tree species in tropical forests is almost entirely lacking. We tested the hypothesis that there would be differences in species richness and tree density under the crowns of nine canopy tree species, as an outcome of species-specific interactions. We carried out this study in a 10.24 ha permanent plot located in a seasonal semideciduous forest reserve (Caetetus Ecological Station), in central-western São Paulo State, south-eastern Brazil. In this plot, we sampled the 'overstorey' trees of nine canopy species and all individuals with diameter at breast height equal or greater than 4.8 cm under their crowns ('understorey' trees). We also measured the crown diameters of canopy trees to calculate crown area and understorey tree density. The overall understorey tree density did not differ among canopy tree species in the analysis of variance.

Correspondence analysis revealed a significant correlation between understorey tree density and the identity of three overstorey species: *Esenbeckia leiocarpa* (Rutaceae), *Savia dictyocarpa* (Phyllanthaceae) and *Ceiba speciosa* (Malvaceae). The first two ordination axis of the correspondence analysis accounted for 61.8% of the total data inertia. Understorey species richness, estimated by re-sampling methods, was higher underneath *C. speciosa* canopies. The potential to attract frugivorous animals and the occurrence of allelopathy may be some of the mechanisms responsible for the observed patterns. The results showed

the occurrence of species-specific responses in the associations between overstorey and understorey trees, suggesting that the overstorey tree species may act as ecological filters, playing an important role in the structure and composition of the studied community.

Environmental determinants of plant species richness variation across the Subantarctic-Patagonian biogeographic transition

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Understanding the relationship between geographic variation in species richness and environmental gradients is a key issue in most analyses of species diversity. Transition zones are suitable to address for these relationships because these are areas with high species replacement and/or pronounced richness gradients.

We analysed variation in plant species richness along east-west precipitation gradient across the transition between the Subantarctic forest and the Patagonian steppe (Argentina). We tested predictions derived from the species-energy, climatic variability and habitat heterogeneity hypotheses. We sampled vegetation in 50 plots (100 m^2 each) encompassing forests, scrublands and steppes. In each plot, we counted the number of herbs, shrubs, and trees species and estimated the canopy and total cover of shrubs and herbs. We used path analysis to model and to test the relationships between species richness and plant cover, mean minimum daily temperature, mean range in daily temperature, mean annual precipitation, ground heterogeneity and the impact of habitat use by cattle (estimated indirectly by the number of faecal pats).

The spatial variation in species richness showed a unimodal pattern with a peak within the scrublands. Across the whole gradient, a local increase in precipitation promoted an increase in shrub and canopy cover associated with an increase in species richness. An increase in daily temperature variation was negatively associated with richness of shrub and tree species. The herb richness was weakly associated with herb cover, but not associated with temperature variation. In addition, the herb richness increased in more heterogeneous sites and decreased in sites with high canopy cover. The species richness data of forests and scrubland-steppes analysed separately confirmed that our model was not suitable to explain the species-environment relationships in the forests. In the semi-arid shrubland-steppes, the results were slightly different from the whole gradient. A local increase in precipitation and ground heterogeneity had a positive direct effect on the richness of trees and herbs, but

sites with a greater amount of faecal pats had lower richness of herbs. Although direct and indirect climatic effects are primary determinants of the spatial variation in plant species richness across the whole gradient, different functional types respond differently to the environmental determinants. Richness of trees and shrubs are associated to variations in climatic conditions, but herb richness is affected by other local factors such as the impact of habitat use by cattle, ground heterogeneity, and the likely competition with trees.

Primary production of dry pioneer grassland: augmentation by nitrogen addition?

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The cycles of carbon and nitrogen are both affected by global change, and both are closely linked. Increasing nitrogen deposition in terrestrial ecosystems could increase the capacity of ecosystems to sequester carbon, provided that nitrogen is a limiting factor for primary production. Potentially, there could be a significant carbon sequestration of very unproductive ecosystems, the productivity of which could be especially responsive to nutrient addition. However, this hypothesis has been challenged, and experimental data from plant communities with initial productivity (before fertilisation) below 100 $g.m^{-2}.yr^{-1}$ are scarce.

We examined dry, nutrient-poor grassland for 4 years in the upper Rhine valley (Germany). The annual atmospheric nitrogen deposition was ca. 17 $kg.ha^{-1}.yr^{-1}$. Within a 5-fold replicated randomized block design, 10 m^2 plots were given single or combined applications of nitrogen (two dosages), phosphorus, potassium and other essential nutrients. Data were analyzed by mixed linear models.

Above-ground vascular plant species productivity more than doubled from 90 to 210 $g.m^{-2}\,yr^{-1}$ after nitrogen addition in high dosage (100 $kg.ha^{-1}.yr^{-1}$). Additional nutrient elements did not increase productivity further. However, productivity remained at a low level. The cover of 10 and the height of 15 species were significantly enhanced by nutrient addition. This provides evidence for nutrient limitation of many individual species across all life forms. Mostly a phosphorus/nitrogen co-limitation is established. *Centaurea stoebe* is nitrogen limited and exhibits a decisive impact on total above-ground vascular species productivity.

The results show that the productivity of very unproductive plant communities can respond to nutrient addition. Actually, the response was more pronounced than in plant communities with higher initial productivity (before nutrient addition). Addition of nitrogen in a low dosage (25 $kg.ha^{-1}.yr^{-1}$) had not have significant impact on productivity in our experiment yet.

We conclude that ambient and slightly increased atmospheric nitrogen deposition rates are not sufficient to enhance carbon sequestration. Nutrients did not affect phytodiversity. No species was suppressed completely, nor was there an encroachment of new species recorded. Nevertheless the characteristic species composition of pioneer stages is dependent on nutrient-poor soils – high-dosage nitrogen addition results in accelerated succession.

Altitudinal and latitudinal species richness patterns of woody plants in Taiwan

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We analysed patterns species richness of woody plants along altitudinal and latitudinal gradients in Taiwan, a major island reaching altitudes as high as 3952 m and located at the western edge of the Pacific Ocean, 150 km off the SE coast of the mainland China. The long axis of south-north oriented Taiwan is as long as 400 km (lat. range: 3°). Taiwan was divided into twenty altitudinal belts and thirteen latitudinal bands. 2662 vegetation plots (20 m x 20 m) were sampled in these belts and bands. A computer program RangeModel was used to estimate species richness for each belt/band, and to evaluate correlations between spatial patterns of species richness and the mid-domain effect (MDE). 58% species in our dataset had latitudinal ranges greater than half of the whole latitudinal range of Taiwan. In contrast, only 37% species had altitudinal ranges longer than half of the whole altitudinal range of Taiwan. This indicates that in Taiwan altitude has more effect on environmental factors associated with vegetation patterns than is the case of latitude. Along the altitudinal gradient species richness peaked in the altitude belt spanning 800–1000 m and decreased sharply above the altitude of 2000 m. Species richness peaked in the centre of the island along the latitudinal gradient. The latitudinal species richness (R^2 = 95%) was much better correlated with the MDE null model than was the altitudinal species richness (R^2 = 19%). The latitudinal species richness pattern is mainly attributed to the MDE along the latitudinal gradient. It is also suggested that, apart from the MDE, environmental fac-

tors such as temperature and humidity (both associated with the altitudinal gradient) are responsible for the altitudinal species richness patterns.

Large functional diversity but weak predictive traits for 20 C_4 grasses, in response to water availability and defoliation

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C_4 grasses are often treated as a single functional group. While C_4 grasses are considered to have evolved relatively recently, they currently occur over a wide range of habitats (from mesic to arid, grazed to non-grazed) and dominate the vegetation in many temperate and subtropical ecosystems. A large amount of functional diversity with the C_4 group is therefore expected. This is apparent in the form of many documented studies of changes in the relative abundance of C_4 grass species in South African ecosystems in responses to changes in annual rainfall or grazing regime. Furthermore, as rainfall, temperature and stocking rates of grazers are likely to change substantially in the coming decades, the functional diversity of C_4 grasses warrants investigation and a system to predict likely changes in the abundance of dominant C_4 grass species is required.

To determine whether C_4 grass species show similar growth responses to both precipitation and grazing, the growth of 20 C_4 perennial species from five grassland and savanna sites in South Africa was measured for 3 growing seasons. The effect of intra-seasonal variation in precipitation on growth was estimated by measuring rainfall and soil moisture (at 3 depths) during sampling intervals of 4 to 6 weeks. The effect of grazing was simulated by clipping certain individuals at start of each interval. Species were then grouped according to their intra-seasonal growth responses using two-way frequency tables. Co-occurring species showed little similarity of growth responses to pulses in water availability. No association was found between optimal depth of soil water utilisation, changes in depth of soil water utilisation with defoliation, and tolerance of defoliation. This indicates a high degree of functional diversity within these C_4 grasses, and suggests that predicting the effects of changes in precipitation and grazing on species composition will be complex for many grass communities. Groups of easily-measured, above-ground traits were identified that could predict optimal depth of soil water utilisation and changes in soil water utilisation with defoliation, but not tolerance of defoliation. Further research is required to deter-

mine whether these 'predictive traits' are functional, and to make meaningful predictions of changes in the composition of grass communities dominated by C_4 species.

Composition, structure, and diversity patterns in Kyrgyz grasslands

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Native grasslands throughout the world are threatened by conversion to cropland, habitat degradation, exotic species invasions, desertification, and woody encroachment. Among the most extensive temperate grasslands remaining are in Central Asia. About 40%–50% of the land area of the Kyrgyz Republic retains native grassland vegetation. With one of the highest human population growth rates in Central Asia, agricultural and grazing pressures on the land are expected to grow, increasing the urgency to document regional biodiversity.

Three expeditions were conducted to characterise floristic diversity, composition, and structure of Kyrgyz grasslands ranging from semi-deserts to high-elevation meadow steppes. 682 species were recorded in 832 quadrates (0.5 m^2) sampled along 43 transects throughout the Kyrgyz Republic. 50% of all species occurred in a single transect and only 30% occurred in more than two transects. The species accumulation curve had a continuously rising profile. Alpha diversity (species density) was 11–12 species, while the mean richness was 41 species per transect. The dominant species included*: Festuca valesiaca, Carex turkestanica, Artemisia scoparia, A. persica, A. serotina,* various species of *Artemisia* subgen. *Serifidium, Bothriochloa ischaemum, Stipa capillata, Poa bulbosa,* and *Bromus oxydon*. These dominants accounted for 26% of the importance value (sum of relative cover and frequency) among all taxa.

Landscape variables explaining significant variation in the data (based on canonical correspondence analysis) were elevation and longitude, while among variables in community structure, species density and percent bare ground accounted for significant variation among sites. Ten vegetation types forming three broad classes identified by a cluster analysis (desert/semi-desert/semi-savanna, montane steppe/meadow steppe, and subalpine meadow) were found to span a moisture gradient. While steppe habitats were more species rich, arid communities had greater richness of indicator species compared to steppe habitats and beta diversity was much greater in arid compared with steppe communities. Plant functional group diversity also was greater in arid communities and significantly lower in moist meadows. Arid habitats were dominated by C_3 annual grasses, C_4 grasses, annual and

biennial forbs, and shrubs while more mesic steppe vegetation was characterised by greater abundance of perennial C_3 grasses, perennial forbs, and legumes.

Acknowledgements: Research was supported by a grant from the National Science Foundation (USA).

Forest structure and dynamics of a tree-line on Mt. Fuji

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We investigated forest structure near a tree-line on the northern slope of Mt. Fuji to determine early-successional processes and mechanisms of primary succession in a subalpine area based on the analysis of age structures. On Mt. Fuji, a tree-line is composed of many wedge-shaped vegetation which extends toward the summit. We chose a typical wedge-shaped vegetation from those. The purpose of our study was to determine what role the plant species play in vegetation vegetation of these wedge-shaped slopes. Another purpose of our study was to determine the expansion rate of the wedge-shaped vegetation. We established three plots in the typical wedge-shaped vegetation. Each plot intersected this vegetation at different altitudes, i.e. upper plot (2450 m); 40 m x 25 m, middle plot (2390 m); 160 x 10 m, bottom plot (2330 m); 220 m x 10 m. All woody plants were mapped, and height and either DBH or basal diameter was measured. Age was determined by counting annual growth rings or by counting the number of whorled branches on a trunk.

This vegetation stretched over a concave topography. The dominant species were *Larix kaempferi* in the top plot, *L. kaempferi* and *Betula ermanii* in the middle plot and *Abies veitchii* in the bottom plot. *Betula ermanii* hardly occurred in the top plot. In all plots, a few aged and large trees of dominant species occurred in the west side of the forests while most small trees occurred in the east side. Canopy tree *L. kaempferi* occurred only at the forest edge, whereas those of *Betula* occurred in the central portion of the forest – i.e., the bottom of concave topography – in the middle plot. Saplings of *Larix* and *Betula* occurred mainly on the bare ground and forest edge of the middle and bottom plots. Conversely, saplings of *Abies* occurred on the forest floor in the bottom plot. Growth rate of *Larix* saplings was higher than that of *Betula* saplings. The average age of *Larix* trees was lower at the outside of the forest edge than in the inside of the wedges. This age gradient of *Larix* around the forest edge indicated grdual expansion of the forest edge. The expanding speeds in the forest was calculated using linear regression of tree age as a function of the

position from the forest edge for *Larix*; 11–22 cm per year at the east side, and 6–8 cm per year at the west side. This is an indicating of the windbreaking effect of the surrounding forest as the prevailing winds here come from the west. In the subalpine areas of Mt. Fuji, *Larix* is the most dominant pioneer tree species and plays an important role in the formation and the expansion of wedge-shaped vegetation. *Betula* is specialist pioneer on concave topographies because of its higher tolerance to snow pressure. Finally, *Abies* appears to regenerate after the forest of pioneer tree species established.

Predicting changes in potential distributions of 27 coniferous species following climate change in Japan

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Predicting potential distributions of native plant species under changing climate is an important indicator for risk assessment. Developing bioclimatic models enables the prediction of potential distributions of native plant species under current and future climates. Using data on actual distributions of species and corresponding environmental factors, many statistical models were developed to predict changes of potential distributions of species under current and future climatic conditions in western countries. In order to predict potential distributions of plant species, we found it necessary to construct a database such as the Phytosociological Relevé Database (PRDB) to aim development of models of these predicting potential plant distributions.

Using the distribution data on 27 coniferous species native to Japan, classification tree models were developed to predict potential distributions for all the species, and to assess impacts of climate changes in the same manner. In the models, response variables were the presence/absence data on the species extracted from the PRDB, while the four climatic variables on the 10 km resolution (Warmth Index WI, defined as the annual sum of positive differences between monthly means and +5 degree Celsius, the monthly mean daily minimum temperature for the coldest month TMC, winter (December–March) precipitation PRW, and summer (May–September) precipitation PRS) were the predictor variables. The models were validated by AUC values in ROC analysis. The models were incorporated into by the RCM20 climate change scenario for 2081–2100 predicted future occurrence probability of the species.

AUC values validating model prediction for 27 species were more than 0.8, indicating a good prediction. However, the AUC was influenced by the number of presence/absence records as well as by predictive power. The model might be unstable for those species with fewer presence records and for species whose distribution is more influenced by factors other than climatic ones.

The results of the modelling were shown in a form of atlas indicating a variety of statistical values and maps for each species. The models showed climatic conditions for varying occurrence probability for each species, suggesting that the variables controlling the species distribution and their thresholds vary among species. Maps of occurrence probability and habitat suitability for the species were depicted under the current climate and under the RCM20 scenario.

Does the mistletoe *Psittacanthus robustus* on population of *Vochysia thyrsoidea* behave as a metapopulation?

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Psittacanthus robustus (Loranthaceae) is a neotropical hemiparasite found almost exclusively in species of Vochysiaceae from the Brazilian savanna ('cerrado'). The study was carried out in an area of rocky cerrado (2.82 ha) in Lavras, Minas Gerais, Brazil. The aim of this study was to ascertain if the population of the hemiparasitic *P. robustus* behaved as a metapopulation on *Vochysia thyrsoidea* population. The dynamic of the mistletoe was investigated in intervals of six months (December 2006 to February 2008).

In Sample 1 a total of 276 individuals of *V. thyrsoidea* were sampled of which 79 (28.6%) were parasited. The number of hemiparasites was 193 (1 to 11 per tree). In Sample 2 a total of 255 trees of *V. thyrsoidea* were sampled of which 69 (27.05%) were found to be parasited. The number of hemiparasites was 193 (1 to 12 per tree). The rate of net change for *V. thyrsoidea* was -8.09% and for *P. robustus* this change was -21.49%. In Sample 3 a total 256 individuals of *V. thyrsoidea* were found, of which 78 (30.46%) were parasited (1 to 16 hemiparasites per tree). The rate of net change for *V. thyrsoidea* was 0.78% and for *P. robustus* 15.78%.

We conclude that the populations of *P. robustus* on each tree of *V. thyrsoidea* can function as a metapopulation, since the colonisation of unoccupied habitats occurs (Sample 2: a

new tree was colonized; Sample 3: 17 new trees were colonized), present probability of extinction in each spot (Sample 2: 11 extinct spots; Sample 3: seven extinct spots) and the dynamic in the spots are asynchronous (the mortality and colonisation rates in each spot are independent of the others). However, the majority of the extinctions occurred due to death of the host (disappearance of the spots) and the distribution of the hemiparasites is aggregated (associated to the behaviour of disperser) and non-random as expected by the host distribution.

Species response curves for Turkish white oaks

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By using a database of 1181 relevés for *Quercus*-dominated vegetation in Turkey, we created species response curves for the following 10 white oak taxa: *Q. frainetto*, *Q. hartvissiana*, *Q. infectora* subsp. *infectoria*, *Q. infectoria* subsp. *boissieri*, *Q. petraea* subsp. *petraea*, *Q. petraea* subsp. *iberica*, *Q. pontica*, *Q. pubescens*, *Q. robur*, and *Q. vulcanica*. Habitat data used for constructing response curves included elevation, slope aspect, steepness of slope, degrees longitude and latitude, species richness, and total percent plant cover. Response curves for 10 taxa along an altitudinal gradient were constructed. We statistically tested the fitted curves for goodness of fit to four distribution models, including GAUS, GAM, GLM, and HOF. Almost all response curves were found to be unimodal except for *Q. frainetto*, which exhibited bimodal pattern. By comparing the shape and range of response curves among oaks for the same environmental factors, we were able to detect patterns of similarity which could be interpreted in terms of niche or plant functional type relationships. Such similarities could also be shown for completely non-sympatric species, such as white oaks from Turkey and white oaks from California that occupy disjunct, Mediterranean-climate regions. It is possible that parallel response curves might provide insight into phylogenetic relationships among oaks that have been isolated from each other for a long time—relationships not yet been examined by systematists using molecular methods. Important Californian white oaks which might be compared with Turkish oaks include *Q. douglasii*, *Q. engelmanii*, *Q. garryana*, and *Q. lobata*.

Establishment strategy of mangrove zonation in Iriomote Island (Japan) based on nitrogen resorption efficiency and light effect

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Iriomote Island is close to the northern limit of mangrove habitat in the subtropics of Japan. Four major mangrove species, *Avicennia marina, Sonneratia alba, Rhizophora stylosa,* and *Bruguiera gymnorrhiza*, occur in a coastal zonation determined by tidal range. *A. marina* and *S. alba* occur at the shoreline where nitrogen is lowest and the salinity level is high. These species have different strategies for using nitrogen for osmoregulation to adapt to the high-salinity environment.

In this study, we discuss the establishment strategies of *R. stylosa* and *B. gymnorrhiza* that determine the zonation of these two species. Plots (10 m x 50 m) were set up in the vegetation zones dominated by *R. stylosa* and *B. gymnorrhiza*. In each plot, we studied soil conditions, including the amounts of nitrate and ammonium in the soil, and light conditions, as relative photosynthetic photon flux density. In all adult trees we measured tree height, DBH, rate of atrophy, chlorophyll density, and nitrogen content per unit mass or area of the canopy leaves. Tree height, chlorophyll density, and nitrogen content per unit leaf mass or area were also measured for all seedlings and saplings. The seedlings and saplings of *B. gymnorrhiza* and *R. stylosa* showed different light requirements. Different micro-topography (convex versus concave) appeared not to influence seedlings habitats. Seedlings and saplings of *B. gymnorrhiza* can grow in less light than *R. stylosa*. This means that *B. gymnorrhiza* would able to replace the *R. stylosa* zone in the future, since the lower light in the mangrove forest permits *B. gymnorrhiza* to grow up under the *Rhizophora* canopy. *R. stylosa*, however, can tolerate river disturbance and still maintain its dominance at riverside along the middle to upper stream course.

Effects of climate change and forest vegetation management on the viability of two insect and two bird species

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We investigated the relationship between forest vegetation changes caused by temperature changes, rise of CO_2 concentration and forest vegetation management, and the viability of four different species. We applied a soil dynamic model, a vegetation dynamic model (SMART2 and SUMO2) and an animal population model (LARCH). With these models we evaluated the effect of climate change and management change on the viability of the Stag Beetle (*Lucanus cervus*), European Hornet (*Vespa crabro*), Middle Spotted Woodpecker (*Dendrocopus medius*) and Black Woodpecker (*Dryocopus martius*) for the Netherlands. All four species prefer old forests. These species may expand their territory in the Netherlands as a result of climate change. Another advantage for these animal species could be the current tendency to manage forests more naturally, which would result in an increase of the amount of dead wood. Therefore, we hypothesised that these four animal species will profit from changes in vegetation processes caused by climate change and changes in forest management intensity.

We created four scenarios by varying temperature, CO_2 concentration and forest management intensity. We calculated habitat quality for every scenario based on the dominant tree species, dead wood biomass and average stem diameter of trees, all provided by SMART2-SUMO2. The LARCH model subsequently estimated the viability of the four species in the landscape based on the quality and the distribution of habitat and the species parameters (e.g. density, dispersal distance).

The effect of forest management intensity on the viability of the species was large. In contrast, the effect of the temperature and CO_2 concentration scenarios via the vegetation on the species' viability was relatively marginal.

We predict that forest management intensity in the Netherlands will have a larger effect on population viability of the Stag Beetle, European Hornet, Middle Spotted Woodpecker and Black Woodpecker, than changes in forest vegetation caused by climate change for the next 100 years.

Modelling the suitability of ecological networks for plant species

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Landscape fragmentation diminishes habitat size and connectivity and thus survival of

plant-species populations. Habitat connectivity is especially important now when climate change may shift suitable habitat, and may force species to disperse for survival. To enhance habitat connectivity and species survival, ecological networks have been designed. The effectiveness of ecological networks has been tested for animal species, but not yet for plant species.

Our aim was to test the connectivity of the Dutch ecological network for plant species. We applied the spatially-explicit, mechanistic model DIMO to simulate plant dispersal. The DIMO model includes seed-dispersal mechanisms via wind and animals, and effect of habitat suitability, biomass in grasslands and barriers. Input includes a seed-bank map and a chance-of-occurrence map.

We validated DIMO using *Juncus tenuis*, introduced on known places in The Netherlands around 1825. We ran DIMO till present day, to compare simulated *J. tenuis* distribution with its current distribution. In Run 1, we assumed that all habitats were suitable without barriers. The resulting distribution almost equalled the current distribution. In Run 2, we assumed only habitat within the ecological network was suitable, and barriers occurred. The resulting distribution was constrained to two main areas.

We analysed the suitability of the present Dutch ecological network using an artificial plant species with a low dispersal distance (25 m/yr) and a short-living seed-bank (1 yr). We assumed an initial distribution in a 1-km zone on the southern Dutch border and suitable habitat only within the ecological network. The resulting distribution was constrained to the south; dispersal was halted in areas where habitat connectivity was insufficient for this short-distance disperser. The analysis showed that current habitat connectivity in the Dutch ecological network is not suitable for short-distance dispersers such as *Gentiana pneumonanthe*, *Erica cinerea* and *Sedum reflexum*.

The DIMO model showed that plant species with a low dispersal capacity may become extinct in The Netherlands, given current ecological-network design and expected climate change. Design of ecological networks should incorporate plant-species' needs.

Environmental effects on forage nitrate accumulation, and its association with climate change in the North American Great Plains

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Environmental conditions such as the availability of water, nutrients and light affect the rate of growth in plants, which is related to the rate at which absorbed nitrate is reduced and utilized in the production of proteins and other nitrogenous biological molecules. When growth rate diminishes out of phase with nitrate uptake from soil, nitrate can accumulate in plant tissues to the extent that it becomes a poisoning hazard to ruminant herbivores.

To assess whether expected changes in climate in the Great Plains of North America may have an impact on the occurrence of plant-associated nitrate poisoning, we conducted a retrospective study on nitrate assays, performed at the Kansas State Veterinary Diagnostic Laboratory (52 records from zip code 66427 for the period 2001–2007), weekly nitrate assays at multiple sites at Konza Prairie Biological Research Station and surrounding areas in 2007, precipitation records and patterns of photosynthetically active plant biomass as indicated by Normalized Difference Vegetation Index (NDVI) values. Nitrate accumulation events in forage plants were clustered in the summer growing seasons of 2002 and 2003 and were associated with summer drought and unseasonal declines in NDVI values. Analyses of specific sites revealed that soil conditions and soil moisture were important factors in determining nitrate accumulation. These results indicate that nitrate accumulation events and, consequently, livestock poisoning risk could increase if climate change leads to increased summer drought frequency and duration in the Great Plains, as predicted by climate models and observed in climate records of the last 40 years. It also suggests that the assessment of nitrate accumulation potential in forage using remote sensing methods is potentially viable.

The management of alien conifers in South Africa: Three centuries of benefits, impacts and conflict resolution

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Alien conifers have been planted in South Africa for a range of purposes for over 300 years. The introduction of alien conifers, mainly pines, has brought many benefits but has also resulted in many unforeseen problems. The management of alien conifers has evolved in

response to emerging problems, changing values and markets, and the realities of a new and largely irreversible ecological order brought about by invasive alien conifers. South Africa also has a long history of research in the fields of forestry and environmental management. Priorities with regard to environmental management have changed over the past three centuries, human values have changed, and markets have become increasingly globalised.

This paper reviews the history of conifer introductions to South Africa, the benefits and impacts with which they are associated, and the ongoing and evolving research that has been conducted to underpin their management. The South African experience has involved a number of novel and innovative approaches aimed at maximising benefits and minimising impacts. Some of these, such as restrictions placed on forest expansion to reduce the impacts on surface water runoff have worked well; others, such as the clearing of planted areas to restore biodiversity, remain controversial. The approaches, and lessons learnt, are summarised.

Congruence between species richness and human population density: reconciliation or conflict?

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Human action is often claimed to be the main cause behind habitat loss and biodiversity reduction. However, human population density and species density both respond positively to net primary production (NPP), leading to contested biological resources in these areas. This is the underlying reason for many tough conflicts between local people, environmental management and governments at different political levels. This large-scale pattern may in part be ascribed to the fact that very few people live in very unproductive species-poor areas, such as deserts, sub-arctic-biomes, or high mountains. Nevertheless, large parts of the globe have enhanced NPP and biodiversity, and at the same time these areas have a high density of poor people.

The correspondence between species richness and human density may not be evident at shorter spatial extents such as along an elevation gradient. The Himalaya has one of the longest bioclimatic gradients in the world with a biological zone covering more than 6,000 elevation meters. The present study analyses the altitudinal distribution of seven taxonomic groups including vascular plants, cryptogams, and fungi in Nepal. The diversity

pattern of each group was correlated with area, relative forest cover and human population density. Fungi, trees, and ferns showed high positive correlation to land area as well as human population density. Liverworts, mosses and lichens did not follow this general pattern and showed distributions with a high correlation to relative forest cover, indicating a negative impact of human disturbance. An understanding of the man and biodiversity interaction is important for development of conservation strategies in the Himalayas. The intermediate disturbance hypothesis and the concept of cultural landscape must be considered as a potential tool for reconciling conservation and human utilisation. This practice may protect part of the biodiversity as supplement to traditional protected areas without human interference.

Statistical analysis of morphological traits in European white oaks: a probabilistic approach to species identification

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Species are the basic units in ecological and evolution research, and therefore enjoying major attention to define and delimit them efficiently (Sites & Marshall 2004). There has been much debate on the species concepts in European white oaks (*Quercus*), in particular due to the difficulties with species delimitation based on morphological traits. In addition, interspecific gene flow, owing to the absence of effective reproductive barriers within the genus (Jensen et al. 1993) and rampant introgression is known to lead to proliferation of fertile hybrids (Gellini & Grossoni 1997).

Quantitative and qualitative traits of leaves, buds, branches, and fruits were measured to investigate morphological relationships among 308 oak specimens of subgenus *Quercus* assigned putatively to 6 taxa (*Q. dalechampii, Q. frainetto, Q. petraea, Q. pubescens, Q. robur, Q. virgiliana*). The samples were collected from pure and mixed oak forests in central-southern Italy. 26 morphological variables were used to investigate population structure and adaptive variation in *Quercus* by means of à priori assignment of trees.

The proposed method corrected the original taxonomic identification based on morphology and identified the hybrids through discriminant functions which were used to compute the probability of each individual belonging to particular species.

A two step analysis (CVA) was performed to estimate the probabilistic assignment which

allowed identifying pure species and hybrids: (1) first CVA was performed to obtain a statistical model and to define a new classification (using morphological features) of all *à priori* classified specimens; (2) all not classified specimens were included in the model to identify species and hybrids trees. Finally, morphological structure of populations and the probability that a population was a pure or hybrid was established by means of 'probability of group membership' computed from discriminant functions. A significant correlation (Mantel's test) was found ($r = 0.542$; $p = 0.001$) supporting good agreement between the assignment of individuals to species on the basis of morphology and geographical location.

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Jensen, R.J., Hokanson, S.C., Isebrands, J.G. & Hancock, J.F. 1993. Morphometric variation in oaks of the Apostle Islands in Wisconsin: evidence of hybridisation between *Quercus rubra* and *Quercus ellipsoidalis* (Fagaceae). *Amer. J. Bot.* 80: 1358–1366.

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Understanding land-use induced vegetation changes in the dehesa applying plant functional traits

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In recent years, there has been a growing interest in the role of functional characteristics of plants (plant functional traits) to understand vegetation changes during succession or those induced by management. Analysing traits instead of species may also be useful for predictive purposes as well as yielding a better understanding of the mechanisms underlying the changes. Whereas analysing species' response to specific processes is of limited value due to the mostly differing species composition of sites of different habitats and ecosystems, trait responses are regarded to be more general. Therefore, even sites with different species composition or different environmental conditions can be regarded as comparable.

In this paper, vegetation changes in Mediterranean grassland induced by changing grazing regimes have been investigated. For this, the grazing regime of dry Mediterranean grassland was rearranged. Formerly cattle- grazed pasture was divided into *(i)* continuous cattle-grazed pasture, *(ii)* pig- grazed pasture, and *(iii)* fallow. The succession induced through the change in grazing regime could be successfully determined using plant func-

tional traits. cattle grazing facilitated species with higher SLA, smaller plant height, annual lifespan, persistent seed bank, and smaller seed size when compared to pig- grazed and fallow pastures. Species correlated with abandonment pastures showed contrasting plant functional traits, with pig-pasture species situated in between both extremes, showing a mosaic of both cattle pasture and fallow vegetation.

To demonstrate the extent to which plant functional trait results can be interpolated throughout ecosystems, the results have additionally been compared with a study about pig grazing and abandonment of use on different sites, from wet meadow to dry chalk old-fields, in Central Europe. The expected match of traits from pig grazing in different ecosystems could not be confirmed. Moreover, plants facilitated in Central Europe through pig pasturing showed similar traits than species correlated to cattle grazing in dry Mediterranean grasslands.

Thus, the analysis of plant functional traits had proved to be effective in identifying changes in plant composition induced by changing managements in different habitats. However, the comparability of sites with similar disturbance regimes but different evolutionary histories (e.g. climate, land-use history) could not be given in this study using plant functional traits. Traits evolved as adaptation to different climates in Central Europe and southern Spain may overlap with the influences of the different disturbance regimes that were tested in this study.

Prediction of soil conditions and critical loads based on species and association responses for measured abiotic soil parameters

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We collected a database containing approximately 10,000 relevés from the Netherlands with measured soil properties such as soil pH, groundwater table, total N, C/N, NO_3, K, etc. Based on these measurements we estimated response curves for species with respect to soil chemistry. We then used the average soil chemistry per species to predict soil chemistry and groundwater table in relevés where such measurements were lacking. We validated our method for pH on a large set of independent European forest relevés. The response curves of many soil parameters could only be estimated for few species due to a lack of data. This increased the uncertainty in the predicted soil chemistry. We therefore used a set of 160,000 relevés, representing the Dutch vegetation, to estimate additional response curves.

For each relevé the average soil parameters were estimated as the average over the species with a known response, when at least five of such species were present. We then estimated new response curves for all species. These new response curves suffer from contraction of the response axis caused by 'regression to the mean'. We corrected this contraction by using linear regression.

The re-estimated responses were validated on the same set of European forest relevés. For soil pH the average difference between estimated and measured value decreased from 0.53 to 0.38 pH-unit. This method was also used to estimate abiotic ranges for phytosociological vegetation types (associations) for fifteen abiotic soil parameters. Optimal or suboptimal ecological ranges for each species or vegetation type can be defined as percentiles based on frequency distributions. The upper ranges for nitrate concentration and the lower ranges for soil pH will be used to derive critical loads for nitrogen and acid deposition. All responses for species as well as associations can be found on www.abiotic.wur.nl

Phylogenetic analyses of the distribution of mistletoe species on host trees in South Africa

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We analysed the distribution records of mistletoes of the families Loranthaceae and Viscaceae relative to the distributions on host species. An earlier study by Dean et al. (1994) had shown that there was a strong positive correlation between the mean nitrogen levels of their hosts and mistletoe species richness. This makes the simplifying assumption that there is passive nutrient uptake of nitrogen by their hosts, whereby high rates of transpiration by the mistletoes result in direct uptake of nutrients via the xylem of the hosts. However, a number of studies have shown that active nutrient uptake may occur via the hosts' phloem. Moreover, the study by Dean et al. (1994) indicated that there may be phylogenetic confounding of this correlation due to the large number of nitrogen-fixing species in their samples.

We tested for phylogenetic effects based on current understanding of host phylogenies and found no significant association between host nitrogen content and mistletoe species richness. Not only does this study add new insights to our understanding of mistletoe-host interactions but it also highlights the important role that phylogeny can play in such relationships.

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All is not lost: modelling the potential distributions of local endemics in south-western Australia under climate change

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Species distribution models are widely used to predict distribution patterns under changed climatic patterns. Three species of locally endemic and relictual forest eucalypts are recognised as iconic species in south-western Australia (*Eucalyptus guilfoylei, E.brevistylis* and *E.jacksonii*). These species collectively known as tingles are restricted to the high rainfall zone.

We demonstrate that traditional species distribution modelling approaches have limited capacity to predict the impact of climate change on species that are not in climatic equilibrium or that are rare and locally endemic. We propose a framework for providing more effective distribution models for these species. Considerable life history (e.g. germination, seedling survival and mature tree responses to fire patterns), edaphic, eco-physiological and response data (e.g. biological interactions between competitors, and mycorrhizal associations) is required to reliably predict distributions under changed circumstances. Incorporation of these data into a dynamic simulation model reflects current distributions more accurately and is likely to provide more reliable estimates of distributions under currently predicted climate change scenarios. Despite grave predictions for climate change within south-western Australia, evidence is presented from community and assemblage studies to suggest the likely presence of local refugia for these species under considerably warmer and dryer climatic scenarios.

Patterns and relationships between species and functional diversity—conceptual frameworks under empirical scrutiny

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During the last decades many semi-natural habitats such as meadows and pastures have undergone a dramatic land-use change entailing the degradation of the species pool. While changes in dominance and frequency of species as well as changes in α- and β-diversities have been reported in many cases, current research aims to understand the role of functional diversity as a safeguard of community stability and ecosystem services. In this context, the relationship between taxonomic and functional diversity in a given community seems to play a crucial role in defining threshold conditions for community stability. So far, the conceptual model by Petchey & Gaston (2002) predicts a monotonous increase of functional diversity with increasing species diversity. While this pattern may apply to communities with a taxonomic diversity of < 40 species we question the applicability for species-rich communities of > 40 species. In such cases we expect a logistic relationship with a pronounced saturation threshold indicating functional redundancy. This pattern should be consistent across different species-rich community types and spatial scales. Furthermore, we hypothesize that the quantity of functionally common and functionally rare species will have a modulating impact on the slope of the logistic function.

To test our hypotheses, we combined over 10,000 spatially referenced relevés from the inventory of dry grasslands of Switzerland with the functional trait information for each species taken from different European databases (LEDA, CLOPLA3) and from additional field measurements.

Petchey, O.L. & Gaston, K.J. 2002. Functional diversity (FD), species richness and community composition. *Ecol. Lett.* 5: 402–411.

Assessing change at species level in complex landscape systems: Swiss mires in degradation

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How does landscape change translate into species turnover? Can modelled transitions serve as surrogates for observed processes? Do Swiss mires vanish?

In the framework of the Swiss mire monitoring program we took a stratified random sample from the mires listed in the federal mire inventories. We used image segmentation based on aerial photographs for further stratification. A total of 7000 relevés were sampled twice within a 5-year interval. We assigned all relevés to 13 traditionally distinguished wetland types in Switzerland. Shifts of the membership of relevés from one vegetation type to any different type were counted in a contingency table. From this a matrix of transition probabilities was derived. Using a Markovian process we simulated the long-term outcome. We projected the temporal trend on the level of vegetation types to the species level using linear combinations.

There is a general trend in decrease of nutrient-poor mires in favour of nutrient-rich. Many nutrient-rich mires would further transform to meadows. The extrapolation of the process shows that the area of peat bogs would become reduced by 10% within 25 years, while the non-wetland habitats are supposed to expand. A set of species winning and losing at the landscape level is presented and the significance of change is evaluated using randomisation tests.

The approach suggests a long-term trend towards a serious loss of Swiss mires provided the trend observed within past five years remains unchanged. The method used unveils the species most affected by the ongoing processes.

Acknowledgements: The authors thank to the Swiss Federal Office for the Environment for funding this project.

Phytogeographical evidence for refuge areas and postglacial spread of European beech forests

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The postglacial migration of European beech (*Fagus sylvatica*) has been addressed by many studies using either genetic or fossil data or a combination of both. In contrast to this,

only little is known about the migration history of its understorey species. In a review of phytosociological literature, 110 species with a high fidelity to beech forests were identified. The distribution range of European beech forests was divided into 40 geographical regions, and the presence or absence of each species was recorded for each region.

The highest number of the 'beech forest species' is found in the S Alps, the N Apennines, and the NW Dinaric mountains. With increasing distance from this centre of diversity, species richness is decreasing, reaching its minimum in NW and N Europe. This picture is changed when only species with a narrow distribution (less than ten regions) are taken into consideration. In this case, the highest species diversity is observed in the S Apennines, and, although the S Alps, N Apennines, and NW Dinaric mountains still reach high species numbers, secondary maxima were identified in N Spain, the Carpathians, and NW Greece. Extrapolation of the distribution of stenochorous species revealed six main geographical clusters that are in good accordance with the glacial refuge areas of *Fagus sylvatica* as found by recent phylogeographic studies. The possibility of one or several refuge areas in the Carpathians is strongly supported by the floristic evidence but needs further palaeological and genetical confirmation.

Our results provide evidence that the studied species have been closely affiliated with beech for at least one glacial cycle, and that the current distribution of understorey species is a good indicator for the localisation of glacial refuge areas of deciduous forests.

Assembly rules in plant communities: seeking simplicity and distrusting it

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Assembly rules are the patterns that result from restrictions on the identity of co-occurring species. They operate after environmental filtering and general competitive exclusion have occurred. Early assembly rules described the number of species that can co-occur, or general patterns of abundance. However, attention has now shifted back to Diamond's original concepts based on species identity, and to generalisations related to species functional characters that hark back to MacArthur & Wilson's concept of limiting similarity. A whole-community approach is texture convergence.

Evidence for it exists but is hard to find. Within communities, proportionality of guilds

(a.k.a. functional types) has provided better evidence, and objective methods exist for identifying the guilds. More direct examination of limiting similarity has also yielded evidence. There are many factors making the search for assembly rules difficult (95% of which comprises environmental variation). Likewise, there are many traps for the unwary that can give false evidence of assembly rules. As Peter Grubb said: "Seek simplicity but distrust it".

Biological invasions versus natural dispersal and spread

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Understanding the extra-range dispersal of species is becoming an increasingly important challenge for scientists and managers. Much can be learned by combining recent advances in the risk analysis of invasions with insights from genetic analyses of the palaeo-record (natural dispersal) and biological invasions (human-assisted dispersal and subsequent spread).

Here, we review recent studies of invasive species and argue that there are qualitative differences between types of dispersal that are important for understanding the ecology and evolutionary implications of species movements. Invasions (i.e. human mediated dispersal) are often characterised by multiple introductions from multiple sources to multiple locations. When compared to natural dispersal pathways, biological invasions tend to have (1) much higher genetic diversity, (2) they are much more likely to result in admixture or hybridisation, (3) have a lower likelihood of Allee effects, and (4) are more likely to rapidly increase in range size due to human intervention. Moreover, the selective pressures of the dispersal pathway have changed significantly, and invasive species often share little evolutionary history with the recipient environment, at least compared with most range shifts or corridor type species movements. We contend that the dispersal pathway per se defines the likely propagule pressure, genetic diversity, and symbionts associated with species movement, and thus the ecological and evolutionary consequences of such movements. Improved understanding of the dimensions of dispersal pathways is essential to successfully assist, minimise, or prevent future species movements.

Grazing induced stability of grassy ecosystems, fact or fantasy?

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Lowland grasslands occur across a wide range of semi-arid and temperate regions in south-eastern Australia. Persistence and long-term stability of these ecosystems is thought to have been maintained prior to European arrival by periodic drought and / or the use of fire to maintain and create treeless areas. The degradation caused by domestic stock is thought to have occurred quickly following the introduction of European farming systems, creating a grazing tolerant plant community. For this reason it is often hypothesized that grasslands with a historic (100 year) legacy of grazing by domestic stock are in a stable state. These grassy ecosystems, however, occur across a wide range of fertility and rainfall gradients and responses to the removal of grazing are expected to be highly variable and dependant on site productivity.

This presentation discusses information gained from recent studies on the impacts of removing grazing from a range of grassy ecosystems and identifies points along a productivity gradient where grazing or active biomass reduction is required to reduce competitive interactions and maintain these dynamic ecosystems. The patterns that are observed in changes following the removal of domestic stock vary across this gradient. These changes may be attributed to changes in productivity of sites. Sites with higher productivity show greatest reductions in measures of species richness and evenness. These changes reflect the role that competition and disturbance play in these landscapes in driving species persistence. It is clear that the maintenance of grazing disturbance does not cause shifts in the composition, and thus stability, across the gradient investigated. It is also clear that the removal of grazing has marked effects at each end of the continuum. These responses are positive and negative in the low productivity and high productivity regions respectively. This research indicates that competition and disturbance are the drivers of species co-existence in high productivity areas and facilitation is the main driver of species co-existence in low productivity landscapes. This knowledge is then compared with the environmental controls on diversity in the temperate grassy ecosystems of South Africa and North America.

Species traits and the colonisation of coniferous versus deciduous forest stands by vascular plants

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The objective of the study is to examine the ability of various species groups to colonize recent stands (continuity as forested area <150 years) of different tree species composition, and to analyse whether particular species traits such as life history and habitat preference can be used to explain patterns of migration into recent coniferous and deciduous stands. Such investigations are essential for understanding distribution patterns of plants on the local scale and for making suggestions for a future forest management that takes also nature conservation aspects into account. More specifically, we addressed the following questions: (1) Are there differences among species in their preference for coniferous and deciduous stands? (2) Are tree and shrub species better colonizers of recent forest stands than herbaceous species? (3) Do colonisation patterns of plant species groups depend on tree species composition?

In 55 transects from ancient stands (always deciduous) to adjacent recent stands (coniferous or deciduous) we studied the occurrence and percentage cover of vascular plants (Brandenburg, NE Germany). Habitat preference, diaspore weight, generative dispersal potential, and clonal extension were used to explain mechanisms of local migration. Regression analysis was conducted to test whether migration distance was related to species' life-history traits.

The results showed that 25 species were significantly associated with ancient stands, and 10 species occurred significantly more frequent in recent stands. Tree and shrub species were good colonizers of recent coniferous and deciduous stands. In the coniferous stands, all herbaceous species showed a limited potential of colonisation. In the deciduous stands, generalist species were good colonizers or may have survived in the grasslands present prior to afforestation. The fast colonisation of recent stands by trees and shrubs can be explained by their effective wind and animal-assisted dispersal.

Comparing how environmental variables affect the performance of SDM and predicting the spatial distribution of *Tsuga chinensis*

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Prediction about the adaptability of plant communities in response to climate change impacts is dependent on our knowledge of the potential distribution of the vegetation under study. A combination of species distribution models (SDMs) defines the shape of potential vegetation maps (PVMs).

This study focuses on comparing statistical (PCA) and data mining (CART and CIT) methods to find suitable environmental layers for building the spatial distribution of vegetation dominated by Taiwan Hemlock (*Tsuga chinensis*), and then to predict the spatial distribution of this vegetation using Maxent and GAM models. The predicted performance of models is evaluated by both threshold-dependent confusion matrix and its derived indices and threshold-independent area under receiver-operating characteristic (ROC) curve (AUC). Finally, compare and combine different SDMs to synthesize potential vegetation map of the Taiwan Hemlock vegetation. Comparing model techniques combination and the species-vegetation unit combination is another goal of this study. We use three methods, such as summation, average, and composition, to generate a potential vegetation map of the Taiwan Hemlock.

The configuration of disturbance patches modified spatial heterogeneity of vegetation and soil nutrient properties in a Mongolian grassland

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An understanding of the relationships between spatial heterogeneity and disturbance regime is important for establishing the mechanisms necessary to maintain biodiversity. Our objective was to examine how the configuration of disturbance by burrowing rodents affected the spatial heterogeneity of vegetation and soil nutrient properties.

In Mongolian grasslands, Siberian marmots (*Marmota sibirica*) modify plant communities and soil physical as well as chemical properties through activities such as burrowing, grazing, and urinating. We established two 2500 m^2 (50 m x 50 m) plots including some isolated marmot burrows, and two 2500 m^2 plots including the same number of clustered burrows. Each plot was subdivided into 4 m^2 quadrates, where plant species richness, vegetation cover (%), and soil nutrient properties were surveyed. Spatial heterogeneity of vegetation was calculated using the mean dissimilarity of species composition among sample quadrates, and a geostatistical analysis was used to calculate soil properties. Heterogeneous patches grass *Achnatherum splendens* and higher nutrient concentrations were found only near the

clustered burrows. As a result, the spatial heterogeneity of vegetation and soil was higher in the clustered colony than those in the isolated colony. *Achnatherum splendens* may have grown near the clustered burrows because such structures captured a great amount of water. Occurrence of patches with higher soil nutrient status can be attributed to locally concentrated excretions by rodent population and to a reduction of uptake by plants in highly disturbed areas. The configuration of disturbance patches affected the spatial heterogeneity at the landscape scale through the spatial pattern of frequency of disturbance.

Landscape heterogeneity as a driver of species habitat specialisation

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Topographically heterogeneous landscapes such as deep river valleys or high mountain ranges are known to act as important glacial and postglacial refuges. Among other factors, the key role is played by topographical heterogeneity itself which brings very different habitats close to each other. If climatic changes cause a shift in habitat conditions, species need to reach an alternative habitat, and, in heterogeneous landscape, they are more likely to find it. We assume this effect to be more important for habitat specialists, which are more sensitive to changes in habitat conditions than generalists. Consequently, we hypothesize that the above-mentioned mechanism results in a higher ratio of habitat specialists in topographically heterogeneous landscapes.

To test this hypothesis, we analysed the pattern of habitat specialists along a gradient of landscape heterogeneity, using a large dataset of forests vegetation plots from the Czech National Phytosociological Database. As a measure of habitat specialisation, we used the metric proposed by Fridley et al. (2007), based on the species co-occurrences in large vegetation datasets and corrected for the size of species pool. Landscape heterogeneity was expressed as Terrain Ruggedness Index, calculated using the digital terrain model of the Czech Republic. The main source of topographical heterogeneity in this country is deep river valleys. Changes in the ratio of habitat specialists along the gradient of landscape heterogeneity were analysed separately for different vegetation types.

Results show a general increase in the proportion of specialists along the gradient of landscape heterogeneity, the pattern being more pronounced in some vegetation types than in others. We put these results in the context of more general patterns of habitat specialists along the main environmental gradients (soil reaction, nutrients and light) and discuss possible explanations.

Fridley, J.D., Vandermast, D.B., Kuppinger, D.M., Manthey, M. & Peet, R.K. 2007. Co-occurrence based assessment of habitat generalists and specialists: a new approach for the measurement of niche width. *J. Ecol.* 95: 707–722.

Do we need evolutionary explanation for plant diversity patterns—diversity-productivity relationship as an example

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Current theory of species diversity is strongly inclined towards local scale interaction-based explanations for biodiversity patterns, although recent theoretical developments (incl. 'species pool theory') have started to shift the paradigm, claiming that the legacy of the past evolutionary history is the primary driver. In a current paper we address the relationship between biodiversity and habitat productivity as an example to analyze the role of evolutionary processes, dispersal, and biotic interactions in generating empirical diversity pattern.

Although the relationship between plant diversity and productivity exhibit different shapes the unimodal shape has been frequently encountered. The decrease in diversity at high productivity has usually been attributed to competitive exclusion. We suggest that evolutionary history and dispersal limitation may be even more important in shaping the diversity-productivity relationship. On a global scale, unimodal diversity-productivity relationships dominate in temperate regions, whereas positive relationships are more common in the tropics. This difference can be accounted for by contrasting evolutionary history. Temperate regions have smaller species pools for productive habitats since these habitats have been scarce historically for speciation, while the opposite is true for the tropics. In addition, dispersal within a region may limit diversity either due to the lack of dispersal syndromes at low productivity or the low number of diaspores at high productivity. Thereafter, biotic interactions (competition and facilitation) can shape the relationship. All these processes can act independently or concurrently.

We recommend that the common approach to examine empirical diversity-environmental relationships should start by examining the role of large-scale processes such as evolutionary history and dispersal limitation, followed by influences associated with ecological interactions. We conclude that study of plant diversity patterns as well as diversity patterns of whatever organisms, has to address the evolutionary history process to a larger extent than it has been done until now.

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