

PopBio2010

**Plant Population Biology**

**Crossing Borders**

Nijmegen, 13-15 May 2010



Royal Netherlands  
Academy of Arts  
and Sciences



NETHERLANDS INSTITUTE OF ECOLOGY



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- Research School Ecology and Evolution (RSEE)

## **Welcome to Nijmegen!**

Welcome to the "Plant Population Biology: Crossing Borders" meeting which is the 23<sup>rd</sup> annual meeting of Plant Population Biology section of the GfÖ, the Ecological Society of Germany, Switzerland and Austria. The PopBio2010 meeting will cover all aspects of plant ecology, crossing borders between plant population biology and neighboring fields. Our keynote speakers will address how transdisciplinary studies are the way forward in plant population biology and we encourage all contributors to show how progress in their studies depends on adopting and integrating approaches from other disciplines. We like to thank the Radboud University Nijmegen for hosting the event and our sponsors for financial support.

We are looking forward to exciting days with 161 plant population biologists from 15 countries!

**Eelke Jongejans, Mirka Macel, Philippine Vergeer, Koen Verhoeven**

*Institute for Water and Wetland Research, Radboud University Nijmegen*

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## CONTENTS

Programme .....	6
Keynotes .....	18
Talks .....	24
Posters .....	90
List of Participants.....	140

# PROGRAMME

## Wednesday, 12 May 2010

19:00-21:00 *Arrival and registration in café Goossens*

## Thursday, 13 May 2010

08:00 *Conference registration open*

*Plenary Session in Linnaeus 1*

08:50 Welcome

09:00 **Alistair Jump** (keynote) - Integrating dendroecology and population genetics to identify future changes in the diversity and distribution of tree species

09:40 **Roosa Leimu** - Local adaptation in coevolving plant - herbivore interactions

09:57 **Veronica Preite** - Latitudinal and altitudinal differentiation in phenotypic traits and molecular markers of *Campanula rotundifolia*

10:14 **Leon van den Berg** - Direct and indirect effects of nitrogen deposition on species composition changes in calcareous grasslands in the UK

10:31 COFFEE

*Parallel Session I in Huygens 00.304*

11:00 **Steven Wangen** - Stochastic demographic models to project estimates of invasibility for *Hieracium lepidulum* in the Southern Alps of New Zealand

11:18 **Pavel Sova** - Population ecology and genetics of the rare liverwort *Jungermannia caespiticia* Lindenb.

11:36 **Susanne Lachmuth** - Exploring the animal in my weed: Animal models untie adaptive and non-adaptive evolution in plant invader

11:54 **Olga Kostenko** - Disentangling the effects of host plant quality and plant neighborhood on parasitoid community composition on ragwort (*Jacobaea vulgaris* L.)?

- 12:12 **Anna Bucharová** - Limitation of distribution of two rare ferns in fragmented landscape  
*Parallel Session II in Huygens 00.307*
- 11:00 **Philippe Matter** - Genetic structure and contemporary pollen-flow along a altitudinal gradient of *Ranunculus bulbosus* populations
- 11:18 **Elly Morriën** - Climate change induced range expanding plants experience less belowground enemy impact
- 11:36 **Rui Zhang** - Dispersal in a warmer world: Species' responses to climate change
- 11:54 **Christian Lampei** - The effect of maternal environment on seed dormancy and its support for an evolutionary stable strategy
- 12:12 **Marianne Evju** - Interactions between local climate and grazing determine the population dynamics of the small herb *Viola biflora*
- 12:30 LUNCH  
*Plenary Session in Linnaeus 1*
- 14:00 **Nicole van Dam** (keynote) - The chemistry of ecology: Metabolomics of plant - herbivore interactions
- 14:40 **Madalin Parepa** - Invasive knotweed impacts on native plants through allelopathy
- 14:57 **Joseph Wright** – Latitudinal gradient for inter-annual variation in seed production
- 15:14 **Hans de Kroon** - Back to the roots: tracing plant community response to belowground interactions in the Nijmegen Phytotron
- 15:31 COFFEE, POSTERS & PHYTOTRON EXCURSION  
*Parallel Session I in Huygens 00.304*
- 16:50 **Zuzana Münzbergova** - Effect of genetic diversity on invasibility in experimental *Festuca rubra* stand
- 17:08 **Tomáš Dostálek** - Effect of changes in genetic diversity on long term population growth rate in rare plant, *Dracocephalum austriacum* L.



- 17:26 **Anne Petzold** - Parentage analysis in *Populus euphratica* Oliv.
- 17:44 **Francesco Angeloni** - Meta-analysis on the association of population size and life history inbreeding depression in plants
- 18:02 **Karin Kaljund** - Hybridisation in the *Medicago falcata/sativa* complex: a threat to native biodiversity
- Parallel Session II in Huygens 00.307*
- 16:50 **Inger Auestad** - *Pimpinella saxifraga* is maintained in road verges by mosaic management
- 17:08 **Anna Šmídová** - Habitat conditions are better determinants of population performance of perennial species *Ligularia sibirica*, than its size
- 17:26 **Shou-Li Li** - Changes in the demography of a dominant shrub species during dune fixation in Inner Mongolia
- 17:44 **Monika Sosnová** - Effect of resprouting on population dynamic of short lived root sprouting herb: a simulation analysis
- 18:02 **Marco Visser** - Strict mast fruiting for tropical dipterocarp tree: a demographic cost-benefit analysis

## Friday, 14 May 2010

### *Plenary Session in Linnaeus 1*

- 09:00 **Marc Johnson** (keynote) - The past, present and future of community genetics
- 09:40 **Oliver Bossdorf** - Phenotypic variation and plasticity of clonal growth in Japanese knotweed
- 09:57 **Vit Latzel** - Transgenerational plasticity alters response of two *Plantago* species to disturbance and nutrients
- 10:14 **Helene Muller-Landau** - The tolerance-fecundity tradeoff and the maintenance of diversity in seed size
- 10:31 COFFEE

*Parallel Session I in Huygens 00.304*

- 11:00 **Anne Kempel** - Experimental plant introduction: disentangling the roles of propagule pressure, soil disturbance and life-history traits
- 11:18 **Tanja Speek** - Plant traits relating to success of exotic plant species on a regional versus a local scale
- 11:36 **Lidewij Keser** - Determinants of invasiveness in clonal plant species: a database study
- 11:54 **Thilo Heinken** - Consequences of habitat fragmentation on plant species: do we know enough?
- 12:12 **Verena Cordlandwehr** - European mean plant trait values as a surrogate for on-site measurements?

*Parallel Session II in Huygens 00.307*

- 11:00 **Knut Rydgren** - Infrequent sporophyte production maintains a female-biased sex ratio in the unisexual clonal moss *Hylocomium splendens*
- 11:18 **Anna Maria Roschanski** - A battle of the sexes? Sex ratio in dioecious dog mercury (*Mercurialis perennis*)
- 11:36 **Anne-Kristel Bittebiere** - Clonal traits response to competition: strategy or passivity? An experimental study on *T. repens*
- 11:54 **Jana Raabová** - Genetic diversity and clonal structure of the aquatic macrophyte *Menyanthes trifoliata*
- 12:12 **Tanja Pfeiffer** - Makes sex a difference? Genotypic diversity in two species of *Gagea* (Liliaceae) with contrasting reproductive strategies
- 12:30 LUNCH

*Plenary Session in Linnaeus 1*

- 14:00 **Jessica Metcalf** (keynote) - When should you flower if flowering kills you? Life history evolution in a model system
- 14:40 **Elze Hesse** - Life history variation in contrasting habitats: flowering decisions in a clonal perennial herb (*Veratrum album*)

- 14:57 **Jakob Gerstenlauer** - Bet-hedging strategies in perennial grassland plants: linking functional traits to stochastic growth and survival
- 15:14 **Pedro Quintana-Ascenio** - Assessing environmentally driven demographic change for plant management and conservation
- 15:31 **Eric Menges** - Vital rate variation among 14 species over two decades: survival and growth with fire and hurricanes
- 15:48 COFFEE & POSTERS
- Parallel Session I in Huygens 00.304*
- 17:00 **Merav Seifan** - The role of molehill disturbances in maintaining high grassland diversity under different management regimes
- 17:18 **Laura Govers** - Dynamics of *Zostera noltii* transplants with nutrient additions and organic loading - Implications for restoration and mitigation in the Eastern Scheldt, the Netherlands
- 17:36 **Eva Völler** - Land use affects quantitative genetic differentiation in *Bromus hordeaceus*
- 17:54 **Ondrej Mudrak** - Plant seedlings under the different management
- Parallel Session II in Huygens 00.307*
- 17:00 **Heidrun Huber** - Early light and nutrient availability modulates phenotypic expression in response to submergence
- 17:18 **Corina Del Fabbro** - Dependence of dauciform root formation in Cyperaceae on Fe, P, and water availability and implications for species distributions
- 17:36 **Niek Scheepens** - Regional differentiation in life history and susceptibility to grazing in a widespread Alpine monocarp
- 17:54 **Sebastian Keller** - Evolutionary biology of *Plantago lanceolata*: insight from German grasslands
- 18:30 BBQ behind Huygens building

## Saturday, 15 May 2010

### *Plenary Session in Huygens 00.307*

- 09:00 **Martijn Bezemer** (keynote) - Diversity and stability in semi-natural grasslands: temporal and spatial dynamics of plant and soil communities
- 09:40 **Alison Bennett** - How climate changes alter plant - soil feedbacks in *Populus termuloides*
- 09:57 **Gera Hol** - The relevance of rare soil microbes for plant productivity and other soil services
- 10:14 **Karoline Weißhuhn** - A regionally adapted grassland community improves ecosystem services
- 10:31 COFFEE

### *Parallel Session I in Huygens 00.304*

- 11:00 **Thomas Hahn** - Neutral genetic diversity and differentiation in low central and upper peripheral plant populations in the Swiss Alps
- 11:18 **Gitte Hornemann** - Genetic variation, reproductive fitness and long term population development in the endangered *Orchis morio*
- 11:36 **Gerhard Karrer** - Directional spread of *Ambrosia artemisiifolia* L. along waterways - Can source and sink populations be detected by AFLP-analysis
- 11:54 **Jana Ebersbach** - Analysis of genetic variation in endangered *Stratiotes aloides* L. (Hydrocharitaceae) populations using AFLP
- 12:12 **Lucienne de Witte** - Size structure and longevity of arctic-alpine clonal plants

### *Parallel Session II in Huygens 00.307*

- 11:00 **Sabrina Carvalho** - Comparing plant defence chemistry of exotic and native plant species by remote sensing
- 11:18 **Petr Dostál** - Exotic and native congeners accumulate similar richness of enemies along productivity gradient

- 11:36 **Thomas Chrobok** - Generalization with respect to pollinators increases invasiveness of European plants elsewhere in the world
- 11: 54 **Inés Abela Hofbauerova** - Aboveground and belowground insects feeding on *Cirsium arvense* from the native and invasive range
- 12:12 **Annelein Meisner** - Nutrient acquisition and soil nutrient mineralization by exotic range-expanding and related native plants
- 12:30 LUNCH
- 14:00 MILLINGERWAARD EXCURSION

### POSTERS

1. **Maik Bartelheimer** - Impact of the fungicide Azoxystrobin on the abundance of vesicular-arbuscular mycorrhiza
2. **Gabriele Bassler** - The Fate of *Senecio aquaticus* Seeds
3. **Melanie Bodenseh** - Effects of elevated CO<sub>2</sub> on climbing and non-climbing herbaceous plants
4. **Christophe Bornand** - Consistency between population trends estimated with presence-only versus abundance data
5. **Corinna Boye** - Fruits, seeds and germination characteristics of the macrophyte *Stratiotes aloides* L. in Bremen, Germany
6. **Zita Cervenkova** - Mother plant identity has significant effect on plant performance independent of seed size
7. **Luc De Bruyn** - Climate change and leaf phenology in Oak and Beech
8. **Petr Dostál** - Novel Weapons Hypothesis revisited: phytotoxicity of *Heracleum mantegazzianum* in phylogenetic and invasion dynamics context
9. **Eva Frei** - Quantitative genetic differences in growth and reproduction mirror phylogeography in a widespread Alpine plant

10. **Orou Gaoue** - Modeling the impact of non-timber forest product harvest in variable environments
11. **Uwe Grueters** - The next generation of biodiversity modeling: UIBM – the Universal Individual-Based Model
12. **Veroslava Hadincová** - How does genetic variation change during biological invasion? A study of *Pinus strobes*
13. **Aud Halbritter** - Responses of range-edge populations to climate change
14. **Sven Hanoteaux** - The Attractiveness of your neighbours: when does it matter?
15. **Lucie Hemrová** - Factors determining species distribution of abandoned fields
16. **Marloes Hendriks** - How roots interact: unravelling the key response mechanisms belowground and their effect on community productivity
17. **Danny Hooftman** - An introduction to the Good data-set: an excellent opportunity for analysing metapopulation collapse
18. **Iveta Husáková** - The effect of landscape structure on fitness of dry grassland species
19. **Olena Kalinina** - Competitive performance of transgenic wheat resistant to powdery mildew
20. **Lena Kloss** - Effects of land use and species diversity on pollen dispersal in managed grasslands
21. **Jana Knappová** - The effect of mycorrhiza suppression on species composition of experimental dry grassland community
22. **Kaire Lanno** - The survival of transplants of rare *Ligularia sibirica* is enhanced by neighbouring plants
23. **Jana Martínková** - Root-sprouting of diploid and tetraploid populations of *Knautia arvensis* (L.) (Dipsacaceae)
24. **Tiphaine Maurice** - *Ex situ* transplant experiment of *Arnica montana* populations at high and low altitudes
25. **Hana Mayerova** - Monitoring the effect of grazing on vegetation of dry grasslands

26. **Johannes Metz** - Larger seed size consistently provides higher life-time survival for annual species across a steep aridity gradient
27. **Katrin Meyer** - The intelligent plant: paradox or ecological reality?
28. **Ivana Milaković** - Population density effects on growth traits and reproduction of *Ambrosia artemisiifolia* L.
29. **Ronny Mozek** - Collecting demographic data using high precision GPS in *Anacamptis pyramidalis*: a new method
30. **Wenjing Ouyang** - Genetic variation in natural *Solanum dulcamara* populations from flooded and dry habitats in the Netherlands
31. **Hana Pánková** - Effect of arbuscular mycorrhizal fungi (AMF) on plant establishment on abandoned fields
32. **Maan Rokaya** - Population dynamics and harvesting techniques of Himalayan Rhubarb species from Nepal
33. **Anne Ronse** - Seed production of *Helosciadium (Apium) repens* in Belgian populations
34. **Christian Sailer** - A 120-year battle between Apomixis and Sexuality
35. **Wolfgang Siewert** - Projecting plant population dynamics under climate change – a matrix modelling approach
36. **Violeta Simón** - Ecological and genetical factors promoting population differentiation in *Narcissus papyraceus*
37. **Tiina Talve** - New microsatellite primers and population genetic diversity in three *Rhinanthus* species
38. **Sara Tomiolo** - Disentangling the role of biotic interactions for local adaptation
39. **Judith Trunschke** - How altitude and pollination intensity effect flower longevity in six alpine flowering plant species
40. **Martine van der Ploeg** - Polymer tensiometers: a new instrument for investigating plant water uptake in dry and saline soils
41. **Johan van Kessel** - Do populations of *Solanum dulcamara* differentiate in response to contrasting environments?

42. **Clara-Sophie van Waveren** - Disentangling drivers of parasitoid foraging behaviour in structured plant communities
43. **Nicole Voß** - Range expansion of *Ceratocapnos claviculata*: habitat quality and species composition in the native and the invaded range
44. **Zhengwen Wang** - Cost of root foraging and sexual reproduction during genotypic selection in *Potentilla reptans*
45. **Sebastian Werner** - Development of a simulation model describing water qualities of a ditch ecosystem
46. **Nada Zantout** - Possible effects of sediment pore water qualities on *Stratiotes aloides* L. in Bremen, Germany
47. **Yuan-Ye Zhang** - Testing the ecological and evolutionary relevance of heritable epigenetic variation: a project outline
48. **Yanli Zhuang** - The role of dew on *Bassia dasyphylla* plants growing in the desert area of China





## **KEYNOTES**

# **Diversity and stability in semi-natural grasslands: Temporal and spatial dynamics of plant and soil communities**

**T. Martijn Bezemer**

*Netherlands Institute of Ecology, The Netherlands*

The relationship between biodiversity and ecosystem functioning remains highly debated. A number of biodiversity experiments carried out in grassland communities have shown that there is a positive relationship between plant species diversity and ecosystem stability. In these studies plant community diversity has been maintained by hand weeding, and therefore plant communities remain constant over time. In nature, plant communities are temporally and spatially dynamic. However, how changes in plant diversity in natural plant communities will affect stability is poorly understood. Also, ecosystem functioning is typically based on temporal changes in plant biomass and virtually nothing is known about how plant diversity affects the stability of other organisms. I will use results from a long-term biodiversity experiment in which plant communities were not weeded, to show how plant diversity affects the temporal dynamics of individual plant species, and of plant and nematode communities. I will show that plant diversity can greatly affect the dynamics of plant and soil communities, but that plant diversity does not necessarily lead to stability in natural communities. Diverse communities can be both stable and unstable.

# The Past, Present and Future of Community Genetics

**Marc T. J. Johnson**

*North Carolina State University, USA*

Community genetics integrates questions and theories from ecology, population genetics and evolutionary biology to understand the dynamic interplay that exists between the ecology and evolution of species interactions. Biologists have long appreciated the importance of ecology in driving the evolution of populations, but recently we have begun to appreciate that genetic variation and evolution within populations can also have far reaching ecological and ecosystem-level consequences. A growing number of studies show that genetic variation for ecologically important traits within populations can have cascading effects on population dynamics, and the composition and diversity of other species within communities, which can subsequently influence ecosystem processes. Although initial studies primarily focused on the effects of plant genetic variation on insect communities, recent studies show that intraspecific genetic variation within microbial, arthropod and fish populations can also have wide-ranging bottom-up and top-down effects on ecological processes and patterns. Recent theory and microcosm experiments also suggest that rapid evolutionary change might play an important role in driving ecological changes within communities. Despite the numerous studies which have shown that genetic variation in one population can influence ecological processes and patterns within communities, I argue that it is not yet clear whether a community genetics framework is needed in community ecology. To determine the utility of community genetics, I suggest that future research should seek to answer three unresolved questions. First, how important are the community-level consequences of intraspecific genetic variation compared to other ecological factors more typically studied in ecology (e.g., environmental variation, competition, etc.)? Second, does evolution within natural populations associated with changes to the mean and variance of genetically variable traits drive ecological changes within populations and communities over short timespans (1 to 100 generations)? And finally, what are the genetic mechanisms by which genetic variation and evolution shape species interactions and ecosystem processes in nature. Answers to these questions could be achieved in the next decade using a combination of multifactorial field experiments, long-term experimental evolution studies, and new ultra-high throughput sequencing technologies. If successful, I believe we will achieve a synthesis of the ecology, evolution and genetics of species interactions.

# **Integrating dendroecology and population genetics to identify future changes in the diversity and distribution of tree species**

**Alistair Jump**

*University of Stirling, United Kingdom*

Increases in temperature and drought linked to global climate change are having wide ranging impacts on natural populations, from their ecology and distribution to their adaptation and survival. There is abundant evidence from mountain regions that woody species are shifting upwards in altitude: expanding populations at their upper limits are accompanied by declining growth and increased mortality lower down. Understanding the current structure of populations, both in terms of genetics and demography can help us to identify 'at risk' populations. However, by further integrating long-term records of population change, we can increase the value and utility of such data to determine the demographic and genetic trajectory that populations are likely to follow. I will discuss the integration of dendroecological methods with population genetic analyses with specific reference to case studies in the European Beech, *Fagus sylvatica*. I will conclude by considering the theoretical and practical applications of this work and its implications for other species.

## When should you flowering if flowering kills you? Life history evolution in a model system

C. Jessica E. Metcalf<sup>1</sup>, Mark Rees<sup>2</sup>, Dylan Childs<sup>2</sup>, Karen Rose<sup>2</sup>, Peter Grubb<sup>3</sup>, Andy Sheppard<sup>4</sup>, Thomas Mitchell-Olds<sup>5</sup>, Yvonne Buckley<sup>6</sup>

<sup>1</sup>Princeton University, USA; <sup>2</sup>University of Sheffield, UK; <sup>3</sup>Cambridge University, UK; <sup>4</sup>CSIRO Montpellier, France; <sup>5</sup>Duke University, USA; <sup>6</sup>University of Queensland, Australia

Some plant species require less than a year to reach maturity. For others, tens or even hundreds of years may be necessary. Here, we use data from a range of species for which flowering is fatal to untangle the evolutionary determinants of timing of reproduction. We introduce models of increasing complexity, exploring how both the biotic and abiotic environment may shape the optimal flowering strategy. We show that where sufficient data is available it is possible to predict evolutionary outcomes in natural systems, both for timing of flowering, and for germination strategies. We conclude by discussing ways in which this body of work could interact with the extraordinary wealth of information on proximate mechanisms underlying timing of flowering in *Arabidopsis thaliana*. A synthesis between the two fields opens the way to predicting short-term evolutionary outcomes, of particular interest in the context of a changing environment.

# The chemistry of ecology: Metabolomics of plant- herbivore interactions

Nicole van Dam<sup>1</sup>, Jeroen J. Jansen<sup>2</sup>

<sup>1</sup>*Radboud University Nijmegen, The Netherlands;* <sup>2</sup>*University of Amsterdam, The Netherlands*

When ecologists talk about the phenotype, they usually think of plant traits that are visible to the human eye. However, for most herbivores the plant phenotype is largely determined by its chemistry. Primary compounds—e.g. sugars and amino acids—are usually nutritious, whereas secondary compounds—such as glucosinolates or alkaloids—may be toxic and deterrent. Primary and secondary metabolites together form the ‘metabolome’ of a plant. The metabolome composition is important in determining herbivore preference and performance, and thus the amount of damage that the plant suffers. Recently developed plant metabolomic approaches allow ecologists to analyse a large part of the plant’s metabolome in a single analysis. The analyses of induced responses visible in the plant metabolome after herbivory may reveal various defence strategies of plants, such as induced responses and tolerance. This allows plant ecologist to test existing hypotheses regarding optimal defence strategies in plants more rigorously than was possible with *targeted* chemical analyses. In my presentation, I will show several examples in which a metabolomic approach has led to novel insights in the role of specific compounds in plant-herbivore interactions. Despite some limitations that metabolomic analyses may have, the implementation of broad-spectrum chemical analysis in plant ecology will definitively open up new horizons for plant ecologists and enhance our understanding of the importance of plant chemistry in plant-environment interactions.

## TALKS



# Meta-analysis on the association of population size and life history with inbreeding depression in plants

Francesco Angeloni<sup>1</sup>, N.Joop Ouborg<sup>1</sup>, Roosa Leimu<sup>2</sup>

<sup>1</sup>*Radboud University Nijmegen, the Netherlands;* <sup>2</sup>*University of Oxford, United Kingdom*

Inbreeding is common in plants and can have considerable effects on plant fitness and population viability, because of inbreeding depression. Understanding what determines the magnitude of inbreeding depression is of fundamental importance for conservation. We used meta-analysis of 119 studies and 107 plant species to investigate the effects of population size, test environment, life history characteristics and stage, and various fitness traits on the magnitude of inbreeding depression. We found lower levels of inbreeding depression for small compared to large populations. In general, inbreeding depression was found to be common across species and environments. Yet, the magnitude of inbreeding depression was significantly influenced by plant longevity and life history stage, and varied depending on how plant fitness was measured. Our findings highlight the fundamental role of population size in influencing the magnitude of inbreeding depression in plants. This clearly has important implications for conservation. Moreover, our findings on the overall generality of inbreeding depression confirm that inbreeding depression is one of the key factors reducing plant population fitness and viability. Hence, we need a better understanding on the architecture of inbreeding depression, how different ecological and historical conditions influence the levels of inbreeding depression in natural plant populations, and its impacts on community dynamics.

## ***Pimpinella saxifraga* is maintained in road verges by mosaic management**

Inger Auestad<sup>1</sup>, Knut Rydgren<sup>1</sup>, Eelke Jongejans<sup>2</sup>, Hans de Kroon<sup>2</sup>

<sup>1</sup>*Sogn og Fjordane University College, Norway;* <sup>2</sup>*Radboud University Nijmegen, The Netherlands*

Road verges have been proposed as refuges for vulnerable grassland species in the modern, changing landscape, but little comparative knowledge exists on how management regimes affect population dynamics of such species. We compared the effects of various management regimes on the population dynamics of *Pimpinella saxifraga* in road verges and pastures, using elasticities and LTRE analyses with underlying vital rates as model components in three road verges and three pastures in an agricultural landscape in W Norway. Under present management regimes, we observed slightly higher population growth rates in pastures than in road verges. The pasture populations had comparatively lower survival but higher reproduction than the road verge populations, thus demonstrating a management-induced negative correlation. Such negative correlations may reflect species' adaptability to environment changes, thereby reducing the extinction risk. We generally observed small changes in *P. saxifraga* demography to management but considerable variation along environmental gradients, underlining the importance of studying multiple populations. The linear form of the road verges enabled a fine-scale mosaic application of different management regimes. Individuals growing in zones receiving survival-lowering management produced seeds that compensated the lack of seeds in zones receiving fertility-lowering management. The observation of 'mosaic' management that allows road verge metapopulations to complement each others life-history characteristics exemplifies the unique potential of road verge ecosystems to maintain semi-natural grassland species like *P. saxifraga*, as well as providing habitats for different species exhibiting various life histories.

## How climate changes alter plant-soil feedbacks in *Populus tremuloides*

Alison E. Bennett<sup>1</sup>, Richard L. Lindroth<sup>2</sup>

<sup>1</sup>Scottish Crop Research Institute, UK; <sup>2</sup>University of Wisconsin, USA

To date very little attention has been paid to the effects of climate change on plant-soil feedbacks. Negative plant-soil feedbacks have been shown to maintain diverse plant communities. In this study we examined the effects of elevated CO<sub>2</sub> and O<sub>3</sub> on the relationship between aspen (*Populus tremuloides*) and its soil community. We gathered soil from the Aspen FACE site that had been fumigated with elevated CO<sub>2</sub>, elevated O<sub>3</sub>, elevated CO<sub>2</sub> and O<sub>3</sub>, or ambient air for eleven years, and had hosted only *P. tremuloides* or a mixed *P. tremuloides* and paper birch (*Betula papyrifera*) community. We grew five genotypes of *P. tremuloides* in each soil to address whether increased atmospheric levels of CO<sub>2</sub> and O<sub>3</sub> are likely to influence the relationship between plants and their soil community. Our results indicate that under ambient conditions *P. tremuloides* performed best in soil from the *P. tremuloides*-*B. papyrifera* community, and experience negative feedbacks in their own soil. This relationship changed in soil that had experienced elevated CO<sub>2</sub> and O<sub>3</sub>. Fumigation with CO<sub>2</sub> eliminated any negative effects of aspen growth in its own soil, while fumigation with O<sub>3</sub> alone or the combination of CO<sub>2</sub> and O<sub>3</sub> resulted in a switch from negative to positive feedbacks for *P. tremuloides* grown in *P. tremuloides*-cultured soil. These results have strong implications for the future of plant communities under climate change conditions. Our results suggest that elevated atmospheric CO<sub>2</sub> and O<sub>3</sub> may negate the enhancement of plant diversity typically afforded by negative plant-soil feedbacks.

# Clonal traits response to competition: strategy or passivity? An experimental study on *T. repens*

Anne-Kristel Bittebiere, N. Renaud, B. Clément, C. Mony

University of Rennes 1, France

Local interactions of plants for resources alter their spatial distribution. Plant communities are in temperate systems dominated by clonal plants presenting the ability to modify their horizontal growth to forage for resources. We aimed at evaluating the impact of the competitive environment on (i) the clonal plant architecture and (ii) the biomass allocations to clonal organs within the plant. We analyzed the clonal response to competition of *T. repens* L., a stoloniferous Fabaceae. *T. repens* was grown in experimental garden without competition and in four competitive environments composed respectively of a rhizomatous species (*Elymus repens* L.), a stoloniferous species (*Agrostis stolonifera* L.), a caespitose species (*Lolium perenne* L.) and a monoculture. At the end of the experiment, the biomass of matrix plants differed between treatments inducing an increasing competitive pressure from the rhizomatous matrixes to monocultures matrixes. The architecture of the target species, recorded through a non destructive mapping method, depended on the competitive environments, as well as biomass allocations. *T. repens* growing with the rhizomatous, the stoloniferous and the caespitose species has longer primary stolon compared to its size than in the treatment without competition. The response was partly explained by size-effects due to plant biomass reduction in competitive environments, except for the treatments with *Elymus repens* and *Agrostis stolonifera*. These results suggest that the type of matrix species and especially its growth form may be determinant in the plasticity of the target species. Spatial distribution of matrix plants may induce indirect heterogeneity in resources.

# Phenotypic variation and plasticity of clonal growth in Japanese knotweed

Oliver Bossdorf<sup>1</sup>, Markus Fischer<sup>1</sup>, Christine Krebs<sup>2</sup>, Madalin Parepa<sup>1</sup>

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Japanese knotweed (*Fallopia japonica*) is one of the most noxious plant invaders in the world. A key mechanism of the species' success is its extremely aggressive clonal growth. Another particularly intriguing aspect of Japanese knotweed is that all invasive European populations, which cover a range of latitudes and habitats, are composed of the same single genotype. It is conceivable, however, that heritable variation caused by non-genetic, in particular epigenetic, means has allowed the species to colonize different environments. If this is true, then plants from different origins should show significant phenotypic variation in a common environment. Here, we report on an experiment in which we studied clonal growth characteristics of *F. japonica*, their plastic responses to different nutrient and water conditions, and their geographic differentiation. We found that clonal growth traits are generally highly plastic in *F. japonica*. Differences in water and nutrient conditions not only change the numbers of vegetative offspring and their rates of spread, they also alter the relative allocation to different components of clonal growth. Plants from different geographic regions, albeit genetically identical, displayed significant phenotypic differentiation, both in terms of their biomass, and in terms of the plasticity of some of their physiological and clonal traits. We hypothesize that these observed phenotypic differences are the result of heritable epigenetic changes.

# Limitation of distribution of two rare ferns in fragmented landscape

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Species distribution in the landscape is limited either by diaspore production and dispersal abilities or by availability of suitable habitats or by combination of both factors. Relative importance of these factors is species dependent and was studied mainly for seed plants. We studied the importance of habitat and dispersal limitation for distribution of two rare fern species, *Asplenium adulterinum* and *A. cuneifolium*, restricted to serpentine rocks using analysis of their distribution at regional scale (several kilometers). Within a model region, all 98 serpentine rocks were mapped. We used data on abiotic characteristics and on presence of all vascular plant species of the rocks to predict which of the rocks are suitable for the two *Asplenium* species. Suitable habitats were defined mainly by presence of certain types of microhabitats, height of the highest rock and negatively by nutrient richness of the locality. Features of suitable habitats differ between species. Both species do not occupy all suitable habitats indicating dispersal limitation. Habitat isolation significantly affected one of the species but not the other suggesting that distant dependent habitat isolation is species dependent. Overall, the results suggest that both fern species have suitable but unoccupied habitats in the region and demonstrates that ferns, similar to seed plants, are limited by their dispersal ability in the landscape.

## Comparing plant defence chemistry of exotic and native plant species by remote sensing

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Remote sensing of plant chemical constituents by hyperspectral spectroscopy enables to predict crop quality by, for example, nitrogen measurements from hyperspectral large scale imagery. Currently, hyperspectral spectroscopy is being developed to tackle ecological questions at the larger scales which are nowadays still limited to financial and logistic resources. Here, we use hyperspectral spectroscopy for comparing plant chemistry between native and invasive exotic plants. In this project we test if we can predict plant chemical defence constituents of *Senecio inaequidens* and *Senecio jacobaea* (syn *Jacobaea vulgaris*) from hyperspectral reflectance patterns using spectroscopy. This is a completely novel approach that we started under highly controlled laboratory experimental conditions. Several plants from each species were sown in sterile or soil with different biotic characteristics and submitted to low or high nutrient treatments throughout the greenhouse growing phase. To each plant spectral measurements were done and the chemical extraction carried out for spectral validation. Our aim was to predict contents of pyrrolizidine alkaloids (PAs), the main defence compound for these species. We are especially interested in how nutrients and soil biota influence plant PA content and whether that can be detected by remote sensing technology. The next step will be the testing of this method for ecological studies in the field. If PAs can be predicted through this method, then a new way to study the species defence mechanisms may be accomplished to be used for large scale studies on plant defences in, for example, invasive exotic species.

## **Generalization with respect to pollinators increases invasiveness of European plants elsewhere in the world**

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Plant invasions are among the most serious threats to biodiversity, and may cause large ecological and economic costs. Although the reasons for plant invasions are still poorly understood, there is more and more evidence accumulating that species characteristics are among the major determinants of invasiveness. Previous studies have shown that plant species that do not rely on pollinators for seed production due to the capacity for self-fertilization are more likely to become invasive. Nevertheless, there are also many invasive alien species that are visited by pollinators in their introduced ranges. It has been suggested that plant species with generalized pollination systems (i.e. plant species that can use many different pollinators) are more likely to become invasive. However, to the best of our knowledge, this hypothesis has never been tested. We used data from plant-pollinator interaction networks from 117 sites in the German Biodiversity Exploratories to calculate an index of pollinator specialization for 169 European plant species. We related this index as well as other measures of pollinator specialization (the number of pollinator species and pollinator families visiting a plant species) to their invasiveness in several regions of the world. Our results show that plant species with low levels of pollinator specialization frequently have a wider distribution in non-native regions where these plant species were introduced. We conclude that plant species that can use many different pollinators are more likely to become invasive than highly specialized plant species, because they are more likely to find suitable pollinators in their introduced ranges.



## European mean plant trait values as a surrogate for on-site measurements?

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Trait-based approaches are frequently used in community ecology, amongst others to get insight in the assembly rules shaping plant communities. Trait measurements can be very time-consuming, especially for large sets of species. To share the effort, plant trait databases have been compiled all over the world. These databases often consist of mean trait values per species measured on individuals of that same species over a more or less large spatial scale, and are thus averaging trait values over multiple populations of the same species. The aim of this study was to test whether the analysed trait distribution of a plant community in a study site of only a few square kilometres is altered by the origin of the used species trait values. Trait values per species were aggregated (1) using per species measurements on a 2x2m base, (2) using all per species measurements of the study site, and (3) using species mean values from a Northwest European trait database, the LEDA-traitbase. At two sites in the Netherlands we looked at the widely used morphological plant traits canopy height, specific leaf area and leaf dry matter content of wet hayfield and salt-marsh species respectively. Our results show that for both studied communities the trait distribution is changed when using mean European trait values instead of on-site measurements per species. Nevertheless species ranking after the single traits of the different aggregation levels is correlated.

# Back to the roots: tracing plant community responses to belowground interactions in the Nijmegen Phytotron

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Biodiversity mechanisms and ecosystem properties often find their origin in processes belowground. Root competition and feedbacks between roots and soil biota play a prominent role, but we still have incomplete information how they scale up to the community. The Nijmegen Phytotron ([www.ru.nl/phytotron](http://www.ru.nl/phytotron)) was designed as an experimental facility in which long-term experiments can be carried out, with ample opportunities to study underlying processes belowground. Communities at the mesocosm scale can be maintained under near-ambient conditions, but with automated irrigation control. Belowground abiotic conditions are continuously monitored as needed. Containers are standardized equipped with mini-rhizotrons to census root development non-destructively. Containers can be subdivided into smaller units and any type of substrate can be applied. An example of an experiment will be given in which root development is traced down in experimental monocultures and mixtures of four grassland species. Our measurements revealed rapid elevated root production in the mixtures compared to the average of the monocultures. Applying a quantitative molecular technique to distinguish the roots of different species revealed that species aggregated rather than segregated underground. Our results suggest that novel belowground interactions play an important role for community performance. We have work in progress to study the interaction mechanisms involved, and the demographic consequences for the constituent species.

# Dependence of dauciform root formation in Cyperaceae on Fe, P and water availability and implications for species distribution

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Some Cyperaceae species build small carrot-shaped root structures with long hairs, so called dauciform roots, in response to internal phosphorus deficiency. The influence of other factors on dauciform root formation as well as their ecological significance are widely unknown. We investigated the dependence of dauciform root formation on iron supply, phosphorus supply and water level in *Carex panicea* and *Schoenus nigricans* in a 12-week pot experiment. To determine if dauciform root forming Cyperaceae fill a special ecological niche, we investigated how their occurrence is related to site conditions in eight Swiss mires. In the pot experiment, dauciform root formation depended on phosphorus supply but not on iron supply or water level. Plant biomass also depended only on phosphorus supply. Thus, plant growth appeared to be unaffected by variation in iron supply and water level; this might explain the absence of response in dauciform root formation. In the field survey, Cyperaceae species with the ability to form dauciform roots occurred in a wide range of vegetation types. This indicates that dauciform-root forming Cyperaceae do not fill a special ecological niche. The presence of these species was unrelated to phosphorus and iron concentrations of plant biomass, but it was associated with higher soil pH and lower ecological indicator values for soil moisture. Overall, our results confirm the role of phosphorus availability in determining dauciform root formation. Results further suggest that soil pH and water availability may play a role in shaping the niche of dauciform root bearing species within Swiss mires.

## Size structure and longevity of arctic-alpine clonal plants

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Long-lived clonal plants are believed to enhance community stability and ecosystem resilience in Arctic and Alpine ecosystems. It is suggested that populations of clonal plants persisted locally despite past global changes. This persistence can be quantified by the assessment of population age structure and dynamics of present populations. We analyzed the size and age structure in several populations of four long-lived arctic-alpine clonal plant species. The number and size of genets was determined with molecular markers (AFLP) using a standardized sampling design in homogeneous climax populations. Age was then estimated by dividing plant size by a mean annual size increment obtained from in situ measurements in several populations. The measured size and age structures indicate that the individuals of clonal plant populations usually are differently aged with a dominance of younger and a low number of large and presumably very old individuals. The presence of large and old individuals is evidence for the persistence of populations during centuries, in some cases over thousands of years, including past climate change. The presence of age differences among individuals and the dominance of young individuals suggest regular recruitment. Thereby, necessary adaptive responses to rapidly changing climate are feasible. Together, population persistence and genet turnover ensure maximum ecosystem resilience. Our results indicate that some clonal plants in arctic-alpine habitats are extremely long-lived, survived past periods of climate oscillations and have the potential to resist to changing climate in the future.

# Exotic and native congeners accumulate similar richness of enemies along productivity gradient

Petr Dostál

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Abiotic factors such as climate and geology, or physical barriers limit the latitudinal and altitudinal distribution of organisms. Biotic interactions may be equally important biogeographic factor. Increasing traffic between continents decreased the importance of physical barriers as constraint of species range. Biotic barriers, in opposite, are assumed to be increasingly important in control of whether species succeed to expand their range or not. To assess how native pests may regulate the performance of exotic plants, it is needed to identify which factors determine most variation in their diversity and impact on novel targets. In a field study I screened for herbivores and pathogens on 12 exotic plants, invasive to Central Europe, and assessed the relative importance of 17 predictors of pest load. These predictors described introduction history of exotics (i), characteristics of habitats (ii) and plant communities (iii) where exotics occur and their life-history traits (iv). I also explored, whether the same predictors explain similarly the variation in diversity and impact of enemies on native congeners. And finally, I asked whether invasives experience smaller enemy impact than natives. Habitat productivity and moisture, and plant size were shown to be the most important determinants of pest diversity and impact on invasive species. These predictors influenced variation in pest load on invasives and natives similarly. Invasives were however far less attacked by the frugivores. Enemy Release Hypothesis, rather than resource-Enemy Release Hypothesis, is more likely explanation of invasiveness of studied exotics.

## **Effect of changes in genetic diversity on long term population growth rate in rare plant, *Dracocephalum austriacum* L.**

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The aim of this study is to understand the effect of changes in genetic diversity on long term population growth of *Dracocephalum austriacum*, critically endangered plant species throughout the whole Europe. We connected our previous study on 1) relationship between genetic diversity (expressed as expected and observed heterozygosity based on allozyme analysis) and plant fitness (expressed as seed production per flowering stem) and 2) study on full life cycle of this species in 3 Czech and 3 Slovak Karst populations for 4 years. Using relationship between heterozygosity and seed production we estimated the effect of change in heterozygosity on long term population growth rate. Although the effect of reduction in heterozygosity on decrease in seed production was strong, only severe decrease of heterozygosity caused significant decrease in long term population growth rate. Changes in heterozygosity had also significant effect on importance of single life history traits for population growth measured by their elasticity. The proportional importance of survival, growth and fecundity did not change with the highest importance of survival in all cases. There was also strong negative effect of reduction of heterozygosity on extinction probability of the populations. All these effects were consistent between two Karst regions but they were stronger in Slovak Karst. This study is the first study explicitly linking changes in population dynamics and changes in genetic diversity. Wider use of such approach is likely to enhance our understanding of the long term consequences of changes in genetic diversity.

## **Analysis of genetic variation in endangered *Stratiotes aloides* L. (Hydrocharitaceae) populations using AFLP**

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The aquatic macrophyte, *Stratiotes aloides*, is regarded as a key species for ditch ecosystems characterized by high biodiversity and an important indicator for conservation of these systems. In the past, a decline of the species in north-western Germany was observed. This led to a research project on *S. aloides* funded by the Deutsche Bundesstiftung Umwelt (DBU) with the aim of testing different management methods to preserve its habitats. One hypothesis for the decline in this dioecious species assumes a connection between the observed dominance of vegetative reproduction and potential poor inter-species competition abilities due to genetic uniformity. In order to investigate the genetic variation in *S. aloides* stands of Bremen, where both sexes of the plant occur, a protocol for Amplified Fragment Length Polymorphism (AFLP) analysis in this species was developed using 26 individuals from three sites in Bremen and one in Brandenburg, north-eastern Germany. First results showed that the method could successfully be used to detect polymorphisms within and among populations of *S. aloides*. Seven AFLP primer pairs generated 786 well distinguishable bands, 39% of which were polymorphic. AFLP markers indicated high mean genetic similarity (0.87-0.94). Two genotype groups were detected by neighbor-joining cluster analysis and Bayesian assignment tests. Analysis of Molecular Variance (AMOVA) found low genetic differentiation between sites (12%). Further studies with more sample organisms from the study sites near Bremen, other parts of Germany and the Netherlands are needed to examine genetic variation in this endangered species.

## Interactions between local climate and grazing determine the population dynamics of the small herb *Viola biflora*

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Plants of low stature may benefit from the presence of large herbivores through removal of tall competitive neighbours and increased light availability. Accordingly, removal of grazers has been predicted to disfavour small species. In addition to this indirect beneficial effect, the population dynamics of plants is strongly influenced by variation in external conditions such as temperature and precipitation. However, few studies have examined the interaction between large herbivores and inter-annual variation in climate for the population dynamics of small plant species not preferred by herbivores. We studied three populations of the perennial herb *Viola biflora* exposed to different sheep densities (high, low and zero) for six years in a field experiment. Plants were also impacted by invertebrate and small vertebrate herbivores (rodents). Rates of growth were marginally higher at high sheep densities, and during warm summers both survival and growth were higher when sheep were present. Thus, while the height of tall herbs was positively related to July temperature, it was less so in the treatments with sheep, suggesting that sheep reduce the negative effects of interspecific competition for this small herb. The population growth rate ( $\lambda$ ) was slightly lower in the absence of sheep, but between-year variation in  $\lambda$  was larger than variation among sheep-density treatments.  $\lambda$  was negatively related to July temperature, with an additional negative effect of vertebrate grazing frequency (sheep or rodent grazing). The evidence from this six-year study suggests that the population dynamics of *Viola biflora* is determined by a complex interplay between climate and grazing by both large and small herbivores.



# **Bet-hedging strategies in perennial grassland plants: linking functional traits to stochastic growth and survival**

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All plant species have to cope with uncertainty in environmental resources and conditions. This unpredictability is reflected in demographic rates, such as seedling survival and fertility. Both mean and variance of these rates may be altered by land-use intensification. Therefore, it becomes increasingly important to predict the response of species to land-use intensification. These predictions will only be valid if they are based on functional traits linked to life history attributes. For example, seed dormancy and perenniality are coupled with preadaptation to harsh and unpredictable environments. However, we do not know the trade-offs among these traits and key traits such as asexual reproduction, seed biomass and the ability of spatial dispersal. Here, we use stochastic stage-structured matrix population models to investigate the interplay between functional traits and environmental conditions in terms of stochastic growth and survival of plant populations. We look at both communities of European grassland plants and specific plant species. We show that seed dormancy, sexual reproduction, and small seed size increase population growth for a wide range of environmental conditions, whereas other traits such as local seed loss due to dispersal and clonal biomass seem to be of minor importance. Finally we emphasize the need to bridge the gap between field workers and modellers using models which focus on measurable traits.

# **Dynamics of *Zostera noltii* transplants with nutrient additions and organic loading – Implications for restoration and mitigation in the Eastern Scheldt, the Netherlands**

**Laura Govers**<sup>1</sup>, Jan de Brouwer<sup>1</sup>, Marieke van Katwijk<sup>1</sup>, Wouter Suykerbuyk<sup>1,2</sup>, Tjeerd Bouma<sup>2</sup>, Fons Smolders<sup>1</sup>, Leon Lamers<sup>1</sup>

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Seagrass (*Zostera noltii*) meadows in the Eastern Scheldt, the Netherlands, have been declining since the construction of the storm surge barrier in the 1980's. Dike reinforcements in the Eastern Scheldt delta threaten seagrass beds growing near the dikes. Some of this seagrass has been moved to other suitable areas within the National Park of the Eastern Scheldt. However, transplantation success has varied between locations and years. In this experiment we tried to enhance transplantation success by means of artificial nutrient addition and looked at the effects of increased organic loading of the sediment (sulphide toxicity). Within a seagrass bed gaps of 35 cm diameter were created, by removing the seagrass. These seagrass patches were transplanted outside the bed in empty sediment. Both patches and gaps were treated with nutrients (NPK Osmocote) and organic matter. Although fertilization was successfully applied, seagrass biomass did not increase in response to elevated nutrient concentrations. *Zostera noltii* in the Eastern Scheldt appeared to be absolutely non-nutrient limited in growth and metabolism, so nutrient addition will probably not improve seagrass restoration success in the Eastern Scheldt. Organic matter addition stimulated sulfide production in the sediment. No sulfide was formed in organic matter + NPK Osmocote treatments, because by providing a lot of nitrate in the sediment, denitrification became dominant over sulphate reduction. High porewater sulfide and ammonium concentrations had a negative effect on seagrass performance of patches, but did not affect gaps. These results state that sediment biogeochemistry can play an important role in seagrass restoration success.

## **Neutral genetic diversity and differentiation in low central vs. upper peripheral plant populations in the Swiss Alps**

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Plant species in mountainous areas occur along steep environmental gradients. Core regions of species distributions are considered more favourable for growth and reproduction than the periphery. Theoretical predictions suggest that neutral genetic diversity will be greater in lowland core populations than in upper peripheral populations, as a function of differences in population size and the degree of isolation. Yet, the connectivity of plant populations across the landscape via gene flow is determined by a number of additional variables, including landscape elements and the mode of pollen dispersal. We combine molecular (AFLP) and GIS techniques to study genetic diversity and patterns of genetic differentiation among pairs of core and peripheral populations (1200 and 1800 m a.s.l.) in *Briza media* and *Trifolium montanum*. Both are common in semi-dry grasslands (Mesobrometum) and have contrasting pollination modes. A subset of sampled populations showed no differences in neutral genetic diversity or differentiation among central and upper peripheral populations in each of the two study species. Estimated population size did not relate to mean expected heterozygosity ( $H_e$ ) or mean pair-wise population differentiation per respective population ( $F_{ST}$ ). In *T. montanum* a principle coordinates analysis (PCoA) showed grouping of individuals into clusters, resembling the spatial locations of the populations and we found an isolation-by-distance relationship, whereas in *B. media* there was no evidence of genetic differentiation. We discuss the results of our study in relation to the influence of different landscape elements and the pollination mode of our study species on patterns of inter-population gene flow.

# Consequences of habitat fragmentation on plant species: do we know enough?

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Habitat fragmentation and loss are among the primary causes for species declines and local extinctions. A number of mechanisms have been suggested how habitat fragmentation affects plant populations and the fitness of individual plants. These are centered around population genetics, demography, and population dynamics. The number of case studies testing these is, however, rather low. The question rises whether species chosen for habitat fragmentation studies represent a non-random sample of all species present in a flora. To test this, we compared Central European plant species subjected to habitat fragmentation studies with the remaining species of Germany's vascular flora with regard to plant trait representation. We found strong discrepancies between groups. Whereas more red list species than expected were among study species, narrowly distributed species were underrepresented. The two groups differed in a number of biological traits relevant to habitat fragmentation: insect pollinated species were strongly overrepresented in study species whereas selfing and abiotically pollinated species were underrepresented. Taxonomic biases were due to a low number of graminoids and orchids among study species. We conclude that our current knowledge on mechanisms of habitat fragmentation effects relies on a small number of species not necessarily being representative for a flora. We suggest that selecting study species in new studies should consider such biases and that drawing general conclusions concerning effects of habitat fragmentation should still be handled with caution.

## Life history variation in contrasting habitats: flowering decisions in a clonal perennial herb (*Veratrum album*)

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Quantifying intra-specific demographic variation provides a powerful tool for exploring the diversity and evolution of life histories. We investigate how habitat-specific demographic variation and the production of multiple offspring types affect the population dynamics and evolution of delayed reproduction in a clonal perennial herb with monocarpic ramets (white hellebore). In this species, flowering ramets produce both seeds and asexual offspring. Data on ramet demography is used to parameterize integral projection models, which allow the effects of habitat-specific demographic variation and reproductive mode on population dynamics to be quantified. We then use the evolutionary stable strategy (ESS) approach to predict the flowering strategy – the relationship between flowering probability and size. This approach is extended to allow offspring types to have different demographies and density-dependent responses. Our results demonstrate that the ESS flowering strategies differ substantially among habitats, and are in excellent agreement with the observed strategies. Reproductive mode, however, has little effect on the ESSs. Using analytical approximations, we show that flowering decisions are predominantly determined by the asymptotic size of individuals rather than variation in survival or size-fecundity relationships. We conclude that habitat is an important aspect of the selective environment and is a significant factor in predicting the ESSs.

## **Aboveground and underground insects feeding on *Cirsium arvense* from the native and invasive range**

**Inés Abela Hofbauerová**, Zuzana Münzbergová

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The aim of this project is to explore two alternatives of weed biological control to find which is more likely to limit invasive plant density; a single most effective type of herbivore insect or a set of insects in complementary feeding guilds. These two strategies for biological control are based on conflicting conceptual models of the factors structuring phytofagous insect communities and their effects on plant individuals and populations. Existing patterns of occurrence and impacts of herbivore insects on *Cirsium arvense* were quantified by experimentally testing for direct and indirect effects of non-overlapping herbivore insect guilds on plant performance. We compared this effect between plants from the native (Spain and the Czech Republic, Europe) and invasive range (Nebraska and Illinois, North America) in different soil conditions. By choosing two types of substrates we studied the effect of soil resources on the way how herbivore guilds affect plant performance. A common garden experiment was performed. Herbivore insects were added alone and in combinations to *Cirsium arvense* which were planted in Czech Republic in March 2008 and grew from seeds for two growing seasons. One underground insect (*Cleonis pigra*) and 3 aboveground insect species were used (*Cassida rubiginosa*, *Rhinocyllus conicus*, *Urophora cardui*). Our preliminary results show that plants from the invasive range grew more than the ones from the native range. Plants to which herbivores were not added were bigger than plants to which herbivores were added, showing a negative effect of insects on plant growth.

# **The relevance of rare soil microbes for plant productivity and other soil services**

**Gera Hol**

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Rare species are assumed to have little impact on community interactions and ecosystem processes. However, very few studies have actually attempted to quantify the role of rare species in ecosystems. Selective removal studies point at high redundancy within the microbial community for a range of functions such as decomposition and degradation of pollutants. Plant-associated soil organisms are supposed to have less functional redundancy than decomposer organisms and indeed, loss of rare microbial species in soil affects primary production (plant biomass and quality) and herbivore performance, as well as the effects of herbivores on plants. Two crop plant species growing in soil where rare microbes were reduced, had tissues of higher nutritional quality, which theoretically makes them more susceptible to pest organisms such as shoot-feeding aphids and root-feeding nematodes. Reduction of rare microbes increased aphid body size. Rare soil microbes are not redundant but may play a role in crop protection by enhancing aboveground and belowground plant defense. Simplification of soil microbial communities by land use intensification could enhance productivity, but reduce the insurance value of the soil microbial community in controlling pests and pathogens.

## **Genetic variation, reproductive fitness and long term population development in the endangered *Orchis morio***

**Gitte Hornemann**, Walter Durka

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Orchid populations are showcases of plant conservation because of their sensitivity to habitat changes like nutrient enrichment. *Orchis morio* (L.) (*Anacamptis morio* (L.) R.M. Bateman, Pridgeon, Chase) populations declined strongly within the last century in Germany due to intense habitat loss. In the surroundings of Halle/Saale where the species has been abundant in the past, only a few populations remained on isolated dry grasslands. Although there exist long term population size data we still have only little knowledge about the present state of these populations. Declines in population sizes and increasing isolation of habitats are known to negatively affect plant fitness and genetic diversity via drift and inbreeding. Thus, in turn, population viability may be reduced, leading to an extinction vortex. We analysed genetic diversity (AFLP), reproductive fitness (fruit and seed set) in 20 *O. morio* populations. Additionally we analysed long term population size development over the last 5 decades. We found high genetic variation within but also high differentiation between populations. Genetic isolation by distance was detected even on the small scale (size of main study area ca 7 x 4 km). We assume that gene flow is restricted between populations and mainly occurs on a small local scale between neighbouring sites. Low fruit set across populations indicated widespread pollen limitation. Population size correlated positively with reproductive fitness, genetic diversity and growth rate. We conclude that there is a need for enhanced conservation effort particularly for the small populations which represent the main proportion (75 %) of the studied populations.



## Early light and nutrient availability modulates phenotypic expression in response to submergence

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Plants in nature are exposed to different environmental cues which may interact in determining phenotypic expression to one of these environmental factors. We tested the hypothesis that environmental conditions experienced at early developmental stages may affect the phenotypic expression to subsequent environmental cues. This prediction was tested by exposing *Rumex palustris* plants to different light and nutrient conditions, followed by complete submergence at later developmental stages. While the two distinct environmental cues shading and submergence basically initiate the same phenotypic response (increased petiole elongation and specific leaf area) we found that expression of plasticity in response to shading negatively affected the plasticity in response to submergence. Interestingly, low nutrient availability increased the submergence induced plasticity. The relative response however, was modulated by the preconditions, resulting in a different ranking of the submergence-induced plastic elongation responses among populations and genotypes depending on the conditions the plants had experienced in early developmental stages. These results show that conditions experienced at early developmental stages modulate the responses to subsequent environmental cues, and can change the interpretation of plasticity experiments. We discuss how populations may have evolved distinct response patterns, resulting in different effects of preconditions on the plasticity expressed, and conclude that interactions between environmental cues need much more attention.

## Hybridization in the *Medicago falcata/sativa* complex: a threat to native biodiversity

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Hybridization between crops and their wild relatives can cause genetic modification of native wild forms and formation of aggressive weeds. The *Medicago falcata/sativa* complex is an excellent example of hybridization between a crop and its wild form. The wild *M. falcata* L. is native in North and West Estonia and is confined to natural calcareous grasslands, whereas the cultivated *M. sativa* was introduced in 1830ties. *Medicago falcata* and naturalised in Estonia *M. sativa* L. can well be distinguished by morphology, while their hybrids (*M. x varia*) form a continuum. *Medicago sativa*, *M. x varia* and *M. falcata* are autotetraploids ( $2n=32$ ) which mate freely producing fertile hybrids and are therefore also treated as subspecies of *M. sativa* s.l. Among the 89 populations of sickle medic studied, 76 revealed significant contamination with hybrid plants. The proportion of plants with variegated flower color was not dependent on the habitat type (natural and disturbed habitats, fallows, wastelands, road verges), however, smaller populations had higher percentage of plants with variegated flowers. The sickle medic populations showed 132 accompanying species of which more than one third were calcicole species, followed by species indicating strong human impact and species inhabiting disturbed habitats. The color of flowers varied independently from the shape of pods. Our data show that Estonian native populations of *M. falcata* are under a strong pressure of genetic modification due to the crop-wild hybridization, with introgression occurring in both natural and disturbed habitats.

## **Directional spread of *Ambrosia artemisiifolia* L. along waterways – Can source and sink populations be detected by AFLP-analysis**

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*Ambrosia artemisiifolia* (Common Ragweed) is an annual weed from North America nowadays dispersing in Austria. This neophyte poses a major threat to human health given its allergenic pollen and leads to enormous economic costs. We analysed genetic diversity and genetic structure of 23 invasive *Ambrosia* populations linearly arranged along the Danube riverbed in Vienna and Lower Austria, using the AFLP fingerprint method to answer the following questions: How is genetic diversity in Common Ragweed partitioned among and within populations along the waterways? Is there any population structure observable indicating possible migration routes and source and sink populations? We obtained 284 reliable polymorphic AFLP markers across 446 individuals. The genetic diversity within populations was higher ( $H_W=0.091$ ) than among populations ( $H_B=0.007$ ). Indicating that *A. artemisiifolia* was likely introduced from similar mixtures of sources or spread from a single introduction of mixed propagules. Therefore, identification of source or sink populations was impossible. Our results did not unveil an obvious genetic structure among the study populations and revealed low to moderate genetic populational differentiation ( $F_{ST}=0.124$ ). The detected lack of population structure is indicative for high current gene flow; hence no indication of genetic drift could be found. No isolation-by-distance pattern confirmed the lack of a linear population structuring. Migration routes following the Danube River downstream was not achievable. The likely multiple introductions into the sampled area are facilitating by human disturbances and different kind of dispersal by man.

# Evolutionary Biology of *Plantago lanceolata*: Insight from German grasslands

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In the 1980s Dutch scientists introduced *Plantago* species as model systems to study local adaptation and phenotypic plasticity. Some 20 years later, *Plantago lanceolata* is again in the focus of research: *P. lanceolata* is known to form ecotypic differentiation in response to its environment. In the German Biodiversity Exploratories project that includes three German regions we sampled seeds from 176 plants from 33 populations of *P. lanceolata* with known land use schemes and planted offspring from these plants in a common garden in Bern. The ~1500 plants were subjected to four different environments including control, clipping, shading and fertilising in order to simulate major land use consequences such as grazing, dense vegetation or fertilising. The aim was to test whether populations were locally adapted to the land use of their origin and to quantify differences in phenotypic plasticity to the environments. In addition, microsatellites were used to quantify the degree of population genetic differentiation in neutral markers. First results show that meadow plants produced fewer rosettes and fewer seeds per spikes compared with pasture plants. However, differences in seeds diminished in the fertiliser treatment and even were even reversed in the shading treatment. We will also calculate  $F_{st}$  as a measure of neutral population differentiation and compare it with  $Q_{st}$  which measures differentiation in quantitative traits to test whether traits differ due to directional selection or random genetic drift. These results will illustrate the importance of land use for the genetic variation in a common grassland species.

# **Experimental plant introduction: disentangling the roles of propagule pressure, soil disturbance and life-history traits**

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An important question in ecology is which factors determine successful population establishment of plants. Identifying these factors is particularly relevant for biological invasions. The importance of species traits may depend on environmental factors and might be overwhelmed by the introduction history of species, including time since introduction and propagule pressure. These factors are often not known for natural invasions, and they might be confounded. Therefore, their importance can only be assessed by controlled introduction experiments. We present results of the first experiment that quantifies and disentangles the roles of species traits, soil disturbance and propagule pressure on establishment success. We experimentally introduced 46 ornamental alien and 45 native herbaceous plant species at different propagule pressures in eight grassland sites with and eight grassland sites without soil tilling. Of these species, we determine the establishment success over three years, and assess how this relates to propagule pressure, soil disturbance and species traits. To determine the roles of species traits for establishment success, we assessed a variety of plant characteristics for most of our study species in greenhouse experiments. Results from the first two years show that seed mass and proportion of germination in the greenhouse are positively associated with germination in the field, whereas propagule pressure, soil disturbance, growth rate and the ability to produce induced and constitutive resistances against herbivores determine establishment success of seedlings. These results indicate that propagule pressure, soil disturbance and species traits all affect establishment success, but that their relative importance changes over time.

# Determinants of invasiveness in clonal plant species: a database study

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Many studies have investigated which species characteristics are associated with plant invasiveness. One frequently emerging pattern for floras in different world regions is that clonal plant species are overrepresented among invasive exotic plant species. Which clonal plant traits are responsible for this pattern, has not been investigated yet. In our study, we aim to elucidate the importance of different clonal plant traits for plant invasiveness using a data-base approach. For our analyses, we have compiled a database with Central European plant species for which we have combined data from the Clonal plants database, the Global compendium of weeds and the Bioflor database. This database includes information on plant clonality (e.g. type of clonal growth organ, yearly number of clonal offspring) and a proxy for global invasiveness (number of references in the Global compendium of weeds, number of world regions in which plant species is considered weedy or invasive). Preliminary results show that species with some types of clonal growth organs (e.g. rhizomes) tend to be more invasive than species with other clonal growth organs (e.g. root tubers). Furthermore, we have found an increase in plant invasiveness with increasing distance between mother and daughter ramets, suggesting that plants with a guerilla growth form are more invasive than those with a phalanx growth form. More results will be presented and discussed at the meeting.

# **Disentangling the effects of host plant quality and plant neighbourhood on parasitoid community composition on ragwort (*Jacobaea vulgaris* L.)?**

**Olga Kostenko, T. Martijn Bezemer**

*Netherlands Institute of Ecology, The Netherlands*

Plant nutritional quality directly affects primary consumers such as insect herbivores but plant quality can also affect secondary consumers such as parasitoids. In nature, individual plants are never isolated but coexist and compete with neighbouring plants within plant communities. It is well known that parasitoid community composition differs greatly between plant communities. Studies on the effects of plant community on parasitoid communities typically use a community approach where plant and parasitoid community interactions are determined per area unit. These studies do not provide insight into plant-insect interactions as they occur on individual plants growing within those plant communities. In contrast, studies that focus on the effects of plant quality on performance of parasitoids are typically carried out with isolated plants. Therefore, how host plant quality and the identity of the plant community interactively affect arthropod communities on individual plants remains largely unanswered. We studied parasitoid communities associated to individual ragwort plants (*Jacobaea vulgaris* L.) across a chronosequence of former arable fields in the Netherlands. Plant community composition and ragwort density varied greatly between sites. Moreover, there were more than three fold differences in individual ragwort size and primary and secondary chemistry between fields. I will show how parasitoid community composition responds to host plant quality and plant community characteristics between and within the fields.

# Exploring the animal in my weed: Animal models untie adaptive and non-adaptive evolution in plant invader

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Evolutionary processes are increasingly studied as factors determining the success of invasive plant species. Still, it is rarely taken into account that invading genotypes are not just influenced by adaptive, but also by non-adaptive evolution. Non-adaptive evolution may arise from non-equilibrium demographic conditions that lead to alterations in genetic diversity and organization. Here, we present the results of a common-garden experiment testing for effects of inbreeding depression and evolutionary differentiation on the competitive and reproductive ability of European invasive populations of *Senecio inaequidens*. To analyze these results, we adopt a statistical tool from quantitative genetics originally developed for animal breeding – the so called 'animal model'. In these animal models random effects on the population level are weighted according to molecular estimates of mean relatedness within and among populations. This enables us to disentangle the roles of adaptive evolution on different spatial scales, inbreeding depression, and non-adaptive processes in forming systematic variation in competitive and reproductive ability among populations of one of Europe's fastest plant invaders.



# The effect of maternal environment on seed dormancy and its support for an evolutionary stable strategy

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Between-year seed dormancy is considered adaptive in unpredictable environments. However, many other factors besides environmental variability are known to influence germination fractions. Especially the importance of maternal effects has only recently been accounted for. In 2005, Tielbörger and Valleriani presented a bet-hedging model, which predicts an evolutionary stable strategy with increased seed dormancy after favorable years as a means to reduce generalized competition in the following season. If this is true, these effects should be stronger in populations from highly competitive environments. To test this hypothesis we raised a total of 738 plants of two target species (*Biscutella didyma* (Brassicaceae), *Bromus fasciculatus* (Poaceae)), that descended from 4 and 3 populations, respectively, along a natural climate gradient in Israel. They were subjected to 12 levels of increasing water stress and controlled offspring germination was evaluated in the following year (2007/08). Our results for *Biscutella* support the model prediction, but the maternal effect was weakest in the most mesic population and increased steadily with increasing environmental aridity. Conversely, seeds from the three *Bromus* populations did not show any maternal effect. The absence of an effect of maternal environment of offspring germination in *Bromus* corresponds to the absence of adaptive between-year dormancy in this species and to a higher fecundity of mother plants at equal water stress. We conclude that maternal environmental effects play an important role in the evolution of seed dormancy strategies. However an adaptive dormancy fraction is a requirement for maternal effects to be able to operate.

## Transgenerational plasticity alters response of two *Plantago* species to disturbance and nutrients

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In experiment with two *Plantago* species we tested whether compensation for biomass loss after disturbance is driven by maternal effects (ME) due to nutrients and disturbance. Although there are numerous examples of ME in perennial plant species, studies usually follow the fate of progeny only in their juvenile stages or for one growing season. Therefore, we tested whether ME are affecting progeny differently during their first two growing seasons. Maternal effects resulted in different performance of disturbed over undisturbed progeny in relation to nutrient status of the progeny environment along with disturbance and nutrients experienced by mothers. Progeny of *P. lanceolata* grew more leaf biomass when grown in the same nutrient conditions as experienced by their mothers suggesting that maternal effects might be adaptive. ME had also different effect on plant performance between seasons. The progeny of mothers that suffered nutrient insufficiency produced longer leaves and more spikes in the first season but this was not the case in their first year. We conclude that compensation for biomass loss is driven both by ME and by progeny environment. This may lead to the different success of regenerative strategies in environments with contrasting nutrient levels. The different role of ME even between related species may contribute to ecological diversity among species. The changing expression of ME over life span of perennials showed the necessity of longer term studies in identifying these effects and in determining their roles in the ecology of perennial species.

## Local adaptation in coevolving plant-herbivore interactions

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Local adaptation is central for creating and maintaining spatial variation in coevolving antagonistic interactions. The occurrence and degree of local adaptation is predicted to vary among populations and in time due to the dynamic nature of the coevolutionary process. This variation may be driven by the abiotic and biotic environments, and may be influenced by population genetic structures. In coevolving antagonistic interactions with a long-lived host and an enemy with much shorter generation time, the enemy is predicted to show stronger local adaptation than the host. Yet, adaptation of the host to its physical or biotic environment may affect traits that are central for the antagonistic interaction. Our results on local adaptation in the coevolving interactions between *Vincetoxicum hirundinaria* (Asclepiadaceae) and its specialist herbivores show that some of the herbivore populations were locally adapted to their sympatric host-plant populations while others were not. The two investigated specialist herbivores did not show local adaptation to the same host-plant populations. Some host-plant populations were more resistant to their sympatric compared to allopatric herbivore populations. The observed spatial variation in local adaptation was driven by variation in plant chemistry and population size, but not the geographic or genetic distances among the populations. Finally, the host plants did not have higher female fitness when grown on their home environments, thus were not locally adapted, but plants from one of the populations had higher male fitness in their home environment.

# Changes in the demography of a dominant shrub species during dune fixation in Inner Mongolia

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Many plant species have a wide range of distribution, which requires these species to adopt their life history traits to be able to survive and maintain populations in different habitats. Plants in mobile dune systems in Inner Mongolia need to adapt to the changing growing conditions during the dune fixation process. Here we studied the changes in demography of a dominant shrub in the Mu Us sand district in Inner-Mongolia, *Artemisia ordosica*. Our study species occurs in three dune fixation stages at different densities: semi-fixed dunes, fixed dunes and fixed dunes covered with microbiotic crusts. We performed a 2-year field study to monitor populations in these habitats. We then constructed Integral projection models (IPMs) to describe habitat-specific demography and analyse changes in demography along the dune fixation process. We found that both growth and reproduction declined strongly as the dune fixation proceeded. Shrinkage in plant height was frequently occurring, in particular in the fixed dunes with microbitic crust. Population growth rate declined from strongly positive growth ( $\lambda = 1.33-1.09$ ) in semi-fixed dunes to population decline in fixed dunes with microbiotic crusts ( $\lambda = 0.94-0.89$ ). Elasticity analysis showed that population growth was determined by different drivers in the three habitats: shrub growth and reproduction contributed most to  $\lambda$  in the semi-fixed habitat, while survival and shrinkage contributed most to  $\lambda$  in fixed dunes with microbiotic crusts. Finally, we performed life table response experiments (LTRE) to identify the vital rates that were most important in realizing the differences in population growth across habitats. It appeared that differences in growth and reproduction between habitats were mainly responsible for the strong differences in  $\lambda$  that we observed. In all, our results show that the demography of *Artemisia ordosica* varied strongly across habitats. The fast population growth in early stages of the dune fixation process and the decline towards the end of the succession are probably responsible for the strong dominance of this species in early stages of the dune fixation process.

# **Genetic structure and contemporary pollen-flow along an altitudinal gradient of *Ranunculus bulbosus* populations**

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Climate change is predicted to shift the distribution of plant species to higher elevations. This expansion of formerly central population into peripheral populations may have genetic consequences such as outbreeding depression. Our project aims to assess the general historical and contemporary patterns of gene flow by pollen across an altitudinal gradient in the insect pollinated plant *Ranunculus bulbosus*. We investigated genetic structure among populations along a single mountain side in the Swiss Alps. Up to 45 mature plants were sampled each from five populations along a 1 km transect from 1200 -1800 m.a.s.l. The genetic structure of these populations was assessed with a set of nuclear microsatellite markers. In addition we sampled 10 progeny from 20 mother plants from the same populations to conduct a pollen pool structure analysis (TwoGener) to estimate average pollen dispersal distances. Combining this natural population-approach and artificial population pollen dispersal experiments using paternity analysis we will model the pollen dispersal curve. Ultimately we will combine our estimates of historic and contemporary pollen flow with results from breeding experiments between populations of different altitude to assess the potential for local adaptation to be disrupted by anthropogenically altered gene flow in the context of current climate change scenarios.

# Nutrient acquisition and soil nutrient mineralization by exotic range-expanding and related native plants

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Due to climate warming, plants can expand their range to higher latitudes. Some of these exotic range-expanding plants may become invasive in the new range. When exotic range-expanding plants establish in the new range, new interactions between soil microbes and plants can alter rhizosphere-driven nutrient mineralization and litter decomposition. To study these interactions, two experiments were performed: one in a greenhouse and one in a climate chamber. In the greenhouse, we studied if exotic range-expanding plants might alter rhizosphere nutrient mineralization and plant nutrient acquisition compared with congeneric natives. In the climate chamber, we studied if litter of range-expanding plants might alter soil nutrient availability and litter feedback to plant biomass production when compared with related native plants. We observed species-specific differences in rhizosphere nutrient mineralization and plant nutrient acquisition, but no consistent differences between exotic range-expanding plants and congeneric natives. We also found species-specific differences in soil nutrient availability and litter feedback to plant biomass production, but soil N availability was increased more often by litter of exotic range-expanding plants than of related native plants. This increase in soil N availability resulted in increased biomass production for both exotic range-expanding and related native plants. Our results suggest that exotic range-expanding plants may alter N cycling, but that these effects are species-specific and not consistently different between plant origins. If litter of exotic range-expanders increases N availability, this can create a positive feedback to plant biomass production for both exotic range-expanding and native plants.

# Vital rate variation among 14 species over two decades: survival and growth with fire and hurricanes

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Long-term demographic data can provide information on variation in vital rates among life history syndromes. Here, we analyze vital rates from 14 species over as many as 22 years in Florida xeric uplands (Florida scrub and sandhill), pyrogenic ecosystems dominated by shrubs and herbs. Over 50,000 individually marked/mapped plants provide estimates of annual survival (excluding seedlings) and relative growth rates (RGR; based on height, rosette diameter or number of stems, depending on the species). We compare vital rates in years with (or without) the two dominant disturbances in Florida uplands: fire and hurricanes. In addition, we contrast these vital rates between species that typically resprout following fire and those that are killed by fire. Annual survival of non-seedlings varied from 48-99% among species (0-100% for individual years). Sprouters had significantly higher survival (91%) than non-sprouters (65%). Fire almost always kills non-sprouting individuals, but four sprouting species with sufficient data had similar survival rates whether burned or not. Survival varied significantly among species but did not vary among years, including between years with (76%) and without (74%) major hurricanes. Resprouter RGRs bracketed zero (no net growth); significantly lower than RGR for seeders. Resprouting shrubs showed negative growth from before to after fire, but resprouting herbs tended to be larger post-fire. Overall, RGR varied by species and marginally among years, with a significant species by year interaction. Life history syndromes followed the post-fire resprout/not resprout dichotomy, suggesting that fire has been an important selective force.

# Climate change induced range expanding plants experience less belowground enemy impact

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Due to climate warming many plant species in Europe expand their ranges northwards. The aim of our project is to determine how plant species expanding ranges from southern latitudes to northern latitudes perform in their new environment. Range expanding plant species might have lost part of their native soil community when dispersing into their new range and therefore could have an advantage over native plant species in their new environment. To test this we conducted a phylogenetically controlled experiment with cross comparison of plants grown in soil conditioned by their own species and a control soil conditioned by other species. We found that range expanders performed equally well on their own soil than on the control, native plants on the contrary, performed less well on their own soil compared to the control. This revealed a possible competitive benefit for the exotic range expanders over the native plant. Recently, we have profiled the belowground community of fungi and bacteria using PCR-DGGE. Within soil treatments, native and range expanding plants had significant dissimilar soil communities. Moreover, when we compared the amount of plant parasitic nematodes per gram root biomass, there were less plant parasites in roots of range expanders than in native plant roots. Herewith, we show that patterns in the soil communities reflect the aboveground plant performance and provide a possible mechanism that could play a role in the abundance of range expanding invaders.



## Plant seedlings under the different management

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Meadow communities are important for the maintaining of the diversity in cultural landscape. They host large diversity of species not only among plants, but also among the other groups of organisms. However, they are dependent on regular mowing, so the management has to be often directed according to the requirements of the different biota. To assess effect of short term management changes on plant generative regeneration we carried out experiment at species rich meadow (White Carpathians Mts., Czech Republic), where we applied 6 different management regimes (mowing in June; mowing in September; mowing in June and in September; mowing in June and high stubble left; no management; mowing in June and mulching). Experiment run for three years in three types of vegetation (dominated by *Bromus erectus*, *Molinia arundinacea*, and *Calamagrostis epigejos*) and in third year seedlings in different treatments were determined and counted. The highest number of seedling species was observed in grassland dominated by *Bromus*, the lowest number was observed in grassland dominated by *Calamagrostis*. The same pattern was observed also for the total seedling density. Seedlings were supported most (both the number of species and its total density) by traditional management i.e. mowing in June. On the contrary cessation of the management created the least suitable conditions and led to reduced number and diversity of plant seedlings. Management regimes had similar effect in all vegetation types. Cessation of the management therefore suppressed not only the adult plants (as is usually observed), but also their reestablishment.

# The tolerance-fecundity tradeoff and the maintenance of diversity in seed size

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Seed size commonly varies by five to six orders of magnitude among coexisting plant species, a pattern ecologists have long sought to explain. Because seed size trades off with seed number, small-seeded species clearly have the advantage in fecundity, but what is the countervailing advantage of large seeds? Higher competitive ability combined with strong competitive asymmetry can in theory allow coexistence through a competition-colonization tradeoff, but empirical evidence is inconsistent with this mechanism. Instead, the key advantage of large seeds appears to be their tolerance of stresses such as shade or drought that are present in some but not all regeneration sites. Here I present a simple, analytically tractable model of species coexistence in heterogeneous habitats through a tolerance-fecundity tradeoff. Under this mechanism, the more tolerant species win all the more stressful regeneration sites and some of those that are less stressful, while the more fecund species win most but not all of the less stressful sites. The tolerance-fecundity tradeoff enables stable coexistence of large numbers of species in models with and without seed limitation. The tolerance-fecundity mechanism provides an excellent explanation for the maintenance of diversity of seed size within plant communities, and also suggests new hypotheses for coexistence in animal and microbial communities.

## Effect of genetic diversity on invasibility in experimental *Festuca rubra* stand

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The importance of diversity for ecosystem functions is a topic of many recent studies. While a lot has been done on the effect of species diversity, the effects of genetic diversity are less explored. In our previous experiment we explored the importance of genetic diversity within *Festuca rubra* on stand productivity in a 4 year experiment. We established stands consisting of 1, 6 or 18 clones in nutrient poor and rich soil. We demonstrated that more genetically diverse stands have higher productivity with the effect disappearing over time. Now we tested if genetic diversity of the stand affects invasibility of the stand and if the invaders have an effect on performance of *F. rubra*. We did this by sowing four species – *Plantago lanceolata*, *Campanula rotundifolia*, *Trifolium repens* and *Anthoxanthum odoratum* into the stands at the end of year 4 of the experiment. The results show that performance of one of the species *A. odoratum* is lower in stands of high genetic diversity. This pattern was especially clear in low nutrient soil. Biomass of *F. rubra* is affected by performance of the invaders but this effect does not depend on genetic diversity of the *F. rubra* stand. Overall our results demonstrated that stands with higher genetic diversity are more resistant to invasion by some but not by other species. They have also shown that the invaders have significant effect on performance of the native species which is independent of genetic diversity within the native stand.

# Invasive knotweed impacts native plants through allelopathy

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There is increasing evidence that some of the most successful and troublesome invasive plants can suppress the growth of their native competitors through allelopathy. One of the most dominant and at the same time least understood group of plant invaders in Europe and North America are the clonal knotweeds *Fallopia japonica*, *F. sachalinensis* and their hybrid *F. x bohemica*. To thoroughly investigate the ecological significance of *Fallopia* allelopathy, and its underlying ecological and evolutionary mechanisms, we are undertaking a series of complementary ecological experiments. In one experiment, we tested for general allelopathic effects of *Fallopia x bohemica* on experimental communities of six native European plant species. We found that addition of activated carbon to the soil greatly reduced *Fallopia* rhizome biomass, and it reduced the suppressive effect of *Fallopia* on native forbs by 35% which suggests that the invader indeed exerts strong allelopathic effects on native forbs. These effects must act on the growth rather than the germination of natives, since we did not find any evidence for decreased germination rates or germination times in a follow-up experiment in which we tested whether *Fallopia* leachates and soil residues affected the germination of several native species. Other, ongoing follow-up experiments investigate the effects of litter leachates and soil residues on later life-history stages of natives, the role of soil biota in mediating allelopathic effects, and the consequences of knotweed hybridisation for the species' allelopathic potential and invasiveness.

## Parentage analysis in *Populus euphratica* Oliv.

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Parentage analysis based on microsatellite marker genotyping was used to investigate pollen and seed dispersal within an old-growth, abundantly flowering riparian *Populus euphratica* stand in Xinjiang, Western China. A set of eight microsatellite markers was chosen and used to genotype 200 saplings and 295 potential parents. The saplings were collected along the river, so first it had to be excluded that they were root suckers from the neighbored adult trees. For parentage analysis a likelihood-based method implemented in FaMoz software was used. To estimate the pollen flow directly, sticky slides were used to trap the pollen around three isolated male trees. Pollen grains were counted and a dispersal curve up to a distance of 200m in each direction from the pollen-bearing tree was calculated. Preliminary results of a parentage analysis showed that about 40% of 36 investigated saplings have one or both putative parents within the analysed plot, compared with 14% putative parents for a plot 20km away. That corroborated the results of pollen dispersal, showing that most of the pollen falls down within 150m distance. It can be concluded that immigration of pollen from outside a stand is not common. Most of the seeds ripening in a stand will not be drifted away, although floating seeds germinate successfully on the water surface. We thus conclude that gene flow between *Populus euphratica* stands is much lower than expected for a wind-pollinated and wind-dispersed species. This observation coincides with the high genetic differentiation between seven genotyped stands.

## Makes sex a difference? Genotypic diversity in two species of *Gagea* (Liliaceae) with contrasting reproductive strategies

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The Liliaceae *Gagea lutea* and *G. spathacea* are naturally co-occurring woodland geophytes. They are characterised by contrasting reproductive strategies: The hexaploid *G. lutea* first relies on vegetative reproduction by bulbils but completely switches to sexual reproduction once a certain bulb size is attained. The nonaploid *G. spathacea* is virtually sterile and only reproduces vegetatively, plants continue to form bulbils even in the rare event of flowering. The study uses AFLPs to investigate the genetic consequences of these reproductive strategies. For 150 (*G. lutea*) and 100 (*G. spathacea*) samples from three Western Pomeranian populations AFLP fingerprints were generated and analysed for three different spatial scales. Applying a threshold for genotypic identity of  $<0.05$  simple matching distance, 22-30 genotypes were detected in the three *G. lutea* populations, with all genotypes confined to single populations. The mixed reproductive strategy and the different dispersal abilities of the respective diaspores (subterranean bulbils vs. more mobile seeds) are evident in the molecular data: Clonal genotypes consisted of 2-9 samples and extended over up to 28m, but never occupied the whole length of a transect; even on small scales genotypes intermingled. Genotyping of *G. spathacea* revealed a single clonal genotype for all three populations sampled within 30km distance. The absent genetic diversity confirms the suspected sexual sterility. If this holds true for more remote locations as well (investigations are underway), *G. spathacea* is one of the few non-apomictic but fully clonal plant species able to occupy a significant range solely by dispersal of vegetative diaspores.

## Latitudinal and altitudinal differentiation in phenotypic traits and molecular markers of *Campanula rotundifolia*

Veronica Preite, Georg Armbruster, Jürg Stöcklin, Niek (J.F). Scheepens

*University of Basel, Switzerland*

To cope with climate change, plant populations have either to rely on phenotypic plasticity or to adapt genetically to their changing environment. Differentiation of phenotypic traits along climatic clines suggests genetic adaptation. Assessing their heritability can reveal whether they have potential to adapt to a changing environment. A common garden experiment was carried out in order to investigate differentiation and heritability in morphological and phenological traits and competitive ability of *Campanula rotundifolia*. Populations originated from three regions along a latitudinal gradient (Scandinavia, Northern Europe and Central Europe) and from one region at high altitude (Alps). Fourteen out of fifteen phenotypic traits showed a significant regional variation. Length of the flowering period decreased with latitude and altitude, which probably is an adaptation to season length. Above-ground biomass and reproductive output also showed a decrease with increasing latitude and altitude. This can be due to increasing discrepancy between the climate of origin and the common garden in Basel with latitude and altitude. Morphological traits and competition ability showed genetic variation but not in a clinal fashion, suggesting adaptation to varying local conditions. Narrow-sense heritability in all traits was substantial ( $0.285 \pm 0.081$ ), suggesting adaptive potential. Additionally, a  $Q_{ST}-G'_{ST}$  comparison using RAPD's was performed indicating unifying selection for all traits except for above-ground biomass, for which diversifying selection is indicated. We conclude that those traits correlating clinally need to adapt to future climate change.

# Assessing environmentally driven demographic change for plant management and conservation

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Understanding demographic variation in response to environmental variation helps to evaluate human impact and facilitate effective management actions. We use matrix modelling to simulate population dynamics with and without the inclusion of common environmental drivers. We evaluate optimal fire regimes for Florida scrub plants, the importance of mowing for the persistence of a Netherlands heathland plant, the rate of population decline of an Illinois prairie herb with grass competition, and population variation for an Oregon grassland herb in response to herbivory and weather. We compare modelling outputs to independent population data collected later in time, after models were parameterized. We contrast population trajectories overall population sizes, and population structure from scenarios including environmental drivers to scenarios based on independent and identically-distributed (iid) random variables. Models that incorporated environmental variation had similar average predictions for the overall population sizes compared to iid approaches. However, including environmental drivers produced smaller confidence intervals and trajectories more closely mimicked observed population trajectories. We argue that incorporating information on demographic variation associated with environmental drivers allows the identification of critical features of population dynamics with important consequences for management and conservation. These include the timing and relative magnitude of population inflection points and predictable changes in population structure and vital rate change. This approach emphasizes the recognition of functional population properties directly associated to management actions or specific environmental conditions.



# Genetic diversity and clonal structure of the aquatic macrophyte *Menyanthes trifoliata*

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Many aquatic plants have the capacity for sexual and vegetative reproduction. As a result of habitat fragmentation, however, the balance between sexual and vegetative reproduction can be biased. Furthermore, in heterostylous species, a bias towards one of the morphs can hamper sexual reproduction. We studied genetic diversity and clonal structure in the distylous aquatic macrophyte *Menyanthes trifoliata* in nine Belgian populations from two regions. The size of the studied populations ranged from 30 to 1,500 flowering ramets. We genotyped 18-52 ramets per population at ten microsatellite loci (for a total of 311 ramets). Furthermore, we analyzed small-scale clonal structure in two 2 × 2 m plots in each of one large (> 300 flowering ramets) and one small population in both regions. We detected 119 multilocus genotypes, each of which was present in only one population. The clone diversity at the small spatial scale (2 × 2 m) was very low (1-2 clones). Most of the populations had a biased morph ratio among genets. We calculated within-population, among genets genetic diversity indices and expected heterozygosity corrected for sample size, as well as genetic distances between populations. The expected heterozygosity and Shannon-Wiener diversity were reduced in small populations. We conclude that the number of compatible genotypes for sexual reproduction may be severely reduced in small populations of *M. trifoliata*.

## **A battle of the sexes? Sex ratio in dioecious dog mercury (*Mercurialis perennis*)**

**Anna Maria Roschanski, Tanja Pfeiffer, Martin Schnittler**

*Ernst-Moritz-Arndt-University Greifswald, Germany*

It has often been reported that the sex ratio of the shoots of *Mercurialis perennis*, a clonal dioecious woodland herb, is skewed favoring males. By excavation and subsequent genotyping, we investigated the sex ratios at shoot, merigenet and genet level. We adapted a set of eight microsatellite markers from *M. huettii* for use with the decaploid *M. perennis*. With up to ten alleles per locus, the resulting patterns can only be treated like dominant markers. However, using a semi-automatic scoring and context data (sex, replicates), we could show that the combination of only two loci allows a reliable genotyping. Three plots, including 409 shoots belonging to 223 merigenets and 34 genets, were investigated. Sterile shoots were assigned to the sexes with the help of information obtained from excavating and genotyping. At all levels, the skewed sex ratio was maintained (ratios 1:4.8, 1:4.4 and 1:2.2, respectively). Female clones had on average 7.8, male 12.7 shoots; two oversized clones were both male. Quantifying reproductive resource allocation by measuring nitrogen allocation to male flowers vs. female seeds showed that females invest on average 3.6 times more nitrogen into generative reproduction. We conclude that, compared to females, males save resources at sexual reproduction and invest them into clonal growth. This enables them to spread faster, perhaps in the long run out-competing females. We assume that the sex ratio can be more biased in old-growth than in forests with a higher intensity of usage. For persistence of female clones, disturbance is probably a key factor.

# Infrequent sporophyte production maintains a female-biased sex ratio in the unisexual clonal moss *Hylocomium splendens*

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Unisexual bryophytes normally have female biased sex ratios in contrast to unisexual seed plants where male biased sex ratios predominate. The female bias in bryophytes is surprising since it is generally believed that the females carry the largest cost during reproduction. One approach to understanding sex-ratio patterns is to study relationships between sex distribution and population growth rates ( $\lambda$ ). This approach has never been applied to bryophytes. We investigated how variation in sex ratio and sporophyte frequency influenced  $\lambda$  by matrix modeling using a linear two-sex model. We found strong variation in  $\lambda$  in response to variation in sex ratio and sporophyte frequency. The highest  $\lambda$  was observed at very low sporophyte frequencies and at a slightly female-biased sex ratio. An explanation for this sex-ratio pattern, common among bryophytes, may be that males generally perform slightly poorer with respect to survival and vegetative offspring than non-sporophytic females. A performance hierarchy of males and females coupled with little efficient fertilization systems in bryophytes may therefore explain the commonly observed female-biased sex ratio.

## Regional differentiation in life history and susceptibility to grazing in a widespread Alpine monocarp

Niek (J.F.) Scheepens, Eva S. Frei, Jürg Stöcklin

*University of Basel, Switzerland*

Glacial history caused regional differentiation in neutral molecular markers in numerous widespread Alpine plant species. Several distinct phylogeographic lineages resulted from the glacial survival in refugia and subsequent recolonisation of different parts of the Alps. These historic processes could also have affected genetic differentiation in phenotypic traits among these regions, either as a result of drift, regional adaptation or both. A two-year common garden experiment with the monocarpic *Campanula thyrsoides* from 21 populations across the European Alps was performed to reveal differentiation among four phylogeographic lineages in morphological, functional, life-history and reproductive traits. A clipping treatment was applied to simulate the effect of herbivory and to estimate its influence on fitness. A trend was visible showing that clipping did not affect morphology and reproduction in plants from the Western Alps, whereas the other regions were clearly affected. In the Western Alps *C. thyrsoides* occurs frequently in grassland, potentially explaining this result as adaptation to higher grazing pressure. Plants from the Eastern Alps were differentiated in morphology and life-history: inflorescences were taller but had lower flower density, and plants showed delayed, indeterminate flowering. Compared to the short growing season of the high Alps, this contrasting flowering behaviour of Eastern Alpine plants is adaptive in the long submediterranean summers in the native range in Slovenia.  $Q_{ST}-G'_{ST}$  comparisons indicated that all investigated traits were subject to unifying selection. This suggests that, although genetic drift during Ice Ages is a strong force affecting phenotypes, natural selection limits neutral differentiation to maintain adaptations.

# The role of molehill disturbances in maintaining high grassland diversity under different management regimes

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*Tübingen University, Germany*

Disturbances are one of the main factors determining grassland community composition. However, the effect of disturbances is not unified, and different disturbances may have distinct effects on plant community dynamics. Classifying disturbances according to their scale and predictability (i.e. spatial/temporal autocorrelation) helps in estimating their effect. It is predicted that environmental heterogeneity will increase with small and unpredictable disturbances. On the other hand, large, predictable disturbances are expected to homogenize the habitat, because only species adapted to the specific disturbance may survive. Therefore, larger and more predictable disturbances are predicted to decrease trait variability and species diversity, while small-scale unpredictable disturbances will increase them. Many management methods in semi-natural ecosystems may be considered as large-scale disturbances, but their relative predictability differs. For example, the effect of mowing is assumed to be more spatially and temporally correlated relative to grazing, thus more predictable from the plants' point of view. Natural disturbances such as molehills may be considered small-scale and unpredictable relative to mowing and grazing. Because mole activity is less predictable, it is expected to have weaker effect on trait and species selection. However, the smaller scale of mole activity increases habitat heterogeneity, and therefore it may increase species and trait diversity. Here we present data from a theoretical model and observations collected in the Swabian Alb, Germany, in which we compared species composition and trait variation between undisturbed vegetation and molehills in several grasslands experiencing different management (either mowing or grazing) and tested the above hypotheses.

## Habitat conditions are better determinants of population performance of perennial species *Ligularia sibirica*, than its size

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The aim of this study was to perform population viability analysis for a relict wetland long-lived perennial plant species *Ligularia sibirica* (Asteraceae) in the Czech and Slovak Republic. We collected detailed data on full life cycle of the species in 11 populations over three transition intervals and used transition matrix models to analyse the data. Most of studied populations of *L. sibirica* in the Czech and Slovak Republic are performing well and only those growing in degraded habitats show a decreasing trend. This can be seen in relationship between vegetation composition and population growth rate. The results thus support our hypothesis that there are differences in performance of populations growing in well preserved fens and populations growing in degraded habitats. On the other hand we found no relationship between population size and population growth rate. The results also indicate that mortality of adult individuals is very low, individuals of studied species may live for several decades and some populations show features of remnant populations. Detailed demographic data are thus needed to understand the long-term prospects of these populations and may serve as an early warning system by suggesting the need of active management of the species long before obvious decline of the population.

# Effect of resprouting on population dynamic of short lived root sprouting herb: a simulation analysis

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The persistence of short lived species occurring in disturbed habitats relies on seed bank. However, the possible effect of regeneration through bud bank has only recently been acknowledged. In a simulation study we asked how timing and probability of disturbance affect population growth and structure in short lived *Rorippa palustris* with potential bud bank on roots. Using transition matrices calibrated by experimental data we simulated density-independent population growth under six different disturbance scenarios. Population growth was significantly affected by disturbance in summer months, whereas resprouting was important for over-wintering without respect to disturbance. In spring months, the effect of resprouting on population growth increased with disturbance probability. Disturbance whenever in the season affected size structure of populations; the effect was, however, reset by over-wintering except for early summer disturbance. The results of the modelling study implies that potential bud bank on roots affect population growth and structure in studied species. This is especially true if the disturbance comes with high probability in spring, while survival in summer is more dependent on seed bank. Additionally, winter could be regarded as a special case of highly predictable disturbance and its survival thanks to potential bud bank could have evolutionary implications for root-sprouters.

## **Population ecology and genetics of the rare liverwort *Jungermannia caespiticia* Lindenb.**

**Pavel Sova**

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*J. caespiticia* is an early invading species and a weak competitor. Its persistence in a landscape is determined by occurrence of favourable habitat with reduced intensity of competition which is mostly frequently disturbed substrata often related to anthropogenous sites. The research on population dynamics and reproduction showed the species developed several unique adaptations to be a successful colonist being an example of wide spectrum of life forms in early land plants. Mass production of endogenous gemmae, growth form and timing are the most important features for the species continuity. There is strong disjunction in range of *J. caespiticia*. ISSR and microsatellite molecular markers were used to reveal genetic variability, fitness, relationships and history of selected Central European and Scandinavian populations. Both the specific and nonspecific markers show low genetic differentiation among populations with most variability being distributed within populations. Predominant way of reproduction, clonality, the role of isolation by distance, the origin of the populations and potential impact of ice ages on population structure will be discussed. Current threat status of *J. caespiticia* was revised based upon revision of the historical localities, knowledge of ecology and molecular data. Some conservation measures are proposed. Stress is put on disturbance regime.



## **Plant traits relating to success of exotic plant species on a regional versus a local scale**

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To estimate invasiveness of exotic plant species, many studies have used regional abundance of a defined region. This measure is informative about how widespread invasive species are, however, it does not inform on local invasive dominance of exotic plant species. Therefore, it is important to know for predicting invasions whether results from the regional scale can be adopted to predict invasiveness at the local scale. To address our question, we used information on all exotic plant species in The Netherlands and compared traits of established exotic plants on both scales. We created minimal adequate models with plant traits predicting abundance of neophytes (N=111) on the regional and local scale. To investigate possible survey bias for local plot data, we created a version modified to expert opinion. The models that predicted the success on the local and the regional scales differed. On the regional scale the plant traits correlating positively with high abundance were: non-European origin, large height, polyploid chromosome number, long flowering season, long residence time and therophyte life form. The two versions of the local dominance data both included lateral vegetative spread as a predictor, but varied for the other predictors. This indicates survey bias is a real problem for using this data for local dominance. On the other side, none of these predictors matched with the predictors in the model for regional abundance. We conclude that different traits predict invasiveness at the regional and the local scale. This indicates the importance of studying invasiveness at multiple scales.

## **Direct and indirect effects of nitrogen deposition on species composition changes in calcareous grasslands in the UK**

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The effects of atmospheric nitrogen and sulphur deposition on the species-richness and species composition in calcareous grasslands was analysed spatially and temporally in the presence of confounding variables such as climatic conditions and site characteristics including soil chemistry. We analysed permanent quadrat data from 106 plots collected during a survey between 1990 and 1993 and compared the data with the results from resurvey between 2006 and 2009. Atmospheric nitrogen deposition was not related to species-richness in 1990-1993 or in 2006-2009, nor did it explain the average loss of species which we found over the last 15 years. Despite this apparent lack of response to atmospheric N-deposition, the temporal analysis showed that atmospheric N-deposition significantly affected the changes in species diversity and evenness of the plots. A decline in species diversity and plot evenness was observed with high N-deposition. In addition N-deposition was positively related to the grasses to herb ratios in both surveys and we showed a strong decline in some of the herbaceous plants at the species level. These results indicate that, biodiversity in these plots has changed significantly over time as a result of atmospheric nitrogen deposition. A breakdown of indirect and direct effects of atmospheric N-deposition on plant species diversity shows that the effects are largely direct but a significant proportion of the effects is also explained indirectly via the soil.

## Strict mast fruiting for a tropical dipterocarp tree: a demographic cost-benefit analysis

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Strict masting, the production of large seed crops at intervals of several years, is a unique reproductive adaptation displayed by many tree species in South-East Asia. The predator satiation hypothesis predicts that starvation of seed predators between mast years and satiation during mast years decreases seed predation, enhancing tree regeneration. However, mast fruiting comes at the demographic cost of missed reproduction opportunities. It remains unknown if predator satiation constitutes a sufficiently large benefit for masting to evolve as a viable life history strategy, as previous studies have not quantified the net fitness consequences of masting. Using a long-term demographic dataset of the dipterocarp *Shorea leprosula* in a Malaysian forest we constructed stochastic matrix models and performed a demographic cost-benefit analysis. For observed values of mast frequency and seed predation rates, we show that strict masting strongly increases fitness compared to annual-fruiting. Model results show that the demographic costs of mast fruiting are very low compared to costs of seed predation at annual fruiting. We also find that even at low levels of seed predation there would be a selection pressure on mast-fruiting strategies. Our study shows that a life cycle modeling approach is an elegant method for weighing fitness benefits and costs of a phenomenon like strict masting. The predator satiation hypothesis proved to be a very plausible selection pressure.. A population model approach also seems the way forward for investigating exactly these research questions.

# Land use affects quantitative genetic differentiation in *Bromus hordeaceus*

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Human land use is one of the main drivers of global environmental change. It affects not only species composition and diversity, but also the genetic composition of species as well as the selection pressures acting upon them, and the resulting evolutionary changes may feed back on population persistence, ecological interactions, and ecosystem processes. However, in contrast to land use effects on species diversity, effects on genetic diversity and intraspecific genetic variation have so far received much less attention. Here, we have taken advantage of the German Biodiversity Exploratories – a large network of field plots for studying the relationships between land use, biodiversity and ecosystem functioning – for investigating how land use affects quantitative genetic variation among and within populations of the grass *Bromus hordeaceus*. We collected seeds from all Exploratories plots where *B. hordeaceus* occurred and grew offspring of all populations in a common garden. We found significant differences in flowering phenology and biomass between *B. hordeaceus* populations from different land use types, and that genetic differentiation in flowering phenology was strongly influenced by the timing of mowing or grazing in the populations. Our results demonstrate that land use also affects the genetic diversity within species, with potential consequences for the ecological interactions of these species. Such intraspecific effects must not be overlooked in studies of the ecological effects of environmental change.

# Stochastic demographic models to project estimates of invasibility for *Hieracium lepidulum* in the Southern Alps of New Zealand

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Demographic models provide a valuable tool for assessing the viability of invasive plant populations. Projecting the growth of a population reveals the likelihood of long-term demographic success, which can serve as a measure of a system's invasibility. In this study we develop demographic models from an intensive field experiment designed to describe the population level growth of *Hieracium lepidulum*, an invasive weed found in stream catchments in the Southern Alps of New Zealand. We use individual-level observations to extrapolate population-level responses in order to separate the inherent viability of the population from external propagule supply. The demographic models are parametrized for each habitat using a Bayesian hierarchical modeling approach, providing a realistic estimate of the uncertainty in the parameters. This uncertainty is incorporated into stochastic matrix models to project the population growth. The projections are utilized to assess invasibility of different habitats within the landscape, and interpreted in the context of landscape structure and current observed plant abundances. Results are also compared against projections from a non-stochastic simulation. Although uncertainty in the parameter estimates can lead to dramatic variability in the projected abundances, broad differences in suitability between the habitats are easily discerned. While incorporating the uncertainty reduces the precision of projections, their forecast is more representative of what we can accurately predict given our current knowledge. Knowing this uncertainty and the potential for variation in responses, along with long-term projections of population-level success can have a drastic effect on the potential for different management options.

## **A regionally adapted grassland community improves ecosystem services**

**Karoline Weißhuhn<sup>1</sup>, Harald Auge<sup>1</sup>, Markus Fischer<sup>2</sup>, Daniel Prati<sup>2</sup>**

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Local adaptation is a major driver of plant evolution, and consequently the Convention on Biological Diversity calls for protection of local provenances. Whereas numerous studies have shown the importance of local adaptation for individual species, much less is known about the ecosystem consequences of local adaptation of entire communities. A plant community consisting of populations locally adapted to their habitat and to each other may influence ecosystem processes positively, which is particularly important for restoration ecology. We therefore tested whether grassland established from seed material of the respective region provides better ecosystem services than grassland communities based on foreign seeds. In a field experiment at one site in Germany, we sowed grassland communities consisting of the same set of species but originating from five different European provenances using seeds from commercial suppliers. During the two subsequent growing seasons, we monitored establishment and survival of the species sown, recruitment from soil seed bank, community biomass and composition, as well as total plant cover. Across both study years, the regional grassland community performed significantly better than foreign communities in terms of plant cover and weed suppression. In addition, local communities reduced the percentage of bare soil prone to erosion compared with foreign ones. To conclude, our experiment reveals the importance of regionally adapted plants for successful restoration of grasslands, and that adapted communities may improve ecosystem services such as productivity, weed suppression, or prevention of soil erosion.

## **Latitudinal gradient for inter-annual variation in seed production**

**S. Joseph Wright**

*Smithsonian Tropical Research Institute, Panama*

I will examine the first latitudinal gradient for inter-annual variation in seed production. Ten to 23 year records of seed production for five tropical forest will be compared with recent compilations of hundreds of studies from temperate and boreal latitudes. The five tropical sites are Luquillo, Puerto Rico; San Lorenzo and Barro Colorado Island, Panama; Nouragues, French Guiana and Yasuni, Ecuador. I will evaluate interspecific synchrony in seed production among years and possible long-term changes in levels of seed (and flower) production through time for each forest. I will also evaluate possible synchrony among the five Neotropical forests. Synchrony might be expected among BCI, San Lorenzo, Nouragues and Pasoh where the El Nino Southern Oscillation influences climate.

# Dispersal in a warmer world: Species' responses to climate change

Rui Zhang, Katriona Shea

*The Pennsylvania State University, USA*

Studies show that climate change alters phenology, growth, and reproduction in many plant species. However, little work has been done on dispersal-related characteristics. We use a two-cohort study to examine the responses of two congeneric invasive thistles, *Carduus nutans* and *C. acanthoides*, to manipulated warming and precipitation addition based on climate projections in the Northeastern USA. Open top chambers (OTCs) were used to elevate daily temperatures in warmed plots by 0.58°C on average across seasons. A 30% increase in winter precipitation and a 15% increase in summer precipitation were achieved using passive precipitation collectors. Our results show that both species advanced their flowering and grew significantly taller in warmed plots. However, *C. nutans* was more responsive to warming in terms of enhanced fall seedling emergence, faster early rosette growth, improved winter survival, and greater flower head production. Precipitation addition did not have any significant effect in our experiment, except to delay bolting in *C. acanthoides*. Our results, combined with population spread models, indicate that the large increases in reproduction and plant height of *C. nutans* are likely to cause more rapid spread of this invasive species under climate change. Furthermore, our study provides insights into potential changes in plant dispersal and spread due to climate change. This information can supplement present climate envelope models to better project future species' distributions.





## POSTERS

# Impact of the fungicide Azoxystrobin on the abundance of vesicular-arbuscular mycorrhiza

**Maik Bartelheimer**, Benedikt Müller, Peter Poschlod

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The manipulation of vesicular-arbuscular mycorrhiza (VAM) often involves the use of fungicides, but the formerly used fungicides have been criticized for their impact on the environment and on human health. A possible alternative could be the fungicide Azoxystrobin. We examined its applicability for VAM manipulation in a field experiment and a greenhouse experiment. The field experiment involved repeated fungicide applications to calcareous grassland over the course of two years. It examined the impacts on VAM itself as well as on abundance of different species. The controlled greenhouse experiment assessed the effect of different concentrations on VAM and on plant biomass in juvenile plants of *Hieracium pilosella*. In the field experiment, infection rates were only marginally reduced and species abundance only slightly responded to fungicide treatments. Meanwhile, the greenhouse experiment yielded a clear dose-dependent response between fungicide concentration on the one hand and mycorrhizal infection or biomass production and the other hand. We can conclude that, under field conditions and especially in established vegetation, short- to medium-term effects of Azoxystrobin on VAM infection rates are weak. However, under controlled environmental conditions and when juvenile plants are involved, VAM can well be manipulated by this fungicide.

## The Fate of *Senecio aquaticus* Seeds

Gabriele Bassler, Gerhard Karrer, Monika Kriechbaum

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*Senecio aquaticus* occurs frequently in wet meadows with intermediate nutrient supply in Lower Austria (Waldviertel region). In the context of the project “Poisonous Plants in Grasslands”, the population biology of *Senecio aquaticus* is analysed in order to develop control measures. This presentation deals with the biology of diaspores, i. e. seed bank characters, germination rates, safe sites for germination, and its relevance for control options. Germination of fresh and buried seeds was observed in climate chambers and on permanent field plots from 2005 to 2009. Furthermore, soil samples representing 3 populations in the Waldviertel region were collected in June 2008 just before the seed set and put into petri dishes to test for germination rate. In the field *Senecio aquaticus* germinates in autumn and spring. High densities of seedlings occur at micro soil gaps formed by the decay of mother plants or by mouse activity. Such structures are quite common in grasslands with usually dense canopy. The germination rate of fresh seeds in our experiments was 56 to 93 %. After one year of burial the rate decreased to 60 %. Seeds buried for 4 years still germinated at a rate of 37 %. Therefore, we could verify a persistent seed bank at all three localities. Our results imply that *Senecio aquaticus* should be controlled from the very beginning of an invasion process. Otherwise, management measures have to be carried out for several years because of the seed longevity in the seed soil bank.

## Effects of elevated CO<sub>2</sub> on climbing and non-climbing herbaceous plants

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The rising CO<sub>2</sub>-concentration in the atmosphere affects the growth of plants. However, species may react differently to the change. It has been hypothesized that climbing plants may invest less into supporting structures than non-climbers and use elevated CO<sub>2</sub> more effectively as they may invest more resources into leaves. Thus, climbing plants are hypothesized to react more strongly to elevated CO<sub>2</sub> than non-climbers. We studied the reaction of ten climbing and ten non-climbing herbaceous species to ambient (380 ppm) and elevated CO<sub>2</sub>-concentrations (600 ppm). The climbers included twining and scrambling plants as well as plants with tendrils. The biomass, leaf mass and leaf area of climbing plants was higher than that of non-climbers. Climbing and non-climbing plants invested a similar proportion of their biomass into supporting structures (stems). Plants grown at elevated CO<sub>2</sub> generally produced more biomass, but the two functional groups reacted differently to elevated CO<sub>2</sub>. Contrary to our expectation, non-climbing plants increased their biomass, leaf mass, leaf area and the length of their shoots more strongly than climbers. Moreover, while non-climbers did not change their root:shoot ratio in response to elevated CO<sub>2</sub>, climbers strongly increased their allocation into roots. The results do not support the hypothesis that climbing plants in general invest less into supporting structures and react more strongly to elevated CO<sub>2</sub>.

## **Consistency between population trends estimated with presence-only versus abundance data**

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Assessment of extinction risk relies widely on an effective detection of population trends. Since most old records are in the form of presence-only data, population trends cannot be directly estimated by comparing former and current population sizes. Indirect evidence such as reduction of the number of locations where a species is present can be used to estimate total population reduction. Discrepancies between direct and indirect estimation of population reduction are likely and could hinder any reliable inference for a species where past abundance data lack. Therefore we will study the relationship between the percentage of location loss and the reduction of total population size by looking at 20 plant species where unusually good historical data with information on population size are available. The study species are still widespread but threatened in Switzerland. For each species, 50 locations with known former population size will be revisited. Population size will be recorded during two consecutive years in order to assess the effects of yearly variations on the estimation of population reduction. We will compare population trends estimated from abundance data (percentage of total population loss) and presence-only data (percentage of location loss). We will try to find the causes for deviations between the two estimates. This will assist determining the minimal sampling effort required to reliably assess extinction risk for species with different quality of historical data. This information will be made available for the elaboration of the next update of the Red List of Vascular Plants of Switzerland.

# **Fruits, seeds and germination characteristics of the macrophyte *Stratiotes aloides* L. in Bremen, Germany**

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The aquatic macrophyte *Stratiotes aloides* L. is an important indicator species for conservation of ditch ecosystems characterized by high biodiversity. A decline of the species in north-western Germany led to a research project on *S. aloides* funded by the Deutsche Bundesstiftung Umwelt (DBU) with the aim of testing different management methods to preserve its habitats. One hypothesis for the decline in this dioecious species assumes a connection between the observed dominance of vegetative reproduction and potential poor inter-species competition abilities due to genetic uniformity. This examination delivers data about morphology of fruits and seeds, seed production, germination and buoyancies. In the investigation area Hollerland 1300 female plants were collected and 124 fruits (83 parthenocarpic, 41 with ripe seeds) and 245 ripe seeds were found. The number of seeds per capsule varied between 0 and 23 (average 6 seeds per capsule). In laboratory experiments seed germination started 72 hours after incubation, the observed germination rate was determined with 75 %. Experiments on seed buoyancy revealed a maximum of 8 hours. Overall the results of these investigations show similarities to previous studies on *S. aloides* in the Netherlands. On the basis of this data a production of at minimum 10.000 germinable seeds in the investigation area of approximately 300 hectares can be assumed. Whether the high potential of generative reproduction can be confirmed under field conditions has to be investigated in future.

## **Mother plant identity has significant effect on plant performance independent of seed size**

**Zita Cervenkova<sup>1</sup>, Zuzana Munzbergova<sup>1,2</sup>**

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Seed weight is one of the most important factors determining offspring performance. While a lot of studies looked at the effect of seed weight on offspring performance, this effect is often combined with the effect of maternal plant. To explore this effect, we studied the effect of seed weight, maternal plant and locality on seedling performance in a perennial herb *Scorzonera hispanica* (Asteraceae). We also studied the effect of locality, mother plant, position of the flower head on the plant and position of the seed within the flower head on seed weight. Average seed weight per inflorescence differed between localities. It also depended on mother plant height and flower number and it decreased between early to late-opening flowerheads within the individual plants. Within the flower heads the outer achenes were heavier than the central ones. Seed weight affected the germination probability and seedling growth. We also observed strong effect of maternal plant on germination probability and time to germination, which, however, was not connected to plant height and or flower number. Three factors (seed weight, maternal plant identity and locality) affected significantly the seedling size in the first period of seedling growth. Overall the results indicate that the effect of maternal plant on plant growth is mediated not only by the seed size, but that other maternal properties also play an important role. These maternal effects are, however, not caused by mother plant height and or the flower number. The determinants of these maternal effects thus remain to be uncovered.



## Climate change and leaf phenology in Oak and Beech

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Since 2002, the Research Institute for Nature and Forest (INBO) records the phenological activities of a number of selected *Quercus robur* (Oak) and *Fagus Sylvaticus* (Beech) trees in different plots in two forests in Flanders, Belgium. Oak is the most sensitive to temperature fluctuations. Leaf development starts in April. Leaves develop faster when temperature in spring is higher. Leaf burst in April was about 10 days earlier in 2007 than in 2003. Leaf development was fastest in 2003 (5.8 weeks) and slowest in 2006 (9.6 weeks). Beech did not react to temperature differences during the study period. On average, development of the leaves started at the end of March and took about 11 weeks.

# **Novel Weapons Hypothesis revisited: phytotoxicity of *Heracleum mantegazzianum* in phylogenetic and invasion dynamics context**

**Petr Dostál, Jana Müllerová**

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Invasion success of some exotics was shown to be due to production of unique phytotoxic compounds that are harmful to plants from new range but not to plants from original one. Two questions of this mechanism remain however unanswered. First, what determines the chemical uniqueness of allelochemicals in new range, whether origin *per se* or rather phylogenetic isolation of colonizing species. And second, how long the advantage of such novelty persists in new range. In this project (duration 2010-2013), we want to study both questions by surveying allelopathy of exotic umbellifer *Heracleum mantegazzianum*. We want to compare composition and effects of root exudates of *H. mantegazzianum* and variably related native umbellifers. We will survey whether *H. mantegazzianum* has allelochemicals not present even in its close native relatives. Next we want to explore populations of native grasses from sites that differ in invasion history. We hypothesize that populations of grasses experiencing longer presence of *H. mantegazzianum* will be more adapted to its phytotoxic effects than populations invaded only recently.

# Quantitative genetic differences in growth and reproduction mirror phylogeography in a widespread Alpine plant

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From the perspective of preserving biodiversity, it is important to understand how historic processes affect contemporary genetic pattern in widespread plant species. Numerous studies demonstrated the impact of glacial history on molecular geographic structure in alpine plants. However, studies testing whether regional molecular differentiation at the large scale of the Alps is mirrored as well in quantitative genetic differentiation in phenotypic traits are lacking so far. Here, we studied molecular differentiation and in parallel quantitative genetic differentiation among 16 populations of the widespread Alpine plant *Geum reptans*. In a common garden experiment including 592 plants, we recorded quantitative genetic differences among regions, populations and genets. In parallel, the 128 genets used in the common garden were analysed with RAPD markers to detect a putative molecular geographic structure, to measure genetic diversity and to estimate gene flow among regions and populations. A distinct molecular differentiation splitting the Alps in three phylogeographic regions was detected indicating highly restricted gene flow particularly among regions. A strong isolation by distance indicates the importance of neutral drift during isolation in glacial refugia. In the common garden regional effects on quantitative traits concerning growth, reproduction and leaf morphology were consistently larger than differences due to populations and genotypes, thereby indicating that glacial history has also effected phenotypic differentiation. Results suggest, that besides drift, adaptation to climatic and other environmental conditions in present-day habitats maintain strong fitness related differentiation as evidenced for instance by trait variation correlated with the altitudinal origin of populations.

## Modeling the impact of non-timber forest product harvest in variable environments

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Harvesting wild plants for non-timber forest products is an important source of income, food and medicine for millions of people around the world. Over-exploitation of these plant resources may lead to species extinction and their availability for future use by people who depend on them for their livelihoods. Yet, our knowledge of the way harvesting some non-timber forest products may affect population dynamics is still limited. We used the case study of *Khaya senegalensis* (Meliaceae) foliage and bark harvest by indigenous Fulani people in Africa to demonstrate that harvesting reduces population growth rate even further when environmental conditions vary stochastically. The drivers of such effect of harvest, consistently with the previous knowledge on the dynamics of long-lived species, are mainly related to survival. However, the response of *Khaya senegalensis* to harvest and the resulting stochastic elasticity structure differ fundamentally between ecological regions. When ecological conditions are more stressful and harvesting pressure increased, increase in survival rates tended to be the only process that can ensure population persistence in variable environment. We propose that the temporal sequence of harvest intensity matters when modeling the impact of wild plant harvest and urge the use of stochastic demographic analysis in the study of NTFP harvest effect to mimic the best indigenous harvesting strategy.

# The next generation of biodiversity modeling: UIBM – the Universal Individual-Based Model

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The majority of the Central-European vascular plant diversity lies in herbaceous grassland communities. The interaction of management intensification, nutrient load and climate change factors are threatening species with extinction in those communities. UIBM shall contribute to our understanding of biodiversity responses to these threat factors. UIBM is an individual-/agent-based model with a functional–structural basis. UIBM’s functional basis consists of widely-used energy and gas exchange models and a newly-developed ageing model, which both were parametrized for a template species (False oat-grass, *Arrhenatherum elatius*) at the organ level. A layered radiation interception and turbulent transfer model scales the organ level up to the canopy level. For the structural basis a methodology was developed to construct the template species from trait minima/maxima contained in plant trait databases. The methodology, in principle, relies on universal scaling laws as well as multivariate allometry together with serial biological reasoning. UIBM is proposed to enter the next, the process-based generation of biodiversity modeling with the following basic idea behind: The modelers, who have successfully constructed one species from databases, are likely capable to construct all species, since the information is identical for all species contained in the databases. When this is done, virtual environmental and biological manipulation experiments done with UIBM will allow us to study biodiversity responses to major threat factors.

## How does genetic variation change during biological invasion? A study of *Pinus strobus*

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Many alien species show a substantial time lag between initial establishment and the appearance of strong ecological impacts. Time lags can exist for both ecological and evolutionary reasons. Basically two scenarios could be taken into account. Firstly, a time lag can result simply from the fact that a new alien species requires time to disperse into favourable habitat patches throughout the region and to build up populations capable of producing abundant offspring. Secondly, an initial population may lack evolutionary adaptations that permit explosive population growth. After some period, through genetic reorganization within a population, an evolutionary breakthrough may occur, enabling the alien to become an invasive species. We have tested abovementioned hypothesis using North American tree *Pinus strobus* invasive in the Czech Republic. We have tested the differences in population genetic composition between native and introduced populations and compared genetic diversity among invasive and non-invasive populations within the Czech Republic. The European populations of *Pinus strobus* are more likely to be derived from several regions in the native range. Further analysis of population structure indicate that intraspecific hybridization among genotypes from geographically distinct regions of the native distribution range occurred following colonization in the Czech Republic.

## Responses of range-edge populations to climate change

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Human-induced climate change is affecting the distribution of plant species and the composition of ecological communities. These effects tend to be most evident at the range margins, as species spread into previously unoccupied habitat at higher altitudes or latitudes. However, the ability of edge populations to respond to changing climate depends upon what factors limit their current distribution. Because these factors are likely to be different at the upper altitudinal and latitudinal edges of the range, the response of populations to changing conditions at these edges might also differ. Therefore comparing multiple edges offers a promising and so-far unexploited approach to understanding the factors that constrain species ranges, and predicting how they will respond to climate change. The main goal of this project is to compare the capacity of plant species for dispersal and adaptive responses to climate change at their upper altitudinal and latitudinal range edges. In a first step we will model the match between the realised niche limits of ruderal plant species along altitudinal (Swiss Alps) and latitudinal (Scandinavia) gradients, based on field survey data to be collected this summer. Subsequently we will use experimental and genetic approaches to investigate the potential for migratory and adaptive responses to climate change at these range edges for selected model species. This study will provide insight into the factors limiting the distribution of species, as well as helping to predict changes in the distribution of plant species due to climate change.

# **The Attractiveness of your neighbours: when does it matter?**

**Sven Hanoteaux, Merav Seifan, Katja Tielbörger**

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The outcome of plant-pollinator is influenced by several factors. While the effects of the density of floral resources have been intensively investigated, little is known about the effect of the spatial patterns. In a plant community, the spatial arrangement of neighbouring species affects the perception of the community pollinators are foraging in. Spatial aggregation of attractive species could deter pollinators to visit the less attractive ones whereas spatial dispersion of attractive individuals should decrease the intensity of this effect. The attractiveness of neighbouring species, its density and spatial arrangement will therefore determine the outcome of the plant-pollinator interactions. Here we present first results from a field experiment in which we tried to quantify the plant specific attractiveness by using model selection based on pollinator observations. We further more have tried to characterize the behaviour of the major pollinator groups in relation to the density of floral resources and their spatial arrangement.



## Factors determining species distribution of abandoned fields

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Semi-natural grasslands belong to habitats with highest species richness. Cessation of traditional management in many regions has led to overgrowing and ruderalization of grassland localities and many species are becoming rare and endangered. Considerable changes in agriculture after 1989 have also led to abandonment of many arable fields in the surrounding of these grasslands. Colonization of such newly opened habitats may allow grassland species to persist at the landscape level. We wanted to find out which species were able to colonize abandoned fields and what were the most important factors determining successful colonization. In the area of 60 km<sup>2</sup> in Northwest Bohemia (Czech Republic) we made an extensive survey of dry grasslands and abandoned fields. At each grassland locality and recently abandoned field (max 20 years) we recorded presence of 93 dry grassland species. Based on DEM (digital elevation model) and digital geological map, we assessed TWI (topographic wetness index), slope, incoming solar radiation, soil properties, area and isolation for each abandoned field. Then we tested, what factors (abiotic conditions, age or isolation) influenced the number of dry grassland species on the abandoned fields and their species composition. We found 59 (63%) of the dry grassland species on the abandoned fields. We also found that number of species depended much more than species composition on abiotic conditions of abandoned fields, as well as on their isolation from the surrounding grasslands. Higher number of species is associated with higher slopes and incoming solar radiation and with lower isolation of abandoned fields.

## How roots interact: unravelling the key response mechanisms belowground and their effect on community productivity

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Plant diversity has profound effects on primary production. Plant diversity has been shown to correlate with increased primary production in nutrient-limited grassland ecosystems. The mechanisms underlying this phenomenon are hotly debated, but essentially unknown. However, we do know that the answer is likely to be found belowground and that niche complementarity and/or facilitation between species are involved. A recent study on four common grassland species showed that the aboveground overyielding may start with overyielding belowground. The belowground overyielding was mainly driven by enhanced root investments of one species, *Anthoxanthum odoratum* in the densely-rooted topsoil layer without retarding the growth of the other species. We have indications that these root interactions were driven by non-nutritional, density-dependent feedback mechanisms. Soil and rhizosphere bacteria and/or root exudates may thus be important players. However, the underground network of all these factors is all but clear. Therefore, this experiment aims to investigate the role of the soil microbial community and its interaction with nutrients for the belowground overyielding in diverse grassland communities. The design of this first experiment is a classic plant-soil feedback experiment, in which soil of the different monocultures and the mixture is conditioned using a pre-phase, after which the different species are grown on all soil combinations. In order to investigate whether growth responses are due to the living microorganisms in the rhizosphere or root exudates a sterilization treatment after the pre-phase was planned. Checks for interactions with nutrients are included.

# **An introduction to the Good data-set: an excellent opportunity for analysing metapopulation collapse**

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Biological extinction is one of the major environmental concerns of our time. Understanding the drivers driving species extinction at local and regional scale is a necessary first step to halting them. Our study focuses on connectivity among populations; a prerequisite for regular gene flow. Such recurrent gene flow provides populations with the adaptability to cope with a changing environment. On the contrary, loss of part of a metapopulation could cause cascading extinctions across the remaining populations, without any apparent anthropogenic or abiotic drivers. Detecting metapopulation collapse is only possible by using long-term data-sets of multiple populations, comprising a wide range of species. Our study combines contemporary data of 160 rare and notable species, with a unique dataset of 7500 vegetation releves collected in the 1930s by Prof. Ronald Good in Dorset (UK south coast). Using GIS, we compile detailed overviews of habitat change and destruction of Dorset since the 1930s. We will separate correlated population extinctions, caused by loss of connectivity, from anthropogenic and abiotic factors, by using climatic and soil data both from existing maps and the vegetation itself (Ellenberg). Development of novel spatial statistics is a central part of the project. This framework will allow us to set the threats to biodiversity, such as anthropogenic habitat destruction, climate change and the extinction debt, in context, and suggest amelioration strategies. This poster will contain an introduction into the Good data-set, snapshots of work done on habitat change, and a rationale for analysing extinction debt.

# The effect of landscape structure on fitness of dry grassland species

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Many recent studies explored the relationships between population size and individual fitness. Each of these studies, however, deals only with a single species and has different study system. The results of such studies are hardly comparable. The aim of this study is thus to identify effects of habitat configuration on population size and fitness of a set of dry grassland species with different biological traits. We collected data on distribution of 110 dry grassland patches in the study region and on distribution of 24 plant species, varying by their traits, at these localities. For each species we estimated population size at 20 localities of different area and connectivity and the fitness of individual plants. In the field we used number of seeds per plant and their germination as a measure of fitness. Furthermore, in the experimental garden we sow the seeds from plants coming from field and record their growth. We will study the relationship between population size and isolation and plant performance for each species separately. Then we will ask, how the slope of this relationship depends on species traits related to reproduction and dispersal. The preliminary data for *Potentilla argentea*, *Hieracium pilosella* and *Veronica dillenii* show that plants from larger populations as well as larger individuals have more developed seeds per flowerhead. The slope of the relationship is steeper in *Potentilla argentea* with lighter seeds than in *Hieracium pilosella* with heavier seeds. The landscape structure and its changes can thus have strong effects on species survival and reproduction.

# Competitive performance of transgenic wheat resistant to powdery mildew

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One of the major concerns linked to the introduction of transgenic (GM) crops is their possible persistence in natural or agricultural habitats. This is particularly relevant for plants genetically modified to be resistant to pathogens. Due to possible genotype x environment interactions, the performance of GM plants should be assessed in different abiotic and biotic environments. We used a phytometer technique to study the performance of transgenic spring wheat *Triticum aestivum* expressing wheat *Pm3b* gene against the fungus powdery mildew *Blumeria graminis* f.sp. *tritici*. Seedling-phytometers of twelve lines and varieties were transplanted from the glasshouse and grown in field plots under two soil nutrient conditions in twelve wheat competitive environments. The competitive performance of four *Pm3b* transgenic lines was compared with that of four corresponding sister lines, their mother variety Bobwhite and three modern wheat varieties. The *Pm3b* transgene enhanced resistance to powdery mildew in all nutrient and competitive environments. Fertilization favoured the spread of the pathogen and increased the difference between transgenic lines and control. Being planted into twelve competitive environments, *Pm3b* lines showed weaker performance compared to corresponding control lines. This difference was observed in both nutrient treatments and exceeded the variation among three conventional wheat varieties. Among the four transgenic *Pm3b* lines, those with higher resistance to a pathogen were weaker competitors compared to the lines with lower level of resistance. Apparently, these lines have less chance to persist as volunteers in conventional wheat fields, presumably due to physiological costs of resistance that impair their performance.

## Effects of land use and species diversity on pollen dispersal in managed grasslands

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Many flowering plants depend on pollinators which disperse pollen and therefore are responsible for gene flow within and among plant populations. Plant species differ in their pollination syndrome, ranging from specialisation on few pollinators to attraction of a large variety of pollinators. The attractiveness of a plant community to pollinators depends on the identity, density and diversity of species. It has been shown that plant species richness, blossom cover or the presence of so called magnet species can lead to a facilitation in pollination. We investigate the effect of land-use type and species diversity on pollinator service and gene flow by setting up a pollination bioassay experiment where we introduced test plants in the field along a gradient of species diversity. The experimental sites were situated on managed grasslands in the Biodiversity Exploratory Hainich. We used two plant species, one with a generalised pollination syndrome (*Raphanus sativus*) and the other being rather specialised (*Lychnis flos-cuculi*). At a total of 14 sites, five clusters of three plants of each species were situated along 50 m-transects at defined distances (0, 5, 10, 25, 50m) and were freely pollinated over 8 weeks. We will assess pollinator service quantitatively as seed set and gene flow qualitatively as pollination distance. We will genotype the mother plants and their offspring in order to identify the pollen donor for the seeds, to calculate the pollen dispersal distances. First results will be presented.

# The effect of mycorrhiza suppression on species composition of experimental dry grassland community

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The role of symbiotic AM fungi in competition between plant species differing in their mycorrhizal dependency is well acknowledged. However, we lack information on the effect of AM fungi on development of more complex natural communities. To test the impact of AM fungi suppression on development of plant communities in different soil conditions, we performed a garden mesocosm experiment. In spring 2009, we sowed seeds of 54 dry grassland plant species into pots 0.5 m in diameter containing two types of native soil – either soil from abandoned field or from dry grassland. One half of the pots was treated monthly with selective fungicide benomyl. All the aboveground biomass was harvested in autumn 2009, sorted into species and weighted. Fungicide application explained 16.0 % of variability in species composition, soil origin explained 6.2 % and interaction of both factors explained 8.5 %. We also found significant differences between treatments in total aboveground biomass, species number, Shannon's D and Equitability. Response to fungicide differs between species from different families with 13 species responding positively and 25 responding negatively (16 species did not germinate). We revealed significant impact of mycorrhiza on plant species composition and on different measures of community structure. Furthermore, the application of fungicide has different effect in the two soil types. We plan to extend our study with data from second growing season, data on species traits and at the end of the experiment we will test for root colonization.

# The survival of transplants of rare *Ligularia sibirica* is enhanced by neighbouring plants

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One method to restore viability of populations of endangered plants is reinforcement (addition of individuals to existing populations). *Ligularia sibirica* (L.) Cass. is a wetland-associated species, which is endangered in Europe and has in Estonia considerably declined due to drainage leading to the overgrowth of habitats by shrubs and trees. The purpose of this work was to assess the effectivity of reinforcement of degraded populations of *Ligularia* and to estimate the extent of the impact of a) habitat change due to overgrowing, and b) competition by neighbouring plants, on the survival of transplants. The transplants grown from seeds in laboratory were planted into four populations of their origin to 0,25 m<sup>2</sup> plots arranged in two (vegetation unmanipulated or removed) × two (open habitat or overgrown habitat) factorial experimental design and their survival was followed for two years (visited twice per year). The survival differed notably between populations, but on average the percentage of survived plants per plot was higher in plots with intact vegetation and in open habitats. The latter indicates that overgrowing indeed decreases the habitat quality for *Ligularia*. The lower survival in plots where vegetation had been removed can largely be explained with increased damage by animals whereas in unmanipulated plots neighbouring plants provide shelter and protection. Our results stress the importance of restoration of habitat quality for preservation of this rare plant species and show that if necessary the population size of *Ligularia* can relatively easily be increased with supplementation of new individuals.



# Root-sprouting of diploid and tetraploid populations of *Knautia arvensis* (L.) (Dipsacaceae)

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*Knautia arvensis* (L.) is a perennial herb inhabiting dry and mesophilous, often human-influenced grassland, shrub lands, forest and field margins, road embankments etc. The species is widely distributed throughout Europe and its two ploidy levels are often classified as separate subspecies – diploid subsp. *pannonica* (Heuff.) and tetraploid subsp. *arvensis*. Even though the subspecies show parapatric distributions, a few diploid populations were found in areas otherwise occupied by tetraploids. These diploid populations inhabit relict habitats of serpentine outcrops (subsp. *serpentinicola*) or subalpine glacial cirques (subsp. *pseudolongifolia*). Mixed populations of diploids and tetraploids both in natural and semi-ruderal sites were also found. Spatial and semi-natural/semi-ruderal preference segregation of cytotypes indicates difference in ecological traits between the cytotypes. *Knautia arvensis* is known as a root-sprouter, i.e. species regenerating from roots after severe injury. This ability is relatively rare among plants however it is a crucial trait for survival of plants in disturbed habitats. The ability of root-sprouting is known to be affected by nutrition level and disturbance. Semi-natural vs. semi-ruderal areas are notable contrast in nutrient conditions as well as disturbance regime. Therefore in the presented running greenhouse experiment, we test the effect of artificial injury and nutrient level on regeneration of plants from 7 tetraploid, 4 diploid and one mixed population of *Knautia arvensis*. Obtained results on ecological difference of cytotypes will enlarge information on root-sprouting in general and also will contribute to our knowledge on species trait evolution within polyploid complexes.

## ***Ex situ* transplant experiment of *Arnica montana* populations at high and low altitudes**

**Tiphaine Maurice<sup>1,2</sup>, Guy Colling<sup>2</sup>, Serge Muller<sup>1</sup>, Diethart Matthies<sup>3</sup>**

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In order to study local adaptation within the framework of climatic warming scenarios, we conducted a common garden study with *Arnica montana* as a model species. We selected 21 populations both in lowland (Ardennes in Belgium, Eifel in Germany, altitude 500 m) and in mountain regions (Vosges in France, 1200 m). In each population, seeds from 20 randomly chosen mother plants were collected and the offspring was partitioned between the Haut-Chitelet garden in the Vosges Mountains (1215 m above sea level) and the University garden in Metz (150 m above sea level). During two years, we measured the number of leaves, the length of the longest leaf, the number of rosettes, and the width and length of each plant. Our first results indicate that altitude and climatic conditions of the two gardens had a significant influence on the growth of *A. montana*. Generally, plant growth was lower in the high altitude garden. However, we found that individuals from lowland populations produced significantly more leaves and rosettes than those from mountain populations, indicating genetic differentiation between the two habitats. The smaller size of mountain plants could be an adaptation to the harsher climatic conditions in mountain areas. Descendants of different families (half-sibs) differed in their growth depending on the garden into which they had been planted (significant family by garden interaction), indicating that genetic differences between families were considerable. Genetic differences between families within populations may be important for the ability of *A. montana* populations to respond to predicted environmental changes.

## **Monitoring the effect of grazing on vegetation of dry grasslands**

**Hana Mayerova<sup>1</sup>, Katerina Cihakova<sup>1</sup>, Zuzana Münzbergova<sup>1,2</sup>**

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The aim of this project is to describe the effect of grazing on communities of dry grasslands, which are endangered by expansion of mesophilous grass species and shrubs. Grazing management has been implemented in 2005 and 2006 at three sites. To understand the influence of grazing regime on vegetation, we observe the changes in vegetation composition on grazed and ungrazed plots over time. We perform vegetation surveys on permanent plots each spring before the grazing period. First significant effects of grazing were detected just in 2008, i.e. 4 years after introduction of the grazing regime. In the analyses of 2009, detected effects changed noticeably; its effect differs on different sites, on different vegetation types and in different years. Part of these differences is caused by different timing of grazing. Our results show that the implemented management influences dry grasslands only slowly. This stresses the need for long-term observations. We conclude that it is essential to graze the sites before the blooming of the expanding grasses but after the blooming of endangered species. We also demonstrate that species with different response to grazing differ in their traits.

## **Larger seed size consistently provides higher life-time survival for annual species across a steep aridity gradient**

**Johannes Metz, Katja Tielbörger**

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Seed size strongly influences plant fecundity due to the trade-off between seed size and seed number. Life-history theory assumes that numerical advantages of producing small seeds are offset by lower subsequent seedling survival. However, it is uncertain whether such survival advantages of large-seeded species can be maintained up until reproduction. Furthermore, it remains virtually unknown if seed size – survival relationships are modified by environmental variation in space and time and by contrasting plant functional groups. We investigated survival rates under natural conditions in 3 sites along a steep rainfall gradient. During seven years, we monitored 49 annual species from established seedlings to reproductive plants and related their survival rates to seed size, site along the gradient (semi-arid, Mediterranean, mesic-Mediterranean), and functional group (grass, legume, forbs). Large-seeded species had higher survival rates, indicating that larger seed size provides survival advantages beyond seedling establishment. Larger seed size also reduced between-year variation in survival rates and thus provided a bet-hedging strategy in temporally unpredictable environments. Interestingly, along the rainfall gradient we detected no difference in the seed size–survival relationships, but variation between years was lower in more benign sites. Legumes showed lower survival and higher between-year variation than grasses, what may partly result from their disparity in seed dormancy. Our findings indicate that current life-history theory needs refining by accounting for both benefits of larger seed size, higher survival rates and bet-hedging. Moreover, inclusion of environmental gradients is crucial to examine patterns of plant traits and plant performance under changing environmental conditions.

## The intelligent plant: paradox or ecological reality?

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Behaviour is traditionally attributed to animals only. Recently, evidence for plant behaviour is accumulating, mostly from plant physiological studies. Our aim was to provide ecological evidence for plant behaviour and, more specifically, for the ability to evaluate costs and benefits and make corresponding decisions in plants. To this end, we analysed seed abortion patterns of *Berberis vulgaris* plants including parasite-host-interactions and environmental stress. We statistically tested a series of null-models with Monte-Carlo simulations to establish selectivity and adaptivity of the observed seed abortion patterns. Seed abortion in stressed or parasitized fruits occurred with significantly greater probability if there was a second intact seed in the fruit. None of the existing alternative explanations for seed abortion did pass the statistical test against the observed seed abortion patterns. Seed abortion in barberry plants was found to be selective with respect to outer conditions such as parasitism or drought stress, but also adaptive to inner conditions. We provide ecological evidence for the ability of plants to make complex cost-benefit evaluations and corresponding abortion decisions. Costs were invoked by abortion, seed predation or drought mortality and benefits by saving resources invested in the second seed or in the fruit coat. This adaptive selective behaviour contains the major ingredients of intelligent behaviour: structural memory (the second seed), simple reasoning and cost-benefit analysis (integration of inner and outer conditions), decision-making (abortion), and predictive evaluation of future fitness loss.

# **Population density effects on growth traits and reproduction of *Ambrosia artemisiifolia* L.**

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*Ambrosia artemisiifolia* (Common Ragweed) is an invasive neophyte with highly allergenic pollen. It is an annual Asteraceae, which can produce up to 60 000 seeds/individual. The knowledge about the morphological and reproductive traits under different management treatments is essential for the development of efficient sustainable management strategies, such as mowing. Population density and the cutting regime can have an influence on growth traits as well as on the reproductive success of this species what is relevant on intensively managed roadsides. Under glasshouse conditions we investigated architectural characteristics and reproductive success of ragweed plants grown for 12 weeks after sowing under high versus low density. Eight cutting treatments have been applied to both high and low density grown groups. Biometrical measurements (i.e. height of the first and second node, total plant height, number of lateral shoots below the cutting height, number of male inflorescences, number of female flowers) and phenological observations were done on five terms during the vegetation period, one before each cutting term and one at the end of the vegetation period. We found population density effect for most vegetative traits, whereas the cutting regime influenced reproductive traits. Plants originating from low density populations had higher plant height, lower 2nd node height, higher number of nodes under the cutting height and higher number of lateral shoots of 1st order. These results suggest that plants growing in low density populations have dense follow-up of main axis nodes, which allow them a higher resprouting ability after the cutting management is applied.

## Collecting demographic data using high precision GPS in *Anacamptis pyramidalis*: a new method

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We studied the demography of six populations of *Anacamptis pyramidalis* (Orchidaceae) in former open pit mines in the south of Luxembourg. To collect demographic data at the individual plant level, we used an innovative method with a high precision GPS (RX1250 Smart Rover, Leica ®). In spring 2007, we first tagged individual plants with yellow plastic tabs in permanently marked circular patches with a diameter of 6 m. In a second step, precise GPS spatial references were recorded of each individual plant with a precision of 1 cm. For each individual plant we also recorded plant height, inflorescence length and the number of leaves. All measurements were repeated in 2008 and 2009 in each patch. The raw data set was analyzed with a GIS program (Arc View 3.3.). The graphical overlay of all three datasets allowed us to follow the fate of individual plants and identify newly established plants in 2008 and 2009. The data were used to construct a series of demographic transitions matrices and to compare the population structure in each growing season.

## **Genetic variation in natural *Solanum dulcamara* populations from flooded and dry habitats in the Netherlands**

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*Solanum dulcamara* (bittersweet) is one of the few native species of *Solanum* present in Europe and is closely related to important crop species such as potato and tomato. It is a common weed that can tolerate a wide range of habitats from continuously flooded to very dry. This study is part of a larger project investigating the underlying mechanisms enabling *S. dulcamara* to cope with the wide moisture gradient (see accompanying poster by van Kessel *et al.*). Six *S. dulcamara* populations were collected from four geographical locations in the Netherlands. Three populations were collected from continuously flooded sites while the others occupied dry habitats. In two of the four locations a population pair differing in moisture conditions was sampled. The work presented in this poster aims to determine whether populations show molecular differentiation among locations and habitats. The genetic diversity was assessed by using amplified fragment length polymorphisms (AFLP) markers. Based on an analysis of molecular variance (AMOVA), 76% of the genetic variation was within populations and 24% among populations. Principal coordinate analysis and UPGMA clustering showed four major clusters corresponding to the four collection locations. No clustering of dry versus flooded populations was observed. Also the two locations that contained both flooded and dry habitats seem to lack molecular differentiation between the habitats. This may be the result of high gene flow due to *e.g.* bird dispersal of the seeds.



## Effect of arbuscular mycorrhizal fungi (AMF) on plant establishment on abandoned fields

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The economic changes in the last 20 years led to abandonment of agricultural fields in many areas. These habitats are now undergoing secondary succession, which leads to plant communities with lower plant diversity than on neighbouring grassland. Many projects thus try to modify the course of secondary succession by sowing the target endangered species to the former fields, but many of these species are not able to grow there. In this study we tested the hypothesis that the limited ability of many plant species to grow on abandoned fields is caused by changes in AMF communities in the soil. To test this hypothesis we performed field and common garden experiment. To establish common garden experiment we sowed 51 plant grassland species into 40 litres pots filled with dry grassland soil. In the field we marked twenty 1x1 plots. On half of the pots in the field and in the common garden we applied selective fungicide every month. We measured vegetation composition and amount of AMF propagules in the soil. Our results shows that number of AMF in the soil significantly decreased after fungicide application and this change significantly affected vegetation composition in both experiments. The abundance of many forbs such as *Linum* sp., *Prunella grandiflora*, *Knautia arvensis* strongly decreased after fungicide application. In contrary, graminoids such as *Carex* sp., increased their abundance. These results therefore suggest that absence of many rare forbs species from the abandoned fields could be caused by changes in AMF communities in the soil.

# Population dynamics and harvesting techniques of Himalayan Rhubarb species from Nepal

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Himalayan rhubarb species are widely used in herbal medicines in Nepal. Plant populations face harvesting pressure and are under threat. The demography of two highly threatened Himalayan perennial Rhubarb species (*Rheum acuminatum* and *Rheum australe*) is studied to know the life cycle and effects of harvesting on population dynamics of populations from different habitat types in central part of Nepal. Population growth rate ( $\lambda$ ) is significantly higher than 1 in all populations of both species. According to stable stage distribution, the majority of populations of both species should be formed seedlings with very low proportion of flowering plants. The reproduction of plant takes place after 4-5 years. The mortality of adult individual is very low compared to mortality of small plant individuals. Populations of both species have, however, high probability of extinction if the plants are harvested for medicinal purposes. These species are thus expected to face decline if the current harvesting techniques are not changed. In our project we thus aim at developing proper harvesting techniques for management of the species to stop the decline of the populations in the nature.

## Seed production of *Helosciadium (Apium) repens* in Belgian populations

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*Helosciadium (Apium) repens* (Apiaceae) is a rare plant throughout its restricted, mainly European distribution range, and is listed in annexes II and IV of the European Habitats Directive. This small creeping species reproduces both sexually and clonally by aerial stolons. For a conservation biology research project on this species, demographic monitoring was effected in the four most stable Belgian populations from 2003 to 2007. Among other features, the seed production was measured monthly during the growth season in permanent plots. Seeds were found from June to October, with a peak in August each year. The total number of seeds counted per year fluctuated markedly. Seed productivity was expressed as number of seeds per m<sup>2</sup> and compared between populations and between years. There were large differences both between populations and between years. The trend of seed productivity differed completely between populations, apparently reflecting the overall condition of each population. Indeed, during the course of this study, some populations have decreased dramatically and have nearly disappeared while other remained more or less stable or have increased, probably as a result of management. Seed production was also expressed as annual production per vegetative ramet for each permanent plot. This reveals a marked difference between plots according to their location. Finally, the average number of seeds per inflorescence (umbel) was computed for each year and population.

## **A 120-year battle between Apomixis and Sexuality**

**Christian Sailer<sup>1</sup>, Jürg Stöcklin<sup>2</sup>, Ueli Grossniklaus<sup>1</sup>**

*<sup>1</sup>University of Zürich, Switzerland; <sup>2</sup>University of Basel, Switzerland*

Apomixis, the clonal propagation through seed, has a tremendous potential in plant breeding but it can also be used as a surrogate for a trait of a genetically modified (GM) plant (“GM-trait”) for the following reasons: first, apomixis and GM traits are dominant; second, both traits confer conditional advantages; third, both traits can outcross via pollen. To address the mid- to long-term dynamics of apomixis/GM trait spread, we perform an observational field study at the Morteratsch proglacial area. We monitor the facultative apomictic species *Hieracium pilosella* L., which occurs in the proglacial area from 152 years to about 30 years of de-glaciation. Distinct apomictic clones of *H. pilosella* are expected to differ in their degree of apomixis, i.e. the percentage of residual sexuality. We expect that the occurrence of distinct clones varies along the proglacial succession, allowing us to investigate the relationship between the establishment of a clone and the degree of apomixis over time. I collected leaf and seed samples from several plants of randomly chosen populations. They are genotyped to determine distinct apomictic clones using AFLP markers. The degree of apomixis is determined using a Flow Cytometric Seed Screen. The distribution of distinct clones with different levels of apomixis along the proglacial succession will be analysed. From this data we can draw conclusions about how the degree of apomixis influences mid- and long-term success of an apomictic clone and allows extrapolations about the possible spread and establishment of GM plants in an ecosystem.

# Projecting plant population dynamics under climate change – a matrix modelling approach

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A warming of the Earth's climate system since 1750 due to human activities is unequivocal, but its effects on biological systems are still not well understood. Species responses to climate change are modelled mostly with the so called 'climate envelope', a type of ecological niche-distribution model which assumes that species distribution is mainly determined by climatic factors. The major weakness of these models is their poor performance with respect to dispersal, biotic interactions and population dynamics. Model predictions are thus afflicted with large uncertainties. Matrix population models are a powerful tool that can explicitly address population dynamics and aspects of life history in relation to environmental conditions. They can help us not only to improve forecasting species reaction to climate change but also generate a greater understanding of the ultimate causes of this reaction. Understanding can further be improved by studying species that grow in the 'natural laboratories' of climatic gradients. Based on a 8-year-record of demographic data collected in four field sites situated along a steep climatic gradient in the Eastern Mediterranean, we construct matrix population models to explore the population dynamics of annual plant species. Relating species' vital rates to environmental (climatic and biotic) conditions enables us to project population dynamics under predicted future climates.

## **Ecological and genetical factors promoting population differentiation in *Narcissus papyraceus***

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*Narcissus papyraceus* is a widely polymorphic geophyte common in Northern Africa and Southern Iberian Peninsula, an area divided by the Strait of Gibraltar. The most remarkable polymorphism affects style length, which is bimodal within populations, although perianth traits are also variable. It shows a geographical pattern which could be related either to ecological or genetic factors. Pollinator fauna and demographic characteristics are considered as ecological factors. Among the genetic ones founder events, drift, gene flow and mating system could be of importance. To ascertain the role of these factors, data on ecological features and genetic diversity are being compiled for about thirty populations. To complete the comprehension of factors implied, further studies on pollinator efficiency and breeding systems will be conducted. We expect that our data will throw light on the origin and maintenance of style polymorphism, an issue which has long interested to plant population biologists since Darwin's time, and other flower traits.

## New microsatellite primers and population genetic diversity in three *Rhinanthus* species

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The study of genetic diversity is essential for revealing, evaluating and maintaining the local and global biodiversity. Since both taxonomic and genetic diversity are highly dependent on reproductive and dispersal mode, it is expected that these aspects of diversity may be related to each other. Genus *Rhinanthus* (Orobanchaceae) consists of approximately 26 species, mainly of European distribution. Out of these 26 species, eight are presumably endemic. *Rhinanthus* species are natural components of species-rich grasslands and well-known for their high morphological variability. We used six new polymorphic microsatellite loci to investigate genetic diversity and differentiation in three species: *Rhinanthus osiliensis*, *R. rumelicus* and *R. minor*. Observed genetic diversity was expectedly the lowest in rare and endemic *R. osiliensis* populations ( $H_o = 0.13$ ) compared to widespread *R. rumelicus* ( $H_o = 0.19$ ) and *R. minor* ( $H_o = 0.26$ ). Positive fixation index of *R. osiliensis* and *R. rumelicus* ( $F_{is} = 0.30$  and  $F_{is} = 0.14$ , respectively) indicates the predominant self-fertilization but, outcrossing breeding mode in *R. minor* ( $F_{is} = -0.32$ ). *Rhinanthus minor* is remarkably differentiated from *R. osiliensis* and *R. rumelicus* ( $F_{st} > 0.66$ ). Microsatellites detected low genetic differentiation between closely related *R. osiliensis* and *R. rumelicus* ( $F_{st} = 0.13$ ). The analysis of molecular variance (AMOVA) revealed that 26% of the genetic diversity was explained by differentiation among three species. According to our results we suggest that *R. minor* is a well differentiated species, while *R. rumelicus* and *R. osiliensis* seem to be the closest congeners in phylogenetic perspective.

# Disentangling the role of biotic interactions for local adaptation

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Plant species capacity to persist under rapidly changing environments greatly depends on the degree of local adaptation to the current environment and potential pre-adaptation to future conditions. Two major classes of 'ecological filters', abiotic stress and biotic interactions, with neighbours and soil community, constrain the performance of plants and interact in determining local adaptation. These filters may be inversely correlated along a climatic-environmental gradient with competition being more important at the more productive end of environmental gradients and facilitation at stressful one. While local adaptation to abiotic factors has been studied intensively, the role of biotic interactions has been largely ignored. In particular, above-ground interactions have received some attention, relatively little work was done on below-ground interactions (mainly mycorrhizal symbioses, influence of nematodes and soil pathogens). The aim of the current project is to understand the relative importance of abiotic factors (climate) and below- and above ground interactions in determining local adaptation and potential plant response to climate change. A reciprocal sowing experiment along a steep climatic gradient in Israel will be combined with soil community and neighbour interactions to test the following hypotheses: 1) relative to above-ground interactions, the importance of below-ground interactions for plant performance increases with increasing aridity, 2) adaptation to stress is more important at the arid end, 3) local adaptation to positive plant-soil interactions adds to adaptation to climate but may be buffered by negative plant-soil interactions.



# How altitude and pollination intensity effect flower longevity in six alpine flowering plant species

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Flower longevity is a trait, optimized to balance reproductive success against flower maintenance costs, with shorter flower longevity when pollination and maintenance costs are high, and vice versa. A strong negative correlation of flower longevity with pollination success has been demonstrated. Supporting expectations, comparative studies found increased flower longevity at high altitudes where abundance and activity of pollinators is lower. So far, few studies investigated flower longevity in response to pollination intensity and comparing lowland and alpine populations of the same species. Here we hypothesized, (1) that flower longevity is generally increased at high altitude, and (b) that the increase in flower longevity is higher at altitudes when pollination is excluded. 2009 we studied flower longevity of six alpine species under three pollination intensity treatments (hand-pollination, natural pollination, pollinator exclusion) at 1600 versus 2600 m a.s.l. at the Furka Pass, Central Swiss Alps. Hand-pollination did not decrease flower longevity in any study populations indicating high levels of natural pollinations at both sites. Flower longevity was not generally increased at high altitude. But pollinator exclusion increased flower longevity in only three species at low altitude but in all six species at the high altitude site. These results indicate a higher plasticity in flower longevity in alpine populations that probably evolved to cope with the more unpredictable pollination in the cold: Increased flower longevity compensates for low pollination during unsuitable conditions for pollinators thereby guarantying a minimum reproduction, whereas a rapid flower senescence after pollination saves redundant floral costs when conditions are suitable.

## **Polymer tensiometers: a new instrument for investigating plant water uptake in dry and saline soils**

**Martine van der Ploeg**<sup>1</sup>, Harm Gooren<sup>1</sup>, Gerben Bakker<sup>2</sup>, Walter Russell<sup>3</sup>, Cornelis Hoogendam<sup>1</sup>, Cindy Huiskes<sup>4</sup>, Peter Shouse<sup>3</sup>, and Gerrit de Rooij<sup>5</sup>

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The distribution of vegetation in semi-arid and arid regions is ultimately tied to the soil water and salinity status. The plant physiology of such vegetation has been investigated thoroughly, but the relation with in situ soil properties (soil moisture and salinity) may be more difficult to unravel as soil moisture sensors are less sensitive in dry soil, and the signal of most soil moisture content sensors is strongly attenuated by soil salinity. Recently, polymer tensiometers were developed that are able to measure matric potentials (closely related to a soil's moisture status) in dry soils. Polymer tensiometers consist of a solid ceramic, a stainless steel cup and a pressure transducer. The ceramic consists of a support layer and a membrane with 2 nm pore-size to prevent polymer leakage. Between the ceramic membrane and the pressure transducer a tiny chamber is located, which contains the polymer solution. The polymer's osmotic potential strongly reduces the total water potential inside the polymer tensiometer, which causes build-up of osmotic pressure. Polymer tensiometers would thus be an ideal instrument to measure in dry soil, if the polymer inside the tensiometer is not affected by the salts in the soil solution. We will address some key issues regarding the use of POTs in saline environments by showing results from a field experiment conducted in a very saline soil.

## Do populations of *Solanum dulcamara* differentiate in response to contrasting environments?

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The perennial species *Solanum dulcamara* is characterized by a wide ecological amplitude as it can occur in continuously wet habitats as well as in dry dune areas. The Institute of Water and Wetland Research of the Radboud University Nijmegen has recently started an interdisciplinary project investigating the underlying mechanisms and developmental patterns enabling *S.dulcamara* to span the wide moisture gradient. The objective of the study presented in this poster was to determine which morphological characteristics play a crucial role in the adaptation of *S. dulcamara* to different moisture availabilities. Following specific questions were addressed: Are seedlings originating from populations at the extreme ends of the moisture gradient capable of adapting to a range of water availabilities? Do the conditions experienced at early developmental stages influence the response to conditions encountered at later developmental stages? To test whether conditions experienced at early developmental stages modulate the plastic responses to subsequent environmental cues, seedlings were transferred to contrasting environmental conditions after having been subjected to either dry, control or waterlogged conditions for three weeks. Traits associated with plastic adaptation to different water conditions (e.g. allocation to roots, root porosity) as well as subsequent consequences for growth and performance was measured. Ultimately, this study will not only look at the morphological adaptations. The collaboration with scientists in the field of genetics (see accompanying poster by Ouyang *et al*) will enable the comparison between the molecular pattern of different populations, and the morphological adaptations of environmental characteristics experienced at different evolutionary time scales.

## Disentangling drivers of parasitoid foraging behaviour in structured plant communities

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In lab experiments, parasitoids have been shown to use volatiles from the host, from the host plant and from the microhabitat to locate hosts. In the field, parasitoids also respond to host density, while the structure and diversity of a plant community can physically affect parasitoid movement by concealing host plants, or by obscuring chemical cues used for host location. Due to the difficulty of disentangling these factors in the field, we developed a spatially explicit pattern-oriented simulation model to investigate the influence of host density, patch size, volatile emission, and habitat complexity on the foraging behaviour of female and male parasitoids. The model is based on two release-recapture field experiments with the tritrophic system *Brassica nigra*, *Pieris brassicae*, and *Cotesia glomerata*. In the first field experiment plant patch size was manipulated, and in the second experiment host density and habitat complexity varied. The central model parameter is parasitoid searching efficiency, which is influenced by the source of chemical cues, experience, the strength of attraction, wind and flying speed, and habitat structure. The model will be used to determine the relative importance of attraction by volatiles as compared to other biotic and abiotic factors under field conditions. Preliminary simulations indicate that attraction is crucial to explain the observed patterns.

## Range expansion of *Ceratocarpus claviculata*: habitat quality and species composition in the native and the invaded range

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The short-lived forest species *Ceratocarpus claviculata* showed a recent increase in frequency within its native range and a range expansion into sub-continental and north-temperate regions. In order to evaluate factors for the distribution and present range expansion we addressed the following objectives: (i) to test whether abundance of *C. claviculata*, community composition and habitat quality varied between the native and the invaded range and (ii) during the past decades within the old range. We used information from the Dutch National Vegetation Database to obtain old (before 1970) and new (after 1990) vegetation relevés from mixed oak forests of the original range and own vegetation surveys from three regions of which one was situated in the old (NW-Germany) and two situated in the invaded range (NE-Germany and Sweden). (i) A comparison of old and new relevés revealed significant differences between the two groups due to a decrease of species diversity and an increase of nutrient indicators, neophytic and hemerobic species in new relevés. However, abundance of *C. claviculata* decreased between the time periods considered. (ii) Floristic differences were larger between the two regions of the new range than between old and new range sites and there was only a tendency for a higher cover of *C. claviculata* in the invaded range. A generalizable difference between native and invaded range might be a larger human impact indicated by higher proportions of neophytic (NE-Germany) and hemerobic species (NE-Germany, Sweden) or a higher degree of disturbance through forestry (Sweden).

# Cost of root foraging and sexual reproduction during genotypic selection in *Potentilla reptans*

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Trade-offs among life functions that contribute to fitness is a central concept of life history theory. We tested the hypotheses that root foraging ability in heterogeneity is at the cost of fitness manifested in homogeneity, and that the sexual reproduction is at the expense of clonal growth during long-term genotypic selection in natural habitats. We subjected the ramet pairs of 22 different genotypes of *Potentilla reptans* to Null, Low and High contrasted adjacent patches in terms of nutrient availability, and at harvest we counted the number of primary stolons, offspring ramets and flowers, and measured the dry weight of original ramets, stolons and roots produced by each ramet. Our results revealed that root foraging response was independent of genotypes, but linearly and positively correlated to patch contrast. Overall root-shoot ratio of the whole ramet pair was higher while the total biomass became lower under higher patch contrast, suggesting current cost of root foraging. We failed to detect the hypothesized trade-off between root foraging ability manifested in heterogeneity and performance expressed in homogeneity among genotypes, due to the likelihood that genotypes burdened by high costs of plasticity have been purged from natural populations by natural selection. However, we did find the trade-off between number of flowers and aboveground or total biomass produced by a ramet pair among genotypes. Moreover, such trade-off was found to be stronger under High patch contrast than under Null and Low patch contrasts, suggesting that pattern of heterogeneity has effects on sexual-clonal trade-off.

## Development of a simulation model describing water qualities of a ditch ecosystem

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The aim of the development of the "ditchsimulator" is to provide a basis for a complex model of a ditch ecosystem, which describes the development and changes of different components and their concentration in the ecosystem. For this reason an eutrophication model with a simplified foodchain was developed, which includes the waterbody, phosphorus as an example for a nutrient cycle and the development of biomass represented by phyto- and zooplankton. To estimate the quantities of the state variables and model parameter, data was taken from the research project "Trail of management methods for preservation of the water soldier (*Stratiotes aloides* L. in Bremen, Germany" which is financed by the Deutsche Bundesstiftung Umwelt (DBU). The data was taken from the nature reserve *Westliches Hollerland*. The simulation model was developed in FORTRAN using the modelling environment eStIM, developed at the Hochschule Bremen. This first version of the model describes basic processes and is designed for further extensions. The model is designed to describe the time course of important state variable within defined connected sections of a ditch which are simulated simultaneously. Simulation scenarios show, that the "ditchsimulator" is able to describes states like the change of the waterbody in a satisfying way. However, more complex elements, like the phosphorus-cycle need enhancement and further study of the processes in the system. A first step in the development of the "ditchsimulator" as a complex model of a ditch ecosystem is made and shall be further developed in future works.

## Possible effects of sediment pore water qualities on *Stratiotes aloides* L. in Bremen, Germany

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The aquatic macrophyte, *Stratiotes aloides* L., is regarded as a key species for ditch ecosystems characterized by high biodiversity and an important indicator for conservation of these systems. In the past, a decline of the species in north-western Germany was observed. This led to a research project on *S. aloides* funded by the Deutsche Bundesstiftung Umwelt (DBU) with the aim of testing different management methods to preserve its habitats. In the investigation sites Hollerland and Werderland the *Stratiotes* populations are largely vital whereas a strong decline was observed in the Niedervieland. The results of the pore water analyses in winter 2009 revealed significant site-specific differences in some critical parameters for the vitality of *Stratiotes* (ammonium, sulphide, phosphate and alkalinity). In Niedervieland the mean ammonium concentrations (541  $\mu\text{mol/L}$ ) were about four times higher, the orthophosphate concentrations (126  $\mu\text{mol/L}$ ) about 14 times higher and the alkalinity (8499  $\mu\text{mol HCO}_3^- / \text{L}$ ) twice as high as in the other two research sites Hollerland and Werderland. The average sulphide concentrations ranged from 1  $\mu\text{mol/L}$  (Hollerland) to 4  $\mu\text{mol/L}$  (Werderland) and 7  $\mu\text{mol/L}$  (Niedervieland). Water and pore water qualities were shown to be involved in the decline of *Stratiotes* in the Netherlands (“multiple environmental stress hypothesis”). Some of these mechanisms (ammonium toxicity, eutrophication due to high phosphate concentrations and high alkalinity) may as well be important factors for the decline of *Stratiotes* in the research site Niedervieland in Bremen, since this site showed the highest concentrations for all parameters.



# Testing the ecological and evolutionary relevance of heritable epigenetic variation: a project outline

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Most plants exhibit significant intraspecific variation in ecologically relevant traits. This intraspecific variation is not only the raw material for plant adaptation and evolution in response to environmental change, it is also an important component of biodiversity, with consequences for ecological interactions and ecosystem processes. Usually intraspecific variation is assumed to result from underlying genetic variation, i.e. differences in DNA sequence. However, we now know that intraspecific variation can also be caused by heritable variation in epigenetic modifications of the genome, such as DNA methylation. We have recently started a project to investigate the ecological and evolutionary relevance of such heritable epigenetic variation. We use a set of several hundred epigenetic recombinant inbred lines (epiRILs) of *Arabidopsis thaliana*, which are genetically identical but significantly differ in their heritable patterns of DNA methylation, to address the following hypotheses: (1) epigenetic variation causes significant variation in ecologically important plant traits, (2) epigenetic diversity influences ecosystem-level processes, (3) epigenetic variation can serve as raw material for rapid microevolution in response to environmental change. Here, we outline the experimental set-ups and statistical approaches that we will use to address each of these hypotheses.

## The role of dew on *Bassia dasyphylla* plants growing in the desert area of China

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Dew is the condensation of atmospheric moisture on objects that have radiated sufficient heat during the day to lower their temperatures below the dew-point temperature of the surrounding air. Although rainfall is the most important contribution to overall plant water status, especially in arid zones, the importance of dew on the survivability of plants also needs to be taken into consideration. This additional moisture source can become significant both during drought conditions and in summer, when the amount of moisture in the soil declines. Dew has also been identified as an important source of moisture for the primary food chain in arid regions. The effects of dew on the water status and photosynthetic capacity of *Bassia dasyphylla* grown in the desert area of Hexi (northwest of China) were measured. Pot-grown *Bassia dasyphylla* seedlings were subjected to contrasting watering regimes (normal and deficient) and two dew regimes (dew-prevented and dew-present). Dew significantly promoted shoot relative water content and biomass in both water regimes, and increased diurnal shoot water potential and stomatal conductance before 10:00 a.m., as well as photosynthetic rate, which reached its maximum under the water-stressed regime. The absence of dew did improve the biomass of yellow leaves in the water-stressed regime. Dew promoted aboveground growth and photosynthetic accumulation in leaves, and decreased the root-to-shoot ratio in both water regimes. Dew may have an important role in improving plant water status, especially in plants exposed to prolonged drought. These results also support the hypothesis that the contribution of dew to plants exposed to prolonged drought may be critical.



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