# Netherlands Annual Ecology Meeting

**7 & 8 February 2012**

**Congrescentrum De Werelt, Lunteren**

# *Handout*

# Programme

## Tuesday 7 February

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| | **Main Entrance Hall** | | | |
| **8:30** | Registration and coffee in the Lounge and setting up posters | | | |
| | **Europe Hall** | | | |
| **10:15** | **Word of Welcome**<br>• Hans de Kroon (Chair of the Meeting, Radboud University Nijmegen)<br>• Jaap van der Meer (Chair organising committee, Royal Netherlands Institute for Sea Research) | | | |
| | **Plenary 1: The reciprocity of ecological and evolutionary dynamics** | | | |
| **10:30** | 1. **Eco-evolutionary dynamics: a conceptual framework** (Andrew Hendry, McGill University, Montréal) | | | |
| **11.15** | 2. **Evolving meta-communities: a race between adaptation and immigration** (Luc de Meester, KU Leuven) | | | |
| **12:00** | Lunch in the restaurant | | | |
| | **Europe Hall** | **America Hall** | **Asia Hall** | **Africa Hall** |
| **13:30** | **Parallel 1a:**<br>**Biodiversity and Conservation** | **Parallel 1b:**<br>**Experimental evolution** | **Parallel 1c:**<br>**Plant Eco-physiology – special focus: Intraspecific variation of plant traits** | **Parallel 1d:**<br>**Behavioural Ecology: Individual variation in animal behaviour** |
| | *Conveners*:<br>1. Roel van Klink (University of Groningen)<br>2. Toos van Noordwijk (Radboud University Nijmegen / Bargerveen Foundation) | *Conveners*:<br>1. Bart Pannebakker (Wageningen University)<br>2. Arjan de Visser (Wageningen University) | *Conveners*:<br>1. Eric Visser (Radboud University Nijmegen)<br>2. Phlippine Vergeer (Radboud University Nijmegen) | *Conveners*:<br>1. Kees van Oers (Netherlands Institute of Ecology)<br>2. Raymond Klaassen (Werkgroep Grauwe Kiekendief / University of Groningen) |
| **13:30** | Biodiversity research in space and time.<br>(Roel van Klink, University of Groningen) & Toos van Noordwijk, Bargerveen Foundation / Radboud University Nijmegen) | Laboratory evolution—for lack of a time machine (1).<br>(Bertus Beaumont, Delft University of Technology) | Intraspecific variation of plant traits in the floodplain - patterns, mechanisms and consequences of flooding induced morphological variation.<br>(Eric Visser, Radboud University Nijmegen) | Individual differences in songbird territorial behaviour.<br>(Marc Naguib, Wageningen University) |
| **13:50** | Spatial patterns of methane-oxidizing bacteria in a riparian wetland in relation to ecosystem function.<br>(Sascha Krause, Netherlands Institute of Ecology) | Laboratory evolution—for lack of a time machine (continued).<br>(Bertus Beaumont, Delft University of Technology) | Genomics of flooding stress tolerance: exploiting genetic variation in *Arabidopsis thaliana.*<br>(Divya Vashisht, Utrecht University) | Daily variation in the home range size of Montagu's harriers during the breeding period.<br>(Raymond Klaassen, Montagu's harrier foundation) |
| **14:10** | Management as tool for biodiversity conservation in shallow lakes and ponds.<br>(Pieter Lemmens, K.U. Leuven) | Studying life histories with experimentally evolved fruit flies.<br>(Agnieszka Doroszuk, Leiden University) | The effect of shade stress on phenotype, epigenetic patterns and gene expression in outbred and inbred lines of *Scabiosa columbaria.*<br>(Marjolein Bruijning, Radboud University Nijmegen) | Habitat use throughout migration: linking individual consistency with current and future breeding success.<br>(Bart Nolet, Netherlands Institute of Ecology) |
| **14:30** | Break | | | |

| | Parallel Session 1 Continued | | | |
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| **14:40** | Species loss, invasion and diversity of plant communities; a N:P stoichiometry perspective.<br>(Harry Olde Venterink, ETH Zürich) | The genetic basis of parasitoid resistance of *D. melanogaster* against *A. tabida* in artificially selected populations.<br>(Kirsten Jalvingh, University of Groningen) | Species intraspecific chemical and high-resolution spectral signatures variation: what possible benefits could we have towards plant monitoring? The case study of Senecio species.<br>(Sabrina Carvalho, Netherlands Institute of Ecology) | How different are the individual foraging strategies of Oystercatchers wintering in the Wadden Sea?<br>(Adriaan Dokter, University of Amsterdam) |
| **15:00** | Acidification lowers food quality status of heathland ecosystems through an increase in plant nitrogen to phosphorus ratios.<br>(Joost Vogels, Bargerveen Foundation / Radboud University Nijmegen) | Toward masculinity in mushrooms by experimental evolution.<br>(Bart Nieuwenhuis, Wageningen University) | Intraspecific variation in phenotypic plasticity in response to sand burial in a desert shrub.<br>(Liang Xu, Chinese Academy of Sciences / Netherlands Institute of Ecology / Utrecht University) | Nest visiting behaviour in an Australian finch.<br>(Erica van Rooij, Maqcuarie University) |
| **15:20** | Vulnerability of butterflies to climate change and nitrogen deposition.<br>(Michiel WallisDeVries, Vlinderstichting / Wageningen University and Research Centre) | Selection on learning rate in *Nasonia vitripennis*: the costs and benefits of a memory.<br>(Katja Hoedjes, Wageningen University) | Does the presence of *Festuca rubra* trigger root overproduction of *Plantago lanceolata* in mixture communities?<br>(Francisco Padilla, Radboud University Nijmegen) | Low growth rates and survival of Black-tailed Godwit chicks born on intensively managed agricultural land.<br>(Rosemarie Kentie, University of Groningen) |
| **15:40** | Coffee and tea in the lounge | | | |
| | **Europe Hall** | **America Hall** | **Asia Hall** | **Africa Hall** |
| **16:00** | **Parallel 2a:**<br>**Adaptation of migratory organisms in a changing world** | **Parallel 2b:**<br>**Genomics of Adaptation & Species interactions** | **Parallel 2c:**<br>**Phenotypic Plasticity** | **Parallel 2d:**<br>**The ecology of artificial habitats** |
| | *Conveners*:<br>1. Christiaan Both (University of Groningen)<br>2. Jeroen Reneerkens (University of Groningen)<br>3. Janne Ouwehand (University of Groningen) | *Conveners:*<br>1. Bregje Wertheim (University of Groningen)<br>2. Louis van de Zande (University of Groningen)<br>3. Ken Kraaijeveld (Leiden University Medical Center) | *Conveners:*<br>1. Silvia Paolucci (University of Groningen)<br>2. Lucia Salis (Netherlands Institute of Ecology) | *Conveners*:<br>1. Wouter Lengkeek (Bureau Waardenburg)<br>2. Joop Coolen (Stichting de Noordzee) |
| **16:00** | Adaptation of migratory organisms in a changing world.<br>(Christiaan Both, Jeroen Reneerkens and Janne Ouwehand, University of Groningen) | Genomic interactions between Wolbachia and its host.<br>(Ken Kraaijeveld, Leiden University) | The role of phenotypic plasticity in adapting to a warming world.<br>(Marcel Visser, Netherlands Institute of Ecology) | Introduction & the ecological importance of shipwrecks in the North Sea.<br>(Wouter Lengkeek, Bureau Waardenburg and Joop Coolen, Stichting de Noordzee) |
| **16:20** | Interaction between timing of migration and reproduction in European Honey Buzzard.<br>(Willem van Manen, Dutch Centre for Field Ornithology) | Phenotypic and genomic characterization of parasitoid resistance in Drosophila species.<br>(Laura Salazar Jaramillo, University of Groningen) | Seasonal adaptation in the parasitoid wasp *Nasonia vitripennis*: photoperiodic induction of diapause and its genetic basis.<br>(Silvia Paolucci, University of Groningen) | Cod and sole behaviour in an offshore wind farm.<br>(Erwin Winter, Wageningen University and Research centre) |
| **16:40** | Weather-induced spatiotemporal migration dynamics of raptors at a monitoring site suggest predictable variability in detectability: implications for research.<br>(Wouter Vansteelant, University of Amsterdam) | Genomic and phenotypic differences in *Caenorhabditis elegans* isolated from different habitats.<br>(Rita Volkers, Wageningen University) | Adaptation to seasonal environments in a butterfly: alternate life history strategies and their hormonal regulation.<br>(Vicencio Oostra, Leiden University) | Artificial reefs in the Dutch coastal zone.<br>(Godfried van Moorsel, Ecosub) |
| **17:00** | Break | | | |

| | Parallel Session 2 Continued | | | |
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| **17:10** | Age-specific density dependence in seasonal survival in a long-distance migrant.<br>(Tamar Lok, University of Groningen / Royal Netherlands Institute for Sea Research) | Phenotypic variation of mate preferences and male pheromones in hybrid Nasonia.<br>(Wenwen Diao, University of Groningen) | Predictive adaptive response: modelling the life history of *Bicyclus anynana.*<br>(Joost van den Heuvel, Leiden University) | Urban biotopes.<br>(Floris Brekelmans, Bureau Waardenburg) |
| **17:30** | Heterogeneity in the use of a stopover in decline: staying ruffs have lower survival.<br>(Lucie Schmaltz, University of Groningen) | Genetics of interspecific mate discrimination in the parasitoid wasp *Nasonia vitripennis.*<br>(Maartje Giesbers, University of Groningen) | Is being plastic fantastic? Opposite consequences of locally adapted salt-marsh pioneer vegetation on ecosystem-level robustness.<br>(Jim van Belzen, Royal Netherlands Institute for Sea Research) | Urban avian conservation in a global perspective.<br>(Jip Louwe Kooijmans, Vogelbescherming / Birdlife NL) |
| **17:50** | Successful reintroduction of Houting, a migratory fish, despite severe change in environment.<br>(Erwin Winter, Institute for Marine Resources and Ecosystem Studies, Wageningen University and Research centre) | The genomics of personality in great tits.<br>(Kees van Oers, Netherlands Institute of Ecology) | Phenotypic plasticity and population viability: the importance of environmental Predictability.<br>(Thomas Reed, Netherlands Institute of Ecology) | Artificial bat habitats: From old fortresses to innovative building.<br>(Herman Limpens, Dutch Mammal Society) |
| **18:10** | Drinks in the Lounge and from **18:30** onwards dinner in the restaurant | | | |
| **19:30** | **Poster sessions 1: Authors present at odd-numbered posters / Coffee** | | | |
| | **Europe Hall** | | | |
| **21:00** | **<u>Evening Programme:</u>**<br>Bleker's plan, Haring's philosophy and new nature fascism in the Netherlands (Frank Berendse, Wageningen University) | | | |

## Wednesday 8 February

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| **7:30** | Breakfast in the restaurant | | | |
| **8:00** | Registration for those coming on Day 2 only | | | |
| | **Europe Hall** | **America Hall** | **Asia Hall** | **Africa Hall** |
| **8:30** | **Parallel 3a:**<br>**Aquatic ecology: dynamics and feedbacks and consequences for ecosystem management** | **Parallel 3b:**<br>**Ecotoxicology and ecosystem functioning: impacts of chemicals related to ecological traits** | **Parallel 3c:**<br>**Plant-Insect Interactions** | **Parallel 3d:**<br>**Advanced statistical methods for Ecology** |
| | *Conveners*:<br>1. Lisette N. de Senerpont Domis (Netherlands Institute of Ecology)<br>2. Steven DeClerck (Netherlands Institute of Ecology) | *Conveners*:<br>1. Geert de Snoo (Leiden University)<br>2. Willie Peijenenburg (Leiden University) | *Conveners*:<br>1. Maaike Bruinsma (Leiden University)<br>2. Luisa Carvalheiro (University of Leeds, NCB-Naturalis) | *Conveners*:<br>1. Bob Douma (VU University Amsterdam)<br>2. Eelke Jongejans (Radboud University Nijmegen) |
| **8:30** | Contributions of aquatic ecology to ecosystem management: how to make ecological principles operational.<br>(Lisette de Senerpont Domis, Netherlands Institute of Ecology) | Towards a more efficient predictability of adverse effects of chemicals on ecosystems.<br>(Willie Peijnenburg, Leiden University / RIVM) | Plant-insect interactions under increasing herbivore diversity.<br>(Tibor Bukovinszky, Netherlands Institute of Ecology) | Trends in mathematical and statistical methods for ecology.<br>(Will Cornwell, Vrije Universiteit Amsterdam) |
| **8:50** | Unravelling the responses of Nile perch population dynamics to changes in Lake Victoria.<br>(Andrea Downing, Wageningen University / Netherlands Institute of Ecology) | Effective design of programmes for monitoring risks of Cu, Ni and Zn to aquatic ecosystems.<br>(Anja Verschoor, Leiden University / RIVM) | Neighbour identity matters: Effects of plant diversity and identity on the insect communities of individual ragwort plants.<br>(Olga Kostenko, Netherlands Institute of Ecology) | Non-linear multi quantile regression: a new tool in Species Distribution Modelling.<br>(Francesco Cozzoli, Royal Netherlands Institute for Sea Research) |
| **9:10** | The Cod delusion – or timing problems of a marine predator: The bliss and curse of density dependence.<br>(Anieke van Leeuwen, University of Amsterdam) | Traits could be helpful to predict toxicity of Nano copper among cladoceran species.<br>(Lan Song, Leiden University) | Benefits of host shifting in a tephritid fruit fly – *Rhagoletis alternata* on native and non-native roses.<br>(Kim Meijer, Groningen University) | Do resource availability and disturbance act on a different suite of plant traits? Using structural equation modelling to statistically test for causality.<br>(Bob Douma, Vrije Universiteit Amsterdam) |
| **9:30** | Break | | | |
| **9:40** | Body size and dispersal mode as key traits determining meta-community structure of pond organisms.<br>(Steven Declerck, Netherlands Institute of Ecology) | Natural toxins and their molecular and life-history effects on non-target soil invertebrates.<br>(Elaine van Ommen Kloeke, Vrije Universiteit Amsterdam) | The challenging interactions between a plant and an insect that is both pollinator, seed predator and vector of disease.<br>(Arjen Biere, Netherlands Institute of Ecology) | Measuring dispersal kernels through inverse modeling: density dependence of seed dispersal in a Neotropical palm.<br>(Marco Visser, Radboud University Nijmegen, Smithsonian Tropical Research Institute, Panama) |
| **10:00** | Hitchhiking in wetland ecology: Seed transport by ducks.<br>(Erik Kleyheeg, Utrecht University) | Collisions drive Brownian motion in self-organized mussel beds.<br>(Monique de Jager, Royal Netherlands Institute for Sea Research) | The influence of plant responses to herbivores on behaviour of pollinators, and consequences for plant fitness.<br>(Dani Lucas-Barbosa, Wageningen University) | If a tree falls in the forest… Predicting long-term decay dynamics from short-term observations.<br>(James Weedon, Vrije Universiteit Amsterdam) |
| **10:20** | Water level fluctuations and their role in shoreline biodiversity.<br>(Judith Sarneel, Utrecht University / Netherlands Institute of Ecology) | Disease invasion dynamics: brucellosis and tuberculosis in African buffalo<br>(Erin Gorsich, Oregon State University) | Reduced seed set by root herbivory: are pollinators involved?<br>(Céline Ghyselen, Ghent University) | The contribution of covariance: Statistical decomposition of the stochastic growth rate.<br>(Raziel Davison, Max Planck Institute for Demographic Research, Germany) |

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| **10:40** | Coffee and tea in the lounge | | | |
| | **Europe Hall** | | | |
| | **Plenary 2: "Ecological interactions on different scales: can we meet in the middle?"** | | | |
| **11:00** | 1. **José M. Gómez** (Universidad de Granada) | | | |
| **11.45** | 2. **Nicole van Dam** (Radboud University Nijmegen) | | | |
| **12:30** | Lunch in the restaurant | | | |
| **13:30** | **Poster Session 2: Authors present at even-numbered posters / Coffee** | | | |
| | **Europe Hall** | **America Hall** | **Asia Hall** | **Africa Hall** |
| **15:00** | **Parallel 4a: Marine Ecology** | **Parallel 4b: Disease Ecology** | **Parallel 4c: Establishment in a new environment** | **Parallel 4d: Microbial Ecology and Systems Biology: Questions and Methods** |
| | *Conveners*:<br>1. David Thieltges (Royal Netherlands Institute for Sea Research)<br>2. Jan Dent (Royal Netherlands Institute for Sea Research) | *Conveners*:<br>1. Fred de Boer (Wageningen University)<br>2. Nienke Hartemink (Université catholique de Louvain, Louvain-la-Neuve)/Utrecht University) | *Conveners*:<br>1. Kim Meijer (University of Groningen)<br>2. Judith Sarneel (Netherlands Institute of Ecology) | *Conveners*:<br>1. Liesje Mommer (Wageningen University)<br>2. Wolf Mooij (Netherlands Institute of Ecology) |
| **15:00** | Overfishing promotes algal blooms.<br>(Britas Klemens Eriksson, University of Groningen) | Disease Ecology.<br>(Fred de Boer, Wageningen University and Nienke Hartemink, Université Catholique de Louvain/Utrecht University) | Dispersal of aquatic organisms by waterbirds.<br>(Casper van Leeuwen, Netherlands Institute of Ecology) | Loss of rare microbes affects ecosystem functioning.<br>(Gera Hol, Netherlands Institute of Ecology) |
| **15:20** | Size based species interactions shape cod and herring dynamics in the face of exploitation.<br>(Daniel van Denderen, Institute for Marine Resources and Ecosystem Studies, Wageningen University and Research centre) | Cyanobacteria protect Daphnia against diseases.<br>(Marlies Coopman KULeuven) | Germination and seedling survival influence riparian plant species distribution along hydrologically restored lowland streams.<br>(Rob Fraaije, Utrecht University) | The effect of atmospheric change on arbuscular mycorrhizal fungal communities.<br>(Anne Cotton, University of York / University of Hull) |
| **15:40** | Density-dependent movement leads to self-organized patterns in ecological systems.<br>(Quan-Xing Liu, Netherlands Institute of Ecology / University of Groningen) | Bovine tuberculosis and feline immunodeficiency virus co-infection: a possible threat for conservation of lions.<br>(Miriam Maas, Utrecht University) | The establishment of fern diversity in newly created habitats .<br>(Arjen de Groot, Utrecht University) | Rapid C flow through the plant-soil system in differently managed grasslands.<br>(Gerlinde De Deyn, Lancaster University / Wageningen University) |
| **16:00** | Break | | | |
| **16:10** | Can we protect our coastline and the beach ecosystem at the same time?<br>(Sarah Vanden Eede, Ghent University) | Spatio-temporal variation in the distribution of chytrid parasites in diatom host populations.<br>(Alena Gsell, Netherlands Institute of Ecology) | Climate change induced range-expanding plants.<br>(Elly Morien, Netherlands Institute of Ecology) | Microbial Ecology is dead. Long live Microbial Ecology.<br>(Gerard Muyzer, University of Amsterdam) |
| **16:30** | How size-selective seasonal predation risks mould the timing of reproduction in a symbiotically fuelled bivalve.<br>(Matthijs van der Geest, Royal Netherlands Institute for Sea Research) | Aggregated distribution of ticks on hosts explained by clustered distribution of ticks in the field.<br>(Jasper van der Linden, Wageningen University) | Shrubs facilitate tree invasion in northern peatlands.<br>(Huib van Veen, Wageningen University) | Emergence of microbial cooperation in the human gut.<br>(Roeland Merks, Centrum Wiskunde & Informatica, Amsterdam / Leiden University) |

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| **16:50** | Competition and niche segregation following the arrival of the exotic brush-clawed shore crab (*Hemigrapsus takanoi*) in the formerly European shore crab (*Carcinus maenas*) dominated Dutch delta. (Sander Wijnhoven, Royal Netherlands Institute for Sea Research) | Seasonal variation in LPAI virus infection in mallards and the role of migrants. (Jacintha van Dijk, Netherlands Institute of Ecology) | The influence of an invasive plant species on the pollination success and reproductive output of three riparian plant species. (Koen Thijs KU Leuven) | From metabolic networks to microbial communities. (Frank Bruggeman, Vrije Universiteit Amsterdam) |
| | **Europe Hall** | | | |
| **17:20** | Closing Session (Hans de Kroon)<br>• Awards ceremony<br>  ○ Best PhD research paper Award (Chair Evaluation Committee)<br>  ○ Best Poster Award (Roland Bobbink, Chair NECOV)<br>• Synthesis (Louise Vet) | | | |
| | **Lounge** | | | |
| **18:00** | Fare-well drinks and Dinner | | | |
| **19:30** | Travel Home (Shuttle available between Conference Centre and Station) | | | |

# Plenary Session 1

## The reciprocity of ecological and evolutionary dynamics

It is increasingly recognized that ecological and evolutionary dynamics often take place over similar spatial and temporal scales, and may thus interact with each other. This interplay leads to novel and interesting complexities in the way populations, communities and ecosystems respond to environmental gradients and to environmental change. In this keynote session, eco-evolutionary dynamics are examined from different viewpoints, emphasizing conceptual issues and also illustrating different approaches using empirical examples. The session will critically address the circumstances under which evolution is and is not expected to influence ecological dynamics, and it will highlight perspectives and challenges for future research.

1. **Eco-evolutionary dynamics: a conceptual framework**
   (Andrew Hendry McGill University, Montréal, Canada)

The speed of evolution has traditionally been considered too slow to materially impact ecological dynamics playing out in contemporary time. I will first review evidence that challenges this assumption through studies documenting rapid evolutionary change in organisms experiencing altered environments. Many of the observed changes are in phenotypic traits that strongly interact with aspects of the environment, including other species. Rapid evolution is therefore expected to have ecological consequences and the population, community, and ecosystem levels. I will outline a conceptual framework for these eco-evolutionary dynamics and illustrate its components through a series of empirical examples from diverse natural systems. Among the various influences, I will pay particular attention to the role of population dynamics in responding to evolutionary change and in then having community and ecosystem consequences. I will then generate a set of predictions for when evolution will and will not have important influences on ecological dynamics. I will close with a discussion of outstanding questions in this emerging synthetic field of investigation – some of which will lead directly into the following talk by Luc De Meester.

2. **Evolving metacommunities: a race between adaptation and immigration**
   (Luc De Meester, KU Leuven)

Ecological and evolutionary processes have largely been studied separately, yet there is growing evidence that ecological and evolutionary dynamics can occur at the same time scale and can strongly interact. Ignoring these interactions may distort our view of population, community and ecosystem responses to environmental change, including human impact. The evolving metacommunities framework tries to disentangle the relative importance of species and genotype sorting in determining community trait responses to environmental gradients locally and regionally. A key aspect that determines the outcome of eco-evolutionary interactions is the rate of local species sorting and genetic adaptation versus immigration rates. I will illustrate these concepts amongst others with our own research, using the water flea and its responses to natural and anthropogenic stressors as main model system. I will discuss evolution-mediated priority effects and responses to climate change, and I will try to sketch an integrated approach that integrates widely different approaches ranging from field based community research to eco- and paleogenomics.

# Plenary Session 2

## Ecological interactions on different scales: Can we meet in the middle?"

Ecology by nature is a broad scientific discipline, involving scientists studying interactions between organisms on widely diverse scales. Both large scale analyses and small scale studies have their own values, but only seldom they are combined. The question we would like to address in our back-to-back presentations is whether and how we can apply a large scale approach, such as interaction network analyses, to a small scale study on individual interactions between a plant species and its herbivores or mutualists.

**1. José M. Gómez (Universidad de Granada)**

Dr. José María Gómez is full professor in Evolutionary Ecology at the University of Granada, Spain. His research focuses deals with the ecology and evolution of plant-animal interactions in multispecies systems. He is mostly interested in understanding how ecological interactions may shape phenotypic evolution, and how organisms can evolve in generalist scenarios. To answer this question, his lab works both at micro and macroevolutionary scales, using contrasting approaches (field experiments and observations, genetic analyses, numerical simulations and modeling, etc.).

**2. Nicole van Dam (Radboud University Nijmegen)**

Dr. Nicole M. van Dam is full professor in Ecogenomics at Radboud University Nijmegen. The research in her department focuses on herbivore-induced plant responses and interactions between biotic-abiotic stress responses. The people in her department analyze these responses on the transcriptomic, metabolomic as well as ecological level. By merging these different approaches and scales, the aim is to gain a full understanding of adaptive plant stress responses in complex and changing natural environments.

# Session 1

## 1a: Biodiversity and Conservation

**Conveners:** Roel van Klink (University of Groningen)
Toos van Noordwijk (Bargerveen Foundation , Radboud University Nijmegen)

### 1. Biodiversity research in space and time

Roel van Klink and Toos van Noordwijk
University of Groningen

Biodiversity is what inspired great biologists such as Linnaeus (1707) and Darwin (1809) to start their seminal works. Biodiversity is heterogeneous on spatial and temporal scales and, variation of (a)biotic factors at the right spatial and temporal scales is a major driver of biodiversity. Over the last decades many processes and factors involved in shaping communities have been identified. Nonetheless, the relative importance of all these factors and the way they interact, remains elusive. Meanwhile a great number of anthropogenic threats put biodiversity under pressure. Land use change, habitat destruction and fragmentation, nutrient loading, chemical pollution, climate change and species invasions all drastically alter the functioning and the species composition of ecosystems. Conservation and restoration measures are being taken worldwide to preserve biodiversity, but full understanding of the effects of anthropogenic change and the possibilities for restoration are still lacking.

Diversity patterns are apparent at different interacting spatial scales from local to regional and even global scales. Recently, compositional differences between communities (Beta-diversity) have been receiving new attention and geographical distance, productivity, environmental heterogeneity and also conservation measures have been appointed as drivers of Beta-diversity. This gives rise to exciting possibilities of determining the degrees of stochasticity and determinism in community assembly.

Another exciting development is the resurgence of trait based research in fundamental and conservation ecology. Studying species' life-history traits and their interactions enables to mechanistically understand species' responses to their environment. This greatly helps to understand species decline and allows formulating new restoration and conservation strategies. These new approaches will aid the transformation of community ecology from a descriptive to a predictive science.

### 2. Spatial patterns of methane-oxidizing bacteria in a riparian wetland in relation to ecosystem function

Sascha Krause, Marion Meima-Franke and Paul L.E. Bodelier
Netherlands Institute of Ecology

Microbes form a major part of earth biomass and biodiversity and have an important role for biogeochemistry and ecosystem functioning. However, microbial communities are still hardly considered in debates about biodiversity loss, global change and conservation strategies although they can be very sensitive to environmental disturbances. Hence, there cannot be longer ignored in conservation and management issues. Here we focus on aerobic methane oxidizing bacteria (MOB) as a model system because they have a well-characterized physiology, can be targeted specifically with molecular tools and catalyze an important ecosystem function.

Since more extreme weather events such as rainfall will increase due to climate change flooded soils will appear more frequently. This process can turn a soil from a methane sink to a methane source. The amount of methane emission is strongly dependent on oxidation by MOB. Characterizing spatial patterns of the MOB community could facilitate to understand the relationships between their ecology, their biogeochemical process, their ecosystem function and consequently give implications for conservation and management strategies. We first applied geostatistical modeling to map and predict the spatial distribution of MOB in a riparian wetland along a hydrological gradient, and second correlated these spatial patterns to soil properties and distribution of methane fluxes/ oxidation rates as a proxy for their ecosystem function. Preliminary results indicate that the MOB community was clearly correlated to the hydrological gradient as expressed in moisture content of the soil. Spatial patterns for different groups of MOB were both contrasting and overlapping. Finally, results indicated a relationship between MOB community and their ecosystem function.

### 3. Management as tool for biodiversity conservation in shallow lakes and ponds

Pieter Lemmens, De Bie T., Mergeay J., Van Wichelen J., De Meester L., and Declerck S.A.J.
K.U. Leuven

Shallow lakes and ponds are valuable biodiversity hotspots in Europe. Human impact and disturbance of these aquatic systems resulted, however, in ecological degradation and species loss. More recently, the concern for sustainable management and biodiversity conservation significantly increased. Our study explores the relationship between pond management, diversity and community

composition of different aquatic biota on local and regional scale. We surveyed a total of 39 shallow ponds in Belgium, representing five major management types: (1) culture of young of the year fish; (2) carp farming; (3) extensive management; (4) absence of management; and (5) absence of fish. We will discuss the effects of pond management practices on a variety of ecological variables and community characteristics of phytoplankton, zooplankton, macro-invertebrates and macrophytes. Secondly, we will focus on the importance of fish communities for nature conservation.

**4. Species loss, invasion and diversity of plant communities; a N:P stoichiometry perspective**

Harry Olde Venterink, Luciola S. Lannes, Mercedes Bustamante, Martin Wassen and Peter Edwards
ETH Zurich, Switzerland

Nutrient availability is considered as an important controlling factor for species diversity in plant communities, and nutrient enrichment is seen as a major cause for species loss and alien plant invasions. Whereas in many studies ‚nutrient', ‚nitrogen (N)' and ‚phosphorus (P)' are used as synonyms, we specifically studied aspects of species loss, invasion and diversity from a perspective of the relative availabilites of N and P.

We present four theoretical mechanisms by which species richness might be different under N or P limitation, and data from Eurasian wetlands to support one of them. We show that species that are actually getting lost – Red List species – persist better under P limitation than under N limitation, both in Eurasian wetlands and in the Brazilian Cerrado. In the wetlands this is more likely a result of P enrichment than of N enrichment. For the Brazilian Cerrado we found that also alien plant invasions are related to N:P stoichiometry. The alien plants, particularly some African grasses, dominate under N limitation. Moreover, in fertilization experiments they respond to P fertilization, not to N fertilization. Under unfertilized conditions they profit more than native species from increased phosphatase activity induced by species interactions.

All our results show that plant species and communities respond very differently to N or P enrichment. Since also different management measures are required to counterbalance such enrichments, it is crucial to evaluate how such measures might influence N:P stoichiometry. Ignoring discrepancies between demanded and predicted effects on the type of nutrient limitation likely will frustrate the achievement of conservation targets.

**5. Acidification lowers food quality status of heathland ecosystems through an increase in plant nitrogen to phosphorus ratios**

Joost Vogels, Arnold van den Burg, Eva Remke and Henk Siepel
Bargerveen Foundation / Radboud University Nijmegen

Emissions of reactive nitrogen and other acidifying compounds increased dramatically in the past decades and are still increasing at a global scale This has a strong negative impact on ecosystem functioning and biodiversity, potentially even stronger than increased carbon emissions. In the Netherlands, deposition levels of nitrogen and other acidifying compounds used to be one of the highest worldwide. At present, levels have dropped considerably, but are well above natural levels nonetheless.

The negative effects of these air-borne pollutants are most pronounced in nutrient poor, acidic ecosystems. Heathland ecosystems are an example of such an environment, large areas of protected nature reserves in the Netherlands consist of heathlands.

Past research has shown that increased nitrogen deposition leads to a shift in dominance of dwarf shrubs such as Calluna vulgaris and Erica tetralix towards a dominance of tall grasses, mainly Molinia caerulea and Deschampsia flexuosa. Effects on the fauna are less well documented, research focused mainly on indirect effects of increased N-deposition, for instance the effects of alterations in vegetation structure due to grass-encroachment. In this talk I will present a different approach and focus on the effects of shifts in the nutritional status of heathland vegetation on heathland fauna species. Increased nitrogen deposition leads to shifts in plant macronutrient stoichiometry, in particular nitrogen to phosphorus ratio's. These shifts are, quite paradoxically, mostly an effect of acidification and resulting decrease in soil phosphorus availability than of increased availability of soil nitrogen. N:P ratios were in turn negatively correlated with density and species richness of heathland fauna species among several trophic levels. Higher plant N:P ratio's in Dutch heathlands as a result of nitrogen deposition could therefore be one of the major cause of the observed decline of fauna species richness in these landscapes.

**6. Vulnerability of butterflies to climate change and nitrogen deposition**

M.F. WallisDeVries and C.A.M. Van Swaay
Dutch Butterfly Conservation / Wageningen University

Butterfly communities have been shown to lag behind in their response to climate change across Europe. High levels of anthropogenic nitrogen deposition has been advanced as a factor contributing to this delay. A focus on trends in relation to species traits may elucidate the observed trends. We

show four main PCA axes describing 63% of the variation in species traits among north-western European butterflies. The first axis groups species according to vagrancy, population density, adult size, reproductive capacity and hibernation mode. The second axis reflects the thermal range and moisture requirements. The third axis contains variables determining the number of generations per year and the last axis describes host plant specialization. The first and third axes relate significantly to species-specific nitrogen indicator values. Nitrogen-sensitive species show stronger declines at high deposition levels. Long-term trends in Butterfly Community Indices in the Netherlands reflect increases of species from both thermophilic and eutrophic conditions. The climatic lag is mainly explained by species from low-nitrogen environments, in particular by species hibernating as eggs or larvae. Cooling of spring microclimates and reduced food quality offer mechanistic explanations to explain the different response of these species.

## 1b: Experimental Evolution

**Conveners:** Bart Pannebakker (Wageningen University)
Arjan de Visser (Wageningen University)

### 1&2 Laboratory evolution—for lack of a time machine

Hubertus J. E. Beaumont
Delft University of Technology

Life's staggering complexity evolved by the interplay between random genetic variation and ecological processes. Ecology, genetics and comparative analysis have provided deep insight into the mechanisms behind evolution, but direct experimental investigation is hampered by its slow time scale. In spite of this, research in the field of experimental evolution is providing empirical insight. By examining key dynamics in experimental populations that are evolving in the laboratory, it offers a window into the mechanisms of evolution—from mutation to ecological interaction—as it happens. One factor critical to the evolution of life that experimental evolution is beginning to illuminate is evolvability: the capacity of organisms to generate phenotypic variation suitable for evolution by natural selection. What is it about organisms that allows them to be optimised by random genetic change? How does the interplay between evolvability and ecology shape what evolves when? I will discuss results from evolutionary experiments that speak to these questions, including work examining limits on adaptive radiation, the relation between organismal architecture and evolvability, and the link between environmental variation and the evolution of bet hedging.

### 3. Studying life histories with experimentally evolved fruit flies

Agnieszka Doroszuk, Christina May and Bas Zwaan
Leiden University

We have carried out an experimental evolution (EE) in *Drosophila melanogaster*. Twenty four experimental lines have evolved for 40 generations under different levels of juvenile nutrition combined with selection favouring either early or late reproduction. The combination of selective pressures acting at juvenile and adult stages in a single EE setup is unique and allows studying the evolutionary interplay between developmental and adult life histories. Life history analyses performed at the end and during the evolution experiment indicated a pronounced divergence among the experimental lines in lifespan, developmental time and reproduction in response to the selective environments. Lifespan and developmental time of the EE lines selected for late reproduction were on average extended in relation to those selected for early reproduction, but the exact amount of change depended on the juvenile nutrition during evolution. These results will be discussed in the context of mechanistic links between developmental and adult stages and their role in shaping natural variation in populations.

### 4. The genetic basis of parasitoid resistance of D. melanogaster against A. tabida in artificially selected populations.

Kirsten Jalvingh
University of Groningen

In this study we are interested in how populations can rapidly adapt to selective pressures, and how genetic architecture is influenced by this. We investigate a parasitoid-host system in which fruit fly larvae from the *Drosophila* genus are parasitized by wasps of the *Asobara* genus. Through an evolved innate immune response, in some cases the fly larva is able to sequester and kill the parasitoid egg. There is considerable genetic variation in the strength of the immune response, both within and between *Drosophila* populations. While differences in gene expression associated with parasitoid defense are being characterized, the genetic basis of parasitoid resistance is poorly understood. We aim to elucidate the genetic basis of this adaptive variation in parasitoid defense by sequencing lines artificially selected for increased resistance. By rapidly selecting for increased parasitoid defense we have created a set of selection and control lines that differ in resistance while sharing the same genetic background. Using HT sequencing we associate genomic regions to parasitoid resistance, and aim to pinpoint candidate genes involved in the response.

### 5. Toward masculinity in mushrooms by experimental evolution

Bart Nieuwenhuis
Wageningen University

In hermaphrodites, selection acts on the male and the female role during mating. If there is antagonistic selection on the different roles of mating, this leads to conflicts between these two roles. We have studied this potential conflict in a mushroom-forming fungus that normally reproduces as a hermaphrodite. We have studied trade-offs between male and female roles, by testing how mating exclusively in the male role affects the female function. The evolving strains were consequently mated in the male role with a non-evolving haploid female mycelium for 20 generations. Because the fungus can be multiplied clonally we could test the male, as well as the female function of the same

haploid individual. Most of the adapted strains showed increased competitive capabilities relative to ancestral strains for mating in the male role (for some strains a 100-fold increase). All evolved strains are still capable to mate as a female, furthermore, we did not see reduced capabilities in the diploid phase. Our results suggest that there are no strong trade-offs between male and female function for the traits that we have measured.

**6. Selection on learning rate in *Nasonia vitripennis*: the costs and benefits of a memory**

Katja M. Hoedjes, Louise E. M. Vet and Hans M. Smid
Wageningen University

Animals can learn and form memories, and features of memory formation and underlying cellular pathways are highly conserved. Nonetheless, species-specific differences can be observed as learning rates are shaped by ecological differences. Animal species with a high learning rate will learn a cue or task immediately when first experiencing it, whereas others have a lower learning rate and need repeated learning experiences. Closely related species of parasitic wasps display substantial variation in learning rate and have been instrumental to understanding these differences. Memory formation has both costs and benefits and the balance between these two is different for each species. Artificial selection on learning rate is a powerful tool to study these trade-offs in detail.

We present the first results of our on-going selection experiment on learning rate in the parasitic wasp *Nasonia vitripennis*. This selection experiment will result in lines of wasps with a high learning rate and lines with a low learning rate. The trade-offs of a high or a low learning rate are studied by comparing life history parameters, genetics and brain morphology of these lines.

## 1c: Plant eco-physiology – special focus: Intraspecific variation of plant traits

**Conveners:** Eric Visser (Radboud University Nijmegen)
Phlippine Vergeer (Radboud University Nijmegen)

### 1. Intraspecific variation of plant traits in the floodplain - patterns, mechanisms and consequences of flooding induced morphological variation

Xin Chen, Eric J.W. Visser, Heidrun Huber, Ronald Pierik, Hendrik Poorter, Anton J.M. Peeters, Hans de Kroon, Laurentius A.C.J. Voesenek
Radboud University Nijmegen

Plant species adapted to flooding display a variety of morphological, metabolic and life-history traits that enable growth during waterlogging or submergence. Comparisons of wetland species with closely related non-flood-tolerant species have been helpful to determine the importance of these traits. However, to understand which plant traits are also currently under natural selection in wetland habitats, it is more relevant to compare the occurrence or magnitude of such important trait values between populations of the same species, rather than between different species. We collected seeds from different populations of *Rumex palustris* (marsh dock) in the Netherlands, and determined the variation in flooding-induced shoot elongation of plants grown from these seeds. It proved that both within-population and inter-population variation of the elongation response was high, but that the effect of this variation on the performance during submergence strongly depended on the timing of flooding in the life cycle, and on the duration of the flood. At the physiological level, variation in shoot elongation between two extreme populations could largely be explained by a single step in the signal transduction chain, i.e., a fast decrease in ABA levels upon submergence in the fast-elongating population, and considerably higher ABA concentrations in the slow-elongating population.

### 2. Genomics of flooding stress tolerance: exploiting genetic variation in *Arabidopsis thaliana*

Divya Vashisht
Utrecht University

Flooding is a natural phenomenon which severely affects productivity of arable farmlands since most crops are flood-intolerant. Despite some knowledge being available on the adaptive responses of tolerant plant species to low oxygen conditions, little is known about the relation between gene regulation and plant survival upon flooding and the genetic processes that determine variation in flooding tolerance. We selected 86 accessions of Arabidopsis from different geographical locations around the world to identify and characterize key regulatory components involved in flooding tolerance. Submergence survival screening indicated that there was a considerable variation in the tolerance to complete submergence amongst these accessions. Selected accessions were further characterised for important survival related parameters for submergence such as oxygen and carbohydrate dynamics. Next generation sequencing was used to profile the transcriptome of three tolerant and three intolerant accessions. Using single-nucleotide polymorphism and genome information for each accession from the Arabidopsis database, sequencing reads were aligned to individual reference transcriptomes. This gives a much higher resolution and information compared to data analyses using the sequence information for the standard lab accession Col-0. The variation in the submergence-induced transcriptomes between the 6 accessions in relation to flooding tolerance will be discussed.

### 3. The effect of shade stress on phenotype, epigenetic patterns and gene expression in outbred and inbred lines of *Scabiosa columbaria*

Marjolein Bruijning, Philippine Vergeer, Cornelis A.M. Wagemaker, N. Joop Ouborg
Radboud University Nijmegen

Previous studies have demonstrated that the expression of inbreeding depression differs between families and depends on the environment. In this study, we investigated the link between epigenetics, inbreeding and environmental stress. *Scabiosa columbaria*, a plant species that suffers from inbreeding depression, was used in an experiment where inbred and outbred lines of six families were exposed to shade stress during three months. Phenotypic measurements, gene expression and methylation analysis (by MS-AFLP) were performed. Shade stress negatively affected growth, dry weight, photosynthesis and chlorophyll content. Overall, inbreeding depression was found for dry weight and this effect differed strongly among families. Selected genes were differently expressed as a result of inbreeding or environmental stress, and an environmentally dependent inbreeding effect was found for one gene. Shade stress caused hypermethylation of the DNA and methylation patterns were altered by environmental stress. Furthermore, family and crossing effects on methylation patterns were observed, indicating that epigenetics and genetics are not completely independent. Our study suggests that epigenetic patterns such as DNA methylation are important in the response to inbreeding and the adaptive response to environmental stress. These results could be of high importance for conservation genomics.

**4. Species intraspecific chemical and high-resolution spectral signatures variation: what possible benefits could we have towards plant monitoring? The case study of Senecio species**

Sabrina Carvalho
Netherlands Institute of Ecology

Reflectance spectroscopy has, for the last few decades, studied the link between high resolution spectral signatures and chemical concentration of plants at several scales in a non-destructive way. The current computing capacity, freedom of movement and satellite/imagery system compatibility has provided new possibilities for reflectance studies in plants. However, the studies considering plant intra-specific variation are still in their early stages and much knowledge is needed to understand the level at which the spectral sensitivity is best for plant monitoring.
Much of the chemical variation within plant species arises from interactions with the environment, natural enemies and symbionts. Also soil organisms (e.g. root herbivores) can induce plant responses aboveground. Different levels of soil pathogen attacks or mutualistic symbionts may cause variation in the chemical constitution of plants within the same species that aboveground concepts alone cannot explain.

We aimed to study which canopy chemical and spectral properties could be used to distinguish the different stages of soil pathogenicity or even spatial variation of plants. We hypothesize that soil pathogenic level would affect the concentration of chemical components differently within each species, and the spectral signatures could be able to discriminate between plants grown in soil with different pathogenic levels.

We selected three *Senecio* species with different impacts on Dutch grassland ecosystems and tested in the greenhouse the impact of several soil pathogenic levels in these plants chemical content and spectral variation. There was a significant effect of soil organisms' presence in nitrogen and defence compounds content. Canopy spectral reflectance discriminated species groups with high accuracy (90%) and soil type moderately (50-60%) with the groups' discrimination by chemical content accomplishing similar results.

We conclude that this type of techniques have promising results for the study of plants, in a fast and non-destructive way. This may result in the near future in new techniques for spatial-temporal monitoring of plant-ecosystem interactions in the field. Still further studies are needed to improve such techniques.

**5. Intraspecific variation in phenotypic plasticity in response to sand burial in a desert shrub**

Liang Xu
Chinese Academy of Sciences / Netherlands Institute of Ecology / Utrecht University

Sand burial was conducted on seedlings of Caragana intermedia, a desert shrub species in Inner Mongolia, belonging to 18 seed families to investigate the variation in phenotypic plasticity within species. Traits studied included final plant biomass and mechanical properties of the stems such as height and Young's modulus.

**6. Does the presence of *Festuca rubra* trigger root overproduction of *Plantago lanceolata* in mixture communities?**

Francisco M. Padilla, Liesje Mommer, Hannie de Caluwe, Annemiek E. Smit-Tiekstra, Cornelis A.M. Wagemaker, Hans de Kroon
Radboud University Nijmegen

Plant species coexist in diverse communities in close vicinity, most frequently competing for essential soil nutrients. The consequences of this interspecific competition have traditionally been observed aboveground, but to date it is still unclear how aboveground responses are mirrored belowground. In a previous experiment, we found a strong belowground response to interspecific when compared to intraspecific competition that was not foreseen nor proportional aboveground; 80% more root biomass was produced in mixtures consisting of *Plantago lanceolata* and *Festuca rubra* than expected from monocultures, mostly driven by an overwhelming overproduction of roots of *P. lanceolata*, while no effects were found aboveground. In a new experiment, we expanded on the interaction between these two species and tested whether root overproduction in mixtures was actually triggered by the presence of *F. rubra* roots (alternative hypothesis), instead of by merely self-limitation under high plant density in *P. lanceolata* monocultures (null hypothesis). We used the latest molecular technique to unravel species abundances in mixed root samples and looked at root growth patterns through minirhizotron tubes. Preliminary results suggest that root growth of *P. lanceolata* is self-limited under high-density monocultures, but competition for light and nutrients and soil biota do not seem to be involved since minirhizotron images proved that responses were immediate after planting. Species-specific root recognition processes might explain such an immediate increased in root investments of *P. lanceolata* in mixtures rather than nutritional cues or soil biota. Overall, unveiling the link between root recognition processes and root overproduction may improve our knowledge on carbon budgets, plant community functioning and competition in biodiversity studies.

## 1d: Behavioural Ecology: Individual variation in animal behaviour

**Conveners:** Kees van Oers ( Netherlands Institute of Ecology)
Raymond Klaassen (Werkgroep Grauwe Kiekendief / University of Groningen)

### 1. Individual differences in songbird territorial behaviour

Marc Naguib
Wageningen University

In territorial animals, the strategies in advertising and defending a territory can have substantial consequences for territory tenure and fitness. Individuals thus are expected to optimize their territorial behaviour to effectively defend their resources. To do so, many animals use signals which have been shown to provide information about motivation and quality of the signaller. Yet, individuals still differ strikingly in their signalling behaviour and in their responses to others' signals. Such individual variation can be linked to differences in ecological variables, resource values, state of the individual or also more intrinsic individual characteristics, usually referred to as personality. Personality is known to affect individual decision-making in various ways but still little is known how personality affects signalling and territorial behaviour. By studying territorial behaviour and spatial behaviour of personality-typed great tits in the field, we here show relations between personality and vocal responses to playback and how spatial movements, determined by radio tracking, vary with male personality. We also show that the personality of neighbours affect responses to territorial challenges in the neighbourhood. The field research thus emphasizes that territorial birds form social networks with long distance individualized relations which need to be considered to understand how selection may act on spatial and territorial-defence strategies.

### 2. Daily variation in the home range size of Montagu's harriers during the breeding period

Raymond H.G. Klaassen, Almut Schlaich and Ben Koks
Montagu's harrier foundation

Animals use a certain area for their daily activities, and one could expect that home range size depends on the interaction between food availability and food requirements. We explore this problem by investigating daily variation in home range size in the Montagu's harrier (*Circus pygargus*), during the breeding season. Male harriers were tracked in great spatial and temporal detail using the novel bird tracking system developed by a team from the University of Amsterdam (UvA-BiTS). We quantify the size of daily home ranges, and explore daily variation and variation between individual birds. Subsequently, we explore how home range size varies throughout the breeding period, depending on breeding stage (incubation, feeding nestlings, feeding fledglings), behaviour and environmental conditions. Explaining (daily) variation in the behaviour of animals provides further insight in their basic ecology.

### 3. Habitat use throughout migration: linking individual consistency with current and future breeding success

Bart Nolet, B.J. Hoye, A. Gyimesi, S. Hahn and M. Klaassen
Netherlands Institute of Ecology

Habitat use can influence individual performance in a wide range of animals, either immediately or through carry-over effects in subsequent seasons. Given that many animal species also show consistent individual differences in reproductive success, it seems plausible that individuals may have consistent patterns of habitat use representing individual specialisations, with concomitant fitness consequences.

Carbon stable isotope ratios from a range of tissues were used to discern individual consistency in habitat use along a terrestrial-aquatic gradient in a long-distance migrant, the Bewick's swan (*Cygnus columbianus bewickii*). These individual specializations represented less than 15% of the isotopic breadth of the population for the majority of individuals, and were seen to persist throughout autumn migration and overwintering until aquatic habitats were no longer available.

Individual foraging specializations were then used to demonstrate two consecutive carry-over effects associated with macro-scale habitat segregation: consequences of breeding season processes for autumn habitat use; and consequences of autumn habitat use for future reproductive success. Adults that were successful breeders in the year of capture used terrestrial habitats significantly more than adults that were not successful, revealing a substantial cost of reproduction and extended parental care. Use of aquatic habitats during autumn was, however, associated with increased subsequent breeding success in adults that had been unsuccessful the year before. Experiments showed that juveniles were less effective foragers on aquatic resources than adults, forcing the families to leave aquatic food patches earlier than pairs or singles, despite families being the dominant social unit.

Our results uniquely demonstrate not only individual foraging specializations throughout the migration period, but also that processes during breeding and autumn migration, mediated by individual consistency, may play a fundamental role in the population dynamics of long-distance migrants. These findings therefore highlight the importance of long-term consistency to our

understanding of habitat function, inter-individual differences in fitness, population dynamics, and the evolution of migratory strategies.

**4. How different are the individual foraging strategies of Oystercatchers wintering in the Wadden Sea?**

Adriaan M. Dokter, Martin J. Baptist, Bruno J. Ens, Kees Oosterbeek, Willem Bouten and Emiel E. van Loon
University of Amsterdam

The majority of the Dutch breeding population of Oystercatchers depends on the Wadden Sea for winter survival, where birds feed mainly on bivalve prey like cockles and mussels. Since these prey species are large and require a relatively long handling times, intraspecific competition for food (e.g. through stealing) is large and makes Oystercatchers a typical interference-prone species.

In response to competition, Oystercatchers are known to specialize to specific prey items under certain conditions or defend local foraging territories. However, through the influence of tides and weather and the patchy distribution of food resources, foraging conditions in intertidal areas vary considerably even at fine temporal and spatial scales. Until recently it has been difficult to determine how individual birds use the intertidal area, given both the vast area of intertidal flats and the fact that Oystercatchers forage both during night and day.

The use of high-resolution GPS-tagging leads currently to an explosion of information on fine-scale habitat use and individual behaviour. We equipped 30 Oystercatchers with high-resolution GPS-tags to reveal their spatial habitat use in both the eastern and western Dutch Wadden Sea. Additionally, we performed detailed benthic surveys within the birds' home ranges, which allow us to obtain a complete overview of preferences for prey and foraging site of these individuals in relation to the tidal and diurnal cycles.

A major challenge lies in reducing and generalizing the complexity of individual foraging decisions (as revealed by GPS), in order to obtain a better understanding of the low-water distribution of the entire population. We currently work on combining statistical GPS-data driven models and a mechanistic foraging model, to be able to test hypotheses on what are the driving mechanisms of spatial foraging distributions at the population level.

**5. Nest visiting behaviour in an Australian finch.**

Erica van Rooij and Simon Griffith
Maqcuarie University

The effect of parental feeding rates at the nest have been the focus of many studies, but not many species exhibit nest visit synchrony and few studies have considered why synchrony in parental feeding visits might occur. In this study of parental care in the long-tailed finch, we found that nest visits are very infrequent – each partner visited the nest on average less than once an hour – but highly synchronised between the male and female, comparable to the ecologically similar zebra finch. We found a large variation of nest visit behaviour between individuals/pairs, with some individuals always visiting the nest together while others sometimes visited together but at other times visited the nest separately.

We did find some very limited evidence that synchronized nest visits may affect the reproductive success in this species. Nest visit synchrony however can be linked to foraging synchrony as individuals often forage with their breeding partner or members of the breeding group, therefore nest visit synchrony in this species could simply have developed as a side effect of the pair feeding together. Synchronization might be easier for granivorous species like the long-tailed finch because the food source doesn't move and is more predictable. In addition we believe that synchronized activity by the parents during the breeding and non-breeding seasons may help individuals to reduce vulnerability of themselves and their nests to predators.

**6. Low growth rates and survival of Black-tailed Godwit chicks born on intensively managed agricultural land**

Kentie Rosemarie, Jos C.E.W Hooijmeijer. and Theunis Piersma
University of Groningen

On-going intensification of agricultural grasslands across much of Europe cause populations of specialized birds to decline. Despite the numerous targeted agri-environmental schemes, this is also the case for Black-tailed Godwits (*Limosa limosa limosa*) in The Netherlands. In this study we compare chick growth and apparent survival rates of chicks hatched on herb-rich meadows with high water tables, often managed in traditional ways for meadow birds with chicks born in herb-poor well-drained *Lolium perenne* monocultures intensively managed for maximal grass production. Published data were available to make a comparison with growth rates of chicks born in 1976-1985, a period when population declines of godwits slowly started to become apparent. The mass of hatchlings does not differ between herb-rich and herb-poor meadows, but chicks born on herb-poor intensively managed areas showed lower growth rates than chicks born on traditional herb-rich meadows. The latter category showed growth rates similar to those in chicks in 1976-85. Recaptured chicks before

fledging that were born on herb-poor meadows were on average 15 lighter, and at fledging 31 g. Survival of the chicks first year for chicks born on herb-rich meadows was 3 times higher than that of chicks born on herb-poor meadows.

We show that chicks born on modern herb-poor agricultural land had lower growth and survival rates, indicating that these chicks suffer a higher risk of starvation and/or predation. Conservation efforts for black-tailed godwits and other meadow birds should therefore focus on the provenance of herb-rich meadows with high water tables that are managed in ways that reflect traditional intensities of usage

# Session 2

## 2a: Adaptation of migratory organisms in a changing world

**Conveners:** Christiaan Both (University of Groningen)
Janne Ouwehand (University of Groningen)
Jeroen Reneerkens (University of Groningen)

**1. Adaptation of migratory organisms in a changing world**
Christiaan Both, Janne Ouwehand and Jeroen Reneerkens
University of Groningen

At present, most organisms experience unprecedented changes in their environment, and failure to adapt most likely results in population declines. For many organisms timing of the annual cycle relative to environmental seasonality strongly affects fitness, and environmental change (such as climate change or light pollution) could result in a mismatch between the optimal timing and the actual timing of organisms. In this talk we review the possible processes by which migratory organisms adapt the timing of their annual cycle to changes in the seasonality of their habitats. Migrants could adapt by (1) advancing departure timing, (2) increasing migration speed, (3) select different winter sites, (4) select different breeding sites. For many of these processes we are still at the beginning of our understanding, but we foresee an enormous leap forward with the recent development of ultra-light tracking or geologging devices that allow investigating individual site-use over their entire annual cycle and new statistical tools to analyse site use.

**2. Interaction between timing of migration and reproduction in European Honey Buzzard.**
Willem van Manen, Jan van Diermen, Willem Bouten and Rob Bijlsma
SOVON Dutch Centre for Field Ornithology

The Honey Buzzard is a migratory raptor that breeds in Europe and western Asia and winters in Africa around the equator. Nestlings are mainly fed with the brood of social wasps, which in most years are available from the end of June up to August. Birds that breed early in the season have higher breeding success and produce more fledglings than late breeders. We evaluate the effects of timing of migration on reproductive output in the consecutive breeding season by means the data of 8 data loggered males and 6 females during 2-3 seasons. We found no differences in duration of autumn migration between males and females and autumn migration took 5 days longer than spring migration. On average males departed six days earlier from the wintering areas than females and arrived twelve days earlier, partly due to more and longer stop-overs for females. Birds that departed early also arrived early in the breeding area. Arrival date of females strongly correlated with onset of laying. Interval between fledging and departure of adults decreased with laying date. Late breeding probably not only affects the number of offspring, but probably also the quality, because of a decrease in post fledging parental care. Benefits of early arrival in terms of reproductive output were evident in males as well as in females. This raises the question why not all birds departed earlier from their winter quarters. Although not significant, migration seemed to take longer for birds that departed early. Additionally, foraging conditions may not be favourable during arrival in the breeding area. We think that birds try to maximise their reproductive output by early departure from the wintering area, but on the other hand try to minimise migration effort (duration) and interval between arrival in the breeding area and onset of laying.

**3. Weather-induced spatiotemporal migration dynamics of raptors at a monitoring site suggest predictable variability in detectability: implications for research**
Wouter Vansteelant, Johannes Jansen and Brecht Verhelst
University of Amsterdam

Since 2008 Batumi Raptor Count (BRC) is monitoring the biggest seasonal concentration of migratory raptors in Europe, at Batumi, Georgia. The coverage of breeding population estimates by pilot counts was used to locate impotant priority species for monitoring. Weather may however substantially affect the detecteability of birds from/during fixed observatories/observation times, which clearly should be accounted for in monitoring programs. In this presentation we highlight past and ongoing BRC efforts to better understand raptor migration dynamics at Batumi. We examplify potential implications for monitoring efficacy from typical diel patterns of route choice among raptors and suggest some useful ways to account for weather-induced variation in numbers.

**4. Age-specific density dependence in seasonal survival in a long-distance migrant**
Tamar Lok, Otto Overdijk, Joost M. Tinbergen and Theunis Piersma
University of Groningen / Royal Netherlands Institute for Sea Research

Density dependence is considered of key importance in regulating wildlife populations. Recovering populations offer a unique opportunity to study the role of density dependence in population dynamics. Using 23 years of resightings and recoveries throughout the annual cycle of Eurasian

spoonbills *Platalea leucorodia leucorodia* during a period of population recovery (breeding population size increased 5-fold), we show for the first time that density dependence in survival varies between seasons and age classes in a long-distance migrant. True annual survival of juveniles was quadratically related to population size, increasing at low population sizes while decreasing at high population sizes. In older birds, annual survival consistently decreased with increasing population size. The initial increase in juvenile annual survival was manifested during the non-breeding season, whereas survival during the post-fledging period (i.e. between fledging and start of autumn migration) decreased throughout the study period. In contrast, adult survival was constant and high in summer, whereas it strongly decreased with increasing population size during the late winter period (between December and March). We conclude that the strength of density dependence in survival, as well as the period in the annual cycle where density dependence is strongest, depends on age. This knowledge is crucial for predicting the population consequences of habitat loss, through human activities or climate change, during different parts of the annual cycle.

**5. Heterogeneity in the use of a stopover in decline: staying ruffs have lower survival**

Lucie E. Schmaltz, C. Juillet, Y. I. Verkuil, J. Hooijmeijer and T. Piersma
University of Groningen

Previously considered one of the most common waders in the World, ruffs (*Philomachus pugnax*) have shown remarkable population changes over the last two decades. While birds migrating through The Netherlands and breeding across northern Europe showed a sharp decline following the loss of wet grasslands habitat; numbers have increased on the western Siberian breeding grounds and at a Belarus staging site possibly connected with these breeding grounds. Rather than indicating a global population decline, this suggests a large scale population shift towards the east. To contribute to an understanding of what happens to ruffs in The Netherlands and elsewhere, we here focus on annual survival variation, which is likely to have a large impact on population changes. In our study area covering 400 km² of agricultural landscape along Lake IJsselmeer in south-west Friesland (northern Netherlands), numbers of staging Ruffs have declined by 6% per year between 2001 and 2010. To estimate annual survival rates, between 2004 and 2011, 5497 Ruffs were individually colour-marked. Our intensive colour-ring reading efforts were concentrated on stopover during northward passage - in March-May. The studied population is open and count ruffs with different migration strategies and the ability to disperse to alternative staging site. All individuals do not share same probability to be detected which may affect the reliability of survival estimates. Accordingly, we used multi-event capture recapture models for an open population that account for heterogeneity in individual detection probabilities. We consider in particular two class mixture models with weakly and highly detectable birds. We will present the first estimates of annual survival in ruffs and demonstrate the advantages of the multi-event modeling approach to deepen our understanding of ruffs disappearance over their most western range.

**6. Successful reintroduction of Houting, a migratory fish, despite severe change in environment**

Erwin Winter
Institute for Marine Resources and Ecosystem Studies, Wageningen University and Research centre

North Sea houting (*Coregonus oxyrinchus*) is a diadromous fish species that historically was distributed in the whole Wadden Sea area extending from southern Jutland in Denmark to the Schelde delta in the Netherlands. Houting used esturarine and marine habitats for feeding and streams and rivers for spawning. The species became extinct in the Netherlands in the 1940s. It survived only in a small population spawning in a Danish river. In the 1990s, a reintroduction program was started in the German Rhine. To evaluate this program, data from fish monitoring was used and dedicated studies took place on behaviour of adult houting with telemetry and microchemistry analyses in scale to unravel individual histories in habitat use. A strong increase in houting was observed and stocking of houting larvae ceased in 2006 when sufficient natural reproduction was proven to take place. The telemetry and microchemisty analyses showed large individual behavioural patterns. Where in the past the Dutch delta's encompassed fully functioning estuaries, nowadays these are largely lacking. Instead, large dams (Afsluitdijk, Haringvlietdam) separate newly created freshwater lakes from marine habitats. However, this did not prevent the houting from a successful comeback and the majority of the population appears to complete its lifecycle in freshwater, whereas historically and in the Danish rivers the houting still shows a diadromous habitat use.

## 2b: Genomics of Adaptation and Species interactions

**Conveners:** Bregje Wertheim (University of Groningen)
Louis van de Zande (University of Groningen)
Ken Kraaijeveld (Leiden University Medical Center)

### 1. Genomic interactions between Wolbachia and its host

Ken Kraaijeveld
Leiden University Medical Center

The genomes of species are shaped by interactions with other species. Among the most intimate species interactions are those between endosymbionts and their hosts. For example, many insects are infected with Wolbachia bacteria that manipulate their reproductive behaviour. This particular interaction may involve alterations of host gene expression, horizontal gene transfer and perhaps epigenetic modifications of the host genome. We recently sequenced the genomes of the hymenopteran parasitoid Leptopilina clavipes and its Wolbachia endosymbiont. In this species, Wolbachia induces parthenogenesis, but the molecular mechanism through which it achieves this is currently unknown. Surprisingly, Wolbachia-induced parthenogenesis appears to have unintended side-effects on the abundance of certain transposons in the L. clavipes genome. Parthenogenetic populations harbour more copies of DNA transposons and a *gypsy*-like retrotransposon than sexual populations. We argue that this is due to the complete homozygosity of the parthenogenetic genome and (epi)genetic manipulation by Wolbachia, respectively.

### 2. Phenotypic and genomic characterization of parasitoid resistance in *Drosophila* species

Laura Salazar Jaramillo, L. van de Zande, C. Vermeulen, T. Schwander and B. Wertheim
Groningen University

Immune systems are under constant selection pressure for change driven by the large diversity of parasites they are exposed to. This is at the root of the large genetic variation found in immune genes. At the same time there is high conservation of immune elements across the animal kingdom, because some proteins take part in multiple processes, or because they occupy a key position the interaction network. Using genomics we can gain information about the evolutionary changes in the genome, which in turn gives us insight into conserved functions and novelties. To study the evolution of the immune response in relation to changes in the genome, we compared both the immunological resistance to parasitoids and the genomes of 12 sequenced *Drosophila* species. Parasitoid wasps have profound effects on the fitness of their host, because they are ultimately killed by the wasps during their development. Melanotic encapsulation is the main response found in *Drosophila* against parasitoid wasps. Within *Drosophila* there are species that apparently do not mount an immune response, even though some of these species are natural hosts of the wasps and coexist sympatrically with other *Drosophila* species that are able to respond. This raises the question whether the ability to mount an immune cellular response against parasitoid wasps has been lost in the non-responsive species or gained in the responsive ones, and what genome changes are possibly associated with such gains or losses. We find that the ability to encapsulate is restricted to a lineage. Inside this group, however, encapsulation ability has probably been lost in at least one species. At the genomic level, we find a set of key genes with recent duplications, which are likely to have occurred in the ancestor of the lineage. Moreover, we also find putative functional losses in specific genes of the species that has lost the encapsulation ability.

### 3. Genomic and phenotypic differences in *Caenorhabditis elegans* isolated from different habitats

Rita J.M. Volkers, L. Basten Snoek, Joost A.G. Riksen, Marilyn M. Murindahabi and Jan E. Kammenga
Wageningen University

For several decades now, the bacterivorous nematode *Caenorhabditis elegans* is widely used as a model species. Many aspects of its growth and development are extensively researched and it is important as a model for human disease pathways. Conspicuously, not much is known about its ecology, about where it lives and which bacteria it eats or about its interactions with its environment.

Recently, forty strains of *C. elegans* were isolated from two different locations in France. Half of them were isolated from rotting apples in Orsay and the other half from rotting hogweed stems in Santeuil, both in the vicinity of Paris. In the NEMADAPT project we are currently investigating the adaptive differences between the worms isolated from both locations.

Besides phenotypic differences (length, generation time), we found genomic differences and even differences in gene expression levels between the worms isolated from Orsay and Santeuil. The experiments that resulted in these observations, were all conducted under standard laboratory conditions, *e.g.* the worms were fed with *E. coli* and grown at 20 °C. *E. coli* is not likely to be the most abundant bacterium in the natural environment of *C. elegans*, therefore we are also investigating their responses to bacteria that were isolated from the same locations as the worms.

The results of the various experiments will be presented at NAEM. Ultimately, the combined results will lead to a better understanding of the adaption and evolution of *C. elegans.*

**4. Phenotypic variation of mate preferences and male pheromones in hybrid Nasonia.**

Wenwen Diao
University of Groningen

Sexual isolation mechanisms that act before fertilization are often considered as a primary reproductive barrier during the process of speciation. Mating behaviour is an important form of sexual isolation, and pheromones contribute to species recognition. In jewel wasps *Nasonia* (parasitic *Hymenoptera*), *N.oneida* females have a high mate discrimination against *N. giraulti*, but *N. giraulti* females are less choosy. The two species differ in amount of male pheromones that are used to attract females. We have quantified mating behaviour and the regulation of male pheromone production in recombinant haploid F2 hybrid males, as well as mate discrimination in F3 backcrossed females, in order to determine the underlying genetic architecture and to understand the evolution of reproductive isolation.

**5. Genetics of interspecific mate discrimination in the parasitoid wasp *Nasonia vitripennis***

Maartje Giesbers
University of Groningen

Reproductive isolation plays a key role in the process of speciation. It generates genetic divergence between populations, and can lead to the emergence of new species. In many species pairs, for which isolation is incomplete, hybrid offspring have a fitness disadvantage. Therefore, selection is expected to reduce interspecific matings by favouring traits that eventually result in pre-zygotic isolation barriers.

The hymenopteran parasitoid wasp species *Nasonia giraulti* and *N. vitripennis* occur in sympatry in eastern North-America. Species-specific infection with the endosymbiont *Wolbachia* prevents the production of hybrid offspring, making interspecific mating very costly. Although the two species differ in male courtship behaviour, this is not sufficient to prevent interspecific matings. In addition to male courtship, other reproductive traits potentially play a role in pre-zygotic isolation. *N. vitripennis* females have high mate discrimination against *N. giraulti* males, but *N. giraulti* females do not discriminate against males from different species. *N. giraulti* females predominantly mate before emerging from the host (within-host mating), while *N. vitripennis* females mate after emergence.
Here we report the successful artificial selection for decreased mate discrimination of *N. vitripennis* females. Furthermore, we describe the genetic architecture of this trait using a quantitative trait locus analysis.

**6. The genomics of personality in great tits**

Kees van Oers, Nikkie van Bers
Netherlands Institute of Ecology

Animals within populations consistently differ in the way they deal with environmental challenges. This phenomenon is often referred to as animal personality. Personality differences have been shown to be wide-spread and to influence fitness in natural populations. Quantitative genetic variation underlying personality differences has been demonstrated in studies both on wild as well as captive populations. Until recently it was impossible to connect this variation to molecular genetic variation. Such a connection is essential to identify genes responsible for phenotypic variation and to study the way these genes interact with the environment in which they are expressed, in order to describe or predict micro-evolutionary processes. Here we show the first results of the genomic characterisation of the great tit and its associations with personality in an F2 cross population from lines selected for exploratory behaviour.

## 2c: Phenotypic Plasticity

**Conveners:** Silvia Paolucci (University of Groningen)
Lucia Salis (Netherlands Institute of Ecology)

**1. The role of phenotypic plasticity in adapting to a warming world**

Marcel E. Visser
Netherlands Institute of Ecology

Climate change is affecting many traits, including seasonal timing of reproduction. Because favourable conditions to raise offspring are shifting to earlier dates in the year, organisms also have to initiate reproduction earlier. One way to adapt is via phenotypic plasticity where cues are used to 'predict' the period of favourable conditions. This has led to substantial shifts in seasonal timing. However, as climate change has not affected temperatures in the same way throughout the year it is unlikely that the cues used in plasticity and the environment that need to be 'predicted' are changing at the same rate. Moreover, other cues, like photoperiod, are not changing at all. Hence, adaption via phenotypic plasticity alone will be insufficient and thus micro-evolution of the phenotypic plasticity, which is likely to be slow, is needed.

**2. Seasonal adaptation in the parasitoid wasp *Nasonia vitripennis*: photoperiodic induction of diapause and its genetic basis**

Silvia Paolucci, Louis van de Zande and Leo Beukeboom
University of Groningen

Seasonal adaptation in species with a wide geographical distribution requires optimal synchronization of life cycle with seasonal cycles. Organisms are able to anticipate the seasonal change using different environmental cues and they respond with a broad range of adaptations such as migration, hibernation and diapause. Daily light-dark cycle (photoperiod) represents a reliable signal for upcoming seasonal change and is used by many organisms as a cue for optimal timing of diapause induction. Photoperiodic induction of diapause in the parasitoid wasp *Nasonia vitripennis* shows latitudinal geographic variation which is probably the result of adaptation to local environmental conditions. In order to investigate the genetic basis of diapause variation, we crossed lines from northern Finland (high diapause tendency) and Corsica (low diapause tendency) and scored diapause response in offspring generations under controlled light:dark conditions. The results indicate that photoperiodic induction of diapause has a polygenic basis. Using a QTL analysis and candidate gene approach we could identify some genomic regions involved in diapaue induction.

**3. Adaptation to seasonal environments in a butterfly: alternate life history strategies and their hormonal regulation**

Vicencio Oostra
Leiden University

Virtually all organisms face some level of heterogeneity in the quality of their environment. When such fluctuations are seasonal and thus predictable, there is scope for anticipating them and adjusting life history strategies well in time. Such plasticity is a common feature of animal life, and may include such diverse adaptations as migration, diapause or plumage molt. The afrotropical butterfly *Bicyclus anynana* copes with its habitat's contrasting seasonal environments by expressing alternate life history strategies in each season. In the warm wet season, food is abundant, butterflies reproduce fast and live relatively short lives. In contrast, in the cold dry season, food is limited and butterflies bridge this harsh period as stress-resistant adults, postponing reproduction until the start of the next wet season. We study the role of hormones in interpreting the environment during development and inducing changes in adult traits involved in the seasonal adaptation.

We have found that a continuous temperature gradient induces a treshold response in Ecdysteroids during the pupal stage. This demonstrates that hormones can translate a linear environmental gradient into a discrete signal and, thus, that polyphenic differences between adult morphs can already be programmed at the stage of hormone signalling during development.

Subsequently, we manipulated Ecdysteroid hormones during development. This induced changes in adult body allocation to reproductive function. We then tested whether these morphological changes translated to adult performance, and indeed found an accelerated onset of reproduction, at a cost in later life fecundity and lifespan. Together, our results point to a functional role for Ecdysteroids during development in translating information on environmental quality into adaptive alterations in a suite of traits in the developing adult. This shows how organisms can use systemic hormones to respond to indicators of environmental quality and make strategic life history decisions that allow them to persist in the changed environment.

**4. Predictive adaptive response: modelling the life history of *Bicyclus anynana***

Joost van den Heuvel
Leiden University

Predictive adaptive responses (PAR) are hypothetical ways in which organisms can maximize fitness in varying environments. PAR may have particular significance for human disease; for example, metabolic responses to early nutritional deprivation, which might have been adaptive in adverse environments, may predispose to later-life illness in modern, affluent societies. Insects living in seasonal environments are valuable examples for testing the basic concepts of PAR. By manipulating the larval and the adult environments of the butterfly *Bicyclus anynana*, it has been found that individuals that were food restricted during the larval stage coped better with forced flight during the adult stage compared to individuals with an optimal larval stage. Here we describe a state-dependent energy allocation model with which we have tested whether this response could be adaptive in a field situation where this butterfly exhibits a life history that varies seasonally.

The results confirmed that wet-season individuals coped better with flight stress when restricted in nutrition during early development compared to individuals with an optimal larval stage. This outcome was facilitated by altered allocation patterns during the pupal stage. We conclude that for *B. anynana*, early-stage cues can direct development towards a more optimal phenotype later in life. This suggests that future state-dependent modelling could be used to study whether developmental plasticity is adaptive for longer-lived species, including humans.

**5. Is being plastic fantastic? Opposite consequences of locally adapted salt-marsh pioneer vegetation on ecosystem-level robustness**

Jim van Belzen, Jeroen van Dalen, Johan van de Koppel, Peter M.J. Herman, and Tjeerd J. Bouma
Royal Netherlands Institute for Sea Research

Many ecosystem experience increased rates of environmental changes and degradation due to the pressure of the ever-growing human population. Therefore, a more complete and rigorous understanding of the responses that can be expected, of complex interconnected ecosystems, is of great importance. Ecological communities can respond in different ways and it is important to identify and understand which structural properties are key in determining systems robustness and fragility. Often, it is suggested that adaptive traits will improve ecosystems robustness. For example, phenotypic plasticity is coined as an adaptive developmental strategy in heterogeneous environments, making populations or communities more robust against changes. Here we test this assertion. Combining empirical and computational data establishes how phenotypic plasticity of salt-marsh pioneer vegetation has important implications for ecosystem vulnerability. Growth experiments and field data reveal that cordgrass (*Spartina anglica*) seedlings, developing in an erosive environment, adjust their root development to provide better anchorage to the sediment. Seedlings growing in an accreting environment do not. So, phenotypic plasticity can improve seedling survival chances, thereby, improving the ability to recover once disturbed. Likewise, at the vegetated boundaries of the salt-marsh, plants develop well anchored roots compared to vegetation inside the marsh, thereby, improving resistance against hydrodynamic disturbances. However, incorporation of these plastic traits into a spatial explicit model reveals that these adaptations can lead to catastrophic erosion events. After vegetation edges get disturbed, roots are not able to slow down erosion sufficiently due to underdeveloped anchorage. Although it might seem counterintuitive at first glance, this study underlines that adaptive strategies, optimizing performance locally can have contradicting consequences at ecosystem-level, affecting resilience and resistance in opposite ways.

**6. Phenotypic plasticity and population viability: the importance of environmental predictability**

Thomas Reed
Netherlands Institute of Ecology

Phenotypic plasticity plays a key role in adaptation to variable or changing environments, but we have only rudimentary understanding of how plasticity interacts with the magnitude and predictability of environmental variation to affect population dynamics and persistence. I present insights obtained from a stochastic simulation model, which assesses the population dynamic consequences of plasticity under different levels of environmental stochasticity and cue reliability. In the model, phenotypes could respond to a temporally fluctuating environmental cue and fitness depended on the match between phenotype and a fluctuating trait optimum. When cue and optimum were tightly correlated, plasticity buffered absolute fitness from environmental variability, and population size remained high and relatively invariant. In contrast, when this correlation weakened and environmental variability was high, strong plasticity reduced population size, and populations with excessively strong plasticity had substantially greater extinction probability. The model therefore suggests that reaction norms that evolved under historic selective regimes could imperil populations in novel or changing contexts (e.g. species introductions, altered local climates), which might influence both the variability and predictability of cues and selective factors. I finish by discussing how optimal reaction norms can be shaped by both adaptive plasticity and bet-hedging processes.

## 2d: The ecology of artificial habitats

**Conveners:** Wouter Lengkeek (Bureau Waardenburg)
Joop Coolen (Stichting de Noordzee)

### 1. Introduction and the ecological importance of shipwrecks in the North Sea

Wouter Lengkeek and Joop Coolen
Bureau Waardenburg

The ecological importance and need for conservation of artificial habitats is still subject of debate. Many examples exist of species that depend on artificial habitats for their survival. Bats often roost in old buildings such as military bunkers and these roosting places are protected. Many bird species have adapted to life in urban environments and depend on man-made habitats for their survival. The ecological importance of artificial habitats, however, is not always recognized. In some cases attempts to conserve biodiversity on artificial habitats can lead to resistance. One example is formed by shipwrecks in the North Sea. Some still regard these wrecks as human waste on the seabed. From a recent study, however, it appears that shipwrecks are hotspots for biodiversity and are home to native species that may disappear when these habitats are lost. They have a significant ecological function in the North Sea.

### 2. Cod and sole behaviour in an offshore wind farm

Erwin Winter
Institute for Marine Resources and Ecosystem Studies, Wageningen University and Research centre

Offshore wind energy is a rapid increasing renewable energy sector. The effects of these wind farms on fish can be adverse, e.g. avoidance due to noise disturbance, indifferent or even beneficially, e.g. through local banning of fishing and monopiles with scour beds providing new artificial hard substrate habitats. These effects are likely to be highly species specific. We studied the behaviour of individual cod and sole by means of acoustic telemetry in the Offshore Wind farm Egmond aan Zee (OWEZ) during 10 months by covering 16 of the 36 monopiles with receivers. Individual variation in behaviour was large. Sole appeared indifferent to the monopiles, spending mostly limited time within the vicinity of monopiles, whereas cod, used the areas directly around the monopiles much more intensive. Part of the cod with transmitters stayed near monopiles for several months up to the entire 10 months, sometimes switching to a different monopole. These cod showed very different diurnal patterns in behaviour throughout the seasons. We found no preference of cod for monopiles that were out of order over monopiles that were in production. Our results suggest that cod is attracted to the newly created habitats and in combination with a fishery ban the wind farm may serve as a small refuge for fisheries.

### 3. Artificial reefs in the Dutch coastal zone

Godfried van Moorsel
Ecosub

In 1992, four basalt-stone reefs were deployed in the Dutch coastal zone, 8 km off the coast near Noordwijk. The succession of benthic life on these artificial reefs was studied until 2001. Within weeks, the reefs were discovered by Eel and Edible crab and free-rolling sea-anemones. Biodiversity increased strongly during the first few years. After a decade, a similar number of species was present, but the species composition had changed. Reef effects on the surrounding environment were investigated by benthic sampling and beam trawling. The deployment of reefs quickly resulted in the presence of large schools of Bib (*Trisopterus luscus*). Brown shrimp (*Crangon crangon*) densities were reduced at distances up to 100 m from the reefs, possibly due to predation by these Gadoids.

Unfortunately, the outcome of this study was influenced by the nearby dumping of harbour sludge. Nevertheless, the results served as a basis to predict the ecological succession on and near other structures in the North Sea, such as wind turbines.

### 4. Urban biotopes

Floris Brekelmans
Bureau Waardenburg

The entire Dutch landscape has been manipulated by men and natural habitats have changed tot artificial. Many plant and animal species have adapted to this situation and live in artificial habitats that are similar to natural habitats. But new, previously non-existing habitats have also come into existence. This changing landscape has led to the local disappearance of some species, but simultaneously facilitated new colonisations by others. The urban environment forms a complex artificial biotope that is particularly species rich. But how important is this urban environment for the preservation of our native flora and fauna? Is the protection of artificial urban habitats needed?

**5. Urban avian conservation in a global perspective**

Jip Louwe Kooijmans
Vogelbescherming / Birdlife NL

For long the House sparrow [Passer domesticus] was by far the most common bird in The Netherlands. Because of recent drastic decline in numbers the species became Red Listed in 2004. As the main part of the house sparrow population lives within city boundaries, this draws attention to the fact that cities are rapidly changing, and degrading as a habitat for birds. This was the reason for Birdlife NL to start a program on the conservation on urban birds. Since 2007 more that 50 % of the human world population lives in cities. In this perspective programs on conservation and awareness of urban birds have been started by partners of BirdLife International around the world. A working group, BIG UB [Birdlife International Group on Urban Birds], focuses on the exchange of knowledge and experience on this subject, and the development of joint approaches.

**6. Artificial bat habitats: From old fortresses to innovative building**

Herman Limpens
Dutch Mammal Society

Men and bats have coexisted in buildings such as fortresses for centuries. Old fortresses are still important bat habitats. But most old buildings are eventually replaced by new ones, and modern building can lead to the loss of bat habitat. In recent building projects, however, new innovations are used to deliberately facilitate bat roosts in modern buildings.

# Session 3

## 3a: Aquatic ecology: dynamics and feedbacks and consequences for ecosystem management

**Conveners:** Lisette N. de Senerpont Domis (Netherlands Institute of Ecology)
Steven DeClerck (Netherlands Institute of Ecology)

### 1. Contributions of aquatic ecology to ecosystem management: how to make ecological principles operational

Lisette N. de Senerpont Domis and Steven A.J. Declerck
Netherlands Institute of Ecology

We will give an introduction on which lessons learned from fundamental science have contributed to more effective nature conservation and ecosystem management. We will illustrate this by giving some innovative applications of knowledge obtained in fundamental aquatic ecological research. We focus on four research themes which have been subject to intensive study in the past decades: (1) The role of dispersal in connecting aquatic systems at the landscape scale, (2) The biodiversity-ecosystem functioning relationship, (3) Causes and implications of regime shifts, and (4) Interactions between ecosystem drivers.

### 2. Unravelling the responses of Nile perch population dynamics to changes in Lake Victoria

Andrea S. Downing, Egbert H. van Nes, Marten Scheffer, Wolf M. Mooij
Wageningen University / Netherlands Institute of Ecology

There is serious concern over the fluctuations in Nile perch catches in Lake Victoria. However, a recent study suggests that over-fishing does not drive trends in Nile perch population size-structure, this result has led to the hypothesis that eutrophication drives observed trends. Indeed, over the past decades, Lake Victoria's food web has been greatly restructured and changed; there have been visible signs of eutrophication while human pressure on its resources has also increased. We aim, here, to unravel how Nile perch population growth and size-structures respond to changes in resources and mortality. We build a growth model for Nile perch that accounts for known changes in length at ontogenetic diet shift and observed fluctuations in resource abundance. With this growth model we estimate existence boundaries for Nile perch under different resource and ontogeny scenarios and analyse the effects of mortality, ontogenetic diet shifts and resource abundances on population size-structure. We find that ignoring ontogeny can lead to over-estimating the maximum sustainable mortality of a Nile perch population.

Also, we warn that length-frequency distributions are likely a poor indicator of over-fishing, since ontogeny and the relative abundance of different resources can have a strong effect on population size-structure. We suggest that rather than using population size-structure as an indicator of over-exploitation, Nile perch diet relative to prey abundance could be a better indicator of the resilience of Nile perch populations to fishing pressure.

### 3. The Cod delusion – or timing problems of a marine predator: The bliss and curse of density dependence

Anieke van Leeuwen
University of Amsterdam

The dynamics of several Atlantic cod (*Gadus morhua*) stocks have had population collapses in the last century, without recovery since. Data analysis of the Baltic Sea foodweb has shown that the current situation (with historically low cod biomass) is likely to be an alternative stable attractor of the system. The cause of the bistability in this marine system is generally thought to lie in extrinsic factors such as climate and salinity, but processes within the community are hardly regarded as stabilizing mechanisms.

We investigate the potential for bistability resulting from the population dynamics of cod and sprat, the main predator and zooplanktivore in the system. We use a physiologically structured population model to study the size-structured predator-prey dynamics between these two species and we investigate the occurrence of bistability in this system in two predation models: (1) Piscivorous cod divide their foraging time equally between an alternative resource and sprat and (2) cod completely switches to predation when it becomes piscivorous. The two scenarios represent extremes on a scale of foraging interactions, while data is inconclusive as to where the realized feeding interactions lie in case of Baltic cod.

Only the second model leads to bistability and there are two parameter regions of interest, one with persistence but no invasion ($R_0 < 1.0$) and one with invasion but no establishment ($R_0 > 1.0$). Both phenomena are caused by a mismatch in timing of the predator with prey, resulting from the ecological dynamics in the pre-piscivorous life stage of the predator.

**4. Body size and dispersal mode as key traits determining metacommunity structure of pond organisms**

Steven A. J. Declerck, Tom De Bie, Luc Brendonck, Koen Martens, Boudewijn Goddeeris, Dirk Ercken, Henrietta Hampel, Luc Denys, Leo Vanhecke, Katleen Van der Gucht, Jeroen Van Wichelen, Wim Vyverman and Luc De Meester
Netherlands Institute of Ecology

A better understanding of how and why patterns of community variation differ among organism groups and across spatial scales is important for conservation biology and restoration planning because it may reveal the mechanisms that generate and maintain beta and gamma diversity. Body size and dispersal mode are key organism traits that may strongly determine the relative importance of environmental control and dispersal limitation in metacommunities. We compared metacommunities of a wide variety of aquatic assemblages (12 groups, ranging from bacteria to fish) in a same set of locations (99 ponds) and investigated the association between body size, dispersal mode and the relative strength of spatial patterning and environmental control. For the category of passive dispersers, we detected a positive association between body size and the degree of spatial patterning, suggesting that dispersal limitation is more important in metacommunities of large than small organisms. Organisms with the ability to fly (i.e. insect groups) showed weaker spatial patterns than passive dispersers with similar body size, suggesting lower degree of dispersal limitation. In contrast, dispersal limitation of vertebrate groups (fish and amphibians) seemed to be especially strong and mainly confined to local connectivity patterns. With increasing spatial scale, metacommunities tend to shift from being environmentally controlled to being dispersal controlled. Our study illustrates that the spatial scale at which this shift occurs differs strongly among assemblages and is determined by body size related traits and dispersal mode.

**5. Hitchhiking in wetland ecology: seed transport by ducks**

Erik Kleyheeg, Mary Ann Morison, Casper van Leeuwen, Bart A. Nolet and Merel B. Soons
Utrecht University

Habitat loss and fragmentation are major concerns in wetland ecology. Physical isolation of wetlands hampers hydrochorous dispersal of aquatic and riparian plants, and thus geneflow among populations and colonization of available patches. Can plants rely on other dispersal mechanisms for mitigation of these negative effects of isolation? Ducks and other waterbird species have been proposed as dispersal vectors of a large range of aquatic organisms between wetlands, including plant seeds. Stuck to bare skin or between feathers seeds may be passively transported by flying birds (ectozoochory), but more frequently they are transported while retained in the digestive system (endozoochory). However the digestive system is per definition a hostile environment and most seeds do not survive exposure to mechanical, chemical and microbial processes in the gizzard and intestines. Interspecific differences in survival rate, thus dispersals potential may have implications for the ecology of wetland vegetation. We have tried to quantify this by studying the role of the avian dispersal agent that is most likely to have a large impact on wetland plant population dynamics.

The mallard (*Anas platyrhynchos*) is an abundant onmivorous duck species in Western Europe which forages mainly on seeds during autumn and winter. Mallards have a typical avian digestive system, frequently perform flights within and between wetlands and have been pointed out as a potentially important vector in endozoochorous seed dispersal. To evaluate the incidence and importance of this dispersal process, we analysed the contents of mallard digestive tracts and evaluated the effect of seed traits in feeding experiments with mallards. We found that a high proportion of mallards carries seeds in the digestive tract covering a large range of wetland species. Accumulation of seeds takes place in the muscular gizzard where mechanical destruction causes fragmentation of seeds to facilitate food uptake in the intestines. Only a small proportion of the total amount of seeds will eventually be excreted intact, which is highly dependent on species-specific seed traits such as seed size. We also found that recently shown negative effects of physical activity of mallards on digestive efficiency may be obscured by overall short retention and poor survival of seeds. For biodiversity conservation and wetland management in fragmented habitats this means that the role of waterfowl in preservation of viable wetland plant populations should be recognized and protected, but that the geographical distance between wetlands should still be minimized for effective seed dispersal.

**6. Water level fluctuations and their role in shoreline biodiversity**

Judith M. Sarneel, Merel B. Soons, Roel Janssen and Liesbeth Bakker
Utrecht University / Netherlands Institute of Ecology

In the Netherlands, water levels have become strictly regulated, and natural fluctuations (low in summer and high in winter) are now minimized or even reversed. Nowadays, regime shifts towards more natural fluctuations are established in numerous water bodies. This will have consequences for processes that govern diversity such as dispersal, germination and establishment. The processes that

govern germination and establishment in riparian zones were investigated in a set of field and lab experiments.

In a field experiment in ponds with stagnant water tables, we showed that germination was determined by light availability, which was highest at south-facing banks at the downwind pond end. However, subsequent establishment was severely hampered there because these downwind banks were also attacked by higher waves. Stagnant water tables could therefore hamper new colonization events as most seeds will be deposited in the same location as where the waves are in spring, during germination. More fluctuating water tables, where seeds are deposited higher on the bank during winter and where the gradient from wet to dry is wider, germination and establishment could be enhanced. We also tested the germination of different species at different elevations on the bank in areas where the water was allowed to fluctuate. As expected, riparian species show germination responses to flooding according to the overall wetness of their preferred habitat. However, neither total germination nor diversity was affected by flooding duration, but establishment decreased with increasing flooding duration. This implies that prolonged flooding, especially during late spring and summer may form an important bottleneck for the development of riparian zones with a high biodiversity.

## 3b: Ecotoxicology and ecosystem functioning: impacts of chemicals related to ecological traits

**Conveners:** Geert de Snoo (Leiden University)
Willie Peijenenburg (RIVM / Leiden University)

### 1. Towards a more efficient predictability of adverse effects of chemicals on ecosystems.

Willie Peijenenburg and Martina Vijver
RIVM / Leiden University

Despite decades of scientific research, the ultimate question on the actual impact of chemicals emitted into the environment is still difficult, if not impossible, to answer. Amongst others, this observation challenges risk assessors to derive safe expsoure levels that include high safety factors which in turn compromise the competitiveness of the European chemical industry and are excessively costly to the public at large. Typically, it was common practise to derive safe exposure levels for individual chemicals, based on experimental fate and effect data derived for all environmental compartments (air, water, soil) considered to be potentially at risk. In turn this calls for a massive generation of data for individual compounds for specific environments.

On the other hand, various science-based concepts have been developed and progress is made in predicting adverse effects of (mixtures of) chemical substances. In this respect a special position is taken by emerging classes of chemicals that require specific effect assessment due to their specific physico-chemical properties and/or special use patterns. Examples include nanomaterials and, the new generation of pesticides typically effective at extremely low concentrations, and endocrine disrupting chemicals.

It is the aim of this contribution to review newly developed concepts that allow for improved and more accurate prediction of fate and effects of (emerging) classes of chemicals. Amongst other, the concepts of ecological traits, Quantitative Structure Activity Relationships, and Biotic Ligand Modeling will be dealt with.

### 2. Effective design of programmes for monitoring risks of Cu, Ni and Zn to aquatic ecosystems.

Anja Verschoor, Vink JPM. De Snoo G and Vijver MG
Leiden University / RIVM

Effective monitoring of metal risks urges to minimize the number of samples and parameters without loss of information. A large surveillance monitoring dataset of 372 sites over the period 2007-2010 was explored to find seasonal patterns in metal bioavailability and risks to aquatic ecosystems and to find the a limited set of key parameters that explain variations in risk due to metal exposure.

Sensitivity of species as well as predicted risks of Cu, Ni and Zn exposure shifted among species over space and time, due to changes in metal concentrations, speciation, and biotic ligand binding. Sensitivity of individual species (NOEC) and of the ecosystem (HC5) for Cu, Ni, and Zn showed a spatial variation up to 2 orders of magnitude. Seasonality of metal bioavailability and risks were shown, with an average ratio between lowest and highest risk of 1.3, 2.0, and 3.6 for Cu, Ni, and Zn, respectively. Maximum risks of Cu, Ni, and Zn to ecosystems were predicted in February and minimum risks in September. The seasonal pattern of risks is dominated by the seasonal pattern of metal concentrations. By multiple regression, set of three key parameters could be identified: pH, dissolved organic carbon and either Ca, Na or Mg.

The study indicates that there are possibilities to improve the efficiency of monitoring programmes by focussing on characteristic sampling moments and key parameters for metal bioavailability.

### 3. Traits could be helpful to predict toxicity of Nano copper among cladoceran species

Lan Song, Martina G. Vijver, Willie J.G.M. Peijnenburg and Geert R. De Snoo
Leiden University

Ecological traits of species may provide useful information to investigate the toxicity of Cu NPs because interactions between nanoparticles (NPs) and organisms are target-oriented and could be strongly associated with the morphology and physiology of organisms.

The present study was carried out to investigate if sizes and surface areas of organisms could be the useful traits which indicate toxicity of nano copper (Cu NPs) (25nm, 50nm, 78nm, and 100nm) among four cladoceran species. Sizes and surface areas of juveniles of four species (<24hours) were documented before the start of the experiment. Cu NPs were dispersed in Dutch Standard Water (DSW) by sonication. Sizes and stabilities of Cu NPs were characterized by Zetasizer (Malvent). Organisms were exposure to the medium and $LC_{50}$ were evaluated after 24 and 48 hours, respectively.

The results show that all sizes of Cu NPs induce high toxicity to all cladoceran species. There is no clean relation between the toxicity and the size of Cu NPs. Ceriodaphnia dubia was the most sensitive organism. Size of species is the ecological trait which is most useful to predict the toxicity of Cu NPs to different cladoceran species.

**4. Natural toxins and their molecular and life-history effects on non-target soil invertebrates**

Elaine van Ommen Kloeke, C.A.M. van Gestel, Bauke Ylstra, P. Gong, J. Ellers and D. Roelofs
Vrije Universiteit Amsterdam

Soil invertebrates that belong to the detrital food web are essential for proper soil ecosystem functioning, as they control carbon and nutrient flows and stimulate plant nutrient uptake. Soil ecosystem functioning is challenged by many anthropogenic toxins which can disrupt the soil ecosystem through mortality or reduced reproduction of soil organisms. Natural toxins, on the other hand, are rarely considered a threat to the environment yet can be lethal at low dosages. Natural toxins are organic compounds that are produced as secondary metabolites in fungi, bacteria, algae, plants or animals.

Glucosinolates (GSL) are natural toxins produced as secondary metabolites by many commercial crops (e.g. Broccoli and Cabbage). Tissue damage hydrolyses GSL into several toxic compounds such as isothiocyanate (ITC) and nitriles, which is mediated by the enzyme myrosinase. Current interests in ITCs focus on the toxic characteristics that have, for instance, been exploited for alternative pest management methods, so-called biofumigation, but also the possible chemopreventive nature of ITCs. Due to these social-economic benefits, novel crop varieties with enhanced levels are likely to be introduced in the future. This may introduce a potential risk for soil ecosystem processes by exerting detrimental effects on beneficial non-target soil organisms.

This study focused on the effects of ITC on the detritus food web, using *Folsomia candida* and *Eisenia andrei* as model species for beneficial soil invertebrates that maintain essential soil functions. Data from standardized ecotoxicological tests was combined with gene expression profiles obtained with microarrays to have more insight into the molecular mechanism of the toxic responses.

Results will focus on:

1) Toxic effects on survival and reproduction of allyl ITC *Folsomia candida* and *Eisenia andrei* using ecotoxicological experiments.
2) Gene expression analysis that reflect negative effects of allyl ITC on soil invertebrates, using microarrays.
3) Comparative genomic analysis to identify commonalities in stress response pathways between *Eisenia* and *Folsomia* when exposed to the same stress factor.

**5. Collisions drive Brownian motion in self-organized mussel beds**

Monique de Jager, Andrea Kölzsch, Frederic Bartumeus, Geerten Hengeveld, Bart A. Nolet, Peter M. J. Herman, and Johan van de Koppel
Royal Netherlands Institute for Sea Research

Einstein proposed that collisions provide a universal explanation for Brownian motion in free-moving particles. Whether Brownian motion observed in the movements of searching animals is similarly driven by encounters or alternatively is an innate search strategy, has generated much controversy. Here, we provide experimental evidence that in self-organizing mussel beds, Brownian motion results from frequent encounters between organisms. In a controlled experimental setting, we detected that the observed movement pattern shifts from a Lévy walk when mussel are alone to a Brownian walk with increasing mussel density. Analysis of the encounters between mussels revealed that this shift to Brownian motion is caused by truncation of movement steps due to collisions with conspecifics. We conclude that - opposite to the notion of Brownian motion as an intrinsic search strategy - Brownian motion emerges from repeated encounters between organisms in dense communities, underpinning the generality of Einstein's theory.

**6. Disease invasion dynamics: brucellosis and tuberculosis in African buffalo**

Erin Gorsich
Oregon State University

Invasive diseases can alter the dynamics of native pathogens by altering their transmission, duration of infection, or host mortality. To understand the dynamic consequences of co-infection, I investigate how immune-mediated interactions between an introduced, bacterial infection, bovine tuberculosis (TB, *Mycobacterum bovis)* alter the dynamics of a similar, endemic infection, brucellosis (*B. abortus)* in African buffalo. Both pathogens cause chronic infections in African buffalo and are associated with immune suppression, suggesting a prominent role of host immunity in determining infection patterns. Preliminary data suggests that the probability of becoming infected with brucellosis is associated with TB infection and reduced immunity. Co-infection with TB and brucellosis may also be associated with increased mortality, as co-infected individuals have reduced body condition. These two results are predicted to have opposite consequences for population level disease patterns. Therefore, to assess the combined consequences of co-infection on brucellosis dynamics, I will outline a disease dynamics model. This representation will allow me understand how BTB affects brucellosis dynamics by combining its effects on multiple within-host processes.

## 3c: Plant-Insect Interactions

**Conveners:** Maaike Bruinsma, (Leiden University)
Luisa Carvalheiro (University of Leeds, NCB-Naturalis)

### 1. Plant-insect interactions under increasing herbivore diversity

Tibor Bukovinszky
Netherlands Institute of Ecology

Much of our understanding of the mechanisms that determine species diversity and the resulting effects on ecosystem functioning comes from plant communities. Thus the effects of herbivore species diversity on consumer communities are less known. Using insect herbivore communities, which were experimentally assembled on a single food plant species, we studied the effects of increasing herbivore species richness on growth of the whole community and the population growth of component species within herbivore communities. Our aim was to examine how herbivore communities are influenced by a change in the species richness of the community. Additionally, we studied whether herbivore species within a community responded alike to an increase of species diversity or rather in a species-specific manner. Food quality plays a central role in mediating plant-insect interactions, and determining consumer diversity. We have therefore also manipulated levels of macronutrients (nitrogen and phosphorus) within the food plant and examined if the effects of herbivore diversity on insects would be the same on nutrient poor and rich resources. Herbivore diversity positively influenced community growth, with variable effects on the population growth of component species. The importance of herbivore community diversity in studying plant-insect interactions is discussed.

### 2. Neighbour identity matters: Effects of plant diversity and identity on the insect communities of individual ragwort plants

Olga Kostenko and Martijn Bezemer
Netherlands Institute of Ecology

We use ragwort (*Jacobaea vulgaris*) to elucidate how the composition and abundance of insects on individual plants can be affected by the diversity or identity of the neighbouring plant community. First, we examined insect communities on individual ragwort plants growing in restoration grasslands in the Netherlands that differ in vegetational characteristics and in ragwort abundance. We found higher insect abundance and diversity on ragwort plants growing in old than in young restoration sites. Ragwort abundance in old sites was also lower, and individual plants were smaller but of higher nutritional quality than plants growing in young sites. In this study, both host plant and neighbouring plant community characteristics differed between young and old sites, and both these characteristics significantly explained variation in the insect community on individual plants. In a second field study, we set-up a biodiversity field experiment, where we manipulated and maintained the diversity (0-9 species) and identity of the plant community in 70 experimental grassland plots. After the plant community had established, in each plot 25 ragwort seedlings were planted. During the next growing season, insects were collected from each ragwort plant throughout the season. In each community, we also placed four trap plants that had been infested with a generalist leaf-mining herbivore in the greenhouse, to study the effects of neighbouring plant diversity and identity on the host finding behaviour of parasitoids. We will show how the characteristics of neighbouring plant community affect (i) the performance and nutritional quality of the focal ragwort plants, (ii) its arthropod community, (iii) the host finding behaviour of released parasitoids in the field and (iv) the communities of naturally occurring leaf-mining parasitoids. We will also discuss the importance of characteristics of the surrounding environment for interactions between organisms inhabiting different trophic levels in natural settings.

### 3. Benefits of host shifting in a tephritid fruit fly – Rhagoletis alternata on native and non-native roses

Kim Meijer
University of Groningen

The larvae of *Rhagoletis alternata* flies is a real specialists (monophage). They solely feed on the mesocarp (outer layer) of rose hips, the berries of roses (*Rosa*). In western Europe *Rh. alternata*, occurs in different native rose species (e.g. *R. canina*, *R. arvensis* and *R. rubiginosa*), but nowadays also in the non-native Japanese rose (*R. rugosa*). The native roses and the Japanese rose are taxonomically very different and are expected to be morphologically and physiologically different. Combined with the fact that *Rh. alternata* is a specialist, differences in life history traits between flies feeding on native and non-native roses are expected.

We studied the differences in size of larvae feeding on native and non-native roses, which could give an indication of the differences in food quality / quantity of both groups of roses. Furthermore we studied differences in parasitation of the larvae by parasitoid wasps (Hymenoptera: Braconidae).

**4. The challenging interactions between a plant and an insect that is both pollinator, seed predator and vector of disease**

Arjen Biere
Netherlands Institute of Ecology

In nursery pollinator systems (e.g., the yucca-yucca moth system), insects not only pollinate their host plants but also lay eggs in host flowers or other reproductive tissues. The hatched larvae then consume part of the fruits or seeds that are produced. Models generally show that such interactions easily shift from mutualism to parasitism, unless partners have evolved mechanisms to avoid being over-exploited by the other.

Selective abortion of infested fruit is one of the potential mechanisms for plants to control the development of nursery pollinator larvae. We investigated such selective fruit abortion in the interaction between *Silene latifolia* and its nursery pollinating moth *Hadena bicruris,* and assessed some of the associated costs and benefits. Selective abortion of infested fruit in this system appears to be overall high, but the extent differs between plant progeny families, indicating that there is scope for an evolutionary response to selection for abortion propensity, enabling a fine-tuning of the interaction in response to environmental conditions.

The system is further complicated by the fact that the nursery pollinator is also a vector of a florally transmitted disease that sterilizes its host plant. This poses a challenge for the plant, since plant traits that increase pollinator attraction also increase the probablility of contracting the disease. But it also poses a challenge for the nursery pollinator since diseased plants are of inferior quality for its progeny. We show that the nursery pollinator has evolved an adaptive response by avoiding oviposition on diseased host plants.

**5. The influence of plant responses to herbivores on behaviour of pollinators, and consequences for plant fitness**

Dani Lucas-Barbosa, Joop J.A. van Loon, Marcel Dicke
Wageningen University

The objective of this study was to investigate how plant responses to insect herbivores may affect interactions with pollinating insects, and ultimately plant fitness. Using a common garden setup, in Wageningen/ NL, we collected plant volatiles from herbivore-infested and non-infested *Brassica nigra* plants, and observed whether infested plants were more or less visited by pollinators when compared with non-infested black mustard plants. The behaviour of day-pollinators was observed, at 6 time points spaced between the moment plants were infested with *Pieris brassicae* eggs until the time at which larvae had reached the last stage. It was also investigated whether plant-mediated interactions between herbivores and pollinators have consequence for plant fitness, and what the contribution of night-pollinators to seed set was. Additionally, we estimated dispersal and mortality of caterpillars during the experiments, as natural predation and parasitism were not excluded. Infested *Brassica nigra* plants produced seeds sooner than did non-infested plants. Plant responses to herbivores also resulted in fitness gain, as infested plants produced more seeds. Higher seed set by this obligately outcrossing species could not be explained by interactions with day-pollinators. We discuss how moderate interactions between plants and herbivores might lead to plant fitness benefit.

**6. Reduced seed set by root herbivory: are pollinators involved?**

Céline Ghyselen, Rein Brys and Dries Bonte
Ghent University

Herbivory is often one of the most important environmental factors affecting plant fitness. Because herbivores deplete resource reserves in plants, there may be fewer resources left to invest in reproductive output and/or in pollinator attractive features.

Our study system involves *Cynoglossum officinale*, a monocarpic perennial which is often subject to herbivory by the specialist weevil *Mogulones cruciger*. The larvae of this weevil develop in the roots and feed on root tissue. This larval infestation was found to have a negative effect on the reproductive effort of *C. officinale*. However, it is not clear whether there is only a direct cause to this negative effect: through a lower resource allocation to seed production, or whether there is also an indirect cause: through reduced pollination success due to lower resource allocation to pollinator attraction. In this experiment we investigated whether pollinator attraction is affected by this root herbivory and whether this may have an impact on the reproductive output.

After subjecting study plants to different herbivore pressures, we measured several plant traits, observed pollinator visitation and assessed pollen limitation through supplemental hand pollinations. Plants were harvested after flowering and seed set and root damage were quantified.

In this experiment root herbivory also turned out to have a negative impact on seed set. Moreover, we found that pollinator visitation rate decreased and pollen limitation increased with increasing root damage. Consequently, the results of this experiment indicate that pollination is involved in the reduced seed set caused by root herbivory.

## 3d: Advanced statistical methods for ecology

**Conveners:** Bob Douma (Vrije Universiteit Amsterdam)
Eelke Jongejans (Radboud University Nijmegen)

### 1. Trends in mathematical and statistical methods for ecology

Will Cornwell
Vrije Universiteit Amsterdam

In recent years, there has been rapid progress in developing new mathematical and statistical methods for ecology. We summarize developments in the field, pointing to the trends and the important challenges that remain. Major trends have been: 1) a greater variety of statistical techniques available from authors across the globe; 2) a massive increase in the ability to execute large-scale bioinformatics without a huge infrastructure investment; 3) a focus on effect size rather than significance testing; and 4) a specific focus on developing advanced techniques to forecast species distributions, community composition, and ecosystem function in the context of climate change. This last trend has seen development of new methods that both use observational records in a more sophisticated way and those that seek to model the mechanism of species demography, community assembly, and ecosystem functions in a changing world. We will hear in detail about quantitative progress on new and exciting techniques during this session.

### 2. Non-linear multi quantile regression: a new tool in Species Distribution Modelling

Francesco Cozzoli, T.J. Bouma, T. Ysebaert, and P.M.J. Herman
Royal Netherlands Institute for Sea Research

Complicated forms of heterogeneous response distributions should be expected in observational studies where many important processes interact. Indeed, realized abundances are not deterministically related to the measured gradient, but their reaction is modulated by other variables. As a result species-environment relationships tend to be intrinsically heteroskedastic: variances are smaller in limiting conditions, but they increase for more suitable sites. Traditional regression methods like Ordinary Least Squares focus exclusively on changes in the means and they may fail to distinguish real nonzero changes in heterogeneous distributions. These considerations motivate the use of simultaneous estimates of different components of the realized distributions instead of only focusing on the maximum. Distributions (especially significantly skewed distributions like expected in a regime of complex interaction within environmental factors) are better described by a set of quantiles than by just the mean. The quantile regression model allow us to transfer the effect of the error distribution to parameters for a family of quantiles indexed within 0 and 1. Non-linear multi-quantile regression is able to quantify the relative importance of other unmeasured factors compared to the potential density under the given value of a focal variable. We extended the use of quantile regression to the non-linear case by the use of spline transformations, and further extended it to the entire distribution range of the response variable by representing the regressions of different quantiles simultaneously. We apply this technique to estimate the entire cumulative distribution of common macrozoobenthic species as a function of granulometry in two neighbouring coastal ecosystems differing (due to recent human interactions) in covariance structures within environmental variables: the Eastern and the Western Scheldt. We conclude that alterations of the sedimentary and hydrodynamic regime in the Eastern Scheldt has effectively lead to a different community composition, and that this shift is related to species preference and adaptability to sediment grain size. This project is part of the innovative program Building with Nature (www.ecoshape.nl).

### 3. Do resource availability and disturbance act on a different suite of plant traits? Using structural equation modelling to statistically test for causality

Bob Douma, B. Shipley, J.P.M. Witte, R. Aerts and P.M. van Bodegom
Vrije Universiteit Amsterdam

Understanding the mechanisms of trait selection at the scale of plant communities is a crucial step towards predicting community assembly. Although it is commonly assumed that disturbance and resource availability constrain separate suites of traits, representing the regenerative and established phases respectively, a quantification and test of this accepted hypothesis is still lacking due to limitations of traditional statistical techniques.

In this talk structural equation modeling (SEM) is used to test whether this proposed hypothesis is likely. Structural equation modelling allows for statistically testing causal relationships between variables and also the inclusion of unmeasured variables. In addition, SEM can quantify the relative contribution of disturbance and resource availability on traits. Our model specifies and reflects previously obtained ecological insights, taking disturbance and nutrient availability as central drivers affecting leaf, allometric, seed and phenology traits in 156 (semi)natural plant communities throughout the Netherlands.

The common hypothesis positing that disturbance and resource availability each affect a set of mutually independent traits was not consistent with the data. Instead, our final model shows that

most traits are strongly affected by both drivers. In addition, trait-trait constraints are in half of the cases more important in community assembly than environmental drivers. Both aspects of trait selection are crucial for correctly predicting ecosystem processes and community assembly and provide new insights into hitherto underappreciated ecological interactions.

**4. Measuring dispersal kernels through inverse modeling: density dependence of seed dispersal in a Neotropical palm**

Marco Visser, P.A. Jansen, S. Joseph Wright and Helene Muller-Landau
Radboud University Nijmegen

Understanding the mechanisms that allow species coexistence in complex systems like tropical forest is a fundamental challenge facing scientists today. One leading hypothesis, dispersal limitation, states that the distribution of species depends on their ability to disperse to suitable habitats. Here we tested the previously unexplored hypothesis that seed dispersal by animals can be negatively density-dependent.

Specifically, we expected that clumping of conspecific adults would increase intra-specfic cometition for seed dispersers, resulting in reduced seed dispersal compare to isolated trees. We measured effects of adult density on seed dispersal distances in the palm Attalea butyracea on Barro Colorado Island, Panama. We sampled dispersed seeds from the soil at varying distances from adult trees at sites that ranged widely in Attalea density. Then we used inverse modeling (IM) to estimate dispersal kernels and compared those across sites. We found that IM-estimated dispersal distances, obtained from fitted dispersal kernels, were indeed negatively related to the density of adults. This provides evidence that animal-mediated seed dispersal can decline with increasing fruiting tree density likely due to satiation. This reduction in seed dispersal effectiveness should increase dispersal limitation, causing less seeds to reach sites suitable for germination and growth.
Density-dependent dispersal may therefore facilitate tree species coexistence.

**5. If a tree falls in the forest… Predicting long-term decay dynamics from short-term observations**

James Weedon**,** G. Freschet, R. Aerts, J .van Hal and J.H.C. Cornelissen
Vrije Universiteit Amsterdam

Variability in the decomposition rate of coarse woody debris can have consequences for predictions of carbon stocks and flows in forest ecosystems, so getting a good handle on how wood traits affect decomposition rates is an important research goal. Unfortunately, the slow rate of wood decay processes make accurate estimations of decomposition rates difficult give the short timescale of the average research program. What's more, assumptions of the functional form of the time-mass loss relationship can introduce biases into the estimate of decay parameters. One way to overcome these difficulties is to incubate wood fragments from various stages of decay in a common-garden litter-bed experiment, and use the mass loss data over a short (2 year) timescale to reconstruct the decomposition dynamics over longer (20-50 years). Such an estimation requires modelling of the intitial age of the different decay-class fragments, for which there is no standardized methodology. We present an iterative latent-variable optimization algorithm that is built-up from standard statistical techniques. Our method was able to make robust estimations of half-life parameters of different wood species, and, when combined with bootstrapping, approximate confidence intervals. We will emphasize the value of experimentation, and common-sense application of standard statistical techniques to create customized solutions to daunting estimation problems.

**6. The contribution of covariance: Statistical decomposition of the stochastic growth rate**

Raziel Davison
Max Planck Institute for Demographic Research, Rostock, Germany

Natural populations in distinct habitats may face different selection pressures, strengthening or decoupling important tradeoffs between vital rates that drive population increase or decline. I present new methods for statistical decomposition of (i) elements of vital rate covariances and (ii) differential selection as drivers of population growth rates, extending the already widespread tools called Life Table Response Experiments (LTREs) to stochastic environments. I illustrate the value of this new statistical tool by showing how differences in the costs of reproduction drive local dynamics in populations of Kidney Vetch (*Anthyllis vulneraria*) growing in Belgium and I use it to show how local habitat conditions (soil depth) may buffer some populations against extreme environmental effects (drought events).

# Session 4

## 4a: Marine Ecology

**Conveners:** David Thieltges (Royal Netherlands Institute for Sea Research)
Jan Dent (Royal Netherlands Institute for Sea Research)

### 1. Overfishing promotes algal blooms

Britas Klemens Eriksson
University of Groningen

Food-web theory suggests that top-down and bottom-up control alternate between trophic levels, resulting in a positive relationship between primary production and the abundance of every second trophic level. Specifically, in food webs with four effective trophic levels, herbivores and 2nd level predators should increase with primary production, while in food webs with three trophic levels, primary producers and 1st level predators should increase with primary production. Marine food webs commonly have four trophic levels, and loss of higher trophic level predators may therefore generate changes in food web structures that increase the biomass of algae. Accordingly, in a number of marine systems higher biomass of algae and an increased frequency of algal blooms have coincided with dramatic declines in commercial stocks of larger predatory fish, suggesting that overfishing promotes algal blooms. Here I present evidence that declines in predatory fish have contributed to the development of bloom forming algae in coastal ecosystems. The results indicate that detrimental effects of overfishing on offshore food webs are spreading to coastal ecosystems, causing problems with near shore water quality and habitat loss.

### 2. Size based species interactions shape cod and herring dynamics in the face of exploitation.

Daniel van Denderen and Tobias van Kooten
Institute for Marine Resources and Ecosystem Studies, Wageningen University and Research centre

Population dynamics of cod (*Gadus morhua*) and herring (*Clupea harengus*) in the North Sea have fluctuated widely since the 1950s, ranging from high population abundances to levels close to extinction. These changes in population densities are most often interpreted in a single species context, as a response to fishing pressure and food availability. This is surprising, because a number of (size-specific) food web interactions among the two species are documented in the literature, and the populations of the species have been shown to covary. We constructed a stage-structured biomass model to study to what extent the food web interactions between adult and juvenile cod and herring may have contributed to the observed patterns in the species' dynamics.

We show that an increase in juvenile resource productivity benefits the adult populations of both species, but at very high resource productivity the herring population will collapse, leading to a further increase of the cod population.

Exploitation of either one of these species changes the observed dynamics and can lead to counterintuitive effects on the abundance and stage distribution of the other species. In general, the effects of fishing and productivity on herring and cod, as mediated by the food web interactions between them, produce patterns in agreement with observed dynamics of the species in the North Sea. Food web interactions are hence a valid alternative hypothesis for the observed patterns. This suggest that management plans for the recovery of cod or the rebuilding of the herring population should include the complex interactions between herring and cod to prevent management failure. Our study highlights once more the importance of size-dependent food web interactions in our thinking about the management of exploited marine resources.

### 3. Density-dependent movement leads to self-organized patterns in ecological systems

Quan-Xing Liu, Arjen Doelman, Monique de Jager, Peter M.J. Herman, and Johan van de Koppel
Netherlands Institute of Ecology / University of Groningen

Turing's activator-inhibitor principle has been the central paradigm for explaining regular, self-organized spatial patterns in ecosystems, ranging from arid bushlands to marine corals. According to this principle, feedback interaction between multiple biotic or abiotic species is an essential prerequisite for pattern formation. Here, we show that regular spatial patterns can develop in a single species as a consequence of density-dependent motion. Experiments with self-organizing mussel beds reveal a novel mechanism, where animal movement direction switches between dissipation to aggregation as a function of local mussel densities. We show that incorporation of density-dependence of mussel movement, directly based on our experimental results, within a partial different equation model leads to the well-known Cahn-Hilliard equation of phase separation in physical systems. Predictions of this model with regard to development of patterns are in close agreement with the results of our experiments. Our results provide the first example of phase

separation due to Cahn-Hilliard dynamics in an ecological system, providing a new paradigm for self-organization in mobile biological species. Moreover, it potentially gives a new insight into emerging order in a broad class of collective phenomena.

**4. Can we protect our coastline and the beach ecosystem at the same time?**

Sarah Vanden Eede and Magda Vincx
Ghent University

Whether we like it or not, the climate is changing. An increase in storms and rising sea levels are particularly problematic for low lying countries like Belgium. Every kilometer of our coastline is intensively used and densely populated. Coastal protection against erosion and flooding is as such absolutely indispensable. Soft coastal defence techniques like beach nourishment might help to solve the problem. The word 'nourishment' means supplying a beach with sand because its sand has either flown away with the wind or got washed off with the waves. As it safeguards the natural dynamics of the coast, beach nourishment has rapidly become a widely applied protective measure in Europe. Although beaches are often regarded as barren deserts, nothing can be further from the truth. Underneath the surface lies the world of the benthic organisms. The macrobenthos are the seafloor inhabiting benthic forms larger than one millimeter. They play a key role in the wider beach ecosystem, being part of the diet of intertidal birds and fish.

Our research aims at unravelling the in-situ ecological effects of beach nourishment on the soft-sediment macrobenthos. We focus on Lombardsijde beach as it was nourished from March until September 2009, under optimal conditions. It can be regarded as a prototype of ecological beach nourishment. Approximately 650000m³ of sand was deposited on top of the beach over a distance of around 1200m. The sand (grain size: 200-250µm) originated from the new fairway to Ostend. The soft substrates of Lombardsijde beach have been and are being extensively monitored since 2004. Comparing the status of the beach before (t0 situation) and after (t1 situation) the nourishment provides us with the necessary answers. To distinguish the effects of beach nourishment from those of natural variation, we included control sites in our monitoring studies. The control site for Lombardsijde beach is the beach in front of Nieuwpoort-Bad.

We discovered that Lombardsijde beach has changed between 2006 and 2010. Most changes took place during and directly following the nourishment with a clearly visible peak value for abundance (intertidal: 6±1species; subtidal: 16±2species), density (intertidal: 745±247individuals.m$^{-2}$; subtidal: 13125±3597individuals.m$^{-2}$) and biomass (intertidal: 0.7±0.1g.m$^{-2}$; subtidal: 85.2±17.0g.m$^{-2}$) during autumn 2010. Unlike previous years, we also found significant differences between the intertidal median grain size of Lombardsijde and its control site. The beach profile of Lombardsijde was altered in such a way that it resembles the beach profile of Nieuwpoort-Bad almost perfectly. No other distinct negative trends for the macrobenthos were found one year after ecological nourishment.

**5. How size-selective seasonal predation risks mould the timing of reproduction in a symbiotically fuelled bivalve**

Matthijs van der Geest, Sall Mamdou Alassane, Sidi Ely, Reinier Nauta, Tamar Lok, Jan A. van Gils and Theunis Piersma
Royal Netherlands Institute for Sea Research

Life-history models for marine invertebrates have focused traditionally on risks of larval development. However, mortality at later stages in life can be severe too. In a tropical intertidal system (Banc d'Arguin, Mauritania), the lucinid bivalve *Loripes lucinalis* is nutritionally fuelled by endosymbiotic bacteria suggesting relatively constant food. Nevertheless, reproduction is highly seasonal. We propose that size-selective seasonal predation may help explain this. Timing of reproduction in *Loripes* was estimated from monthly data on investment in soma and gonads, oocyte sizes and proportion of ovary in spent stage. Using a non-linear model to test for seasonality, we find that spawning in *Loripes* is semi-annual with a major peak in July and a lesser peak in February. *In situ* growth data were obtained to estimate temporal variation in growth of *Loripes*. On the basis of shell-fragments in droppings, during their time in the area (September to May), the diet of red knots (*Calidris canutus*) consists for 50% of *Loripes*, with intermediate size-class (5-8 mm) being preferred. Clearly, *Loripes* should reach intermediate sizes during their absence. We thus reconstructed size-and season-dependent predation risks to derive a possible size- and time-specific window of escape. That February was predicted as the optimal time to reproduce is consistent with the idea that seasonal differences in growth rates, in combination with seasonal and size-selective predation danger, mould timing of reproduction in this bivalve population. The evolution of a second spawning event in summer might result from lower costs of gonad development in spring due to better food conditions. Indeed, isotopic carbon signatures of non-gill *Loripes* tissue reveal a switch to a more obligate symbiotically fuelled, and possibly higher quality, diet in spring.

**6. Competition and niche segregation following the arrival of the exotic brush-clawed shore crab (*Hemigrapsus takanoi*) in the formerly European shore crab (*Carcinus maenas*) dominated Dutch delta.**

Sander Wijnhoven and Anneke van den Brink
Royal Netherlands Institute for Sea Research

Recently two Asian shore crab species of the genus *Hemigrapsus* arrived in the Netherlands, likely via oyster transports. *Hemigrapsus sanguineus* was first recorded for the Dutch delta waters in 1999 and *H. takanoi* in 2000, both in the Oosterschelde. Particularly *H. takanoi* became very abundant in the Dutch delta waters within a few years. The shore crab communities in this region however used to be dominated by the European shore crab *Carcinus maenas*. Analyses of the historic monitoring data of the soft sediment benthic communities of the different Dutch delta waters, in combination with a snapshot survey on the presence of both species on hard substratum in the Oosterschelde in 2010, showed that *C. maenas* populations were already declining before the arrival of *H. takanoi*. Whereas *H. takanoi* at present completely dominates the intertidal hard substrate environments, the native and exotic shore crabs are more or less equally abundant on soft sediment. Differences in developmental patterns related to the typology of the delta waters and the timing of the arrival of *H. takanoi* can be observed. *H. takanoi* appears to be a fierce competitor for particularly smaller sized *C. maenas* specimens expelling it from its shelters. This likely has led to increased mortality due to increased predation. It is suggested that the *C. maenas* populations after several years do not further decline anymore as the species can maintain in the widely available soft sediment habitats. Eventually balanced co-existence of native and exotic shore crabs in the Dutch delta waters is expected.

## 4b: Disease Ecology

**Conveners:** Fred de Boer (Wageningen University)
Nienke Hartemink (Université Catholique de Louvain/Utrecht University)

### 1. Disease Ecology

Fred de Boer[1], Nienke Hartemink[2]
[1]Wageningen University / [2]Université Catholique de Louvain, Utrecht University

Outbreaks of diseases are not only determined by the presence of pathogens, hosts and vectors, but also by ecological factors, such as community composition or habitat fragmentation, epidemiological factors such as immunity, and climatic factors such as temperature. Disease ecology deals with the interactions between the behaviour and ecology of hosts with the biology of pathogens. These interactions often lead to different spatio-temporal patterns of disease outbreaks in populations. In the first part of this talk, we will discuss some examples of disease systems where ecology of hosts or vectors has a profound effect on the disease dynamics. In the second part, we will focus on spatial aspects of diseases ecology. Habitat fragmentation or mobility of hosts, vectors or pathogens are for instance important factors in influencing infection risk and disease prevalence. Hence, landscape factors can play an important role in disease ecology. Understanding the causal factors that influence the spatio-temporal patterns of disease outbreak is an exciting new research field in spatial sciences, ecology and veterinary sciences.

### 2. Cyanobacteria protect Daphnia against diseases

Marlies Coopman, Koenraad Muylaert, Benjamin Lange and Ellen Decaestecker
KU Leuven

Infections by parasites can have a strong impact on populations of their hosts. The susceptibility of a host to its parasites is influenced by the environment. In this study, we evaluated how poor food quality affects the susceptibility of *Daphnia* to infections by parasites. The cyanobacterium *Microcystis aeruginosa* was used as model for poor food quality. *Microcystis* produces different secondary metabolites, such as toxic hepatotoxins that may influence the host and antimicrobial substances that may influence *Daphnia* parasites. In this study, *Daphnia magna* was exposed to the parasite *White Bacterial Disease* and fed with different concentrations of a microcystin producing and a non microcystin producing *Microcystis* strain. Results show that increasing concentrations of the non microcystin producing *Microcystis* (until 20%) protect exposed *Daphnia* from dying. Moreover those *Daphnia* produced more offspring compared with not exposed individuals, due to the bigger clutch sizes. Additionally the parasite suffered from *Microcystis* in the food of *Daphnia magna*. This experiment shows that non microcystin producing *Microcystis* may protect *Daphnia magna* against certain diseases.

### 3. Bovine tuberculosis and feline immunodeficiency virus co-infection: a possible threat for conservation of lions

Miriam Maas, Dewald Keet, Victor PMG Rutten, Hans Heesterbeek and Mirjam Nielen
Utrecht University

Bovine tuberculosis (BTB) is a recently introduced disease in the Kruger National Park (KNP), an ecosystem where feline immunodeficiency virus (FIV) has long been endemic. In humans, a synergistic relation between tuberculosis and human immunodeficiency virus has been described. This results in a disease burden higher than expected only from the additive effect of the diseases. Data collected from 1993-2008 from 671 lions in total was available of several parameters (FIV and BTB status, hematology, pathology, etc) measured on different numbers of lions in the population. After descriptive analysis, it was assessed whether a synergistic relation between the diseases is present in lions. No significant geographical or time-related differences were seen for FIV (overall prevalence 61%), but BTB prevalence decreased from the south to the north (resp. 79-19%), and increased over time in the northern part of the KNP. Both diseases affect blood parameters in subclinical cases, FIV more pronounced than BTB. The effect of co-infection on the blood parameters was always less than the additive effect. Though a large proportion (31%) of the lions is co-infected with FIV and BTB, a synergistic relation like in humans, could not be found. Whether this is a result from different immunopathogenesis remains to be determined. This is the first time the occurrence of FIV and BTB in the same ecosystem has extensively been described and their interaction was assessed.

**4. Spatio-temporal variation in the distribution of chytrid parasites in diatom host populations**

Alena S. Gsell, Lisette N. de Senerpont Domis, Suzanne M. H. Naus-Wiezer, Nico R Helmsing, Ellen van Donk and Bas W. Ibelings
Netherlands Institute of Ecology

Parasite invasion success and population growth are often explained in terms of host density dependence, neglecting that parasite population dynamics are also influenced directly by environmental variability. In lakes, resource availability and environmental conditions change with season due to temperature, irradiance and rainfall patterns, but also with depth due to light, temperature, and chemical gradients. Hence, hosts and parasites live in a spatially and temporally variable environment. Such seasonal variability and vertical gradients in biotic and abiotic factors expose host and parasite individuals to different environmental conditions even within a single population. Nevertheless, time series data on vertical distribution data for aquatic host-parasite interactions are still rare.

We present a 1.5 years dataset of weekly sampling in Lake Maarsseveen (The Netherlands) focussing on the population dynamics of the diatom *Asterionella formosa* and its parasite, the chytrid *Zygorhizidium planktonicum* across four depths. Within this dataset we explore how abundances of hosts and parasites relate to each other but also to environmental variables such as ice cover, temperature, Schmidt stability, global irradiance, light extinction, pH, soluble reactive silicate and dissolved nitrate. Environmental variability results in changes in population aggregation and affects parasite transmission rates through changes in host abundance and in transmission success.

**5. Aggregated distribution of ticks on hosts explained by clustered distribution of ticks in the field**

Jasper F. van der Linden and Nienke Hartemink
Wageningen University

In the ecology of tick-borne diseases (e.g. Lyme borreliosis), the distribution of ticks on hosts is a very important factor. This distribution is known to be highly aggregated, especially for the larval and nymphal stages. This is also the case for the sheep tick (*Ixodes ricinus*), the dominant tick species in the Netherlands. Since this distribution determines to a large extent the transmission potential for pathogens, it is important to understand the mechanism(s) causing this aggregation. Several factors have been suggested to play a role, but their relative importance has not yet been quantified.

In this study, we look at clustering of ticks in the field as explanatory factor for the infestation of hosts by ticks. Using two large datasets, one on ticks counted on trapped rodents and one based on ticks counted by blanket dragging, we show that a large part of the variation in the number of ticks on hosts can be attributed to the distribution of ticks in the field.

This relationship between ticks on hosts and ticks in the field is very strong for larvae, but is also present for nymphs. Given that hosts carrying high larvae burdens also tend to carry relatively more nymphs, this suggests that larvae and nymphs also occur in overlapping clusters in the field. Therewith, a high potential for pathogen transmission (the combination of larvae, nymphs and hosts) seems only to occur in a spatially clustered manner. This would have important implications for our understanding of the eco-epidemiology of tick-borne diseases.

**6. Seasonal variation in LPAI virus infection in mallards and the role of migrants**

Jacintha G.B. van Dijk, Ron A.M. Fouchier and Marcel Klaassen
Netherlands Institute of Ecology

Mechanisms driving seasonal variation in low pathogenic avian influenza (LPAI) virus infections in wild birds are not fully understood. Many surveillance programs are focused on single seasons, while intensive year-round sampling schemes, measuring both current and past infection, are needed to enhance our knowledge on temporal dynamics of LPAI virus infections. We therefore conducted a year-round surveillance on one of the key host species of LPAI viruses, the mallard (*Anas platyrhynchos*), at a duck decoy in the Netherlands. Mallards are partly migratory, meaning that throughout Europe the population consists of both migratory and resident birds. Almost every week, and in spring and summer twice a week, cloacal, oropharyngeal and blood samples were collected. We found the proportionally highest number of LPAI infected birds in autumn, when only few birds contained LPAI antibodies, whereas in spring viral prevalence was lowest, with many birds being seropositive. The peak of viral prevalence in autumn might be explained by the potential influx of migratory mallards in contrast to immunologically naïve young which has previously been suggested as a driver for LPAI virus infection in autumn. With the novel technique of stabile isotope analysis we could determine the origin of the infected mallards (resident or migrant) to test whether migrants are indeed the main driver of seasonal variation of LPAI virus infection. Hereby, in addition, we are trying to answer the question 'who' is spreading the LPAI virus, residents or migrants, which is still a heavily debated issue.

## 4c: Establishment in a new environment

**Conveners:** Kim Meijer (University of Groningen)
Judith Sarneel (Netherlands Institute of Ecology)

### 1. Dispersal of aquatic organisms by waterbirds

Casper van Leeuwen
Netherlands Institute of Ecology

Establishment in a new environment is particularly challenging for aquatic organisms because of the land-barrier between suitable wetland habitats. Many aquatic organisms lack the capacity to travel across land using their own propulsion. However, many can still be found at remote wetlands. Darwin solved this paradox by suggesting waterbirds as transport vectors for aquatic organisms, since birds frequently fly directly between comparable wet habitats in large numbers. Today waterbirds are indeed known to carry various organisms internally (surviving digestion) or externally. However, much of what we know is still anecdotal, and the relative importance of birds compared to other potential vectors is still limited. We present a qualitative overview of which aquatic plant and macro-invertebrates are currently known to be dispersed by waterbirds, and show how different bird species may contribute to dispersal of different propagules. We developed a quantitative model with which we can calculate quantitative exchange of plants and macro-invertebrates between water bodies by waterbirds. The observation that birds are important dispersal vectors for a wide taxonomic variety of aquatic organisms raises the question to what extent aquatic organisms may need specific adaptations for transport. Could more organisms be suitable for bird-mediated transport? We experimentally discuss this question in the light of experiments with aquatic snails: organisms that are well adapted to survive in a stochastic environment, but not known to be adapted for transport by waterbirds. How important are birds compared to other potential dispersal vectors? We support our experimental results by microsatellite analyses of aquatic populations.

### 2. Germination and seedling survival influence riparian plant species distribution along hydrologically restored lowland streams

Rob Fraaije, Leonieke B.S. Breeman, Jos T.A. Verhoeven and Merel B. Soons
Utrecht University

Throughout Europe, many hydrological stream restoration projects have been carried out, but many of them (so far) failed to ecologically improve deteriorated channelized streams. A better balance between hydrology and morphology, with the aim to improve stream functioning - like a restored riparian moisture gradient, a natural inundation regime and more constant flow velocities throughout the year - is more promising and is expected to lead to a higher biodiversity. Changes in soil moisture availability, caused by the restored hydromorphology, are expected to have a structuring influence on the colonization process of riparian plant species. To investigate the effect on germination and seedling survival, seeds of 11 aquatic- and riparian plant species were sown in an elevational gradient along two hydrologically restored lowland streams in the Netherlands. After two and three months, seeds and/or seedlings were excavated after which germination performance and seedling biomass was determined for each species. At each place where seeds were sown, soil moisture content, groundwater level and surface water level were measured hourly. The first two parameters were plotted against germination percentage and seedling biomass per species. With curve-estimation, a normal distribution was fitted to these data and an optimal value of each two parameters was determined where germination percentage or seedling biomass was the highest. Plotting of these optimal soil moisture- or groundwater conditions per species against Ellenberg values for moisture (a 12-point scale indicating a species habitat preference with increasing moisture availability) revealed significant positive relations. This showed that both germination and seedling survival have a determining influence on the distribution of these species along a moisture gradient. Soil moisture- or elevational heterogeneity, can provide the optimal conditions for germination and seedling survival of several plant species. In the light of stream restoration, these results urge that subsequent surface area of a range of moisture conditions are needed to provide the optimal conditions for different plant species. When these conditions are met, an important step is made to a higher biodiversity.

### 3. The establishment of fern diversity in newly created habitats

Arjen de Groot
Utrecht University

Plant diversity is decreasing worldwide. Therefore, nature conservation efforts focus both on maintaining diversity in protected areas and developing new diversity in restored or newly created areas. In either case, dispersal is of vital importance: due to global changes, including the destruction and fragmentation of natural habitats, plants are forced to disperse their seeds or spores over increasing distances. In seed plants, limited colonization success may explain failed diversity improvements following habitat restoration. But how about plants with much smaller diaspores?

This study focused on the establishment of inter- and intraspecific diversity in ferns in new nature areas. Young planted forests in the Dutch IJsselmeer polders, in which a large number of (rare) fern species established over the last decades, were used as a case study. Using a combination of spore bank analyses, demographic studies and population genetic analyses, I showed that long-distance dispersal is sufficiently common to ensure a regular arrival of genetically diverse spores, even for rare species. Habitat availability, rather than dispersal abilities, seem to limited fern diversity at larger scales. However, the mechanisms that allow long-distance dispersal (i.e. self-fertilization) locally result in a strong genetic signature: genetic diversity is high, but strongly partitioned between populations. Young isolated populations harbour only one or a few genotypes. Depending on a set of species-specific plant traits (i.e. ploidy level and breeding strategy), this may lead to inbreeding depression, which can harm the viability of local populations.

Here, I will discuss the mechanisms that cause the observed patterns, as well as some implications for nature conservation measurements.

**4. Climate change induced range-expanding plants**

Elly Morien
Netherlands Institute of Ecology

Rapid climate warming leads to range expansion of plants from warm into previous cold areas. Range expansion brings new interactions within the ecosystem in the new range. This can lead to potential benefits; range expanders might lack their natural enemies in the new range and become invasive. Relatively little is known about the general mechanisms of biological invasions under climate change. Greenhouse experiments showed that aboveground generalist herbivores had less negative effects on range-expanding plants than on closely related native plants. A similar pattern was found for root-feeding nematodes in the soil. Therefore, range-expanding plants suffer less from local herbivores than native plants which results in a competitive benefit for the range expanders. After examining the microbial soil community around the plant roots, range-expanding plants had a different soil community than related native plants. This explains the earlier results in which the range-expanding plants had less negative impact from the soil community than native plants. Similar mechanisms played a role in the field situation, however, the positive position of range expanders over native plants was reduced by competition effects between plant species.

**5. Shrubs facilitate tree invasion in northern peatlands**

Huib van Veen, Milena Holmgren and Juul Limpens
Wageningen University

Northern peatlands cover only 3% of the Earth surface but store 30% of the global soil carbon, mostly in open peat moss-dominated peatlands (peat bogs). The open structure is maintained by the wet and nutrient poor environment. Climate change could affect the structure and functioning of peat bogs through changes in water table level, leading to expansion of woody plants. This process may be accelerated by facilitation between the woody species themselves. To understand the interaction between tree seedlings and shrubs and adult trees, we conducted a manipulative field experiment in the Siikaneva peat bog (Finland) to study the effect of shrubs and trees on the recruitment of tree seedlings. Seedlings and seeds of *Pinus sylvestris* were planted on hummocks with contrasting shrub and tree density. We experimentally manipulated above and belowground competition.
Seedlings performed best on shrubby elevated patches (hummocks) which were drier than less shrubby hummocks and lawns. A shrub canopy also enhanced seedlings performance, presumably by reducing thermal stress during the summer. Our results indicate that shrubs facilitate tree invasion in peat bogs and may accelerate the transition between open moss-dominated peat bogs to forests. Our results contribute also to the theoretical discussions on the role of positive interactions in plant communities.

**6. The influence of an invasive plant species on the pollination success and reproductive output of three riparian plant species**

Koen Thijs, Rein Brys, Hans AF. Verboven and Martin Hermy
KU Leuven

Besides competition for abiotic resources, an increasing number of studies show evidence of the effects of invasive species on the pollination success and reproductive output of indigenous species. We studied the effect of the invasive *Impatiens glandulifera* Royle on the process of reproduction in the indigenous *Lythrum salicaria* L. and *Alisma plantago- aquatic* L. and the naturalized *Oenothera biennis* L. The latter three species (target species) were transplanted into pots and placed in invaded and non-invaded areas. During flowering season of each of these species, we measured species composition and abundance of pollinators, pollinator behaviour, pollen deposition and female reproductive output of the target species. Competitive effects were found for *L. salicaria*, in which fewer pollinator species and number of foraging individuals were observed, and also, lower pollen deposition and seed set were measured in these invaded populations. In contrast, the reproductive success of A. plantagoaquatica and O. biennis was not affected by the presence of *I. glandulifera*.

Our data indicate that when invasive and indigenous species show a large overlap in pollinator community, which is the case for *I. glandulifera* and *L. salicaria*, competition between these species can occur. When both species have a different pollinator community, pollination success and reproductive output is not affected, even when the indigenous populations are densely and abundantly invaded.

## 4d: Microbial Ecology and Systems Biology: Questions and Methods

**Conveners:** Liesje Mommer (Wageningen University)
Wolf Mooij (Netherlands Institute of Ecology)

### 1. Loss of rare microbes affects ecosystem functioning

Gera Hol
Netherlands Institute of Ecology

Microbial communities are crucial for soil ecosystem services such as nutrient cycling and disease suppressiveness. We investigated the effect of rare microbial species loss for intensively and extensively managed agro-ecosystems (grassland, a crop rotation and an intensive wheat rotation) by using soil dilution and incubation. These soils with different diversity levels were used in a greenhouse experiment for growing winter wheat in 2 growing cycles. The evaluated functions were plant quantity and quality (shoot biomass and reflectance), trace gas emissions and pest development. Microbial communities in soil before and after incubation, and after growing winter wheat were assessed using 454 pyrosequencing of 16S rDNA. We can start to understand microbial community composition and functioning by using a classic dilution approach in combination with a novel high throughput method.

### 2. The effect of atmospheric change on arbuscular mycorrhizal fungal communities

Anne Cotton
University of York / University of Hull

Arbuscular mycorrhizal (AM) fungi are highly influential in terrestrial ecosystems affecting element cycles, plant community productivity, diversity and composition and soil properties. Understanding the mechanisms which regulate their communities and how they will be affected by global environmental changes will be vitally important in predicting future ecosystem functioning. We utilised molecular methods (sequencing and terminal restriction fragment length polymorphisms) to examine the effect of atmospheric change on AM fungal communities of soybeans, grown under ambient or elevated CO2 and O3 at the Soybean Free Air Concentration Enrichment (SoyFACE) experiment in three different growing seasons over five years. The results suggest that elevated atmospheric CO2 will alter AM fungal community composition, structure and diversity. In particular increasing the atmospheric CO2 concentration caused a reduction in the relative abundance of fungi of the Gigasporaceae and increased the dominance of the Glomeraceae. We hypothesise that differences in the success of different fungi under different CO2 concentrations may be determined by their differential ability to provide nutrients to their host plants, suggesting a future change in the function of soil communities. However, the observed differences caused by atmospheric change were small compared to the large inter-annual variations in AM fungal communities detected, showing soil microbial communities are unexpectedly dynamic and other environmental factors may be more influential in determining their community characteristics. Overall our studies therefore highlight the urgent requirement for more investigations on the mechanisms regulating soil microbial communities and their function in ecosystems.

### 3. Rapid C flow through the plant-soil system in differently managed grasslands

Gerlinde B. De Deyn, Helen Quirk, Simon Oakley, Nick Ostle, Richard D. Bardgett
Lancaster University / Wageningen University

Plant-soil interactions are of key importance for short-term carbon (C) cycling because plants transfer a substantial part of recently assimilated C to their roots and rhizosphere soil biota. Changes in grassland management can induce changes in C cycling via shifts in composition, abundance or activity of plants and/or soil biota. In this study we investigated whether grassland management practices for plant diversity restoration influences short-term rates of C assimilation and transfer from plants to soil microbes. Thereto we performed an in situ $^{13}C$-$CO_2$ pulse-labelling study in a long-term plant diversity grassland restoration experiment to trace the C uptake by different plant species and the transfer of the plant-derived $^{13}C$ to key groups of soil microbiota. We found marked differences between different plant taxa in the rate of $^{13}C$ assimilation and concentration: uptake was greatest and $^{13}C$ concentration declined fastest in *Ranunculus repens*, and assimilation was least and $^{13}C$ signature remained longest in mosses. Recent plant-derived $^{13}C$ was quickly incorporated in microbial phosopholipid fatty acid (PLFA) markers, as we found them most enriched 24h after labelling. The greatest incorporation of $^{13}C$ was in the PLFA 16:1ω5, a marker for arbuscular mycorrhizal fungi (AMF), while after 1 week most $^{13}C$ was retained in the PLFA18:2ω6,9 which is indicative of assimilation of plant-derived $^{13}C$ by saprophytic fungi. Our results of $^{13}C$ assimilation by plants and its transfer to soil microbes were not altered by the grassland restoration management treatments. Our findings suggest that plant diversity restoration management may not directly affect the C assimilation by individual plant taxa or groups of soil microbes, but can impact on the fate of recent C by changing the abundances of plant and soil taxa. Moreover, across all treatments we did find particular rapid transfer of plant-derived C to AMF and decomposer fungi, indicating their consistent key role in the cycling of recent plant derived C.

**4. Microbial Ecology is dead. Long live Microbial Ecology**

Gerard Muyzer
University of Amsterdam

For a long time microbial ecology has been dominated by descriptive studies. However, by revolutionary developments in DNA sequencing, high-resolution analytical techniques and single cell analysis, microbial ecology is rapidly changing. Bar-coded pyrosequencing of 16S rRNA gene tags is currently used to obtain statistically significant results on the diversity of microbial communities and the dynamics of its constituents after natural or induced perturbations. Metagenomics, sequence analysis of the genomes from all microorganisms in a community, is routinely used to infer the metabolic potential of the community members, while their activity is studied by meta-transcriptomics and meta-proteomics. These 'omics'-approaches, in combination with the use of stable isotopes, makes it now possible to study the structure and function of microbial communities in great detail. The data generated with these approaches can subsequently be used for mathematical modeling. The interaction of experiments and modeling of microbial communities is the basis of a new field called 'microbial systems ecology'. By using a systems biology approach, microbial ecology is changing from a descriptive discipline into a hypothesis-driven discipline, which is essential for a comprehensive understanding of the size and drivers of microbial diversity, the interaction between microorganisms and their environment, and the role of microorganisms in the cycling of chemical elements.

In this lecture I will give an overview of novel approaches in microbial ecology, will present state-of-the-art examples and will discuss plans for future research.

**5. Emergence of microbial cooperation in the human gut**

Roeland Merks and Milan van Hoek
Centrum Wiskunde and Informatica (CWI), Amsterdam / Leiden University

Complex sugars from plant cell walls are important sources of energy in our food, but we cannot digest them by ourselves. Fortunately, each of us hosts a highly diverse microbial community of several hundreds of species that convert the indigestible complex sugars into short-chain fatty acids that the intestinal wall absorbs. Together, these microbiota form a complex food web that can break down food sources we cannot break down ourselves, such as polysaccharides. What explains the emergence and maintenance of microbial diversity in the intestine? To help answer this question, we introduce a multiscale, computational model to study the emergence of metabolic diversity in a spatial, gut-like environment. At the smallest scale, the model represents metapopulations of bacteria, modeled according to a biologically-realistic, genome-scale metabolic model of Lactobacillus plantarum, a lactic acid bacterium commonly found in the human gut. The metabolic model yields an estimate of the local bacterial growth rate, and the uptake and secretion rates of sugars and other metabolites, including short chain fatty acids, as a function of the local metabolite concentrations. At larger scale, we model the spread of metabolic intermediates and the growth and diversification of bacterial metapopulations, where we assume that metabolic networks mutate during the spread to adjacent sites. The model allows us to study how microbial diversity can emerge from realistic metabolic networks. We find that microbial diversity can arise spontaneously through cross-feeding interactions, with a range of specific niches emerging along the simulated colon.

**6. From metabolic networks to microbial communities**

Frank Bruggeman
Vrije Universiteit Amsterdam

This work reports a number of principles of the organization of supra-metabolic network in microbial ecosystems. In their natural habitats, microorganisms form supra-metabolic networks in which they compete for resources, cooperate through metabolic cross-feeding, and engage in predation. I will explain how optimization approaches and a bottom-up approach, from single metabolic reactions to entire microbial ecosystem, offers new insights into the organization and trade-offs of microbial communities. I will explain how metabolic adaptation strategies of single microorganisms within communities can be understood with genome-scale stoichiometric models of their metabolism. Such models consider the entire metabolic network of single organisms, hundreds to thousands or reactions and metabolites, and using optimization approaches optimal flux distributions and products yields can be predicted. Using this approach, different limitation regimes in communities can be distinguished that have to do with limitations imposed by metabolic networks or the environment. I will show that the tendency of microorganisms to ferment at high growth rates drives microbial ecosystems to higher complexity. Another aspect of these systems is that optimal adaptation strategies of microorganisms in dynamic environments can force them to take suboptimal strategies per environmental state. This work aims at bridging the gaps that exists between genotype, phenotype, and microbial communities.

# Poster titles and numbers

Please note that during the poster session on Tuesday all odd-numbered posters will be attended / discussed and on the poster session of Wednesday all even-numbered posters.

| Number | Author | Title |
|---|---|---|
| 1 | Jurgen Batsleer | Mixed fisheries management: The trade-off between ecosystem costs and economic profits. |
| 2 | Jim van Belzen | Do real ecosystems slow down towards the verge of collapse? |
| 3 | Cindy ten Broeke | The effect of rearing plant on the behaviour of lettuce aphids. |
| 4 | Margreet Brouwer | Foraminifera: bio-indicators for the restoration potential of marine ecosystems? Hypoxia in the Scheldt and lake Grevelingen |
| 5 | Martijn Callens | Effect of Microcystis on the symbiotic bacterial community of Daphnia and its consequences for microcystin tolerance. |
| 6 | Jofre Carnicer | A unified framework for diversity gradients: the adaptive trait continuum |
| 7 | Tobias Ceulemans | Plant species loss from European semi-natural grasslands: is it nitrogen or is it phosphorus? |
| 8 | Esther Chang | Mycorrhizal effect on root morphology depends upon N:P stoichiometry |
| 9 | Chiyedza Portia Chifamba | Lake Chivero Hyper Eutrophication; a case for Integrated Lake Basin Management |
| 10 | Willem Van Colen | The influence of the N:P ratio on the phytoplankton productivity and community: a mesocosm study |
| 11 | Joop Coolen | Scheepswrakken in de Noordzee - Het beschermen waard |
| 12 | Marlies Coopman | Influence of toxic microcystis on host-parasite interactions |
| 13 | Ilse Cornelissen | Limiting factors for phytoplankton biomass in the Mwanza Gulf, Lake Victoria (Tanzania) |
| 14 | Roeland Cortois | 49 perennial plant species and how they feel about rhizosphere microbes |
| 15 | Luc De Bruyn | Disturbance by grazing sheep as a management risk for ground-breeding heathlands birds. |
| 16 | Hélène de Paoli | Key factors in the restoration of mussel beds. |
| 17 | Ellen Decaestecker | Food quality effects on Daphnia-pathogen interactions. |
| 18 | Régis Flohr | Generalists diversify less than specialists in an experimental adaptive radiation. |
| 19 | Wimke Fokkema | Migrants in interaction networks: a conceptual framework on how biodiversity is connected over ecosystem borders |

| Number | Author | Title |
|---|---|---|
| 20 | Yuki Fujita | Predicting nitrogen availability on a regional scale: on the necessity to include intricate interactions with local hydrology in a SOM model |
| 21 | Annemarie Garssen | Effects of climate change on riparian plant communities along European lowland streams. |
| 22 | Sylvia Gerritsma | Genomic variation in parasitoid resistance in natural populations of *Drosophila melanogaster* |
| 23 | Luuk van Gerven | Ecosystem modelling withl PCDitch. Current status and future prospects. |
| 24 | Lucy Gillis | Landscape scale facilitation cascades between tropical marine ecosystems: A review and management implications. |
| 25 | Stijn van Gils | Ecology of aquatic plants in National Park Biesbosch |
| 26 | Anouk Goedknegt | Aliens vs parasites: can invasive species limit parasite transmission in a warmer world? |
| 27 | Erin Gorsich | Disease invasion dynamics: brucellosis and tuberculosis in African buffalo |
| 28 | Laura Govers | The effects of anthropogenic stressors on Caribbean sea grass beds. |
| 29 | Arjen de Groot | The establishment of inter- and intraspecific diversity in ferns by means of long-distance dispersal |
| 30 | Bart Grutters | Ecosystem functions of invasive aquatic plants: an introduction |
| 31 | Marloes Hendriks | Root placement in patches of soil biota |
| 32 | Geerten Hengeveld | optimal exploration and exploitation strategies |
| 33 | Jochem t Hoen | Is re-oligotrophication the major driver behind ecological change in the food webs of Lake Ijssel and Lake Marken |
| 34 | Ruth Howison | Bioturbation & Biocompaction in a consumer driven ecosystem |
| 35 | Jinghua Huang | Intraspecific variation in plant defence affects interactions between aboveground and belowground herbivores |
| 36 | Oleksandra Ieromina | Effect of pesticides on taxonomic and trait composition of freshwater macrofauna. |
| 37 | Anne Immers | Delayed macrophyte establishment in a recovered shallow lake due to invasive crayfish |
| 38 | Monique de Jager | Cooperation in mussel beds |
| 39 | Annette Janssen | Is the Dreissena polymoropha (Zebra mussel) population food limited in Lake Ijsselmeer? |
| 40 | Marieke Keller | Influence of temperature on the timing of first feeding and recruitment of European smelt, Osmerus eperlanus. |
| 41 | Lidewij Keser | Is the nutrient foraging response stronger in invasive than in non-invasive plant species? |
| 42 | Elizabeth Koppenaal | Enhanced sea-level rise and its effects on a barrier island salt marsh |
| 43 | Suzanne Kos | A metabolomics resistance test |

| Number | Author | Title |
|---|---|---|
| 44 | Jan Kuiper | Ecosystem modelling with PCLake; current status and future prospects. |
| 45 | Wouter Lengkeek | Scheepswrakken: Geen vervuiling maar natuurparels in de Noordzee |
| 46 | Ingrid Lubbers | Earthworms increase greenhouse gas emissions from soil |
| 47 | Kim Meijer | Community versus Biogeographical approach – two methods is studying trait differences between native and non-native species |
| 48 | Tri Rini Nuringtyas | Differential tissue distribution of defence compounds in Jacobaea vulgaris, Jacobaea aquatica and their hybrids |
| 49 | Veronica Preite | Natural epigenetic variation in apomictic dandelion lineages |
| 50 | Janneke Ravenek | Root placement in patches of soil biota |
| 51 | Erica van Rooij | Mate choice for bill colour in a sexually monomorphic finch |
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