NAEM 2018

Netherlands Annual Ecology Meeting

13 & 14 February 2018

Congrescentrum De Werelt, Lunteren

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Programme

Tuesday 13 February

	Main Entrance Hall				
08:30	Registration and coffee in the Lounge and setting up posters				
	Europe Hall				
10:15	**Word of Welcome and Introduction to NAEM 2018** Hans de Kroon (Radboud University Nijmegen)				
	Plenary 1: "Ecosystem functioning in a changing world: the role of higher trophic levels"				
10:30	**1. How altered animal communities change the functioning of ecosystems, and possibly our climate** Trisha B. Atwood (Department of Watershed Sciences, Utah State University, United States of America)				
11.15	**2. Understanding multiplex networks of species interactions in a changing world** Han Olff (Community and Conservation Ecology, Groningen Institute for Evolutionary Life Sciences, University of Groningen, The Netherlands)				
12:00	**Lunch in the restaurant**				
	Europe Hall	**America Hall**	**Asia Hall**	**Africa Hall**	**Vide Hall**
13:30	**Parallel 1a:** **Community ecology; ecosystem functioning in a changing world - the role of higher trophic levels**	**Parallel 1b:** **Disease ecology; ecology of pathogen-host-community interactions of vector-borne pathogens**	**Parallel 1c:** **Decomposition; integrating drivers of decomposition across time and space**	**Parallel 1d:** **Plant ecology**	**Parallel 1e:** **Exotics and invasives; biotic interactions of exotic and invasive species**
	Conveners: 1. Han Olff (University of Groningen)	*Conveners*: 1. Maarten Schrama (Institute of Environmental Sciences (CML) - Leiden University) 2. Quirine Astrid ten Bosch (Institut Pasteur) 3. Yin Shenglai (Wageningen University & Research)	*Conveners*: 1. Hans Cornelissen (Vrije Universiteit Amsterdam) 2. Joost Keuskamp (Utrecht University) 3. Marta Manrubia Freixa (Netherlands Institute of Ecology)	*Conveners*: 1. Merel Soons (Utrecht University) 2. Nadia Soudzilovskaia (Institute of Environmental Sciences (CML) - Leiden University)	*Conveners:* 1. Kadri Koorem (University of Tartu / Netherlands Institute of Ecology) 2. Kelly S. Ramirez (Netherlands Institute of Ecology) 3. Suzanne Lommen (University of Fribourg)
13:30	Trophic rewilding under global change: risks and opportunities for butterfly communities (Michiel Wallis de Vries, Dutch Butterfly Conservation / Wageningen University & Research)	Host–tick–pathogen interactions along a Neotropical disturbance gradient (Helen Esser, Wageningen University & Research)	Is there a tree economics spectrum of decomposability? (Juan Zuo, Vrije Universiteit Amsterdam)	Not only trees: Grasses fundamentally determine African tropical biome distribution via water limitation and fire (Mara Baudena, Utrecht University)	Alien interference with animal-mediated dispersal of native aquatic plants (Casper van Leeuwen, Netherlands Institute of Ecology)
13:50	An up close view on methane oxidation in Sphagnum-dominated peatlands in novel mesocosm experiments (Martine Kox, Radboud University Nijmegen)	Tick abundance and phenology, the link with vegetation and climatic factors (Nienke Hartemink, Wageningen University & Research)	Does tree cover enhance decomposition in a silvopastoral system in Southern Mexico? (Alejandra Hernández Guzmán, Wageningen University & Research / El Colegio de la Frontera Sur)	Ancient human disturbances may be skewing our understanding of Amazonian ecology (Crystal McMichael, University of Amsterdam)	Metabolomic profiling reveals shifts in chemical defences in the invasive plant Purple loosestrife (Mirka Macel, University of Tuebingen / Radboud University Nijmegen)

14:10	Leaf herbivory is more impacted by forest composition than by tree species richness or edge effects (Irene Lantman, Ghent University)	Human practices promote presence, abundance and shifts in communities of disease transmitting mosquito species (Maarten Schrama, Leiden University)	Diversity in time and space: legacy effects of winter cover crop mixtures in crop rotation (Janna Barel, Wageningen University & Research)	Species specific responses in leaf wax n-alkane composition from six tropical tree species (Milan Teunissen van Manen, University of Amsterdam)	Evolutionary change in invasive plants leading to changes in insect preference (Klaas Vrieling, Leiden University)
14:30	Short Break				
14:40	Effects of restoring top-predators on coastal ecosystems in the Baltic Sea (Casey Yanos, University of Groningen)	Habitat loss facilitates pathogen outbreak and dispersal: An agent-based model of an infected migratory population (Shenglai Yin, Wageningen University & Research)	From fast to slow: Microbial decomposition and stabilisation of organic matter (Joost Keuskamp / Mariet Hefting, Utrecht University)	Long-term herbivore exclusion reveals small herbivores safeguard biodiversity in a back-barrier salt marsh via slowing down succession and decreasing dominance (Qingqing Chen, University of Groningen)	The dynamics of invasiveness: Modelling the evolution of plant-herbivore interactions (Marleen Cobben, University of Wuerzburg / Netherlands Institute of Ecology)
15:00	Wolves and tree logs: the importance of fine-scale risk factors for tree regeneration over a predation risk gradient (Annelies van Ginkel, University of Groningen)	Drivers of spatial heterogeneity of chikungunya virus in Bangladesh – the double-edged sword of human mobility (Quirine Astrid ten Bosch, Institut Pasteur)	Microbial biomass as a driver of litter decomposition at regional scales (Ciska Veen, Netherlands Institute of Ecology)	Global distribution patterns of mycoheterotrophic plants (Sofia Gomes, Naturalis Biodiversity Center)	Drivers of plant-soil interaction variation among closely related native and non-native plant species (Rutger Wilschut, Netherlands Institute of Ecology)
15:20	Landscape-scale gardening by biophysical interactions of flamingos and fiddler crabs: experimental evidence from the Banc d'Arguin intertidal flats (Hacen El-Hacen, University of Groningen)	Ecology and epidemiology of *Lyme borreliosis* in the Netherlands (Hein Sprong, National Institute for Public Health and the Environment)	Plant traits and decomposition rates in the light of light (Hans Cornelissnen, Vrije Universiteit Amsterdam)	The impacts of former plant abundance on the competitive interactions between two grassland plant species through plant-soil feedbacks (Wei Xue, Netherlands Institute of Ecology)	Return of the native facilitated by the invasive? Structure and development of a recently discovered shellfish reef in the Voordelta (Tom van der Have, Bureau Waardenburg)
15:40	**Coffee and tea in the lounge**				
	Europe Hall	**America Hall**	**Asia Hall**	**Africa Hall**	**Vide Hall**
16:00	**Parallel 2a: Functional networks in ecology**	**Parallel 2b: Ecology of movement and dispersal**	**Parallel 2c: Agro ecology; Ecological processes in agriculture for more sustainable farming**	**Parallel 2d: Ecosystem resilience; causes and consequences of climate change**	**Parallel 2e: Ecology and conservation**
	Conveners: 1. Emilia Hannula (Netherlands Institute of Ecology) 2. Elly Morriën (University of Amsterdam)	*Conveners*: 1. Allert Bijleveld (NIOZ Royal Netherlands Institute for Sea Research) 2. Wouter Vansteelant (Novia University of Applied Sciences / University of Amsterdam) 3. Jelle Treep (Utrecht University)	*Conveners*: 1. Raymond Klaassen (University of Groningen) 2. David Kleijn (Wageningen University & Research) 3. Simone Weidner (Utrecht University) 4. Pilar Puentes-Tellez (Utrecht University)	*Conveners*: 1. Maggie Armstrong (Netherlands Institute of Ecology) 2. Tjisse van der Heide (Radboud University Nijmegen) 3. Tjeerd J. Bouma (NIOZ Royal Netherlands Institute for Sea Research)	*Conveners:* 1. Rascha Nuijten (Future for Nature Academy / Netherlands Institute of Ecology) 2. Ignas Heitkonig (Future for Nature Academy / Wageningen University & Research)
16:00	Fungal parasites of phytoplankton: networking with	Modelling the spatial dynamics of Maui dolphins using Agent Based	Functionality and Conservation of diversity for sustainable	Sea level rise: causes & variability across scales	Integrity loss of migration networks induces population

	the enemy? (Alena Gsell, Netherlands Institute of Ecology)	Modelling (Monique de Jager, Wageningen University & Research)	agriculture (Simone Weidner, Utrecht University & Raymond Klaassen, University of Groningen)	(Aimée Slangen, Royal Netherlands Institute for Sea Research)	decline of migratory birds (Yanjie Xu, Wageningen University & Research)
16:20	Model-based analysis of the potential of macroinvertebrates as indicators for microbial pathogens in rivers (Rubén Jerves-Cobo, Ghent University)	Adaptations for dispersal in the invasive cane toad (*Rhinella marina*) (Cameron Hudson, University of Sydney)	Conserving biodiversity in agricultural landscapes: a win-win for farmer and wildlife? (Thijs Fijen, Wageningen University & Research)	Can mutualistic networks increase resilience of seagrasses to global change? (Matthijs van der Geest, Université de Montpellier)	A genomics perspective on conservation (Mirte Bosse, Wageningen University & Research)
16:40	Landscapes of Facilitation: long-range species interactions on intertidal flats (Isabelle van der Ouderaa, University of Groningen)	Home range and movement patterns of tropical Red-capped Lark are influenced by breeding and vegetation and not by rain or invertebrate (Joseph Mwangi, University of Groningen)	Clever Cover Cropping: Cover Crops Diversity and Productivity (Ali El-Hakeem, Wageningen University & Research)	Bridging critical thresholds by temporarily facilitation of the blue mussel using biodegradable habitat structures (Ralph Temmink, Radboud University Nijmegen)	Twenty years of stream restoration in The Netherlands: facts and figures (Paula Caroline dos Reis Oliveira, University of Amsterdam)
17:00	Short Break				
17:10	Mechanisms behind biodiversity effects on ecosystem functioning in European forests (Koenraad Van Meerbeek, Aarhus University)	Seasonal Survival and Migratory Connectivity of the partially migratory Eurasian Oystercatcher in the Netherlands (Andrew Allen, Radboud University Nijmegen)	Effects of land use intensity on the proportion of specialist nematode taxa (Carmen Vazquez, Wageningen University & Research)	Assessing the resilience of insular species to past climatic change (Kenneth Rijsdijk, University of Amsterdam)	EU demand for wood pellets drives US biodiversity changes (Anna Duden, Utrecht University)
17:30	Satellite communities of heterotrophic bacteria growing with *Nitrobacter winogradskyi* in strictly inorganic, nitrite-fed continuous cultures (Noriko Cassman, Netherlands Institute of Ecology)	Arctic geese tune migration to a warming climate but fail to evade a phenological mismatch (Thomas Lameris, Netherlands Institute of Ecology)	Beneficial microbe diversity enhances rhizosphere microbiome function and plant disease suppression (Jie Hu, Nanjing Agricultural University / Utrecht University)	Characterization of phytoliths in premontane western Amazonian forests (Seringe Huisman, University of Amsterdam)	Using sensor technology and machine learning to understand animal behaviour (Jasper Eikelboom, Wageningen University & Research)
17:50	Exploring aspects of predictability in plant - herbivore interactions in Brassicaceae (Daan Mertens, Wageningen University & Research)	Odour-guided foraging of parasitoids in the field is less straightforward than assumed (Ilka Vosteen, Wageningen University & Research)	Bio-organic fertilizer application induces soil disease suppressiveness against banana Fusarium wilt by reshaping soil microbiome (Rong Li, Nanjing Agricultural University / Utrecht University)	Climate change mitigation through adaptation: the effectiveness of forest diversification by novel tree planting regimes (Anouschka Hof, Wageningen University & Research)	The Arctic is melting and scientists are not doing enough (Maarten Loonen, University of Groningen)
18:10	**Drinks in the Lounge and from 18:30 onwards dinner in the restaurant**				
19:30	**Poster session 1: Odd-numbered posters, which are linked to the sessions of the day, are presented and discussed**				
	Europe Hall				
21:00	**Evening Programme: Zombie Nature??** (Prof. Jelle Reumer, Vertebrate Paleontology, Dept. of Earth Sciences, Utrecht University, the Netherlands)				

Wednesday 14 February

07:30	Breakfast in the restaurant				
08:00	Registration for those coming on Day 2 only				
	Europe Hall	**America Hall**	**Asia Hall**	**Africa Hall**	**Vide Hall**
08:30	**Parallel 3a: Ecological stoichiometry; Alterations through environmental change and impacts on organisms and ecosystems**	**Parallel 3b: Monitoring biodiversity change; Essential Biodiversity Variables (EBVs) and beyond**	**Parallel 3c: Eco-evolutionary ecology: Understanding Eco-Evolutionary Dynamics with Experimental Evolution**	**Parallel 3d: Microbial ecology; Community composition and dynamics**	**Parallel 3e: No-Session**
	Conveners: 1. Harry Olde Venterink (Vrije Universiteit Brussel) 2. Vanessa Minden (University of Oldenburg) 3. Judith Sitters (Netherlands Institute of Ecology)	*Conveners*: 1. W. Daniel Kissling (University of Amsterdam) 2. Rob Jongman (Wageningen University & Research / Jongeman Ecology)	*Conveners*: 1. Cyrus A. Mallon (University of Groningen) 2. Karen Bisschop (Ghent University / University of Groningen) 3. Daniel E. Rozen (Leiden University)	*Conveners*: 1. Leo Lahti (University of Turku) 2. Karoline Faust (KU Leuven) 3. Didier Gonze (Université Libre de Bruxelles)	
08:30	A stoichiometric perspective on plant-herbivore interactions in terrestrial ecosystems (Harry Olde Venterink, Vrije Universiteit Brussel)	Essential Biodiversity Variables: status and the way forward (Rob Jongman, Wageningen University & Research / Jongeman Ecology)	Ecosystem engineering and evolution (Raoul van Oosten, Vrije Universiteit Amsterdam)	Multi-stability and the origin of microbial community types (Didier Gonze, Université Libre de Bruxelles)	
08:50	Towards an ecologically optimized N:P recovery from wastewater by microalgae (Tânia Fernandes, Netherlands Institute of Ecology)	Standardising global butterfly monitoring (Chris van Swaay, Dutch Butterfly Conservation / Butterfly Conservation Europe)	Rapid bacterial evolution can lead to cryptic eco-evolutionary dynamics in the plant rhizosphere (Erqin Li, Utrecht University)	Microbial community dynamics and oxic-anoxic regime shifts in a seasonally stratified lake (Gerard Muijzer, University of Amsterdam)	
09:10	Tree diversity does not increase litter and soil stoichiometric heterogeneity (Lionel Hertzog, Ghent University)	Monitoring change in freshwater ecosystems and biodiversity (Jeanne Nel, Vrije Universiteit Amsterdam)	Microevolutionary response to selection for fast growth is partially mediated by phosphorus availability (Kimberley Lemmen, Netherlands Institute of Ecology)	Population dynamics and density dependence (Katri Korpela, University of Helsinki / European Molecular Biology Laboratory)	
09:30	Short Break				
09:40	Direct and indirect effects of resource P-limitation differentially impact population growth, life history and body elemental composition of a zooplankton consumer (Libin Zhou, Netherlands Institute of Ecology)	Use of remote sensing enabled Essential Biodiversity Variables and in-situ data for habitat monitoring (Sander Mücher, Wageningen University & Research)	Evolution experiment with natural undefined starters containing lactic acid bacteria (Anneloes Groenenboom, Wageningen University & Research)	Modelling the dynamics of a synthetic gut community (Karoline Faust, KU Leuven)	
10:00	Contrasting effects of rising CO2 on primary production and ecological stoichiometry at	Using airborne laser scanning for monitoring ecosystem structure	Untangling symbiotic networks (Victor Caldas, Vrije Universiteit Amsterdam)	Biological insights from microbial networks (Lisa Röttjers, KU Leuven)	

	different nutrient levels (Jolanda Verspagen, University of Amsterdam)	(Zsófia Koma, University of Amsterdam)			
10:20	Nutrient stoichiometry as a driver of plant community composition and community responses to global change (Jerry van Dijk, Utrecht University)	Going beyond essential biodiversity variables – Essential Geodiversity Variables (EGVs) (Franziska Schrodt, University of Nottingham)	Host genotype shapes the assembly of both the gut microbiota and the surrounding bacterioplankton in the freshwater crustacean *Daphnia magna* (Ellen Decaestecker, KU Leuven)	Contemporary challenges in population-level studies of the human microbiome (Leo Lahti, VIB / KU Leuven / University of Turku)	
10:40	**Coffee and tea in the lounge**				
	Europe Hall				
	Plenary 2: "Ecosystem services provided by arthropods: from volatiles to landscapes"				
11:00	**1. Landscape complexity effects on arthropod-mediated ecosystem services** (Katja Poveda, Department of Entomology, Cornell University, United States of America)				
11.45	**2. Species interactions underlying arthropod-mediated ecosystem services** (Marcel Dicke, Laboratory of Entomology, Wageningen University, the Netherlands)				
12:30	**Lunch in the restaurant**				
13:30	**Poster Session 2: Even-numbered posters, which are linked to the sessions of the day, are presented and discussed**				
	Europe Hall	**America Hall**	**Asia Hall**	**Africa Hall**	**Vide Hall**
15:00	**Parallel 4a: Ecosystem services; from volatiles to landscapes**	**Parallel 4b: Ecophysiology; Mechanisms of Plant-Environment Interaction**	**Parallel 4c: Soil biodiversity; A methodological consensus to better understand soil biodiversity, their function and interaction with plants**	**Parallel 4d: Theoretical ecology; Unifying principles in ecology and beyond**	**Parallel 4e: Animal ecology**
	Conveners: 1. Erik Poelman (Wageningen University & Research) 2. Daan Mertens (Wageningen University & Research) 3. Matti Pisman (Ghent University)	*Conveners*: 1. Eric Visser (Radboud University Nijmegen) 2. Ronald Pierik (Utrecht University)	*Conveners*: 1. Stefan Geisen (Netherlands Institute of Ecology) 2. Arjen de Groot (Wageningen Environmental Research, Wageningen University & Research)	*Conveners*: 1. Koen Siteur (NIOZ Royal Netherlands Institute for Sea Research) 2. Valerie Reijers (Radboud University Nijmegen) 3. Maarten Eppinga (Utrecht University)	*Conveners:* 1. Chris Smit (University of Groningen) 2. Patrick Jansen (Wageningen University & Research)
15:00	The importance of different biodiversity measures to describe pollinator diversity within an agricultural landscape (Matti Pisman, Ghent University)	Genetic components of root architecture remodelling in response to salt stress (Christa Testerink, Wageningen University & Research / University of Amsterdam)	Soil Biodiversity uncovered (Arjen de Groot, Wageningen University & Research & Stefan Geisen, Netherlands Institute of Ecology)	Multidisciplinary approaches to understanding complexity in ecosystems (Johan van de Koppel, Royal Netherlands Institute for Sea Research)	Rewilding Europe's large grazer community: how functionally diverse are the diets of European bison, free-ranging cattle and horses? (Esther Rodriguez, PWN)
15:20	Caught between friends and foes: Effects of herbivore-induced plant responses on flower visitors (Quint Rusman, Wageningen University & Research)	Hypoxia tolerance of Arabidopsis seedlings varies between developmental stages (Shanice Martopawiro, Utrecht University)	Land abandonment results in species richness loss and homogenization of belowground soil food webs (Maarten Schrama, Leiden University)	Lévy movement as the optimal strategy for building dunes (Valérie Reijers, Radboud University Nijmegen)	Keep calm and carry on: behavioural comparison of naïve and non-naïve deer in response to wolf urine (Annelies van Ginkel, University of Groningen)

15:40	Central flowers provide hotspot for multi-host pollinator pathogen transmission (Niels Piot, Ghent University)	Light signals for aboveground neighbour detection regulate root architecture (Ronald Pierik, Utrecht University)	Active rhizosphere mycobiome (Emilia Hannula, Netherlands Institute of Ecology)	Wide distribution of regular pattern wavenumbers in model and real dryland ecosystems (Robbin Bastiaansen, Leiden University)	Foraging coordination while feeding young: behavioural mechanisms underlying negotiation over offspring care (Davide Baldan, Netherlands Institute of Ecology)
16:00	Break				
16:10	Redefining the field: Large scale stripcropping experiments show benefits for farmers, consumers and nature (Dirk van Apeldoorn, Wageningen University & Research)	Surviving floods: adaptive roots and where to find them (Eric Visser, Radboud University Nijmegen)	Plant-soil feedback and plant persistence are linked in a biodiverse grassland (Dina in 't Zandt, Radboud University Nijmegen)	On scale and function of ecosystem engineered structures (Jim van Belzen, Royal Netherlands Institute for Sea Research)	Do responses to temperature vary spatially in two hole-nesting passerines? (Liam Bailey, Netherlands Institute of Ecology)
16:30	Variation in attractiveness to parasitoids in a landscape context (Yavanna Aartsma, Wageningen University & Research)	Natural variation in tomato specialised metabolites against insects (Petra Bleeker, University of Amsterdam)	Network visualization as a versatile tool for exploring soil biodiversity (Basten Snoek, Utrecht University)	Classifying and unifying and the underlying causality of species competition: a theoretical perspective (Manqi Chang, Netherlands Institute of Ecology)	Maternal effects in a placental live-bearing fish (Andres Hagmayer, Wageningen University & Research)
16:50	Spatial scale dependent effects of urbanization on plants and their above- and belowground invertebrates (Jiao Qu, Ghent University)	Genomic and molecular characteristics of a desiccation tolerant plant (Mariana Artur, Wageningen University & Research)	Toward an integrative understanding of soil biodiversity (Madhav Thakur, Netherlands Institute of Ecology)	Using Fourier Series of the Absorption Spectrum of Phytoplankton (Jürg Werner Spaak, University of Namur)	Self-organisation of nest aggregates in a digger wasp: a spatial pattern driven by density-dependent movement (Femke Batsleer, Ghent University)
	Europe Hall				
17:20	• **Awards ceremony** o NecoV Poster Prize (NecoV representative) o NERN Best Presentation Award (Member of the NERN Board) o #NAEMbingo prizes (NERN / Future for Nature Academy representative) • **Final words** (Hans de Kroon)				
	Lounge				
18:00	**Farewell drinks**				
18:30	**Dinner**				
19:30	**End / Travel Home** (Shuttle available between Conference Centre and Lunteren Station)				

NAEM 2018

Presentation Abstracts

Plenary Session 1

Ecosystem functioning in a changing world: the role of higher trophic levels

The rapid current rate of global change has led to increased interest in relation between the structure of ecological communities and the functioning of ecosystems. Most work in this field has addressed the consequences changing species richness of grasslands for primary productivity. However, much less is know how changes in other trophic levels as herbivores, predators or decomposers will affect key aspects of ecosystem functioning, including strong feedbacks to vegetation processes. This plenary session will address this topic.

1. **How altered animal communities change the functioning of ecosystems, and possibly our climate**
   (Trisha B. Atwood, Utah State University)

The idea that animals act as major regulators of ecosystem functioning is still contentious in ecology. Yet, rapid defaunation and the global homogenization of animal communities, raises urgent concerns about potential impacts to important ecosystem functions and services. Recent research reveals that animals play an important and potentially irreplaceable role in processes that underlie fundamental functions and services in terrestrial, marine, and freshwater ecosystems. One (of many) exciting new research avenue, is the investigation of the role animals play in carbon cycling and climate regulation. Empirical studies show that changes to animal communities can cascade through the food web to alter CO_2 emissions from ecosystems, carbon export from erosion, short-term carbon storage in plant biomass, and long-term carbon storage in soils. This research signifies the potential for the integration of community- and global systems-level ecology to be a highly effective tool for enhancing ecosystem services, such as climate change mitigation.

2. **Understanding multiplex networks of species interactions in a changing world**
   (Han Olff, University of Groningen)

The rapid changes that humans impose on the biosphere require a new thinking about how to preserve its biodiversity. Limits to the size of protected areas and human-wildlife conflicts make it increasingly difficult to preserve fully complete and intact ecosystems in a pristine, wilderness-type setting. Species combinations without clear historical analogous arise and new types of ecological interactions are found. Understanding the resulting ecological changes requires the thorough analysis of ecosystems from the perspective of multiplex (i.e., multi-layer) networks, in which a diversity of interactions (as herbivory, predation, mutualism and ecosystem engineering) jointly determine community structure and ecosystem functioning. Using examples from a range of temperate to tropical ecosystems, I will address how this new multiplex network perspective is important for the preservation and restoration of biodiversity and associated key ecosystem services in a changing world.

Plenary Session 2

Ecosystem services provided by arthropods: from volatiles to landscapes

We will highlight the importance of plant-mediated interactions between different organisms such as herbivores, pollinators and natural enemies at different spatial scales. We will discuss the mechanisms that allow plants to mediate interactions among very different kinds of organisms that might interact with the plants at different spatio-temporal scales. We will also demonstrate how plant-arthropod interactions are shaped by the surrounding landscape and can play a crucial role in agricultural production.

1. **Landscape complexity effects on arthropod-mediated ecosystem services**
   (Katja Poveda, Cornell University)

One of the biggest challenges worldwide is to increase crop production while minimizing the negative environmental impacts of conventional agriculture. Ecological intensification, or the improvement of crop yield through enhancement of biodiversity and ecosystem services, has been proposed as a sustainable pathway toward greater crop production. To be effective, ecological intensification requires a good understanding of the relationships between land use at different scales, the community composition of ecosystem-providing organisms, their interaction with the crop and their contribution to crop production. However, the impact of land use practices at landscape scale, on ecosystem service-providing arthropods, their interactions with the crops and their consequences on yield remain unknown. Here, we will present results from three cropping systems that vary in their dependence on arthropod-mediated ecosystem services for increases in yields: potato, strawberry and cabbage. In all systems, we explore how landscape composition influences crop yield mediated by their interactions with pollinator, herbivore and natural enemy communities by answering the following questions: 1) does the presence of natural areas at a landscape scale affect yield in cropping systems? 2) are the effects on yield determined by the diversity of the arthropod community, single species, or the type of interactions between the crop and the arthropods (pollinators, herbivores and natural enemies)? And, 3) how do local management practices interact with processes at the landscape scale to influence ecosystem services provided by arthropods? We conclude that processes at the landscape scale are crucial at determining the provision of ecosystem services mediated by arthropods with important consequences on crop production.

2. **Species interactions underlying arthropod-mediated ecosystem services**
   (Marcel Dicke, Wageningen University)

Processes at the landscape scale are influenced by species interactions occurring between individuals. Such interactions may represent direct interactions such as predator-prey, herbivore-plant or pollinator-plant interactions. Moreover, interactions between two individuals may also be mediated by a third organism, such as plant-mediated interactions between two herbivores, parasitoid-mediated interactions between an herbivore and a hyperparasitoid, or plant-mediated interactions between rhizosphere microbes and shoot-feeding insects. Moreover, interactions may even be mediated by more than one connecting species. Such interactions may link individuals that are spatially and/or temporally separated. As a consequence, food webs are overlaid with much more reticulate interaction webs and information, such as provided by volatiles, mediates many nodes in the interaction web. The outcome of plant-mediated interaction webs is dependent on plant physiological and subcellular processes that mediate plant phenotype and that can have important consequences for plant fitness. Although most attention has been at small spatial scales (plant, field), less research has been done on effects of local interactions on processes at larger spatial scales. This presentation will focus on species interactions in the plant-associated community linking different levels of biological integration and spatial scales. This bottom-up approach will link to processes as the landscape scale that influence the provision of ecosystem services mediated by arthropods, as discussed by Katja Poveda.

Parallel Session 1

1a: COMMUNITY ECOLOGY; Ecosystem functioning in a changing world – the role of higher trophic levels

Conveners: Han Olff (University of Groningen)

1. Trophic rewilding under global change: risks and opportunities for butterfly communities

Michiel Wallis de Vries
De Vlinderstichting (Dutch Butterfly Conservation) / Wageningen University & Research

With increasing intensification of modern agriculture on the one hand, and land abandonment in areas of marginal agricultural value on the other, the preservation of Europe's biodiversity is seriously endangered. Climate change and nitrogen deposition constitute additional environmental pressures. Trophic rewilding has been proposed as a promising alternative to counter biodiversity loss in abandoned areas. Trophic rewilding can be defined as a restoration strategy that uses species introductions to restore top-down trophic interactions and associated trophic cascades, to promote self-regulating biodiverse ecosystems. Butterflies and other arthropods are rarely considered in the development of rewilding concepts. Here, we set out to fill this gap. We review the existing evidence of species tolerance and sensitivity to grazing intensity and confront the outcome with commonly used perspectives on ecosystem dynamics in rewilding strategies. From there, we identify risks and opportunities to restore-species rich communities. Two main challenges emerge: 1) dealing with the legacy of historical and current human land use, and 2) defining the boundaries of non-interference principles in relation to biodiversity conservation. We argue that, in addressing these challenges, butterfly monitoring may provide a key instrument.

2. An up close view on methane oxidation in Sphagnum-dominated peatlands in novel mesocosm experiments

Martine Kox
Radboud University Nijmegen

Peatlands are estimated to store up to 30% of all terrestrial carbon. Part of this carbon is decomposed anaerobically which ultimately results in methane emission. It is expected that global warming will enhance methane release in many ecosystems. However, methane emissions in peatlands are in general lower than the methane production due to the activity of methane oxidizers. Until now, methane oxidation and production activity have been studied using peat soil slurries and net-production measurements in the field. Here, we developed a novel mesocosm set-up that enables exact control of methane input and monitoring of the dissolved methane throughout the peat in a setting that closely resembles natural conditions. We were able to show that methane consumption only occurred in the mesocosm with mosses present and not in the porewater, indicating that significant numbers of methane-oxidizing bacteria were mainly associated with the moss. In addition, over the 2-month course of the experiments, the methane oxidation rates increased by 50%. Together these findings showed that our mesocosm setup can be used to study methane cycling in peat mosses under defined conditions which is an important step forward towards better understanding the interactions between peat moss and its associated methanotrophic communities.

3. Leaf herbivory is more impacted by forest composition than by tree species richness or edge effects

Irene Lantman
Ghent University

Links between biodiversity and ecosystem functioning are well established. Beyond biodiversity per se, the community composition can have strong effects on ecosystem functioning. Furthermore, spatial processes that translate into edge effects, can impact the diversity-functioning relationship. This spatial context is especially relevant within a food web context, for instance when considering herbivory as an important process for the transfer of plant biomass across the food chain. The relative importance of species richness, composition and spatial context on functioning at a community and at species level is, however, poorly understood. To fill this gap in our understanding, we studied to what degree herbivory in temperate forest plots varies according to the spatial context, tree species richness and composition. In contrast to the prevailing view of tree herbivory increasing at forest edges, we found the effects of forest edge and tree species richness on leaf herbivory were overshadowed by effects forest tree composition. Our findings mainly emphasize the importance of community composition. This warrants consideration of identity effects in future studies if we are to deepen our understanding of the determinants of ecosystem functions across systems.

4. Effects of restoring top-predators on coastal ecosystems in the Baltic Sea

Casey Yanos
University of Groningen

Populations of top predators have collapsed in many ecosystems throughout the world due to overexploitation by humans. Trophic cascades, reciprocal changes to predator-prey relationships throughout a food web, occur in ecosystems characterized by top predator loss and can cause a loss of biodiversity and changes to ecosystem structure. In the Baltic Sea, three-spined stickleback, *Gasterosteus aculeatus*, have increased up to one hundred-fold closely following population collapses of their main predators, the commercial fish species Atlantic cod, *Gadus morhua*, Northern pike, *Esox lucius*, and European perch, *Perca fluviatilis*. We hypothesized that recreational fisheries induce trophic cascades involving cod, pike, and perch, three-spined stickleback, and lower trophic level resources. We tested this hypothesis by comparing fish community composition, algal recruitment, and algal growth in 27 bays with varying degrees of protection, along the eastern Swedish coast.

5. Wolves and tree logs: the importance of fine-scale risk factors for tree regeneration over a predation risk gradient

Annelies van Ginkel
University of Groningen / Mammal research Institute, Polish Academy of Sciences

Large carnivores affect lower trophic levels by influencing ungulate herbivory directly via reducing ungulate numbers and indirectly by altering ungulate behavior due to predation risk. Predation risk factors act at different spatial scales, where carnivore distribution shapes predation risk at the landscape-scale and impediments (objects blocking view and escape routes) affect predation risk at a fine-scale. The relative importance of these two different spatial scales and whether they interact in affecting predator-induced risk effects has often been ignored in trophic cascade studies. Previous work in our study site, the Białowieża forest (Poland), showed that deer behavior is affected by both fine-scale (tree logs) and landscape-scale risk (distance to wolf (*Canis lupus*) core). We studied how and till what distance tree logs affect ungulate browsing intensity and how this is modified over a landscape-scale predation risk gradient (distance from human settlements to wolf core) in the primeval Białowieża forest, Poland. We found that landscape-scale and fine-scale risk factors strongly interacted in determining the strength and magnitude of carnivore induced risk effects on lower trophic levels. In areas with low perceived risk, tree logs reduced browsing intensity in small patches (≤4 m from logs), whereas in high risk areas larger patches with a reduced browsing intensity were found (≤16 m from tree logs). Moreover, the magnitude of these effects changed over a landscape-scale with the strongest reduction in browsing intensity around tree logs in high risk areas (up to 37%) and the smallest in low risk areas (<20%). These results suggest that risk factors operate at different spatial scales, strongly interact and determine the functional role of large carnivores in affecting ecosystem processes. These interactive effects should be incorporated in predator-induced trophic cascade studies, to understand patterns of tree regeneration in ecosystems where large carnivores and herbivores live together.

6. Landscape-scale gardening by biophysical interactions of flamingos and fiddler crabs: experimental evidence from the Banc d'Arguin intertidal flats

Hacen El-Hacen
University of Groningen

Resource production and use shapes the dynamics of distribution and numbers of consumers. With some exceptions (large herbivores, ants, termites), the capacity of animals to garden food at the landscape-scale has received little attention, especially in marine ecosystems. Here, we combined observational studies and exclosure experiments to investigate how coexisting greater flamingos *Phoenicopterus ruber* and fiddler crabs *Uca tangeri* promote their own and each other's food production by creating a spatially complex intertidal mosaic of depressions (bowls, gullies) and hummocks (plateau, mounds), a mosaic of microhabitats with different tidal inundation regimes. The microhabitats are spatially organized in labyrinth-like patterns in the high intertidal zone and by spotty patterns lower in the intertidal and likely arise from biophysical interaction between the organisms and hydrodynamic forces. We show that the resulting spatial complexity is vital for biofilm production. The depression microhabitats were wetter and richer in organic matter and biofilms compared with hummocks. Excluding flamingos and crabs resulted in an increase in the biofilm biomass on the short term (6 months), but a decrease on the longer term (after 1 year). Moreover, our results strongly suggest that the biogeomorphological microhabitats of the mosaics were maintained by the feeding activities of flamingos and crabs. During a period of flamingo exclusion, all the spotty-patterns filled up with sediment, while the exclusion of crabs led to gradual sediment accumulation in the labyrinth-like patterns. We propose that these intertidal mosaics represent a first example of landscape-scale gardening in marine ecosystems.

1b: DISEASE ECOLOGY; Ecology of pathogen-host-community interactions of vector-borne pathogens

Conveners: Maarten Schrama (Leiden University)
Quirine Astrid ten Bosch (Institut Pasteur)
Shenglai Yin (Wageningen University & Research)

1. Host–tick–pathogen interactions along a Neotropical disturbance gradient

Helen Esser, Janet Foley, Yorick Liefting, Nicole Stephenson, Michael Miller, Allen Herre, Frans Bongers, Herbert Prins, and Patrick Jansen
Wageningen University & Research

Control of infectious diseases is considered as an ecosystem service of biodiversity, with high biodiversity buffering against disease risk. One recurrent critique of this "dilution effect" is that higher biodiversity should also come with higher diversity of parasites and pathogens. However, high parasite diversity does not necessarily equate with high disease risk, and it remains poorly known whether and how biodiversity loss affects disease risk in parasite-rich environments. Here, we studied broader communities of wildlife, ticks, and tick-borne pathogens along an anthropogenic disturbance gradient in Panama. We found that microbial and pathogen richness increased with tick species richness, which in turn increased with wildlife species richness. In contrast, densities of questing ticks, tick infestation of small mammals, and pathogen prevalence in ticks were dependent on the structure and composition of wildlife communities, rather than species richness. Specifically, loss of apex predators initially increased tick-borne disease risk through vector augmentation by medium- to large-sized frugivores and herbivores, but subsequent loss of these important reproduction hosts decreased disease risk again by reducing tick abundance. Our study suggests that the relationship between biodiversity loss and disease risk is non-linear, and highlights the importance of directly assessing the structure and composition of wildlife communities.

2. Tick abundance and phenology, the link with vegetation and climatic factors

Nienke Hartemink, Arnold van Vliet, Hein Sprong, Willem Takken
Wageningen University & Research

Ten years of monthly sampling of ticks by volunteers has resulted in a longitudinal dataset that allows us to study the effect of climatic and vegetation variables on the timing and number of questing ticks. Data on infection rates will be available soon. Ticks were collected in eleven locations throughout Netherlands for the full ten year period. We used generalized linear (mixed) models (GLMs and GLMMs) to investigate the effect of several climatic and vegetation-related variables on several outcomes, such as the numbers of ticks collected per session and per year, and the annual onset of tick activity. We focus on vegetation characteristics that we consider relevant for the transmission cycle, e.g. that provide shelter from dehydration for ticks, or food for rodents. We show the importance of temperature and relative humidity for the number of ticks collected per sampling session. The overall trend over ten years was a slight overall increase in tick numbers, but trends differed between locations. Concerning the onset of the questing activity, we again found marked differences between locations, as well as a relationship with temperatures in winter and early spring. Another important finding is that ticks are sometimes active in winter in The Netherlands.

3. Human practices promote presence, abundance and shifts in communities of disease transmitting mosquito species

Maarten Schrama, Ellard Hunting, Danny Govender, Peter van Bodegom, Erin Gorsich
Leiden University

The widespread emergence of human and wildlife vector-borne diseases has challenged ecologists to understand the factors governing communities of disease vectors. Here, we evaluated whether and how 1) human induced landscape changes induce shifts in communities of mosquito species and 2) how these differ between disease vectors and non-disease vector species. To this end, we sampled a 300 km transect on the border of KNP in South Africa to compare mosquito communities within the park to those in the rural areas outside the park. Our findings show that mosquito communities are strongly influenced by anthropogenic changes in the landscape. Mosquitoes exhibited greater abundance outside the park, with the largest changes occurring in commonly mentioned disease vectors (*Culex univittatus*, *Cx pipiens / quinquefasciatus*, *Aedes aegypti*, *Anopheles gambiae* s.l.) A similar pattern was observed for comparisons between disturbed sites around human settlements and non-disturbed sites inside the park, stressing the importance of small-scale ecological changes in driving disease vector communities. Synthesis. This study shows significant changes in mosquito communities associated with human-induced landscape change, even between nearby sites with similar climatological conditions. Hence, it presents a case to consider climatological conditions in concert with local anthropogenic changes for example when improving small- and large-scale predictions of disease risks.

4. **Habitat loss facilitates pathogen outbreak and dispersal: An agent-based model of an infected migratory population**

Shenglai Yin, Yanjie Xu, Mart de Jong, Herbert Prins, Yali Si, Fred de Boer
Wageningen University & Research

Habitat loss can extensively affect migration networks, and thereby influence host-pathogen interactions. For such an intensive impact, we constructed migration networks of a migratory waterfowl population in the East Asian-Australasian Flyway, integrated with an agent-based model, bird migration behaviour, and SIR-type infection dynamics. We studied the prevalence dynamics of the pathogen infection in a migratory population and the pathogen dispersal over the migration network, under three scenarios of site removal. The results showed that habitat loss was mainly observed in the southern part of the East Asian-Australasian Flyway. Migration allowed the birds to escape from infectious sites, and reduced their infection prevalence. In the most extreme scenario of site removal, however, the birds stopped their migration at a higher latitude, and aggregated in a single wintering site, which facilitated pathogen infection. In addition, sites that received more connections from other sites, and with a larger number of migratory birds are more prone to be invaded by pathogens, and site removal increased the pathogen invasion probability. Our findings suggest that habitat loss facilitates disease outbreak in a migratory population, and increase the probability for pathogen invasion.

5. **Drivers of spatial heterogeneity of chikungunya virus in Bangladesh – the double-edged sword of human mobility**

Quirine ten Bosch, Henrik Salje, Kishor Paul, Abu Naser Titu, Mahmudur Rahman, James Heffelfinger, Shafiul Alam, HM Al-Amin, Ziaur Rahman, Sayma Afroz, Derek Cummings, Repon Paul, Stephen Luby, Emily Gurley, Simon Cauchemez
Institut Pasteur

Whether a locality becomes affected during an arbovirus outbreak depends on the complex interplay between environmental and social factors. We characterized the determinants that underlie the spatial propagation of the chikungunya virus in a rural district in Bangladesh. By combining data from social, mobility, and entomological surveys with cross-sectional serological household data on past (CHIKV) exposure from 40 villages (1502 participants) we aimed to examine 1) the proportion of overall transmission that occurred at the household vs community level and 2) the main determinants that underlie the spatial signatures of transmission. We used final size distribution methods in a Bayesian framework to estimate local transmission parameters across the villages. We found significant spatial variability in sero-prevalence across villages, ranging from 0% to 74% (median = 3%). The probability of transmission between household members was stable across the study area and responsible for about 8% of infections. There was significant spatial dependence between community-level transmission rates. This spatial dependence, as well as 45% of variance in community-level transmission could be explained by heterogeneity in mosquito abundance. Human mobility was found to be a significant determinant of both mosquito abundance and sero-prevalence, indicating that the pathogen propagation was driven by the effects of human mobility on both vector dispersal and pathogen spread.

6. **Ecology and epidemiology of Lyme borreliosis in the Netherlands**

Hein Sprong
Dutch National Institute for Public Health and the Environment

How can nature be protected and biodiversity preserved while the threats of zoonotic diseases are minimized? Expanding nature areas and creating ecological networks across Europe are not only beneficial for wildlife, but also for the pathogens they carry. A prominent case is *Lyme borreliosis*, which has risen from relative obscurity to become a major public health problem in Europe. The Dutch research program “Shooting the messenger” took a “One Health” approach aiming at the development of sustainable measures for the prevention of *Lyme borreliosis*. An interdisciplinary network of researchers, public health experts, and nature managers gained and shared knowledge in the ecological processes of ticks, Lyme spirochetes and their vertebrate hosts as well as in the human epidemiology of tick bites and *Lyme borreliosis*. These new insights together with new intervention methods and strategies are described in this presentation.

1c: DECOMPOSITION; Integrating drivers of decomposition across time and space

Conveners: Hans Cornelissen (Vrije Universiteit Amsterdam)
Joost Keuskamp (Utrecht University)
Marta Manrubia-Freixa (Netherlands Institute of Ecology)

1. Is there a tree economics spectrum of decomposability?

Juan Zuo, Mariet Hefting, Matty Berg, Hans Cornelissen
Vrije Universiteit Amsterdam

The plant economics spectrum (PES), based on wide-ranging plant forms, integrates trade-offs in traits among species within and between organs, and affects litter decomposition. We ask whether the PES also features within the same growth form, temperate trees. If so, is there a tree economics spectrum (TES) of decomposability driving the decomposition across organs of different species? And how robust would this TES of decomposability be to different environmental conditions? We conducted a common garden decomposition experiment with ten temperate tree species in two contrasting forests in the Netherlands for 47 months. We evaluated the effects of functional traits of leaves, twigs, branch wood and branch bark on the decomposition rates of those organs and assessing whether there was a multivariate axis of functional traits explaining decomposition rates. We found (1) tree organ specific economics spectra were correlated with each other, (2) leaves were consistently more decomposable than twigs and twigs more than coarse branches, (3) there was a TES with afterlife effects driving coordinated decomposability of twigs and leaves but not of coarse branches, and the effects depended on forest environment. The contrasting decomposability between tree organs confirms an important role of different organic matter inputs in forest biogeochemistry.

2. Does tree cover enhance decomposition in a silvopastoral system in Southern Mexico?

Alejandra Hernández Guzmán, Lourens Poorter, Luis García-Barrios, J. Larsen, Thomas Kuyper
Wageningen University & Research / El Colegio de la Frontera Sur (ECOSUR)

Silvopastoral systems are designed to enhance cattle production and multiple other ecosystem services. Here we test the hypothesis that an increase in tree cover in pastures increases litter input, ameliorates microclimatic conditions, and hence enhances litter decomposition rates. We carried out a litter decomposition experiment in 32 enclosures in paired-wise observations (grazed and non-grazed areas) in 7 rangelands in Chiapas, Mexico. The enclosures covered a large gradient of forest cover from semi-open to high tree-covered pastures. We used two native litter types; dry grass (for semi-open pastures) or a mixture of pine and oak leaves (for tree covered pastures). Decomposition rates and microbial respiration activity through Substrate Induced Respiration were evaluated for a total of 150 days in three incubation periods. In contrast to our hypothesis, decomposition and microbial respiration rates were higher under semi-open pastures with no significant differences between grazed and non-grazed areas. Under forest tree-covered pastures, decomposition and microbial respiration rates were lower and most litter mass loss occurred during the first two incubation periods. Decomposition is a key ecosystem process and deepening its better understanding could shed some light to overall nutrient cycling in human-modified systems.

3. Diversity in time and space: legacy effects of winter cover crop mixtures in crop rotation

Janna Barel, Thomas Kuyper, Jos Paul, Wietse de Boer, Jacob Douma, Hans Cornelissen, Gerlinde De Deyn
Wageningen University & Research

In agriculture, cover crops are a means of improving soil quality. Inclusion of winter cover crops in rotations increases and diversifies the input of organic matter, thereby promoting nutrient cycling and microbial activity. Apart from this diversity in time, diversity in space by mixing species of winter cover crops may provide additional benefits but this has rarely been tested. We grew winter cover crop (WCC) monocultures and mixtures in rotation with main crops oat (*Avena sativa*) and endive (*Cichorium endivia*), to test how plant diversity in space and time influences subsequent crop productivity. Furthermore, we studied how crop rotation influences WCC residue quality, local abiotic and biotic soil conditions, and WCC residue decomposition. We found that WCC biomass and nitrogen concentrations drive the productivity of subsequent crops, and that WCC productivity and decomposition in turn is affected by the previous main crop. Overall, we show that productive WCCs with low lignin content decompose fastest and stimulate organic matter turn-over via their knock-on effect on the soil microbial community. Moreover, WCC mixtures provide additional benefits depending on the species' complementarity. Thus, winter cover crop mixtures have promise for sustainable carbon- and nutrient-cycling management as well as promoting subsequent crop productivity.

4. From fast to slow: Microbial decomposition and stabilisation of organic matter

Joost Keuskamp, Mariet Hefting, Judith Sarneel, Simone Weidner
Utrecht University

Microbial decomposers convert labile organic matter to gaseous carbon dioxide (CO_2) and recalcitrant compounds that are retained in soil. These two processes ultimately determine the faith of freshly produced organic matter. Decomposition rate and carbon stabilisation are therefore both essential to understanding the effects of a changing environment an carbon partitioning between soil and atmosphere. We have compared decomposition rate and stabilisation under various environmental conditions representing elements of global change and soil management. We also explored the potential of manipulating the decomposing environment to sequester more, thus opening possibilities to mitigate climate change in managed ecosystems. Our study shows the importance of considering carbon stabilisation in litter decomposition experiments, while its role is much less pronounced in peat decomposition. The potential of measures to influence carbon stabilisation is large, but its translation to practical measures still far ahead.

5. Microbial biomass as a driver of litter decomposition at regional scales

Ciska Veen, Mark Bradford
Netherlands Institute of Ecology

Litter decomposition is a crucial part of carbon and nutrient cycling and has been studied intensively. It is well-established that across broad spatial scales climate (temperature and moisture) and litter chemical composition are key drivers of the rate of decomposition. We have however much less understanding on the role of micro-organisms in controlling litter decomposition across large spatial scales. Here we use a decomposition experiment in six grassland sites across a gradient spanning from the North of Sweden to the South of France with high within-site replication to test how variation in climate and microbial communities drives litter decomposition. We found that microbial biomass strongly regulates decomposition processes at local and regional scales. This is in contrast with the hierarchical model of litter decomposition, which assumes that climate and litter quality are dominant controls of litter breakdown across broad spatial scales. Our findings suggest that we need to revise the hierarchical model of litter decomposition and that we need to consider microbial communities in global biogeochemical models.

6. Plant traits and decomposition rates in the light of light

Hans Cornelissen, Xu Pan, Guofang Liu
Vrije Universiteit Amsterdam

Microbial decomposition, whether or not via animals, is still generally seen as the dominant driver of the breakdown of organic compounds and mass loss of litter. There is however increasing evidence that abiotic agents of litter decomposition can be very important in particular biomes. In open, sunny environments, e.g. in (semi)arid regions, photodegradation is an important contributor to decomposition. We studied whether, as is popular for microbial decomposition, interspecific variation in plant functional traits can help us to predict which species are subjected by photodegradation more than others. In the sunny north of China we found that, as for microbial decomposition, specific leaf area is a consistent positive predictor of litter mass loss through light exposure. The absolute and relative contributions of microbial decomposition versus photodegradation to litter turnover in different biomes and ecosystems, and their underpinning by leaf traits of different species, may be useful in global models of carbon dynamics.

1d: Plant Ecology

Conveners: Merel Soons (Utrecht University)
Nadia Soudzilovskaia (Leiden University)

1. Not only trees: Grasses fundamentally determine African tropical biome distribution via water limitation and fire

Mara Baudena, Donatella D'Onofrio, Jost von Hardenberg
Utrecht University

Although much tropical ecology generally focuses on trees, grasses are fundamental for characterizing the extensive tropical grassy biomes (TGBs) and, together with the tree functional types, for determining the contrasting functional patterns of TGBs and tropical forests (TFs). To study the determinants of African biome distribution and transitions, we performed the first continental analysis including grass and tree functional types, by combining remote-sensing cover data with a land cover map. In TGBs experiencing less than 630 mm annual rainfall, water limitation to grass growth was fundamental, acting alongside the well-known limitation to tree growth. Above this threshold, fires were especially relevant for TGBs: grass cover and fire recurrence were strongly and directly related. Some TGBs and TFs with annual rainfall above 1200 mm had the same rainfall seasonality, but displayed strongly different fire regimes, thus supporting the hypothesis of alternative stable states maintained by a vegetation–fire feedback. These ecological understandings were also used to evaluate the outcomes of two state-of-the–art DGVMs (Dynamic Global Vegetation Models). As they display high uncertainty in predicting the distribution of tropical biomes and the transitions between them, this analysis was performed to find out how ecological processes needed to be included or improved within the models.

2. Ancient human disturbances may be skewing our understanding of Amazonian ecology

Crystal McMichael, Frazer Bird, William Farfan-Rios, Kenneth Feeley
University of Amsterdam

Amazonia is repository of much of Earth's biodiversity and plays a major role in the global carbon budget. Estimates of tree biodiversity originate from fewer than 1,000 forest inventory plots, and estimates of carbon dynamics are derived from fewer than 200 recensus plots. It is well-documented that the pre-European inhabitants of Amazonia transformed and modified the forest in many regions before their population collapse around 1500 AD; however, the impacts of these ancient disturbances remain relatively unknown. We examine whether Amazonian forest inventory plot locations are spatially biased toward areas with high probability of ancient human impacts. Our analyses reveal that forest inventory plots, and especially forest recensus plots, are located disproportionately near areas containing ancient human impacts. Regions of the Amazon that are ecologically oversampled contain the highest values of predicted ancient human impacts. Given the long lifespan of Amazonian trees, forest inventory and recensus sites may still be recovering from past disturbances, potentially skewing our interpretations of forest dynamics and our understanding of how these forests are responding to global change. Empirical data at forest inventory sites are crucial for determining how past disturbances affect modern patterns of forest composition and carbon flux in Amazonian forests.

3. Species specific responses in leaf wax *n*-alkane composition from six tropical tree species

Milan L. Teunissen van Manen, William D. Gosling, Boris Jansen, Francisco C. Cuesta, Susana León-Yánez.
University of Amsterdam

The plant leaf wax composition is known to be determined by genetics and the environment the leaf was formed in. Understanding what the *n*-alkane fraction of the leaf wax represents is important to reconstruct past environmental change: *n*-alkanes are potential proxies to reconstruct vegetation or environmental change. However, there is debate whether average *n*-alkane patterns primarily reflect vegetation composition or environment. Although a big push has been made to understand average *n*-alkane environmental responses across plant communities, we find there is a lack of studies identifying the species specific responses over wide environmental gradients. We have studied the *n*-alkane composition from 6 tropical tree species sampled along the northwestern flank of the Ecuadorian Andes. The transect spans a wide precipitation gradient (2075-1250 mm/year) and temperature gradient (22-7 ^{o}C/year). We observed that the overall *n*-alkane signal from most of the species studied had a positive correlation with temperature and precipitation but that one taxa showed strong opposite responses. However, we also observed that the longer *n*-alkanes correlated positively with temperature and precipitation regardless of species. Our results suggest that the average *n*-alkane signal is strongly influenced by species specific responses and that the longer *n*-alkane fraction could be a reliable temperature proxy.

4. Long-term herbivore exclusion reveals small herbivores safeguard biodiversity in a back-barrier salt marsh via slowing down succession and decreasing dominance

Qingqing Chen, Ruth A. Howison, Han Olff and Christian Smit.
University of Groningen

The effects of small herbivores on plant diversity remain unclear so far, due to lack of long-term small herbivore exclosures. However, small herbivores are usually abundant or dominant in some grasslands, for instance, salt marshes. A long-term field experiment (22 years) involving small herbivore exclusion (hares and geese), at five locations (differed substantially in nitrogen accumulation and grazing pressure), along a successional gradient in a salt marsh system showed that small herbivores sustained plant diversity over time, especially at locations where grazing pressure was high. This is due to that grazing decreased temporal species turnover, and slowed down succession by suppressing the establishment and expansion of the light competitive, late succession plant species, especially where nitrogen accumulation was low. However, the effect of herbivore exclusion on suppression of late succession species only became apparent after 14 years. Meanwhile, grazing decreased dominance of plant community over time, which otherwise would decrease plant diversity. Our results suggested that small herbivores can have a big influence on plant diversity in salt marsh over time, and that these effects particularly become clear after long-term exclusion experiments. Conservation and management of grasslands should also take small herbivores into account.

5. Global distribution patterns of mycoheterotrophic plants

Sofia Gomes, Peter van Bodegom, Vincent Merckx, Nadia Soudzilovskaia
Leiden University

Mycoheterotrophy is a mode of life where plants cheat the mycorrhizal symbiosis, receiving carbon via their mycorrhizal partners. Despite being widespread, mycoheterotrophic plants are often locally rare, hampering the understanding of its global environmental drivers. Here, we explore the global environmental preferences of mycoheterotrophy as a whole, and of mycoheterotrophic plants associated with arbuscular (AM) and ectomycorrhizal (EM) fungi. We compiled a dataset of mycoheterotrophic plants' occurrences and examined which environmental factors, including soil type, climate, vegetation type and distribution patterns of host mycorrhizal plants relate to occurrence patterns of mycoheterotrophic plants associated with AM and EM fungi. Our results show that mycoheterotrophic plants avoid cold and highly seasonal climates and show a strong preference for forests. AM-associated mycoheterotrophs are predominantly found in broadleaved tropical evergreen forests whereas EM-associated mycoheterotrophs occur in temperate regions and mostly in broadleaved deciduous and evergreen needleleaved forests. Within each mycorrhizal type, major differences in environmental preferences occurred which were significantly associated with plant evolutionary relationships, indicating that these cheater plants have limited adaptive capabilities. Our results highlight the non-trivial nature of mycorrhizal interactions, and that the identity of the partners is not enough to understand the underlying mechanism that promote plant-mycorrhizal interactions.

6. The impacts of former plant abundance on the competitive interactions between two grassland plant species through plant-soil feedbacks

Wei Xue, T. Martijn Bezemer, Frank Berendse.
Netherlands Institute of Ecology

Negative plant-soil feedbacks are thought to promote species coexistence and decline with decreasing species abundance in the community, but most evidence is derived from theoretical models and experiments with soils conditioned by plant monocultures. We grew *Anthoxanthum odoratum* and *Centaurea jacea* in field plots in monocultures and in mixtures with three ratios (3:1, 2:2 and 1:3) for three years. We then tested the performance of *A. odoratum* and *C. jacea* in monocultures and 1:1 mixtures in a greenhouse experiment in live and sterile soils collected from the field plots. In the greenhouse experiment, *C. jacea* produced less aboveground biomass in "own" soil than in "foreign" soil, while *A. odoratum* did not do so. The negative feedback was greater in 1:1 mixtures than in monocultures for *A. odoratum* but did not differ for *C. jacea*. The competitive balance between the two species was negatively correlated to the former abundance of *A. odoratum* in the field in live but not in sterile soil and positively correlated to that of *C. jacea* in the field in both live and sterile soils. The former abundance of a species can negatively influence the performance of that species relative to its competitors, and interspecific competition tends to increase the impacts of negative plant-soil feedbacks. This phenomenon may contribute to the stable coexistence of plant populations under natural conditions.

1e: EXOTICS AND INVASIVES; Biotic interactions of exotic and invasive species

Conveners: Kadri Koorem (Netherlands Institute of Ecology; University of Tartu)
Kelly Ramirez (Netherlands Institute of Ecology)
Suzanne Lommen (Leiden University)

1. Alien interference with animal-mediated dispersal of native aquatic plants

Casper van Leeuwen
Netherlands Institute of Ecology

Many animals ingest, transport and defecate plant seeds. This is an important dispersal mechanism for many native plant species, but can also contribute to the spread of alien plant species. Because a single animal vector can disperse both native and alien plant species simultaneously, the introduction of alien plants into established species networks may affect animal-mediated dispersal of native plant species. I present a literature survey in which I address how alien plants can modify animal-mediated dispersal of native plant species in freshwater ecosystems. Key discussion points are (1) the proportion of animal-dispersed seeds that is of alien origin, and potentially replaced seeds of native plant species, (2) the relative attractiveness of alien *versus* native seeds to animal vectors, which could determine the level of alien interference, and (3) possible facilitation of animal-mediated dispersal of native plants by the arrival of alien plant species. The results of this study emphasize that management of alien species requires a thorough understanding of how alien species integrate into species networks.

2. Metabolomic profiling reveals shifts in chemical defences in the invasive plant Purple loosestrife

Jun Shi, Claudia Hener, Mark Stahl, Mirka Macel
University of Tuebingen / Radboud University Nijmegen

The Shifting Defense Hypothesis predicts that in the introduced range of exotic species, plants evolve increased defences against generalist herbivores and decreased defences against specialists that are mostly absent in the introduced range. Admixture in the introduced range can also affect plant growth and chemistry. We investigated effects of admixture and shifts in chemical defences between native and invasive Purple Loosestrife. Invasive populations had higher growth and higher resistance to a generalist herbivore but lower resistance to a specialist weevil. Untargeted metabolomic profiling revealed novel alkaloids in the invasive populations which were absent in the native populations. Flavonoids were more abundant in the native populations. The chemistry of the west coast USA populations, however, resembled the native European plants. Admixture increased chemical diversity and plant growth but had no effect on herbivore resistance. Our results revealed changes in defences of invasive Purple loosestrife that support the Shifting Defense Hypothesis.

3. Evolutionary change in invasive plants leading to changes in insect preference

Tiantian Lin, Klaas Vrieling, Diane Laplanche, Peter Klinkhamer, Yonggen Lou, Leon Bekooy, Ted Turlings, Gaylord Desurmont
Leiden University

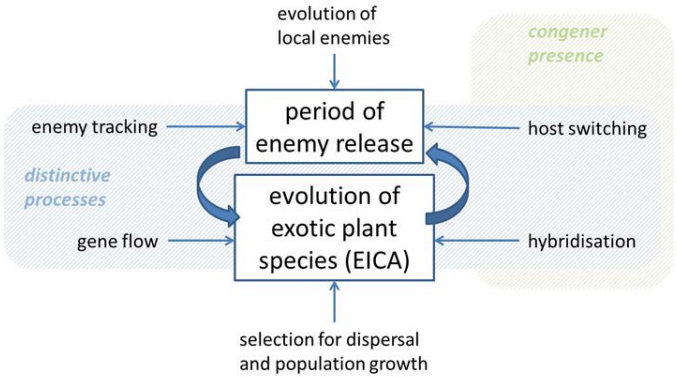
Many plants species have been introduced in exotic ranges leaving there specialist attackers home. When plants are freed of their specialist natural enemies allocation to functions related to defense and growth are quickly changed over time. Invasive ragworts grow faster, allocate 35% more to reproductive output, contain more (and different) alkaloids and invested less in regrowth compared to native ragworts. We investigated if the evolutionary changes in allocation patterns in invasive ragwort affected insect behavior and performance. We found that both specialist and generalist insects were affected in opposite ways that are correlated with the changed defence mechanisms.

4. The dynamics of invasiveness: Modelling the evolution of plant-herbivore interactions

Marleen Cobben, Arjen Biere, Jeff Harvey, Wim van der Putten, Thomas Hovestadt
University of Wuerzburg / Netherlands Institute of Ecology

What makes a terrestrial plant species become invasive? Thus far, there have been few answers to this question, but we do have many hypotheses. Among the most important ones are *enemy release* (ER hypothesis) and the *evolution of increased competitive ability* (EICA hypothesis). Here we use a simulation model to investigate what the implications are of these two hypotheses, increasing our mechanistic understanding of the dynamics of invasiveness. To study whether they can actually explain invasiveness, we make a systematic contrast between invasive species (expanding in a novel environment after a human-induced dispersal event), and range expanders (expanding their native areas e.g. under climate change). While both invaders and range expanders are under selection pressure for increased dispersal capacity and population growth, there are some important differences between them. Differences in enemy tracking and the possibilities of host switching affect *enemy release*, levels of gene

flow and opportunities for hybridization with closely related species affect the exotics' evolutionary potentials, and thus the *evolution of increased competitive ability*. Including these differences that are based on biotic interactions in the new environment should then explain the success of the invasive species, in contrast to range expanders, if these hypotheses are to hold.



5. Drivers of plant-soil interaction variation among closely related native and non-native plant species

Rutger Wilschut, Wim van der Putten, Paolina Garbeva, Paula Harkes, Wouter Konings, Purva Kulkarni, Henk Martens, Stefan Geisen
Netherlands Institute of Ecology / Wageningen University

The success of non-native plant species may for an important part be determined by the impacts of diverse belowground communities on the performance of individual plants. Plant-soil feedback studies show that non-natives are often less negatively affected by belowground communities. However, with most experimental set-ups potential effects of plant origin cannot be disentangled from the effects of phylogenetic distance between plant species. Here, we used eight native and range-expanding *Geranium* species to examine the effects of plant origin, phylogenetic relatedness and root traits on rhizosphere community composition and plant-soil feedback in the new range. We show that, unexpectedly, variation in rhizosphere community composition among these species is not determined by plant origin or phylogenetic distance. Instead, belowground community variation associated with the divergence of root chemistries and root system structure. In line with the rhizosphere community variation, plant-soil feedback was not phylogenetically determined. Surprisingly, plant-soil feedback on average was more negative in range-expanders than in natives. Interestingly, the negativity of plant-soil feedback correlated with root-feeding nematode abundance. Our results highlight variation in plant-soil interactions among closely related plant species independent of their origin or phylogenetic relatedness, thereby emphasizing the difficulty to predict plant-soil interactions of non-natives in their new range.

6. Return of the native facilitated by the invasive? Structure and development of a recently discovered shellfish reef in the Voordelta

Marjolijn Christianen, Wouter Lengkeek, Joost Bergsma, Jop Coolen, Karin Didderen, Martijn Dorenbosch, Floor Driessen, Pauline Kamermans, Emilie Reuchlin-Hugenholtz, Hein Sas, Aad Smaal, Karel van de Wijngaard, Tom van der Have
Bureau Waardenburg

Flat oyster reefs (*Ostrea edulis)* dominated large areas of the North Sea up to a century ago. Overharvesting, habitat disturbance and diseases pushed the native oyster to ecological extinction in the North Sea. A recent discovery of a shellfish reef with flat oysters in the Voordelta prompted a study of conditions for restoration of native oyster beds. Scuba divers surveyed shellfish reef structure and settlement substrate of flat oyster. We found that this reef was composed of native oysters (*O. edulis*), invasive alien Pacific oysters (*Magallana gigas*) and native blue mussels (*M. edulis)*. A relatively low density of living native oysters was observed, but large quantities of dead shells, mainly Pacific oysters, provided a substantial reef structure. Remarkably, our results showed that native oysters predominantly used shell fragments of the invasive oyster as settlement substrate, suggesting a facilitation of the return of the native oyster by shell fragments of the invasive oyster. Our results optimistically show that conditions for native oyster restoration can be favourable at a local scale in the coastal North Sea area and that the return of native oysters may be facilitated by substrate provided by invasive oysters at sites where their species distribution overlap.

Parallel Session 2

2a: Functional networks in ecology

Conveners: Emilia Hannula (Netherlands Institute of Ecology)
Elly Morriën (University of Amsterdam)

1. Fungal parasites of phytoplankton: networking with the enemy?

Alena Gsell, Sabine Hilt, Justyna Wolinska, Rita Adrian
Netherlands Institute of Ecology

Parasitism is the most common type of consumer lifestyle. Nevertheless food-web and network research so far rarely includes parasites explicitly, even though recent studies have shown that parasites can add substantial biomass, diversity, previously unrecognized trophic links and complexity to food-webs. This neglect may be in part due to scarcity in empirical data on the effects of parasites on host and non-host species in the community that would be needed to better understand the direct detrimental and indirect, potentially beneficial effects of parasites in food webs. Here we use the extant long-term collection of weekly samples of Lake Müggelsee (Germany, 1979-ongoing) to quantify the long-term dynamics of chytrid (fungal) infection of multiple pelagic phytoplankton species. We will use these infection time series to run multivariate autoregressive models to identify and quantify the direct and indirect interactions of chytrids with producers and consumers in the planktonic interaction-network of a well-studied eutrophic lake.

2. Model-based analysis of the potential of macroinvertebrates as indicators for microbial pathogens in rivers

Rubén Jerves-Cobo, Gonzalo Cordova-Vela, Xavier Iñiguez-Vela, Catalina Díaz-Granda, Wout Van Echelpoel, Felipe Cisneros, Ingmar Nopens, Peter L. M. Goethals
Ghent University

The quality of water prior to its use for drinking, farming or recreational purposes must comply standards to safeguard both society and the environment. In order to satisfy these standards, expensive analyses are required. Whereas macroinvertebrates have been used as ecological indicators to review the health of water bodies. In this research, the relation between microbial pathogens and macrobenthic invertebrate taxa has been studied in the Machangara River in the southern Andes of Ecuador. Decision tree models (DTMs) have been induced to generate rules that link the presence and abundance of some benthic families to microbial pathogen standards. The models built with the WEKA package, were evaluated based on both statistical and ecological criteria. As a result, three reliable models were obtained, which could be used as proxy indicators in a preliminary assessment of pollution of microbial pathogens in rivers. The DTMs can be applied by staff with minimal training in the identification of the taxa selected by the models. Although the presence of invertebrates might not be used as a guarantee for deciding to use the water as drinking water, the method could be used to detect suspicious conditions during field visits or as a basis for citizen-science projects.

3. Landscapes of Facilitation: long-range species interactions on intertidal flats

Isabelle van der Ouderaa, Rosyta Andriana, Johan van de Koppel, Britas D. H. K. Eriksson
University of Groningen

The past decade we have come to realise that positive species interactions are important biological drivers that structure many habitats. Recent research has highlighted indirect positive effects of facilitation between species – so called facilitation cascades - where a foundation species provides habitat for another foundation species, which in turn facilitates communities of associated organisms. These interactions can take place over both short- and long-range spatial scales, spanning from a few centimetres up to hundreds of meters. Here, I demonstrate that intertidal mussel beds instigate longrange facilitation cascades across the tidal flat by supplying substrate, refuge and stress relief; creating a unique (milder) habitat in their wake where benthic species settle. We show higher cockle densities and algae cover in the mussel bed's wake and increased biodiversity compared to areas without the mediating effects of a mussel bed. Also, decreased cockle growth rates were found coastward of the mussel bed, likely due to food limitation by the filter-feeding mussels. The necessity of taking longrange facilitative interactions between species into account is unquestionable when looking at habitat or ecosystem scales. Doing so will result in a better understanding of species' spatial distributions, which is essential in developing fitting management plans.

4. **Mechanisms behind biodiversity effects on ecosystem functioning in European forests**

Koenraad Van Meerbeek, Sophia Ratcliffe, Fons van der Plas, Juan Zuo, Michael Scherer-Lorenzen, Stephan Hättenschwiler, Lars Vesterdal, Karen Vancampenhout, Leena Finér, Kris Verheyen, Bart Muys

Aarhus University

The FundivEurope project was established to study the functional significance of tree diversity in in mature European forests. Therefore, a network of permanent forest plots was established in six regions, spanning much of the continent's bioclimatic gradient. The project found evidence for positive tree diversity effects on long-term stability of productivity and it has also been shown that tree diversity can improve the resistance of forests to pests and droughts. But whether the effects are driven by aboveground or belowground processes and through which mechanisms remains largely unknown. Moreover, it is known that the magnitude of effects and causal pathways might change along environmental gradients. The observed modulating effects of climate on the biodiversity-productivity relationship provided evidence of this stress-gradient hypothesis. Insight in ecological linkages between above- and belowground components is critical to understand the functioning of terrestrial ecosystems. Here we explored the mechanisms driving tree diversity effects on ecosystem functioning in European forests. To test whether the effect of tree diversity on ecosystem functioning is driven by above- or belowground processes, we modelled causal pathways using structural equation modelling. Ecosystem function-specific SEMs were fitted according to the hypothesized mechanisms driving the studied relationship.

5. **Satellite communities of heterotrophic bacteria growing with *Nitrobacter winogradskyi* in strictly inorganic, nitrite-fed continuous cultures**

Noriko A. Cassman, Anthony D. Barboza, Rosalinde M. Keijzer, Eiko E. Kuramae, H.J. Laanbroek

Netherlands Institute of Ecology

Nitrobacter winogradskyi is a chemolitho-autotrophic bacteria, which gains its energy for autotrophic growth on CO_2 from the oxidation of nitrite. Historically, nitrifying bacteria such as *Nitrobacter* have been difficult to culture axenically because of the persistent presence of heterotrophic bacteria. Here, we hypothesized that the metabolic characteristics of the heterotrophic microbial community growing with *Nitrobacter winogradskyi* are irrespective of the sample origin. We challenged *N. winogradskyi* with suspensions of heterotrophic bacteria from either a calcareous grassland soil (n = 5) or from sewage sludge (n = 4) of a municipal WWTP in inorganic, nitrite-fed continuous cultures. We tracked the bacterial communities in the continuous cultures over ten volume changes using 16S rDNA amplicon sequencing; this was complemented by isolation of strains and shotgun metagenomes at the tenth volume change. We found that the heterotroph communities were composed largely of bacterial phyla Proteobacteria and Bacteroidetes members; these differed by family level between volume changes and also by origin. From the shotgun metagenomes we could bin 16 draft genomes and from the isolates we found diverse strains also from other phyla (Acidobacteria, Actinobacteria, Cytophagia, Flavobacteria and Bacilli). These results shed more light on the metabolic networks of nitrifying communities.

6. **Exploring aspects of predictability in plant - herbivore interactions in Brassicaceae**

Daan Mertens, Erik H. Poelman

Wageningen University & Research

Upon attack by herbivores, plant defences are induced, which can facilitate or inhibit interactions with subsequent herbivores. These plant-mediated interactions have been proven to play a key role in structuring ecological communities and to affect plant fitness. We argue that predicting which interactions are more likely to occur would allow plants to optimise their defence in context of their full herbivore community. The predictability of interaction with a specific herbivore species increases when 1) the associated herbivore species pool is small 2) the community is not even, and 3) herbivore induced changes generate plant-mediated interaction linkages between herbivores through facilitation. To explore these aspects of predictability, we set up a common garden experiment in Wageningen, the Netherlands, involving 12 Brassicacious species. The insect community associated with individual plants was repeatedly monitored with observations spanning the full growth season of the plant. We show that closely related plant species differ in composition and size of their associated insect community. In addition, we show that there is a positive relation between herbivore species abundance and likelihood of interaction. We conclude that plant species differ in aspects of community predictability, with more unpredictable herbivore communities potentially driving selection for plasticity in plant defence traits.

2b: Ecology of movement and dispersal

Conveners: Allert Bijleveld (Royal Netherlands Institute for Sea Research)
Wouter Vansteelant (Novia University of Applied Sciences / University of Amsterdam)
Jelle Treep (Utrecht University)

1. Modelling the spatial dynamics of Maui dolphins using Agent Based Modelling

Monique de Jager, Geerten Hengeveld, Wolf Mooij, Liz Slooten
Wageningen University & Research

Unfortunately, anthropogenic impacts on nature are countless, enormous, and often absolute. Yet, some deleterious effects can still be overcome when man-made stressors are removed from the environment. Here, we focus on whether survival of a highly endangered dolphin species, the Maui dolphin, will be promoted by removing fishing activities from their habitat. The critically endangered Maui dolphin population is declining fast, most likely due to fishing activities. Further collapse may be avoided by regulating commercial fishery activities more strictly, yet current regulations do not explicitly consider particular dolphin movement behaviours. By building a tailor-made agent-based model, we provide a tool to examine how well regulations of commercial fishery activities reduce the impact of fishing on dolphin populations. We calibrate model parameters using the limited amount of field data that is available on Maui dolphins at various scales, ranging from movements of individual dolphins to the population distribution. The calibrated model will be used to evaluate a range of scenarios varying in the degree to which (commercial) fishing activities are regulated. The results and the unavoidable projection uncertainties will be communicated to inform political and societal discussions, such as the International Whaling Committee, the New Zealand government, and with local stakeholders.

2. Adaptations for dispersal in the invasive cane toad (*Rhinella marina*)

Cameron Hudson, Richard Shine, Gregory Brown
University of Sydney

Since their introduction to Australia in 1935, cane toads (*Rhinella marina*) have rapidly expanded their range to occupy 1.2 million km2. The invasion has caused massive ecological disturbances, and the rate of invasion increases annually. Invasion-front toads exhibit higher dispersal rates, directionality of movement, and morphological differences from long-established populations. These changes suggest that vanguard toads are adapting, and evolving high-dispersal phenotypes. Invasive species provide unique opportunities to study evolution, and in particular, how organisms adapt to novel environments. Following introduction, invading organisms are exposed to a host of selective pressures that can result in rapid evolution of novel phenotypes. By studying an introduction with precise historical records, wide geographic area, and a known origin, we are able to observe evolution through both space and time. To examine the evolution of dispersal phenotypes in *R. marina*, we compared skeletal morphology and locomotor performance from individuals across the invaded range, focusing on long-established and recently invaded areas. We conducted common-garden experiments comparing F1 individuals to their parents to determine phenotypic heritability. The observed differences in morphology and performance between populations have shown to be heritable, thus *R. marina* has undergone rapid phenotypic evolution in the 83 years since their introduction.

3. Home range and movement patterns of tropical Red-capped Lark are influenced by breeding and vegetation and not by rain or invertebrate

Joseph Mwangi, Raymond Klaassen, Muchane Muchai, Irene Tieleman
University of Groningen

Home-range studies have received considerable attention from ecologist but are greatly skewed towards the north temperate areas. Tropical areas offer ideal setting to tease apart multiple hypotheses of weather, food and social interactions as important factors influencing home-range. In this study we investigate home range and movement patterns of tropical Red-capped Lark, a year round breeding bird with a changing social structure whose general ecology is poorly studied by tracking and color reading rings during a 23 month period for the period August 2014 - June 2016. Our objective was to study year round variation home range and movement in their highly aseasonal and unpredictable weather and resource variation experienced in their equatorial habitats with the birds changing social structure and year round breeding. The spacing behavior and distribution within the habitat varied between months due to the social-spatial change between gregarious groupings outside breeding to pair formation during breeding. Red-capped Larks had a mean home range size of 48.58 ha but largely varied between individuals (range 2.12 -129.48 ha). Breeding and vegetation were the main factors explaining home range size while movement was influenced also by breeding and by ambient temperature. We also show for the first time the influence of breeding on non-breeders. Our study shows the importance of conducting more studies on the tropical areas. The result of this study suggests the influence of breeding

birds may have considerable effects on home range of non-breeding birds and variation of home range may act more strongly at the population level than at the individual level.

4. **Seasonal Survival and Migratory Connectivity of the partially migratory Eurasian Oystercatcher in the Netherlands**

Andrew Allen, Bruno Ens, Martijn van de Pol, Henk van de Jeugd, Magali Frauendorf, Henk-Jan van der Kolk, Kees Oosterbeek, Hans de Kroon, Eelke Jongejans
Radboud University Nijmegen

The Eurasian Oystercatcher (*Haematopus ostralegus*) has experienced a dramatic decline in recent decades. Multiple threats have been described, and given that these threats vary in space and time, there is an urgent need to estimate demographic rates at the appropriate spatio-temporal scale. We performed a multi-state live and dead recoveries analysis, using data from 4,500 colour-ringed oystercatchers with over 50,000 observations, to estimate seasonal survival and migratory connectivity. We assess varying model structures to account for data complexity, which included two seasons and five geographical areas within the Netherlands. Coastal breeding populations were largely sedentary, whilst inland breeding populations had diverging migratory patterns which have not been described previously. Survival varied among different regions of the Netherlands and also between seasons. A concerning result was that survival for over-wintering oystercatchers in the Wadden Sea, an internationally important site, appeared to decline during the study period. We discuss the implications of our results, and show how citizen scientists were vital for expanding the scale of this study. Our results are part of a larger project that aims to identify the cumulative human impacts on bird populations, and subsequently determine appropriate conservation actions to halt, and ultimately reverse the species' decline.

5. **Arctic geese tune migration to a warming climate but fail to evade a phenological mismatch**

Thomas Lameris, Henk van der Jeugd, Götz Eichhorn, Adriaan Dokter, Willem Bouten, Michiel Boom, Konstantin Litvin, Bruno Ens, Bart Nolet
Netherlands Institute of Ecology / University of Amsterdam

Climate warming challenges migratory organisms to advance timing of reproduction, but this appears strongly limited by arrival on the breeding grounds. An advancement of spring arrival could be achieved by accelerating migration speed and reducing stopover time. Most long-distance migrants are on a too tight time-schedule to do so, but this could be different for capital-breeding migrants which use stopovers not only to fuel migration but also to acquire endogenous body stores needed for reproduction. We connect long-term tracking and reproduction data to link the impacts of climate warming on migration timing and fitness in a long-distance migratory bird (barnacle goose *Branta leucopsis*). We show that barnacle geese accelerate their 3000 km spring migration to advance arrival on its rapidly warming Arctic breeding grounds. However, as egg laying has advanced much less than arrival, they still encounter a phenological mismatch that reduces offspring survival. After accelerated migration, geese shift from capital towards income breeding, using more local resources for reproduction. This suggests the need to refuel body stores locally after reducing stop-over time on migration. While flexibility in the use of body stores allows migrants to accelerate migration, this cannot solve the time constraint they are facing under climate warming.

6. **Odour-guided foraging of parasitoids in the field is less straightforward than assumed**

Ilka Vosteen, Yavanna Aartsma, Felix Bianchi, Erik Poelman
Wageningen University & Research

Parasitoid foraging has been intensively studied in laboratory set-ups, but less is known about parasitoid dispersal and host searching behaviour in natural environments. Herbivore-induced plant volatiles (HIPVs) which are emitted after an herbivore attack are important foraging cues for parasitoids. The ability of parasitoids to follow an odour plume upwind towards its source is likely influenced by weather conditions and foraging environment. In order to see if the parasitoid *Cotesia glomerata* follows HIPV-plumes in the field, groups of 50 females were released in circles of host-containing plants located on a meadow. If *C. glomerata* would follow a HIPV-plume from the release-point to a host-infested plant, we would expect to recapture most parasitoids on plants located upwind from the release point, because HIPVs would mainly travel downwind. Contrary to our expectations, dispersal in circles with a radius of 5 m was in most cases not related to the wind-direction. Upwind directed dispersal could only be observed when humidity was high and wind speed was low. Direct behavioral observation further revealed that upwind flight is often impeded by high wind speeds and that parasitoids may not respond to HIPVs if humidity is low. Our results show that upwind flights over several meters towards HIPV sources are less common than assumed and occur only under favorable weather conditions.

2c: AGRO-ECOLOGY: Ecological processes in agriculture for more sustainable farming

Conveners: Raymond Klaassen (University of Groningen)
David Kleijn (Wageningen University & Research)
Simone Weidner (Utrecht University)
Pilar Puentes-Tellez (Utrecht University)

1. Functionality and Conservation of diversity for sustainable agriculture

Simone Weidner , Raymond Klaassen
Utrecht University / University of Groningen

We are currently experiencing a biodiversity crisis in agriculture. Also from society there is a wish for a more sustainable farming system with a rich biodiversity. In order to make the necessary transition to more sustainable farming, we need to better understand the ecosystem services provided by a rich above and below-ground functional biodiversity. This introductory talk to the session aims to provide a short overview on functionality and conservation of diversity in agricultural systems. The presentations in this session will highlight recent findings regarding the use and conservation of biodiversity in agricultural landscapes.

2. Conserving biodiversity in agricultural landscapes: a win-win for farmer and wildlife?

Thijs Fijen, Jeroen Scheper, David Kleijn
Wageningen University & Research

Although agriculture depends critically on biodiversity-based ecosystem services such as insect pollination, conservation of biodiversity in agricultural landscapes has seen little uptake by the agricultural sector. We argue that this is largely because the relative importance of pollination compared to conventional agricultural inputs is unknown. Using the real-world variation in pollination and agricultural management of 36 commercial leek seed production fields, we show that the benefits of having more wild pollinators is just as large as the benefits of management enhancing plant quality. Although the bulk of the pollination services was delivered by a few abundant species, a diverse pollinator community replaced, or complemented these dominant species, depending on the crop variety. We furthermore show that crop yields are equally large, or even larger with 50% less agricultural inputs, and are consistently larger with more pollinators visits. The most-abundant insect pollinators in these landscapes were correlated with semi-natural habitats. However, they were largely absent in the landscape just prior to leek flowering, possibly because they are specialized in exploiting mass-flowering (crop) plants. Identifying where crop pollinators acquire their resources in agricultural landscapes throughout their flight period is essential for effectively conserving biodiversity in agricultural landscapes.

3. Clever Cover Cropping: Cover Crops Diversity and Productivity

Ali El-Hakeem, Lammert Bastiaans, Wopke van der Werf
Wageningen University & Research

Cover cropping is the cultivation of a green manure crop after a main crop in order to build soil organic matter (SOM) and capture residual nitrogen from the soil to prevent leaching losses. Cover crops are usually grown in pure stands. Studies in natural grasslands and intercrops have, however, shown that mixtures are often more productive and more resilient than single species and contribute more to soil ecosystem services. In a new project, named Clever Cover Cropping, we investigate whether these advantages also hold for mixtures of cover crops. As a first step, we compared the growth performance and productivity of 26 cover crop species, belonging to seven plant families. In addition, two- and three-way mixtures of *Raphanus sativus*, *Avena strigosa* and *Vicia sativa*, representatives of the plant families most commonly used as cover crops in the Netherlands, were grown and compared to their respective mono stands. These mixtures were tested in two spatial configurations; either mixed within the row or in an alternate row design. Furthermore, yield stability and resilience of mixtures were tested at four different locations. The initial results demonstrated clear differences for all factors: species selection, use of mixtures and spatial configuration showing that there are plenty of opportunities for optimizing cover crop production.

4. Effects of land use intensity on the proportion of specialist nematode taxa

Carmen Vazquez, Ron de Goede
Wageningen University & Research

Agricultural intensification has been shown to drive the decline in specialist species. Its effects on soil fauna are harder to assess because the soil is such a complex environment. We propose the use of co-occurrence matrices to calculate the realized niche of nematode taxa, from specialist (co-occurs with few) to generalist (co-occurs with many). We hypothesize that: 1) There is a spectrum of habitat niche

width in nematodes; 2) the proportion of specialist nematode taxa can be used as an indicator of human impact; and 3) Intensive human impact, leads to a decrease in the proportion of specialists. Contrary to our hypothesis, the proportion of specialists increased with increasing land use intensity being lowest in forests and highest in dairy farms. The proportion of specialist taxa present in a community was affected by local weather, season, and increased with mineral nitrogen and total carbon in the soil. Arable farms in sandy soils showed a significant increase in specialist taxa after 5 years. This difference was not observed in dairy farms, or in clay soils. The proportion of specialist species in the soil shows potential to become a flexible and unbiased indicator of the effects of nutrient enrichment in the soil environment.

5. **Beneficial microbe diversity enhances rhizosphere microbiome function and plant disease suppression**

Jie Hu, Zhong Wei, Ville-Petri Friman, Nico Eisenhauer, Yang-chun Xu, Alexandre Jousset
Utrecht University / Nanjing Agricultural University

The use of beneficial microbes has recently re-emerged as a promising alternative to agrochemicals for sustainable agriculture. It is still unclear how many and which species should we choose to construct effective beneficial microbe consortia. Here we present a general ecological framework for assembling effective beneficial microbe communities based on *in vitro* community characterization. Specifically, we show that increasing beneficial microbe consortia diversity enhances their survival in the rhizosphere and increases pathogen suppression via resource and interference competition with the pathogen. This study indicates that biodiversity-ecosystem functioning relationships can be used to develop highly functional synthetic communities to suppress plant diseases and replace agrochemicals. According to the theory of ecology and biology, conductive methods by using beneficial microbes could be carried out to promote plants health and agricultural productivity.

6. **Bio-organic fertilizer application induces soil disease suppressiveness against banana Fusarium wilt by reshaping soil microbiome**

Rong Li, Chengyuan Tao, Qirong Shen
Utrecht University / Nanjing Agricultural University

Banana production is severely hindered by Fusarium wilt disease globally. Application of bio-organic fertilizer (BIO) is becoming more popular in China since more and more farmers are recognizing the effect of BIO not only in promoting plant root growth but also in protecting banana plants from Fusarium wilt disease as well. However, the mechanisms underlying induced disease suppression by different parts of BIO are still unexplored. In our present study, we conducted a 4-season continuously performed greenhouse experiment to evaluate the disease-induction capability of different parts of BIO by amending sterilized BIO, sterilized BIO plus functional microbe, BIO, and organic fertilizer, and subsequently to decipher the mechanisms underlying soil disease suppression formation. Results from the relationship between microbial community structure, pathogen abundance and disease incidence showed that alterations in bacterial community structure and pathogen abundance after functional microbes enhanced fertilizers application were determined to be key factors in suppressing banana wilt disease. In particular, BIO and functional microbe application increased the abundance of indigenous *Pseudomonas* spp.. Of most exacting is *Pseudomonas* spp., isolated from rhizosphere soil were validated to control the disease. These results open our mind for the promotion of soil health.

2d: ECOSYSTEM RESILIENCE: causes and consequences of climate change

Conveners: Maggie Armstrong (Netherlands Institute of Ecology)
Tjisse van der Heide (Radboud University Nijmegen)
Tjeerd Bouma (Royal Netherlands Institute for Sea Research)

1. Sea level rise: causes & variability across scales

Aimée Slangen
Royal Netherlands Institute for Sea Research

Sea level change is one of the major consequences of climate change. It is projected to continue to affect coastal systems and communities around the world. Changes in sea level are the result of changes in different components of the climate system: the ocean, the land, the atmosphere and the cryosphere. Studying sea-level change and its consequences therefore requires a complete and integrative view of the climate system on a range of spatial and temporal scales. I will discuss the different processes that contribute to sea-level change on a range of temporal and spatial scales. An example of how sea level change influences salt marsh resilience will also be discussed.

2. Can mutualistic networks increase resilience of seagrasses to global change?

Matthijs van der Geest, Marianne Holmer, Tjisse van der Heide, Rutger de Wit
Université de Montpellier

Large-scale seagrass diebacks have been related to the accumulation of toxic sulfide in the sediment, which is predicted to increase due to global warming and eutrophication. Recently, it was discovered that an ancient facultative mutualism between seagrasses and sulfide-consuming lucinid bivalves, may mitigate the effects of increased sediment sulfide production. Yet, how the importance of this mutualism varies across environmental conditions, and how its role could change in light of global change is still largely unexplored. Here, we report on a field survey and a field experiment carried out during summer at two *Zostera noltei* meadows that differed in level of eutrophication, within a Mediterranean lagoon (Thau lagoon), where lucinid bivalves are widely abundant. The field survey revealed that sediment sulfide intrusion in seagrass leaves (i.e. a proxy for sulfide stress) increased over summer, and was more pronounced at the eutrophicated meadow. Experimentally enhanced organic loading induced sulfide intrusion, especially at the eutrophicated meadow, while experimentally increased lucinid bivalve densities partly counteracted this sulfide intrusion, but only at the non-eutrophicated meadow. Our results reveal environmental-context dependent strength of the sulfide detoxification mutualism, and suggests that management of local stressors of this mutualism may promote seagrass resilience to global change.

3. Bridging critical thresholds by temporarily facilitation of the blue mussel using biodegradable habitat structures

Ralph Temmink, Greg Fivash, Wouter Lengkeek, Karin Didderen, Tjeerd Bouma, Tjisse van der Heide
Radboud University

Worldwide, human populations along coastal zones are increasingly at risk from flood disasters due to climate-induced accelerated sea-level rise and increased storm intensity. Construction coastal habitat such as salt marshes, mangroves and shellfish reef is increasingly advanced as sustainable and self-maintaining flood defence solutions. However, (re)creation of these habitats is very challenging, because self-sustaining feedbacks generated by environmental modification by the habitat-structuring organisms only work beyond a certain minimum patch size and density. Below these thresholds, unpredictable losses can occur, while (re)establishment is hampered. Using soft-sediment intertidal blue mussel beds (*Mytilus edulis*) as a model system, we tested whether potato waste-derived biodegradable structures (BESE) can serve as temporary establishment substrate, allowing settling mussel larvae to bridge the establishment threshold. Our experimental results demonstrate that BESE strongly facilitated the settlement and subsequent development of young mussel recruits by (1) serving as a suitable attachment substrate, and (2) reducing predation by shrimp and crabs. More specifically, we found the complex 3D-structures to be most successful when they were combined with coconut-fibre rope, which enhanced settlement by 7 times. We conclude that the use of temporary establishment structures is a promising approach for the recovery of vital coastal ecosystems and their services.

4. **Assessing the resilience of insular species to past climatic change**

Kenneth Rijsdijk, Leon Claessens, Sietze Norder
University of Amsterdam

While on continents biota have many options to migrate in response to climatic change, options for insular terrestrial biota are limited they are locked on the island and must either adapt or become extinct. Insular species therefore represent an ideal natural lab species to assess biotic resilience to climatic change. We use islands combined with known past natural climate change events to assess biotic resilience. The dodo, *Raphus cucullatus*, a giant flightless pigeon of the volcanic island of Mauritius, became extinct nearly directly after humans colonized the island in the 17th century. The insular species had however successfully survived a century of anomalous extreme drought conditions 4000 years ago, moreover it had endured many more extreme climatic events. More gradual natural climatic change driven by Milankovitch cycles over millennia induced sea level changes, resulted in repeated drowning of land bridges and contractions of islands. We quantified the rates of environmental change in order to statistically assess the effects of magnitude and rates of environmental dynamics on insular species. We hypothesize that repetitive character of climatic change and climatic extremes train indigenous insular species, promoting their resilience to natural change, whereas human induced changes exceed, both in rates and magnitude, resilience thresholds and promote extinctions.

5. **Characterization of phytoliths in premontane western Amazonian forests**

Seringe Huisman, Crystal McMichael, Mark Bush
University of Amsterdam

Mid-elevation Andean ecosystems hold immense species richness and endemism, yet little is known about how they have changed in the past. The few existing paleoecological reconstructions have focused on pollen, which can travel 10s of kilometers from its source area. Here, we present data on charcoal and phytolith assemblages of premontane western Amazonian forests, based on two 1600-meter elevation lake sediment records spanning ~300 years. Phytoliths are silica-bodies produced by most Neotropical plants, which preserve in fossil records and represent local, instead of regional, vegetation change and human activity through time. The charcoal analysis indicated a fire free system, and no evidence of cultivation was found at either lake. Relative phytolith abundance and richness were shared between the lakes, and three previously unidentified phytolith types were described. The phytolith assemblages indicated large shifts in *Dictyocaryum* abundances, a palm genus that is sensitive to changes in moisture and cloud base position. Our data suggest that Andean phytolith assemblages, particularly those at sites dominated by *Dictyocaryum*, are sensitive to local-scale vegetation dynamics. These phytolith assemblages have the potential to indicate changes in cloud base position through time, which strongly influences the distributions of many plant and animal species.

6. **Climate change mitigation through adaptation: the effectiveness of forest diversification by novel tree planting regimes**

Anouschka Hof, Caren Dymond, David Mladenoff
Wageningen University & Research

Climate change is projected to have negative implications for forest ecosystems. Adaptation studies of forestry practices have focused on maintaining the provisioning of ecosystem services; however, those practices may have implications for climate change mitigation. Assessments of the effectiveness of adaptation strategies to mitigate climate change are therefore needed. Diversifying the forest by planting tree species more likely suited to a future climate is a potential adaptation strategy to increase resilience. The efficacy of this strategy to reduce the risks of climate change is uncertain and other ecosystem services provided by the forest are also likely to be affected. We used a spatially explicit forest landscape modelling framework to simulate the effects of planting a range of native tree species in colder areas than where they are currently planted in a managed temperate coniferous forest landscape in British Columbia, Canada. We investigated impacts on carbon pools, fluxes, tree species diversity and harvest levels under different climate scenarios and found that although the capacity of temperate coniferous forest landscapes to sequester carbon in the future is largely dependent on the future precipitation regime, negative effects may be counteracted to some extent by increasing resilience through tree species richness in forests.

2e: Ecology and Conservation

Conveners: Rascha Nuijten (Future For Nature Academy / Netherlands Institute of Ecology)
Ignas Heitkönig (Future For Nature Academy / Wageningen University & Research)

1. Integrity loss of migration networks induces population decline of migratory birds

Yanjie Xu, Yingying Wang, Yali Si, Yong Zhang, Herbert Prins, Fred de Boer
Wageningen University & Research

Migratory birds rely on a habitat network along their migration routes and seasonally occupy stopover sites between their breeding and wintering grounds. Removal or degradation of stopover sites from the network in response to environmental changes can impede the movements between habitat sites, and thereby negatively affect migration efficiency and success. However, due to their mobility, migratory birds might be able to cope with these impacts by either skipping the lost or degraded sites or altering their migration routes. Whether integrity loss of migration networks, as a consequence of habitat loss and degradation, has an impact on population sizes of migratory bird species remains however unknown. We therefore measured the integrity of migration networks of waterfowl species wintering in the Yangtze River Basin, and migrating over the East Asian-Australasian Flyway. We tested the relationship between changes in wintering population sizes and network integrity along with other spatial and life-history traits. We found that changes in network integrity is the only significant predictor, i.e., the larger the integrity loss, the larger the population decline. Hence, network integrity is an important species trait of migratory species, and a crucial predictor of population decline.

2. A genomics perspective on conservation

Mirte Bosse, Hendrik-Jan Megens, Ole Madsen, Martien Groenen
Wageningen University & Research

Numerous species worldwide are declining at an alarming pace, causing severe reductions in population sizes. Small populations enhance the risk of inbreeding depression, which negatively impacts individual fitness and population viability. To mitigate the effects of inbreeding, its underlying mechanisms need to be better understood. In addition, the integrity of species in zoos as well as the wild can be threatened by hybridization, but hybridization can also be a tool to counteract inbreeding depression. Recent advances in genome sequencing have opened exciting possibilities to better understand inbreeding from a genomic perspective. Moreover, genomic information can illuminate several other characteristics of a species' history that are relevant for conservation, such as past population size, selection and hybridization. I will discuss these techniques and how they can be of use for conservation, using some iconic examples from recent conservation genomics work.

3. Twenty years of stream restoration in The Netherlands: facts and figures

Paula Caroline dos Reis Oliveira, Judith Westveer, Piet Verdonschot
University of Amsterdam

To reconstruct the effectiveness of 20 years of stream restoration in The Netherlands, we analysed questionnaires, regularly answered by water authorities between 1993 and 2015. A large increase is visible in the number of realized restoration projects from 1993 until 2015. Water framework directive legislation typically motivated restoration projects, with the objections to enhance the habitat of certain species and the ecosystem as a whole. Over time, specific techniques related to water quality and hydro-morphological restoration shifted due to changes in legislation and climate. Until 2008 the questionnaires did not include themes related to ecological challenges such as the role of surrounding land use and dispersal capacity of aquatic organisms. What also surprised us was that the effects of restoration are not always monitored. Together with limited land availability and lacking cooperation with stakeholders, these issues were pointed out by the majority of the water authorities as main limitations to stream restoration success. Our results have pinpointed some potential improvements for future stream restoration. The answers provided by the water authorities suggest that specific applied research should be done and communicated to water managers in order to benefit ecological functioning and the field of stream restoration as a whole.

4. EU demand for wood pellets drives US biodiversity changes

Anna Duden, Matt Rubino, Nathan Tarr, PitaVerweij, Andre Faaij, Floor van der Hilst
Utrecht University

Increasing wood pellet exports from the United States (US) are expected lead to changes in land use and forest management. A projected shift from natural forests to pine plantations is projected to impact biodiversity. These impacts are expected to be spatially variable due to spatial variation in species richness, abiotic factors and land use dynamics. This study assesses the impact of an increasing wood pellet demand on biodiversity in the southeastern US in a spatially explicit manner, while taking into account potential developments in other wood markets and trends in other land uses. Urbanization and pine plantation establishment were identified as key drivers of projected species richness declines between 2010 and 2030 due to drivers other than increasing wood pellet demand. Coastal parts of Alabama, Mississippi and South Carolina were identified as potential hotspots for wood pellet demand driven biodiversity loss due to overlapping areas of species richness changes with species richness hotspots. Parts of coastal South Carolina were identified as locations of potential biodiversity gains. This study provides a first step to quantifying potential biodiversity impacts of wood pellet demand. This is vital to reaching the objectives of the European Renewable Energy Directive; to increase the renewable energy share while minimizing the biodiversity impacts of forest harvesting.

5. Using sensor technology and machine learning to understand animal behaviour

Jasper Eikelboom, Henjo de Knegt, Frank van Langevelde, Herbert Prins
Wageningen University & Research

Animals respond to factors that influence their survival chances, thus by analysing this response it should be possible to classify and/or quantify the cause of their response. Sensors like GPS receivers and accelerometers provide us with the necessary data on their response. Using machine learning techniques to analyse these sensor data offers us the perspective from an individual animal to their perceived environment. With these techniques we managed to accurately predict available food biomass over time by solely using sensor data of cows that were grazing there. This study shows the advantages of sensor technology and machine learning in conservation, where certain habitats can be assessed by sensor-equipped animals according to their needs. During the presentation I will discuss how we could use these techniques in general with the purpose of conservation.

6. The Arctic is melting and scientists are not doing enough

Maarten Loonen
University of Groningen

For more than 25 years, I have studied behaviour and ecology of Barnacle Geese in the Arctic. Goose populations boomed, but the Arctic deteriorated. Climate change became an actual reality as ice melted more and faster; it became the most important focus of all research around me. My research was recognized as relevant and funding was secure. Retreating glaciers, avalanches, landslides, melting permafrost, eroding coast lines, rain on snow, starving reindeer and polar bears, rising sea level and sinking buildings increase in frequency. The mechanism is clear, the cause is known. All visitors to the Arctic became witnesses of climate change. While positive steps have been taken, progress is too slow. It is frustrating to experience that the majority of politicians are not moving fast enough. The lobby of the fossil economy is strong while emissions continue. However, ordinary people have the power to facilitate and accelerate the battle against climate change. This made me from a scientist into an activist and every presentation about my research now ends with an appeal to my public to take a positive step in a reduction of fossil fuel emissions and a shift towards a circular economy.

Parallel Session 3

3a: ECOLOGICAL STOICHIOMETRY: Alterations through environmental change and impacts on organisms and ecosystems

Conveners: Harry Olde Venterink (Vrije Universiteit Brussel)
Vanessa Minden (University of Oldenburg)
Judith Sitters (Netherlands Institute of Ecology)

1. A stoichiometric perspective on plant-herbivore interactions in terrestrial ecosystems

Harry Olde Venterink, Judith Sitters
Vrije Universiteit Brussel

Large herbivores affect plant community composition through foliar consumption and other disturbance factors, and by altering nutrient availabilities via urine and dung excretion. How the latter influence varies among nutrients and herbivores species has only received little attention in literature, not even mentioning to which extent it may vary in space and time. We present such results from our studies in African savanna (Tanzania, Kenya and Zambia) and European ecosystems (The Netherlands, Belgium). We also present results from experiments showing how dung from different herbivores species influences plant growth and competition among plant species. We illustrate that herbivore dung should not be considered as a homogeneous fertilizer, but instead varies widely in C, N and P concentrations and stoichiometry among species and environments, and that this variation is large enough to have a significant impact on plant community composition and other ecosystem properties.

2. Towards an ecologically optimized N:P recovery from wastewater by microalgae

Tânia Fernandes, María Muñoz, Lukas Trebuch, Paul Verbraak, Dedmer van de Waal
Netherlands Institute of Ecology

Global stores of important resources such as phosphorus (P) are being rapidly depleted, while the excessive use of nutrients has led to the enrichment of surface waters worldwide. Ideally, nutrients would be recovered from wastewater, which will not only prevent eutrophication but also provide access to alternative nutrient stores. Current state-of-the-art wastewater treatment technologies are effective in removing these nutrients from wastewater, yet they can only recover P and often in an insufficient way. Microalgae, however, can effectively assimilate P and nitrogen (N), as well as other macro- and micronutrients, allowing these nutrients to be recovered into valuable products that can be used to close nutrient cycles (e.g. fertilizer, bioplastics, colour dyes, bulk chemicals). Here, we show that the green alga *Chlorella sorokiniana* is able to remove all inorganic N and P present in concentrated toilet wastewater (i.e. black water) with N:P ratios ranging between 15 and 26. However, the N and P uptake by the algae is imbalanced relative to the wastewater N:P stoichiometry, resulting in a rapid removal of P but relatively slower removal of N. Here, we discuss how ecological principles such as ecological stoichiometry and resource-ratio theory may help optimize N:P removal and allow for more effective recovery of N and P from black water.

3. Tree diversity does not increase litter and soil stoichiometric heterogeneity

Lionel Hertzog, Bram Sercu, Stefanie de Groote, Lander Baeten, Kris Verheyen
Ghent University

More diverse forests containing tree species with varying canopy structure and leaf chemistry are expected to increase litter and soil stochiometric heterogeneity. This increase in abiotic niche heterogeneity is assumed to benefit the diversity of understorey plant species. However, this positive effect of increased tree diversity on small scale heterogeneity has rarely been observed in studies. We investigated whether higher tree diversity leads to higher soil nutrient heterogeneity while taking into account the level of intermixing within a plot. We measured soil characteristics in a tree diversity platform at a landscape-scale, TREEWEB, consisting of a species pool of three regionally common tree species (*Quercus robur*, *Quercus rubra* and *Fagus sylvatica*). Plots form a diversity gradient from monocultures to three species mixtures with replications of all possible combinations. We modeled and compared the within - plot heterogeneity for nutrient content and stochiometric ratio of the litter layer, forest floor and topsoil between species combinations. Despite the presence of clear differences between monocultures in nutrient parameters, mixing tree species did not increase nutrient heterogeneity. We find in our study no support for increased niche heterogeneity in more diverse plots. Future studies should expand on these results by considering tree species with a wider range in litter quality.

4. **Direct and indirect effects of resource P-limitation differentially impact population growth, life history and body elemental composition of a zooplankton consumer**

Libin Zhou Kimberley D. Lemmen, Wei Zhang, Steven A. J. Declerck
Netherlands Institute of Ecology

In planktonic organisms, zooplankton growth rates are strongly determined by food phosphorus (P) content. However, P-limitation may also affect other quality-related aspects of algal food, such as biochemical composition or palatability. So far, the relative importance of direct and indirect effects of P-limitation on consumer performance is poorly understood. We studied population growth, detailed life history and body elemental composition of herbivorous rotifer, *Brachionus calyciflorus*, in response to: high P algae (C:P=112,'HP'), low P algae (C:P=631, 'LP') and LP algae spiked with P just before feeding (C:P=113, 'LP+P'), respectively. LP+P algae thus combined high P content with a growth history under P-limited conditions.Our results showed that the elemental ratios of rotifers in LP+P treatments were equal to those in HP treatments. However, rotifer population growth rate in LP+P treatment was in the intermediate and significantly differed from the other two treatments. Life history experiment further showed that different life history traits differentially responded to the direct and indirect effects of P limitation. Our study indicates that the elemental limitation cannot fully explain reduced performance of consumers in P-limited conditions, further highlights the importance of indirect effects in determining the population dynamics and demographic structure of consumers.

5. **Contrasting effects of rising CO2 on primary production and ecological stoichiometry at different nutrient levels**

Jolanda Verspagen, Dedmer van de Waal, Jef Huisman
University of Amsterdam

Although rising CO_2 concentrations are thought to promote the growth and alter the carbon : nutrient stoichiometry of primary producers, several studies have reported conflicting results. To reconcile these contrasting results, we tested the following hypotheses: rising CO_2 levels (1) will increase phytoplankton biomass more at high nutrient loads than at low nutrient loads, but (2) will increase their carbon : nutrient stoichiometry more at low than at high nutrient loads. We formulated a mathematical model to predict dynamic changes in phytoplankton population density, elemental stoichiometry and inorganic carbon chemistry in response to rising CO2. The model was tested in chemostat experiments with the freshwater cyanobacterium *Microcystis aeruginosa*. The model predictions and experimental results confirmed the hypotheses. Our findings provide a novel theoretical framework to understand and predict effects of rising CO_2 concentrations on primary producers and their nutritional quality as food for herbivores under different nutrient conditions.

6. **Nutrient stoichiometry as a driver of plant community composition and community responses to global change.**

Jerry van Dijk, Ineke Roeling, Wim Ozinga, Maarten Eppinga, Martin Wassen
Utrecht University

The negative effects of increased nutrient levels on plant diversity have been widely documented, but evidence suggests that nutrient stoichiometry may be equally important for structuring plant communities. If this is the case, it can be expected that plant species occupy specific niches along stoichiometric gradients, and that changes in the ratio of available nutrients in response to environmental change would lead to species turnover and possibly also species loss. We analyzed the community composition of 644 vegetation plots of Eurasian terrestrial wetlands, describing the occurrence of 598 plant species in relation to nutrient availability along an N:P gradient from 3 to 53. We show that N:P ratios explained a considerable part of the variation in species composition, independent of productivity or the absolute availability of individual nutrients. Species indeed occupied distinct niches along the N:P gradient. The width of that niche varied considerably among species, but was narrower at very high N:P ratios, suggesting a trade-off between adaptation to extreme P limitation and ecological amplitude. Our results point to the importance of nutrient stoichiometry for community assembly and suggest the need to incorporate a stoichiometric approach in conservation to complement the current focus on reducing the absolute amount of nutrients.

3b: MONITORING BIODIVERSTY CHANGE; Essential Biodiversity Variables (EBVs) and beyond

Conveners: W. Daniel Kissling (University of Amsterdam)
Rob H.G. Jongman (Wageningen University & Research / JongmanEcology)

1. Essential Biodiversity Variables: status and the way forward

Rob Jongman, W. Daniel Kissling
Wageningen University & Research / JongmanEcology

In 2011 the Biodiversity Observation Network of the Group on Earth Observation assessed the Aichi targets of the CBD for 2020. In this assessment, GEO BON included the notion of Essential Biodiversity Variables (EBV), comparable with the Essential Climate Variables (ECV). The EBV concept was introduced to structure biodiversity monitoring globally, and to harmonize the main biodiversity variables. Under the umbrella of GEO BON many scientists around the world have developed, discussed and published concepts on the different types and approaches of EBVs. Major groups are working on it now from the first Science article to the handbooks in 2016 and 2017. However, as with the ECVs it cannot be expected that development of EBVs is a simple and easy process. Agreement and application of EBVs requires that in situ and remote sensing observation systems are integrated and that global harmonisation of monitoring approaches and data systems are being agreed upon. The first steps have been set in published proposals for EBV systems, observation methodologies and global stratification. Now the process has to be continued with scientific cooperation in the terrestrial, freshwater, soil and marine realm, geographic harmonisation for continental and global approaches on ecosystem recognition and political agreement between states to connect and harmonise regional and national data systems. Observation technology is in the process of adapting to the needs of ecological monitoring and there is willingness in the Earth Observation community to cooperate.

2. Standardising global butterfly monitoring

Chris A.M. van Swaay
Dutch Butterfly Conservation / Butterfly Conservation Europe

Population abundance of species is one of the Essential Biodiversity Variables (EBVs) proposed by GEO BON as a minimum set of essential measurements to capture major dimensions of biodiversity change. However, compared to vertebrates only few insects are monitored at a larger scale than local or national. Butterflies are the main exception, with monitoring programs being active since the 1970s, especially in temperate climates. In this talk, I will provide an overview of European efforts to combine butterfly monitoring data for deriving a continental European Grassland Butterfly Indicator. This is currently based on collating national butterfly monitoring data from 22 European countries doing butterfly monitoring. Whereas such butterfly monitoring schemes allow to generate trends in population size, the use of opportunistic data such as those gathered by citizen science and online portals (observado.org and iNaturalist.org) as well as GBIF offers complementary possibilities to produce distribution trends. Although distribution trends react slower to declines than population trends, they have the advantage of being available over larger areas. I will present the first distribution trends for butterflies in Europe and compare them with population trends derived from monitoring schemes.

3. Monitoring change in freshwater ecosystems and biodiversity

Jeanne Nel, Eren Turak, Aaike De Wever
Vrije Universiteit Amsterdam

Global biodiversity is declining, and freshwater systems may be more affected than terrestrial or marine systems. However, the data, tools, methods and governance mechanisms currently available are inadequate to reliably quantify this decline. Recent advances in freshwater monitoring make a global assessment now close to becoming feasible. The Freshwater Biodiversity Observation Network (FWBON) has recently been launched within GEO BON, with the aim to build a network of people and institutions that have the capacity to monitor the state of freshwater biodiversity in a way that improves the observation, reporting and protection of freshwater biodiversity. This presentation will report on some of the activities that are currently underway by FW BON, and how people can get involved. It will also consider a recent review by FW BON members, which shows promise in meeting measurements for three classes of Essential Biodiversity Variables (EBV) by 2020 (species populations, community composition, and ecosystem structure). This requires developing a globally systematic approach to collecting and assessing species data, collating existing and new data within global platforms, coordinating effort towards mapping wetland extent at high spatial resolution, linking in-situ data to modelling across regions, and mobilising citizen science for the collection and verification of data.

4. **Use of remote sensing enabled Essential Biodiversity Variables and in-situ data for habitat monitoring**

Sander Mücher, Stephan Hennekens, Henk Kramer, Wouter Meijninger, Andrew Skidmore, Elnaz Neinavaz, Peter Verweij
Wageningen University & Research

Essential Biodiversity Variables (EBVs) such as species traits, species populations, ecosystem functions as well as ecosystem structure – are being implemented by ecologists to identify global monitoring priorities. However, the biodiversity community still struggles to obtain sufficient field observations of EBVs worldwide. Hence, there is an urgent need for remote sensing (RS) enabled EBVs to fill the spatial and temporal gaps in in-situ observations. Here, we will demonstrate the use of RS-enabled EBVs, e.g. vegetation height, phenology, cover for habitat mapping and monitoring at different scales in order to support local nature organisations as well as international organisations like the European Environment Agency (EEA) and its Topic Centre for Biological Diversity (ETC-BD). EEA and ETC-BD have special responsibilities with regard to European habitats, e.g. reporting obligations towards to the Birds and Habitat Directives. Therefore, much effort is nowadays being put in the spatial identification of European habitats. Integration of RS-enabled EBVs with in-situ field observations is key, and scale-dependent. Cloud computing will make is easier to work on large regions.

5. **Using airborne laser scanning for monitoring ecosystem structure**

Zsófia Koma, Arie C. Seijmonsbergen, Willem Bouten, W. Daniel Kissling
University of Amsterdam

Airborne Laser Scanning (ALS) — a form of Light Detection and Ranging (LiDAR) — provides high precision point clouds which allow to quantify 3D ecosystem structure. Such remote sensing measurements facilitate the monitoring of Essential Biodiversity Variables (EBVs) related to habitat structure (EBV class ‘Ecosystem Structure’). However, using such massive amounts of point clouds from different ALS measurements across broad spatial extents and multiple time periods is challenging. We test the robustness of commonly used LiDAR metrics based on national-wide, open-access and multi-temporal ALS data for selected study areas within the Netherlands. We calculate geometrical properties of the ALS data based on a) total vegetation volume (e.g. variance of vegetation height), b) specific vegetation layers (e.g. canopy height, understory density), and c) multiple vegetation layers (e.g. foliage height diversity) and then explore the relationship between LiDAR metrics and field data. We use the Dutch Vegetation Database as a standardized field data set because it provides open-access data on vegetation sampling events from various habitats across the Netherlands. Our study shows which LiDAR metrics can be successfully applied to ALS measurements with different characteristics (e.g. point densities). This is a crucial aspect for establishing ALS-based LiDAR metrics for monitoring ecosystem structure across time.

6. **Going beyond essential biodiversity variables – Essential Geodiversity Variables (EGVs)**

Franziska Schrodt
University of Nottingham

Essential biodiversity variables (EBVs) and their predecessors, essential climate and ocean variables (ECVs and EOVs, respectively), have proven to be extremely useful tools in capturing complex environmental characteristics and processes for the advancement of scientific research, sustainable stewardship and policy. Yet, the existing essential variables framework almost completely ignores geodiversity - the wealth of abiotic features and processes of the land (sub-) surface – despite of their immense importance for ecosystem functioning, human well-being and natural resource management. I will present the essential geodiversity variable (EGV) approach which is aimed at complementing existing essential variables by providing a framework for definitions of relevant measurements capturing key elements of geodiversity from which scientists and policy makers can draw. I will present the newly launched EGV webpage, discuss the current state of EGVs, show means of integrating the EGV approach with other essential variables and describe ways of contributing to the further development of this essential variable concept.

3c: Eco-Evolutionary Ecology: Understanding Eco-Evolutionary Dynamics with Experimental Evolution

Conveners: Daniel Rozen (Leiden University)
Karen Bisschop (University of Groningen)
Cyrus Mallon (University of Groningen)

1. Ecosystem engineering and evolution

Arend Raoul Van Oosten, Matty Berg, Jacintha Ellers
Vrije Universiteit Amsterdam

Ecosystem engineers modify their physical, abiotic environment, thereby facilitating other species. For instance, beavers constructing dams facilitate the occurrence of all kinds of fish and aquatic plants. In many cases the modifications also have profound effects for the engineer itself, and may, in fact, have been selected for precisely for that reason. If modifications made by ecosystem engineers alter selection pressure on the engineers themselves, they are extended phenotypes (for instance, beavers experience lower predation pressure in the lake they created). Hence, organisms may produce their own selective environment (also known as niche construction theory).Not much is known about the evolutionary component of ecosystem engineering. In this talk, I address what connects ecosystem engineering and eco-evolutionary dynamics, what studies have been conducted in this regard, and what should be done to further integrate ecology and evolution. I will highlight my own study system, where I use the ecosystem engineering amphipod *Orchestia gammarellus* to study how adaptation to environmental stress may alter the organisms' ability to engineer, which can affect the entire system.

2. Rapid bacterial evolution can lead to cryptic eco-evolutionary dynamics in the plant rhizosphere

Ergin Li, Chen Liu, Ronnie de Jonge, Peter Bakker, Ville Friman, Corné Pieterse, Alexandre Jousset
Utrecht University

Bacteria play pivotal role for the health of higher level organisms via mutualistic interactions. Even though these interactions are widespread it is less clear how and at what time-scale they evolve. We explored this experimentally by evolving *Pseudomonas protegens* bacterium in the rhizosphere of *Arabidopsis thaliana* for six plant generations (6 months). We found that Initially antagonistic interaction turned into mutualistic via rapid phenotypic and genotypic diversification. In four out of five selection lines, we observed increase in the proportion of mutualistic bacteria that showed plant growth promotion and improved ability to consume plant derived nutrients. In one of the selection lines, we observed alternative evolutionary trajectory where bacteria evolved selfish stress-response strategy, which improved its colonization ability (biofilm formation) without any beneficial effects on the plant growth. Interestingly, despite increasing degree of mutualism observed at individual genotype level, no clear plants growth promotion were observed during the selection experiment. This suggests rapid evolution can lead to cryptic eco-evolutionary dynamics where ecological interactions between evolved bacterial genotypes mask their individual effects on plants growth. Together these results indicate that mutualism can evolve very rapidly in plant rhizosphere and is thus likely to play an important role in agricultural environments.

3. Microevolutionary response to selection for fast growth is partially mediated by phosphorus availability

Kimberley Lemmen and Steven Declerck
Netherlands Institute of Ecology

Rapid growth is beneficial in low-competition, resource-rich environments. However, the maintenance of high growth rates requires increased RNA production which increases demand for phosphorus (P). We tested if populations cultured in an r-selection environment displayed elevated growth rates within an ecologically relevant timeframe and if increases in growth rate were dependent on resource P-availability. Thirty clones of the micro-zooplankton *Brachionus calyciflorus* were used to seed ten replicate populations which were cultured in a r-selection environment and provided either high (HP) or low (LP) phosphorus food for 35 days. We subsequently performed a fully crossed common-garden experiment with the evolved populations as well as ten of the initial seed clones. Growth rates of populations varied greatly indicating a large effect of demographic stochasticity. Nevertheless, in the majority of cases growth rates of evolved populations were significantly larger than for non-evolved, initial populations. We observed a positive correlation between growth rates of seed clones under LP and HP conditions. Despite this apparent lack of a trade-off, we observed a significant but weak trend towards local adaptation of populations but only under LP conditions. Hence, microevolutionary responses to selection for fast growth seem to be partially mediated by phosphorus availability.

4. Evolution experiment with natural undefined starters containing lactic acid bacteria

Anneloes Groenenboom, Eddy Smid and Sijmen Schoustra
Wageningen University & Research

Evolving ecosystems are often studied using highly simplified or synthetic microbial communities, as they have only a limited number of species. Prevailing processes are described in terms of co-evolution, adaptive radiation and the niche exclusion principle. We executed community evolution experiments using natural microbial communities of a Zambian spontaneous fermented milk product called Mabisi. The microbial communities of this fermented product form an interesting model system for evolution experiments as they have limited yet sufficient species variation, a clear function and potentially give insight into how communities of microbes evolve. We started the evolution experiment with six different natural Mabisi communities containing lactic acid bacteria. As these communities had a different origin, the composition and richness was slightly different, but they share the same core players, being *Lactobacillus* sp. strains. By transferring replicates of these communities in the same environment we can study whether the evolution of these communities shows a divergent or convergent path. At regular intervals during more the than 100 generations of propagation, we obtained aroma metabolite profiles and DNA sequencing data on the genes encoding the 16S RNA region, showing the compositional as well as the metabolic changes in the communities. We found that community composition based on DNA sequencing were influenced by origin of the community, adaptation to the new environment and chance. Aroma metabolite profiles seemed to be mainly influenced by adaptation and less by origin and chance. Assuming that a trait more influenced by adaptation is stronger linked to fitness, would indicate that not community composition but metabolite profile is most important for overall community fitness. Besides giving fundamental insight on microbial community dynamics, the outcomes of this research will help understanding multiple-strain fermentations and how to manipulate these processes to obtain high quality products.

5. Untangling symbiotic networks

Victor Caldas, Anouk van 't Padje, Edgar Correa de Amorim Filho, Tom Shimizu, Toby Kiers
Vrije Universiteit Amsterdam

Arbuscular Mycorrhizal (AM) fungal hyphae form extensive underground webs, foraging for nutrients and connecting roots of different plant species. These adaptive networks are critical for the movement of nutrients around ecosystems. However, to image and quantitatively characterize fungal networks is a challenge. The topological and transport dynamics occur many orders of magnitude apart in space and time. While transport inside the 10-micrometre wide hyphae takes place on the millisecond timescale, network topology changes in hours or days and spans distances of meters. By combining biophysics and ecology, our group is developing modern imaging and analysis tools with high spatial resolution to visualize how symbiotic fungi build their networks. We are using new imaging techniques to track the trade of nutrients, such as phosphate, that we tag multi-colored quantum dots. This allows us to follow how fungi transport and trade nutrients with plants with unprecedented time resolution. Our images quantitatively link transport processes and topology by visualizing how biotic and abiotic factors impact mycorrhizal physiology. Ultimately, our aim is to understand how the fungal network structure reflects conflict and cooperation in AMF-plant symbiosis, and use our new techniques to test how trade strategies change over multiple generations as conditions for host and fungus change.

6. Host genotype shapes the assembly of both the gut microbiota and the surrounding bacterioplankton in the freshwater crustacean *Daphnia magna*

Emilie Macke, Martijn Callens, Francois Massol, Luc De Meester & Ellen Decaestecker
KU Leuven

The gut microbiota mediates important aspects of its host's biology, as well as tolerance to diverse environmental stressors. A key challenge is deciphering the factors dictating the assembly of this community, and establishing the relative contribution of evolutionary and ecological processes to the intraspecies variation frequently observed in the gut microbiota structure. In addition, because gut symbionts are mainly acquired from the surrounding environment, it is crucial to understand the interplay between host, gut microbiota and environmental microbial communities. This question is particularly relevant for aquatic organisms and bacterioplankton, which are in close and continuous contact, and are thus expected to have a strong reciprocal influence. Combining metagenetics with microbiota transplants, we here show that in the freshwater crustacean *Daphnia magna*, host genotype and diet interact to shape the structure of both the gut microbiota and the surrounding bacterioplankton. When different *Daphnia* genotypes were exposed to identical microbial communities, both the gut microbiota and the bacterioplankton diverged to reached a genotype- and diet- dependent taxonomic composition. The exposure of germ-free *Daphnia* to different microbial inocula also revealed an effect of the external microbial source on the gut microbiota structure. Overall, the taxonomic composition of the gut microbiota was however very different from that of the bacterioplankton, and was characterized by a lower alpha diversity, suggesting a selective, genotype-dependent, recruitment of gut symbionts in this species. Together, our results indicate strong reciprocal interactions between *Daphnia*, their gut

microbiota and the bacterioplankton. Importantly, we here provide evidence that *Daphnia* mediate the assembly of their associated microbial communities, both within their gut and in their close environment, depending on their genetic background. This result clearly demonstrates the impact of evolution (i.e. genetics) on ecological processes (i.e. community assembly) and, by illustrating an evo-to-eco link, provides strong support to eco-evolutionary dynamics theory. In addition, by revealing an impact of the external microbial source on the *Daphnia* gut microbiota structure, our results suggest a feedback loop where environmental microbial communities affect the phenotype of *Daphnia*, and thus likely their fitness (i.e. eco-to-evo link).

3d: MICROBIAL ECOLOGY; Community composition and dynamics

Conveners: Leo Lahti (University of Turku, Finland)
Karoline Faust (KU Leuven, Belgium)
Didier Gonze (Université Libre de Bruxelles)

1. Multi-stability and the origin of microbial community types

Didier Gonze
Université Libre de Bruxelles

The analysis of host-associated microbial community composition revealed the presence of alternative community types. Possible mechanisms to explain these observations rely on environmental changes or on exchange with members of metacommunities. Another way to explain the emergence of different community types is through multi-stability. We illustrate with a toy model how multi-stability can derive from microbial community networks and discuss the consequences of multi-stability for data interpretation.

2. Microbial community dynamics and oxic-anoxic regime shifts in a seasonally stratified lake

Gerard Muijzer, Tim Bush, Muhe Diao, and Jef Huisman
University of Amsterdam

Regime shifts are abrupt and persistent changes in the structure and function of ecosystems triggered by gradual changes in environmental conditions. Although regime shifts are known for various ecosystems, the involvement of microbial communities is poorly understood. Here we show the influence of microbial communities on oxic-anoxic regime shifts in a seasonally stratified lake. For this we first developed a mathematical model describing the interactions between microbial communities and the dissolved oxygen concentration. In response to gradual changes in oxygen influx, the model abruptly changed from an oxic state dominated by cyanobacteria to an anoxic state with sulfate reducing bacteria and phototrophic sulfur bacteria. The model predictions were consistent with observations from the lake, which showed hysteresis in the transition between oxic and anoxic states with similar changes in microbial community composition. Our results are important, because they not only contribute to a better understanding of the mechanism of oxic-anoxic regime shifts in lakes and coastal waters, but also provide a warning that increasing eutrophication and global warming may put these ecosystems beyond a critical tipping point, causing rapid transitions from oxic to anoxic conditions that are not easily reversed with detrimental consequences for aquatic organisms.

3. Population dynamics and density dependence

Katri Korpela
University of Helsinki / European Molecular Biology Laboratory

All natural populations, including microbial ones, are influenced by abiotic forces and involved in interactions with other populations. These forces, in addition to population-intrinsic effects, drive the population dynamics, the temporal fluctuations in population size. The magnitude of these forces can be estimated by calculating the density dependence of population growth rate: the effect of population sizes measured at earlier time points on current population growth rate. Estimating density dependence has significant practical value: Due to the fluctuations in population size, observations taken at a single time point are not well suited for the reliable identification of factors regulating the population. The population dynamics of a species, which depends on interspecific interactions, determines the maximum strength of the correlation that can theoretically be observed between the population and an external variable of interest, regardless of the biological impact of that variable. This means that the observed associations between microbial populations and environmental factors, such as host health in host-microbe studies, are very likely underestimated if the effect of population dynamics is not considered.

4. Modelling the dynamics of a synthetic gut community

Karoline Faust
KU Leuven

Due to its high complexity and the impact of the human host, it is very hard to obtain a mechanistic understanding of the gut microbial community from sequencing data alone. Synthetic communities are an excellent tool to complement in vivo studies. Their dynamics can be accurately monitored while exerting a degree of control that is impossible to attain in vivo. Here, I present an in vitro study on a small-scale microbial community consisting of three human gut bacteria. We monitored the abundance of each community member growing in isolation and in co-culture and developed a mathematical model to describe their dynamics. Our model captures well community behaviour, but fails to predict co-culture dynamics from mono-cultures, pointing to emergent behaviour in the presence of interaction partners.

5. Biological insights from microbial networks

Lisa Röttjers
KU Leuven

Studies of human, plant and other microbiomes have revealed correlations to healthy and diseased states of the host. Such studies rarely explain mechanisms governing microbial communities, and experimental verification of these mechanisms remains a challenge. Here, I discuss the use of microbial association networks in microbiome studies. These networks can integrate multiple types of information and may be able to represent systems-level behaviour. However, interpreting associations correctly is not straightforward, and I address approaches to tackle this problem. Additionally, analysis of microbial networks allows researchers to identify hub species and quantify multiple network properties. While these analytical methods are increasingly popular, their applicability to microbiome data has not yet been evaluated. I explain concepts from network theory and ecology and review prior work using these concepts. Finally, I use simulations to investigate network properties. These simulations show how network properties are affected by tool choice, environmental factors and preprocessing steps. For example, hub species are not consistent across tools, and removing low-abundance species affects microbial network inference tools differently. These results highlight the need for robust microbial network inference and provide microbiologists with information on how to infer reliable networks.

6. Contemporary challenges in population-level studies of the human microbiome

Leo Lahti
VIB/KU Leuven / University of Turku

This talk summarizes the session and provides an overview of the contemporary modelling challenges in population-level studies of the human gut microbiome.

Parallel Session 4

4a: ECOSYSTEM SERVICES; from volatiles to landscapes

Conveners: Erik Poelman (Wageningen University & Research)
Daan Mertens (Wageningen University & Research)
Matti Pisman (Ghent University)

1. The importance of different biodiversity measures to describe pollinator diversity within an agricultural landscape

Matti Pisman, Guy Smagghe, Ivan Meeus
Ghent University

Wild pollinators provide pollination services for a multitude of agricultural crops. Several factors, including landscape composition and configuration at multiple spatial scales, can influence the diversity of pollinators at the field level. To assess the impact of pollinator diversity for crops at the field level, alfa diversity can be a sufficient measure of biodiversity. However, when aiming to understand how field biodiversity can be improved, the total landscape biodiversity (gamma) is an essential factor to take into account. We examined how pollinator biodiversity measures can differ within a landscape and explore potential implications for pollinator management in an agricultural landscape.

2. Caught between friends and foes: Effects of herbivore-induced plant responses on flower visitors

Quint Rusman, Dani Lucas-Barbosa, and Erik H. Poelman
Wageningen University & Research

To optimize reproductive output, plants need to maintain interactions with mutualists, such as pollinators, and at the same time deal with antagonists, such as herbivores. Although many plant species have inducible defences to save metabolic costs of defence in absence of herbivores, plant responses induced by herbivore attack can have ecological costs. For example, herbivore-induced responses can affect flower traits and alter interactions with flower visitors, with potential plant fitness consequences. The current knowledge on plant-mediated herbivore-flower visitor interactions and its consequences for plant fitness is limited. In a common-garden experiment we found that herbivore induction by 10 different herbivores result in changes in pollinator communities composition of the annual *Brassica nigra*. In addition, belowground herbivore-infested plants overcompensated in seed set and set more seed compared with uninfested or aboveground herbivore-infested plants. In the greenhouse, we found that herbivory resulted in species-specific changes in the pollinator behaviour of two pollinators. To explain our results, we investigated which flower traits are changed upon herbivory. We found species-specific changes in the volatile emission, flower colour, and flower rewards (nectar and pollen) of flowering *B. nigra* plants. Thus, we show that plant-mediated interactions between herbivores and flower visitor are common, show specificity for the herbivore and pollinator, potential underlying mechanisms, and consequences for plant reproduction and natural selection.

3. Central flowers provide hotspot for multi-host pollinator pathogen transmission

Niels Piot, Guy Smagghe, Ivan Meeus
Ghent University

Pathogens and parasites are important actors within ecosystems. Yet to understand disease prevalence and spread, understanding transmission is a key aspect. The Apidae pollinator community harbours several multi-host pathogens, which have been shown to be able to spread between species via flowers. Yet no studies have shown this transmission mechanism in the field. With the use of a local plant-pollinator network we show that in field transmission via flowers is possible. Moreover we show that the centrality of a plant in a weighted plant-pollinator network is a good predictor for the presence of multi-host pollinator pathogens on the flower. Further we investigate which routes could lead towards contamination of the flowers and evaluate their potential based on the prerequisite that the amount of infective particles present is high enough to infect naïve hosts.

4. Redefining the field: Large scale stripcropping experiments show benefits for farmers, consumers and nature.

Dirk van Apeldoorn, Walter Rossing, Wijnand Sukkel
Wageningen University & Research

In the past decades the agricultural landscape has become more monotonous. Large scale monocultures provide economies of scale but also abundant host for pests and diseases. Since 2014, The Farming Systems Ecology group and Wageningen Plant Research (Lelystad) have been running large scale field-experiments that maintain efficiency, but increase diversity at the field scale by stripcropping.

Stripcropping is the practice of growing at least two species in alternate strips, allowing independent cultivation. This practice has the advantage that it can be implemented with current machinery and remains close to the expertise already present at the farm. By iterating for example mow crops with root and tuber crops, beneficial ground dwelling insects are offered shelter in the neighbouring strip when crops are harvested, subsequently the stubble of the mow crops can be used as traffic lanes when harvesting the root and tuber crops with much less soil damage as would occur on the loosened soil after harvest. Similarly changes of micro climate, increased pest control, reduced disease spread and improved soil quality provide benefits to the farmer. The landscape value and agrobiodiveristy is also enhanced by more diversity in the crops. The objective of our experiments with stripcropping is to force a breakthrough of the lock-in of monocultures, while meanwhile working on the full-potential of intercropping.

5. Variation in attractiveness to parasitoids in a landscape context

Yavanna Aartsma, Wopke van der Werf, Marcel Dicke, Erik Poelman, Felix Bianchi
Wageningen University & Research

Upon attack by herbivores, plants produce herbivore-induced plant volatiles which provide information to parasitoids searching for hosts. While these interactions are commonly studied in a lab context, few studies investigate them under field conditions and spatial scales that extend further than the plant patch scale. Furthermore, little is known on the spatial scale on which HIPVs influence parasitoid behaviour. On a larger spatial scale, landscape ecology shows that aspects of landscape context can affect the spatial distribution of insects, but often neglects why insects move and how they locate suitable habitats. Our study aimed to connect the two approaches by studying parasitism rates of *Pieris brassicae* caterpillars on two cabbage varieties differing in attractiveness to parasitoids in a range of landscapes varying in aspects such as crop area and host plant abundance. Attracting parasitoids and predators to crops from surrounding semi-natural habitats can be important for successful biological control, and using more attractive crop varieties might enhance natural enemy populations in agricultural fields.

6. Spatial scale dependent effects of urbanization on plants and their above- and belowground invertebrates

Jiao Qu
Ghent University

Plant-herbivore interactions are regarded as key ecosystem processes as the consumption by herbivores mediates competitive ability of plants, biomass production and energy transfer to higher trophic levels. However how these interactions are altered by intense urban development is still rarely studied. Additionally, studies on insect herbivores focus on aboveground insect herbivores, ignoring belowground counterparts. Employing three widespread plant species (i.e., *Arabidopsis thaliana*, *Senecio jacobaea*, *Senecio inaequidens*) in Europe as examples of model systems, and a spatial point-pattern analysis method which can explore the impacts of environmental factors on ecological objects in space, we uncover in this talk how organisms change their (extended) phenotype in response to urbanization at multiple spatial scales. We found that (1) plant height and biomass reduced with urbanization in all species but at different spatial scales, and (2) at smaller spatial scales, both aboveground herbivorous insect density and belowground nematode density increased with urbanization in two native species, while decreased in the non-native species. Our results indicate that urbanization imposes pressures on plants for all three species and on insects for the invasive species, and urban development limits distributions of insects. We aim to test in the near future how herbivorous insect diversity changes with urbanization.

4b: ECOPHYSIOLOGY; Mechanisms of Plant-Environment Interaction

Conveners: Eric Visser (Radboud University Nijmegen)
Ronald Pierik (Utrecht University

1. Genetic Components of Root Architecture Remodeling in Response to Salt Stress

Magdalena M. Julkowska, Iko T. Koevoets, Selena Mol, Huub Hoefsloot, Richard Feron, Mark A. Tester, Joost J.B. Keurentjes, Arthur Korte, Michel A. Haring, Gert-Jan de Boer, Christa Testerink
Wageningen University & Research / University of Amsterdam

Soil salinity is highly detrimental to plants, and affects root growth. We examined salt stress-induced changes in Root System Architecture by studying 347 Arabidopsis accessions collected worldwide, and developed an app (https://mmjulkowska.github.io/Salt_NV_RootApp/) allowing interactive exploration of collected data. Genome-wide association studies identified 100 candidate loci, among which CYP79B2 and HKT1. CYP79B2 was validated to be involved in maintenance of lateral root growth during salt stress, possibly by altering auxin biosynthesis. Enhanced expression of the HKT1 ion transporter in root stellar cells repressed lateral root formation under salt stress conditions, revealing that while retention of salt ions in the root is an excellent mechanism of salinity tolerance in larger plants, it is detrimental for primordia development in young seedlings. Thus, our results provide a better understanding of root remodeling in salt, and identifies novel genetic components for plant performance under stress.

2. Hypoxia tolerance of Arabidopsis seedlings varies between developmental stages

Shanice Martopawiro, Hans van Veen, Zeguang Liu, Sjon Hartman, Rashmi Sasidharan, Rens Voesenek
Utrecht University

No abstract received.

3. Light signals for aboveground neighbour detection regulate root architecture

Kasper van Gelderen, Chiakai Kang, Ronald Pierik
Utrecht University

Plants in dense vegetation compete for resources and detect their competitors through reflection of far-red (FR) light from surrounding plants. This reflection causes a reduced red(R):FR ratio, which is sensed through phytochrome photoreceptor proteins. Low R:FR induces shade avoidance responses of the shoot, including upward leaf bending, internode elongation towards the light and early flowering. In addition, also changes in root system architecture are induced, but this has received little attention so far. We investigated the mechanisms through which light detection in the shoot regulates root development, using *Arabidopsis thaliana* as a suitable model system. We used a combination of microscopy, gene expression, physiology, and mutant study approaches in a setup that allows root imaging without exposing the roots to light treatment. We show that low R:FR perception in the shoot decreases the lateral root (LR) density by inhibiting LR emergence. This decrease in LR emergence upon shoot FR enrichment is regulated by phytochrome-dependent accumulation of the transcription factor ELONGATED HYPOCOTYL 5 (HY5) in the LR primordia. HY5 abundance is known be photoreceptor-controlled and HY5 has been previously shown to be mobule between the shoot and the roots. HY5 regulates LR emergence by changing the cellular localization of proteins involved in polar transport of the plant hormone auxin. Accordingly, FR enrichment reduces the auxin signal in the root cortex cells that overlay the developing primordium, which in turn reduces LR outgrowth. This shoot-to-root communication can help plants coordinate resource partitioning under competition for light in high density fields.

4. Surviving floods: adaptive roots and where to find them

Eric J.W. Visser, T. Dawood, Q. Zhang, X. Yang, H. Huber, C. Mariani, H. de Kroon, I. Rieu
Radboud University Nijmegen

Bittersweet, a wetland species of the Solanaceae family, develops a new, shoot-borne root system if the plant is partially submerged in floodwater. The outgrowth of these adventitious roots is strongly regulated by plant hormone action, and is rapidly induced upon the onset of flooding stress. We investigated the expression of this trait among a variety of natural accessions of the species across different habitats, and established the advantages of adventitious roots to the flooded plant. Moreover, we studied the interacting hormonal pathways that cause the timely outgrowth of these roots, to develop an action model of the players involved.

5. Natural variation in tomato specialised metabolites against insects

Ruy Kortbeek, Marc Galland, Aleksandra Muras, Johan Westerhuis, Sasha van Hijum, Alain Tissier, Sebastien Zabel, Michel Haring, Robert Schuurink, Petra Bleeker
University of Amsterdam

With classical chemical insecticides progressively banned, understanding and deploying natural insect resistance found in (wild) ancestral relatives in order to protect our vegetable crops is gaining importance. Wild relatives of cultivated tomato (*Solanum lycopersicum*) display considerable resistance to agronomically important pest insects such as the Silverleaf whitefly and the Western Flower thrips, that vector a number of devastating plant-viruses. We aim to identify compounds produced by wild tomato that have anti-insecticidal properties. In tomato, glandular trichomes are the “biochemical factories” responsible for production, storage and emission of specialised metabolites such as terpene (derivatives) and acylsugars, and some of these compounds have already been implicated useful in protecting plants against insects. We phenotyped a collection of 19 tomato accessions encompassing 10 different wild- and cultivated species for resistance against whiteflies and thrips and analysed their trichome’s specialised metabolite profiles focusing on acylsugars and terpenoids. Logistic regression and survival modelling in combination with a “Random Forest Analysis approach, resulted in a number of compounds predicted to have (insect-specific) anti-insecticidal effects. One of the compounds resulting from the prediction analysis is a derivative of glandular trichome produced 7-epizingiberene, a terpene we previously found to make tomato unattractive to whiteflies and spidermites. The effect of these terpenes was validated in a pure compound bioassay with whitefly and thrips. Moreover, we have elucidated the biochemical pathway leading to the production of these deterrent and toxic terpenoids and identified the (wild) tomato genes. However, introgression of these genes into a cultivated tomato background by backcrossing resulted in only very low levels of the compounds made, presumably by the inheritance of a dominant-negative factor from the cultivated side, a factor that remains as a subject of discussion and further study.

6. Genomic and molecular characteristics of a desiccation tolerant plant

Maria-Cecília D. Costa, Mariana Artur, Jill M. Farrant, Henk W. M. Hilhorst
Wageningen University & Research

When plants colonized land they developed a wide range of adaptations at physiological, structural, regulatory, and molecular levels to cope with variations in a dry environment. Mechanisms of desiccation tolerance (DT) allowed plants to survive the removal of almost cellular water without irreversible damage. DT is common in seeds and various other organisms, but only a few angiosperm species possess vegetative desiccation tolerance. These 'resurrection species' possess different adaptations that allow to survive desert-like conditions. Such plants have the advantage not only of surviving rapid desiccation but also of rapid recovery. To understand the genomic and molecular aspects that characterize desiccation tolerant plants, we produced a high-quality whole-genome sequence for the resurrection plant *Xerophyta viscosa* and assessed transcriptome changes during its dehydration. The *X. viscosa* genome has clusters of desiccation-associated genes (CoDAGs), which show coordinated expression during drying. CoDAGs tend to be downregulated during desiccation, with potential roles in suppressing growth and metabolism. Data revealed changes in expression of transcripts typically associated with desiccation tolerance in seeds, revealing a co-option of pre-existing seed pathways. Our study provides new insights into environmentally induced responses in genomic and molecular levels leading to the resurrection phenotype.

4c: SOIL BIODIVERSITY; A methodological consensus to better understand soil biodiversity, their function and interaction with plants

Conveners: Stefan Geisen (Netherlands Institute of Ecology)
Arjen de Groot (Wageningen University & Research)

1. Soil Biodiversity uncovered

Arjen de Groot, Stefan Geisen
Wageningen University & Research / Netherlands Institute of Ecology

Soil biodiversity is the richest biotic resource on Earth. However, we only now start to have the tools to perform integrated studies of all components of this vast diversity. In this talk, we will give an overview of the diversity and role of key groups of soil biota, including viruses, bacteria, archaea, fungi, protists, and fauna. We will highlight method combinations that provide a better knowledge of ecological processes in soils. Therewith, we will introduce the talks within this session that applied such methods for in depth studies of the diversity, functions, interactions of soil biota, and their spatial and temporal variation. Both alpha and beta diversity will be impacted by land management (Maarten Schrama). This is at least partly due to complex interactions between vegetation and soil organisms (plant-soil feedbacks), as soil biota may govern plant performance (S. Emilia Hannula and Dina in 't Zandt). Given such complex interactions, making links between components of the soil diversity more explicit by visualizing co-occurence patterns will be needed to better understand ecosystem functions (Basten L. Snoek). Last, soil biodiversity is shown to represent a key resource to study and test ecological theories which is so far underused (Madhav P. Thakur)

2. Land abandonment results in species richness loss and homogenization of belowground soil food webs

Maarten Schrama, Casper Quist, Arjen de Groot, Jonathan Leff, Noah Fierer, Richard Bardgett
Leiden University

Land abandonment has been estimated to reach ~30 million hectares in 2030 in Europe. There is wide-spread concern that this will result in a further decrease in biodiversity and related loss in functioning, but the results to date are far from conclusive. Previous studies have shown that for aboveground communities, land abandonment can impact both alpha and beta diversity, but relative effects on alpha and beta-diversity (homogenization) of below ground communities have been poorly addressed. Here, we evaluate whether land abandonment leads to consistent changes in alpha diversity of belowground fauna across a wide range of soil fauna groups, using a range of molecular techniques. We sampled a series of paired grazed and ungrazed experimental sites that had been present between 10-85 years and were positioned along an 800-km long gradient in Britain. Our results indicate that grazers have consistent, positive effects on alpha diversity of all below ground groups, as well as vegetation, but a mixed effect on the homogeneity of microbial and soil fauna groups. Soil fauna groups exhibit a markedly different response to grazing as a homogenizing factor than microbial groups, thus emphasizing the need to increase variation in grassland management when aiming to conserve high biodiversity.

3. Active rhizosphere mycobiome

Emilia Hannula, Elly Morriën, Wim van der Putten, Wietse de Boer
Netherlands Institute of Ecology

Natural grasslands can be highly biodiverse systems. Yet, the drivers of species co-existence in such communities are still debated. Increasing evidence suggests that the interactions between plants and their associated soil biota play a major role. Specifically, co-existence is suggested to result from the accumulation of species-specific pathogens around and in the plants root system over time. This is expected to act as a selecting force on species recruitment of the next generation, species performance and survival, and thus species spatio-temporal growth patterns. We combined three independent datasets to gain insight into how local long-term vegetation patterns, species spread, and plant-soil feedbacks of 24 co-occurring grassland species are associated. The first dataset contained observations of small scale species abundances over 31-years in a biodiverse Czech mountain meadow. The second dataset, the CLOPLA trait database, provided lateral spread data, and in combination with the first dataset, a measure for species persistence. The third dataset contained plant-soil feedback values of the same species obtained from a greenhouse experiment. We show that spatio-temporal vegetation patterns are indeed linked to plant-soil feedback and, specifically, that species with negative plant-soil feedbacks have a high persistence in the field.

4. **Plant-soil feedback and plant persistence are linked in a biodiverse grassland**
Dina in 't Zandt, Tomáš Herben, Annelien van den Brink, Eric Visser and Hans de Kroon
Radboud University Nijmegen

Natural grasslands can be highly biodiverse systems. Yet, the drivers of species co-existence in such communities are still debated. Increasing evidence suggests that the interactions between plants and their associated soil biota play a major role. Specifically, co-existence is suggested to result from the accumulation of species-specific pathogens around and in the plants root system over time. This is expected to act as a selecting force on species recruitment of the next generation, species performance and survival, and thus species spatio-temporal growth patterns. We combined three independent datasets to gain insight into how local long-term vegetation patterns, species spread, and plant-soil feedbacks of 24 co-occurring grassland species are associated. The first dataset contained observations of small scale species abundances over 31-years in a biodiverse Czech mountain meadow. The second dataset, the CLOPLA trait database, provided lateral spread data, and in combination with the first dataset, a measure for species persistence. The third dataset contained plant-soil feedback values of the same species obtained from a greenhouse experiment. We show that spatio-temporal vegetation patterns are indeed linked to plant-soil feedback and, specifically, that species with negative plant-soil feedbacks have a high persistence in the field.

5. **Network visualization as a versatile tool for exploring soil biodiversity**
Basten L. Snoek
Utrecht University

The overall increased availability of observations on soil biodiversity has led to rich datasets in which soil organisms can be linked to abiotic conditions of the soil and possible effects on plant communities growing on that soil. As the dynamics and effects within and between soil- and plant communities can be very complex new and combined applications of visualisation tools are needed for efficient exploration. In this presentation I will show a combination of tools and methods that can be used to visualise and explore community interactions between species, abiotic parameters and plant species.

6. **Toward an integrative understanding of soil biodiversity**
Madhav P. Thakur, Helen Phillips, Erin Cameron, and sWorm Group
Netherlands Institute of Ecology

Soil is one of the most biodiverse habitats on Earth. However, our understanding of the causes and patterns of soil biodiversity still lacks an integrative conceptual framework. Furthermore, whether key biodiversity theories (historically developed to predict the biodiversity of aboveground organisms) explain patterns of soil biodiversity is also less understood. Here, we first carry out a systematic literature review to investigate whether key biodiversity theories can explain the patterns of soil biodiversity. Second, we provide an integrative conceptual framework for improving our understanding of soil biodiversity from microscopic to macroscopic soil organisms. Our review of biodiversity theories (species-energy relationship, theory of island biogeography, metacommunity theory, niche theory and neutral theory) showed general support (>50% of studies) for these theories when tested with soil organisms. However, our results also confirmed a substantial underrepresentation of soil organisms in studies on these biodiversity theories. We show how these theories can be integrated into a conceptual framework and accordingly recommend a spatial compartmentalization of soil into three key parts: soil, soil hotspots and soil microsites. We believe the application of this framework will help improve our understanding of soil biodiversity at relevant scales.

4d: THEORETICAL ECOLOGY; Unifying principles in ecology and beyond

Conveners: Koen Siteur (Royal Netherlands Institute for Sea Research)
Valérie Reijers (Radboud University Nijmegen)
Maarten Eppinga (Utrecht University)

1. Multidisciplinary approaches to understanding complexity in ecosystems

Johan van de Koppel
Royal Netherlands Institute for Sea Research

From the 80s onwards, there has been a continuing push to break down the walls that separate scientific disciplines such as biology, mathematics, and physics. A field where this integration has been successful is Theoretical Ecology, in particular in the study of the complexity of ecosystems. Using mussel beds and salt marshes as example ecosystems, I show that the interplay of geophysical, ecological and behavioral processes can lead to spatial patterns in ecosystems at multiple spatial scales. This multitude of spatial patterns is of essential importance for the functioning of ecosystems, in particular to its resilience to changing environmental conditions.

2. Lévy movement as the optimal strategy for building dunes

Valérie C. Reijers, Koen Siteur, Selwyn Hoeks, Jim van Belzen, Annieke C.W. Borst, Jannes HT Heusinkveld, Laura L. Govers, Johan van de Koppel, Tjisse van der Heide
Radboud University Nijmegen

One-third of the world's shorelines are protected by coastal dunes arising from a biophysical feedback between vegetation growth and aeolian sand trapping. Although dune morphology has been suggested to depend on the plant species involved, the mechanisms mediating this feedback are unclear. Using a cross-Atlantic field survey, a spatially-explicit model and a field experiment, we demonstrate that the dune-building capacity of plants is directly linked to the spatial organization of their shoots. We found that the species associated with the tallest dunes, *Ammophila arenaria*, exhibits a shoot placement strategy in which the step lengths are best described by a truncated Lévy distribution, whereas those of other species resemble Brownian distributions. Moreover, both model simulations and the field experiment demonstrate that a shoot placement strategy following a Lévy distribution optimizes sand-trapping efficiency. Our findings reveal how the formation of coastal landscapes is controlled by plants at the shoot level, and highlights the importance of heavy-tailed movement as an adaptive strategy in complex self-organized environments.

3. Wide distribution of regular pattern wavenumbers in model and real dryland ecosystems

Robbin Bastiaansen, Olfa Jaïbi, Vincent Deblauwe, Koen Siteur, Eric Siero, Maarten Eppinga, Stephane Mermoz, Alexandre Bouvet, Arjen Doelman, Max Rietkerk
Leiden University

The availability of aerial photography around the 1940s led to the discovery of vegetation patterns in semi-arid climates. Since then many theoretical models have been created to explain and describe these patterns. Studies of these models required the use of advanced mathematics and physics behind fluid dynamics. However, the results of these studies were rarely compared to reality - and comparisons often were only visual. Nowadays, data about vegetation patterns becomes more readily available and thorough comparisons are therefore only now possible. In this talk, the theoretical predictions based on reaction-(advection)-diffusion models will be explained and compared to data of vegetation patterns in Somaliland. The similarities between the two show an important spread in a wavenumbers of these vegetation patterns. Moreover, this observation suggest multistability of vegetation patterns, which indicates that patterns in semi-arid climates might be more resilient than is often believed.

4. On scale and function of ecosystem engineered structures

Jim van Belzen, Sil Nieuwhof, Bas Oteman, Peter M.J. Herman, Tjeerd J. Bouma, Johan van de Koppel
Royal Netherlands Institute for Sea Research

Ecosystem engineers are species that modify their environment, i.e. they impose structure to the landscape they live in. Although studies on the role of habitat modifications can already be traced back to Darwin (1842), the concept of Ecosystem Engineering is still in its infancy and was formalized only relatively recently by Jones et al (1994). Since then, the importance of the added complexity for understanding the functioning and stability of ecosystems is generally acknowledged. Yet, we often fail to include a general understanding of the effects as ecosystem engineering is often seen as idiosyncratic and highly context dependent. Here, we draw upon methods from statistical physics to reveal that general laws do exist in the structure-function relationships for various ecosystem processes, such as the dissipation of energy, friction to flow, or the retention of resources. Interestingly, how these processes scale with ecosystem size depends highly on how the spatial characteristics of the added complexity and the underlying landscape interact. Finally, we show how these results fit in with data

from real intertidal ecosystems, and discuss the implications for understanding the role of ecosystems engineers in the stability and the services these ecosystems provide.

5. Classifying and unifying and the underlying causality of species competition: a theoretical perspective

Mangi Chang, Leo Postma, Annette Janssen, Hans Los, Tineke Troost, Wolf Mooij
Netherlands Institute of Ecology

Many ecosystem models have been applied to address the environmental pressures of the Anthropocene. The simulation of species competition is one of the most critical processes in these models. Different types of causality underlie species competition models, causing uncertainty in predicting ecosystem response to external pressure like nutrient enrichment. Here, we take a theoretical perspective to classify and unify species competition models with two types of underlying causality. First, the mechanistic reasoning in models such as Lotka-Volterra, Tilman and Droop constitutes proximate causality; second, the optimization approach of Linear Programming is based on ultimate causality. Our mathematical and graphical analyses unify these models that differ in causality within a single mathematical framework. Scenario analyses show identical outcome of species competition when species coexist in the mechanistic models, but different outcome when alternative states and competition exclusion occurred in the mechanistic models. This is caused by the fact that the proximate causality takes into account the resource intake half-saturation constant but the ultimate causality ignores this constant. In conclusion, our results show convergence and divergence in the outcome of species competition models with different underlying causalities. These similarities and differences can be seen as complementarity and redundancy that result from ‘model-diversity’.

6. Using Fourier Series of the Absorption Spectrum of Phytoplankton

Jürg Werner Spaak, Frederik de Laender
University of Namur

Partitioning of the light spectrum is since long proposed as an explanation for biodiversity in plankton communities. This is because different plankton species have different pigments that are able to capture different parts of the light spectrum. So far this model has only been investigated numerically, due to the complexity of real life pigments (which do not have analytical representations). We used the Fourier series to investigate this problem with the pigments as basis vectors, translating the integrals in plankton community model differential equations into polynomials, allowing formal analysis. We were able to show that partitioning of the spectrum only offers a limited explanation to plankton diversity. The number of species allowed to coexist is at most the number of pigments in the entire community. Combinations of real pigments mostly only leads to coexistence of 5 species.

4e: ANIMAL ECOLOGY

Conveners: Chris Smit (University of Groningen)
Patrick Jansen (Wageningen University & Research)

1. Rewilding Europe's large grazer community: how functionally diverse are the diets of European bison, free-ranging cattle and horses?

Joris P.G.M. Cromsigt, Yvonne J. M. Kemp, Esther Rodriguez, Hubert Kivit
PWN Waterleidingbedrijf Noord-Holland

Free-ranging cattle and horse breeds are being introduced across Europe as substitutes of the extinct aurochs (*Bos primigenius*) and tarpan (*Equus ferus*) to restore or maintain biodiverse open to half-open landscapes. More recently, European bison (*Bison bonasus*) is also being introduced as it is supposed to fill a niche that pure grazers such as cattle and horses leave empty, especially in terms of reducing woody encroachment. But how functionally diverse are the diets of these three species? We investigated this question in the Kraansvlak pilot; a trophic rewilding project in the Netherlands where European bison, horses and cattle have been introduced in spatially heterogeneous landscapes of forest, shrub land and grassland and where no supplementary feeding occurs. We present four years of data from direct observations on the diet choice of all three species. Whereas cattle and bison included a significant proportion of woody plants in their diet throughout the year, horses strictly grazed. However, cattle and bison differed clearly in terms of the woody plant part they utilized (bark versus twigs) and we discuss how this may affect the way they influence vegetation structure. Finally, we discuss the implications of our study for the increasing number of trophic rewilding initiatives in Europe.

2. Foraging coordination while feeding young: behavioural mechanisms underlying negotiation over offspring care

Davide Baldan, Camilla Hinde, Emiel E. Van Loon, C.M. Lessels
Netherlands Institute of Ecology

The amount of parental care provided to offspring is affected by sexual conflict and the negotiation rules that parents adopt. Recently, a 'turn-taking' provisioning rule by the parents has been predicted to increase parental care, and several empirical studies in birds indicate that parents do indeed alternate their nest-visits more than expected by chance. However, little is known as to whether parents actively take turns of feed and how they monitor the provisioning activity of the mate. We proposed two mechanisms by which parents monitor and respond to each other: coordination of foraging trips and monitoring at the nest (e.g. by waiting at the nest for the partner). We combined video recordings at the nests with Encounternet, a new automated radio-tracking technology, to remotely monitor provisioning activity of wild great tit (*Parus major*) pairs during chick rearing. We explored i) whether parents forage in spatial proximity or monitor each other at the nest, and ii) how these two behaviours relate to the pattern of the nest visits. This study links animal movement analysis to visit patterns at the nest and highlights the importance of studying the behavioural mechanisms underlying negotiation rules to better understand the evolution and maintenance of bi-parental care.

3. Self-organisation of nest aggregates in a digger wasp: a spatial pattern driven by density-dependent movement

Femke Batsleer
Ghent University

Local interactions can induce large-scale spatial patterns by spatial self-organisation. These are mostly explained by Turing's activator-inhibitor principle (scale-dependent feedback). Recently, there is more attention to an alternative mechanism of spatial self-organisation: phase separation driven by density dependent movement. In this study we investigated processes involved in the spatial pattern formation of nest aggregates of *Bembix rostrata*. This revealed a bottom-up and top-down regulator of aggregate formation. The first is the nest site suitability, predicted by a microhabitat model derived from remote sensing data with a drone. The latter is formed through a selfish herd mechanism related with brood-parasitic flies, in which high nest densities have lower individual chance of parasite infection. This selfish herd mechanism underlies a strong conspecific attraction during nest formation. These processes are incorporated in a pattern-oriented Individual Based Model (IBM) and evaluated by comparing the spatial pattern and network statistics of the field data with those of the runs of the IBM. Density dependent attraction is of major importance in self-organisation of nest aggregates in this system. This study is a detailed example of the phase separation mechanism operating in an ecological system, supporting the importance of this alternative mechanism for explaining ecological patterns.

4. Keep calm and carry on: behavioural comparison of naïve and non-naïve deer in response to wolf urine.

Annelies van Ginkel, Chris Smit, Dries Kuijper
University of Groningen

Large carnivores are returning to many regions in Europe, where their ungulate prey species have lived in absence of large carnivores for over 100 years. This raises the question whether deer that have lived in absence of carnivores, associate the scent of wolf (*Canis lupus*) with predation risk and adjust their behaviour accordingly. We performed an experiment in which we compared the behaviour of naive deer (living in an area without wolves for 150 years in the Netherlands) and non-naive deer (living an area with wolves for >100 years in Poland) in response to wolf urine. As control cues we used water (no scent) and all-purpose soap as an unfamiliar but low-risk scent. By means of camera traps we recorded deer behavioural responses to the scents. Both the naive and non-naive deer had a vigilance background level of 20%, which surprisingly did not increase in response to wolf urine for deer living in areas with or without wolves. Besides, we found an unexpected behavioural response of the non-naive deer to all-purpose soap which increased vigilance and reduced foraging time, whereas the behaviour of naive deer was not affected. This suggests that scents associated with humans can cause a different response in deer in human-dominated areas (in the Netherlands) compared to deer in remote areas (in Poland), and should be taken into account when designing experiments. The scent of wolf urine, resembling a single urine mark of wolves, is apparently not sufficient to affect naive and non-naive deer behaviour. More intense cues, or a combination of predation risk cues, are likely needed before large carnivores indirectly change the behaviour of their prey species.

5. Do responses to temperature vary spatially in two hole-nesting passerines?

Liam D. Bailey, Martijn van de Pol, Marcel E. Visser
Netherlands Institute of Ecology

Increasing global temperatures can have important impacts on organismal phenology. In many hole-nesting passerines, like the great tit (*Parus major*), timing of egg laying is important to allow synchronisation with local food peaks. Previous studies have documented temperature sensitivity in phenology, but it is not clear whether different populations are sensitive to the same temperature window and whether the strength of responses are uniform across a species' range. We present an inter-population comparison of laying date responses to temperature using over 50 populations of both great and blue tits. We use a newly developed method to determine the window at which temperature most strongly influences laying date in each population. We then determine the relationship between temperature and phenology for each population and look for spatial patterns across the species' range. We consider how other variables, such as photoperiod and habitat type, may help explain spatial patterns in temperature sensitivity. Differences in temperature sensitivity across tit populations of Europe may lead to varying levels of phenological mismatch between offspring development and food peaks. Studying how temperature sensitivity of laying date varies across Europe will give us a better understanding of how climate change impacts may differ spatially across the continent.

6. Maternal effects in a placental live-bearing fish

Andres Hagmayer, Andrew Furness, David Reznick, Bart Pollux
Wageningen University & Research

Maternal effects often provide a mechanism for adaptive transgenerational phenotypic plasticity. The maternal phenotype can profoundly influence the potential for environmentally-induced adjustments of the offspring phenotype, causing correlations between offspring and maternal traits. We studied the effects of maternal phenotype on offspring phenotype prior to and during the pregnancy in the placental live-bearing fish species *Poeciliopsis retropinna* collected from the Rio Terraba in Costa Rica. Specifically, we examined how maternal traits such as body fat, lean mass and length influence pre- and post-fertilization maternal provisioning and how this ultimately affects offspring size and body composition at birth. We found that maternal length proportionally increases egg mass at fertilization and offspring mass at birth, whereas maternal body fat increases offspring mass at birth but does not affect egg mass at fertilization. We furthermore found temporal variation in embryo composition during gestation, with females investing first in embryo somatic lean mass and allocating fat reserves to the embryos only very late in pregnancy. This delay in fat allocation is arguably adaptive, because it postpones an unnecessary high reproductive burden to the mother to late pregnancy. We conclude that offspring provisioning is a plastic phenotypic trait that is strongly determined by maternal phenotype.

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 will be attended /discussed.

#	Name	Poster title
1	Juan Alberti	Long-term large-herbivore exclusion promotes plant composition convergence in salt marshes but not in grasslands
2	Rosyta Andriana	Shellfish reefs facilitate spatial structures of 'the plants' on intertidal mudflat
3	Milagros Barcelo	Environmental drivers of mycorrhizal host plants global distribution
4	Janna Barel	Domestication effects on rhizosphere microbiome and root traits
5	Richel Bilderbeek	Beautier: BEAUti for R
6	Bregje van der Bolt	Climate reddening promotes the chance of critical transitions
7	Annieke Borst	Effects of Common Carp on turbidity via trophic and non-trophic routes
8	Koen Brouwer	Fear of humans? Effect of human disturbance on tree regeneration in the Veluwezoom.
9	Luc De Bruyn	Structure characteristics, temperature regimes and roost site selection in hibernating bats.
10	Chenhui Chang	Effects of epiphyte removal on the microbial community structure of decaying fallen logs in an alpine forest
11	Cong Chen	Exposure to wind affects development of two insect herbivores and reduces predation risk
12	Susanne van Donk	Energetic consequences of foraging strategies in the herring gull
13	Sara Doolittle-Llanos	Plastic as a Vector for Marine Fouling Species in the Galapagos Archipelago, Ecuador
14	Arne van Eerden	The shrimp and the goose: about switching roles and changing trophic cascades in arctic ponds
15	Livia De Felici	Is insect biomass affected by soil wetness?
16	Thijs Fijen	Insect pollination is as important for marketable crop yield as plant quality
17	Mike Fleuren	Functional morphological adaptations in invasive round goby (*Neogobius melanostomus*) populations across Europe
18	Zhilei Gao	Soil protists as drivers for soil disease suppressiveness by shifting bacterial community composition
19	Arjen de Groot	Kennisimpuls Bestuivers
20	Eeke Haanstra	Ecosystem effects of MPAs in the Baltic Sea

#	Name	Poster title
21	Paula Harkes	The differential impact of a native and a non-native ragwort species on the first and second trophic level of the rhizosphere food web
22	Robin Heinen	Plant community composition, but not root traits determine the outcome of soil legacy effects on plants and insects
23	Ruth Howison	Satellite identifies bird-friendly meadows
24	Hui Jin	Effects of benthic animals on nutrient recycling in the water column
25	Yvonne Kahlert	Marker Wadden: A surprisingly self-organised designed ecosystem
26	Megan Korte	Facilitation: a novel mechanism of adaptive capacity
27	Hylke Kortenbosch	A change in microbiome composition during local adaptation of a herbivore to a new host plant
28	Gea van der Lee	Persist or perish: vulnerability of invertebrates to disturbance is determined by their life cycle dynamics
29	Rong Li	Differential soil microbiome responses to *Fusarium oxysporum* invasion in disease-suppressive and -conducive soils
30	Beatriz Marín Díaz	How to manage foreshore ecosystems to gain both coastal protection and ecological value?
31	Bjorn Mols	Large carnivores in anthropogenic landscapes: how landscapes of fear created by humans and large carnivores affect deer behaviour and structure ecosystems
32	Elly Morriën	Does soil inoculation speeds up nature restoration? an analysis of potential drivers.
33	Martina Paulin	Ecosystem Services Decision-Support Toolkit: A synthesis and practical guide for the implementation of ecosystem service methods within decision-making
34	Emma Penning	Local movements of Sanderlings at a staging site in the Wadden Sea
35	Sophie van Rijssel	Soil community functioning in a chronosequence of organically managed farms”.
36	Nils van Rooijen	The Living Archive: a growing network around the National Seed Repository in the Netherlands
37	Lisa Röttjers	From hairballs to hypotheses – biological insights from microbial networks
38	Koen Siteur	Physics derived indicators for the degradation of patchy ecosystems.
39	Lukas Trebuch	Self-sedimenting algal-bacterial communities for wastewater treatment
40	Stijn Vaessen	Modelling the distribution of mycorrhizal plant species
41	Rik Veldhuis	The effects of soil acidification and mycorrhiza on *Juniperus communis*
42	Robert Veldman	Soil-borne fungal pathogens and their hosts in a grassland biodiversity experiment
43	Michiel Verhofstad	Evaluating the benefits of ecological bank restoration along waterways

#	Name	Poster title
44	Roeland van de Vijsel	Algal mats boost present-day biomorphodynamics using Precambrian self-organisation strategies
45	Jip de Vries	Opportunities and limitations of multi-scale aquatic ecological prediction models to support ecological water quality improvement
46	Judith Westveer	Inland dispersal of aquatic invertebrates
47	Jelle Wichers	Ecology of fear: the impact of wolves on meso-predator behaviour
48	Wu Xiong	Soil protist communities form a dynamic hub in the soil microbiome
49	Dan Xiong	Effect of aridity index on soil nematode community along the grassland transect of northern China
50	Liang Xu	Can we infer diversity-dependent diversification from phylogenies under multiple locations ?
51	Pengfei Zhang	The overall competitive superiority of the few dominant species in response to nutrient enrichment drives the loss of species diversity
52	Peihua Zhang	Being Rational Under Attack: How do plant roots respond to an infected neighbour?
53	Mengying Zhong	Contrasting altitudinal trends of leaf anatomy between three dominant species in an alpine meadow
54	Yu Zhu	Effects of livestock grazing on plant-mediated coexistence between dominant grasshoppers in a grassland ecosystem

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NERN Best Presentation Award
Voting instructions

As was done last year, the Netherlands Ecological Research Network (NERN) will not award prizes for the best scientific publications but for the best oral presentations given during the NAEM meeting, in the form of the "NERN Best Presentation Award". NERN has decided this to stimulate young academics to prepare and present an oral presentation of high quality. As usual, there will be a first, second and third prize, € 750,- € 500,- and € 250,- respectively. The award ceremony will be during the closing session on Wednesday afternoon.

Who is eligible to win this prize?

All MSc students and PhD candidates, as well as those who have obtained their PhD degree after 14 February 2017 are eligible to take part in the competition. Note, however, that you can only participate if you will be present during the closing ceremony on Wednesday. When the above applies, you will automatically participate.

Evaluation criteria

All participants of the NAEM meeting can nominate their favourite presentation. Evaluation of the presentations should be based on the quality of the presentation style (voice, body language), content and the PowerPoint. Obviously, you can only nominate a presentation that you actually attended.

Evaluation / Selection procedure

The NAEM audience can cast their vote for the best presentation. One can only vote once during the two-day NAEM meeting. A special website / app will be used for this. The procedure is as follows:

- Scan the QR code below, type the following link in your internet browser of your laptop, tablet, or smartphone: https://live.voxvote.com/?pin=73451&autosubmit, or download the "VoxVote Live Voting App" for Android or IOS in the App Store / Play Store and use pin code **73451** to enter the NAEM voting site.
- Vote for the presentation that, in your opinion, was the best of all the presentations you attended during the NAEM meeting.
- Note that you can only vote once, so you should not cast your vote until you attended all presentations or until you leave!
- You can cast your vote at any time during the meeting, up to Wednesday afternoon 17:20 hrs. After this moment the voting site will be closed.
- The total number of votes for a given presentation will be corrected for the number of people present during that presentation.

SCAN THE QR CODE ABOVE TO CAST YOUR VOTE

NecoV Best Poster Award
Voting instructions

The Netherlands-Flemish Ecological Society (NecoV) will again award prizes for the best poster presentations of the NAEM meeting. As usual, there will be a first, second and third prize, € 300,- € 200,- and € 100,- respectively. The award ceremony will be during the closing session on Wednesday afternoon.

Who is eligible to win this prize?
All participants of NAEM that are presenting a poster during the meeting are eligible to take part in the competition. Note, however, that you can only participate if you will be present during the closing ceremony on Wednesday or when you have informed us about a representative that will be present during the ceremony to collect your prize.

Evaluation criteria
All participants of the NAEM meeting can nominate their favourite poster. Evaluation of the posters should be based on the quality of the content/impact, novelty, appeal, and clarity.

Evaluation / Selection procedure
The NAEM audience can cast their vote for the best poster. One can only vote once during the two-day NAEM meeting. A special website / app will be used for this. The procedure is as follows:

- Scan the QR code below, type the following link in your internet browser of your laptop, tablet, or smartphone: https://live.voxvote.com/?pin=69034&autosubmit, or download the "VoxVote Live Voting App" for Android or IOS in the App Store / Play Store and use pin code **69034** to enter the NAEM voting site.
- Vote for the poster that, in your opinion, was the best of all the posters that were on display during the NAEM meeting.
- You can cast your vote at any time during the meeting, up to Wednesday afternoon 15:00 hrs (the end of the second poster session). After this moment the voting site will be closed.
- The total number of votes for each poster will be calculated and this will lead to a top 3.

SCAN THE QR CODE ABOVE TO CAST YOUR VOTE

NAEM 2018 BINGO

Welcome to the NAEM Bingo! This game is an initiative of the Future for Nature Academy, and is aimed especially at early-career scientists. To participate:

- Complete as many challenges as you can during the meeting. Keep notes about when, how or with whom you completed each challenge in the 'Notes' section on the back of the bingo card.
- Have fun, make new connections and enjoy the meeting!
- Submit your entry to the FFN Academy stall, latest 16:10 hrs (last break) on Wed 14 Feb
- A panel of highly experienced bingo judges will determine three winners based on number of rows, columns and major diagonals completed.
- Prizes will be awarded during the 'Awards and Closing Ceremony' on Wed 14 Feb at 17:20 hrs.
- For any questions please find us at the FFN Academy stall.
- Thanks to Bree Rosenblum (#Evolutionbingo) and Rose Thorogood (#ISBEbingo) for the inspiration.

Tweet your Bingo accomplishments using **#NAEMbingo** and **#NAEM2018**.

Enjoy NAEM 2018! And, thanks for playing!

Future for Nature Academy

The Future for Nature Academy (FFN Academy) is a national network of students and young graduates with a passion for nature conservation. By organising various activities such as lectures, meetings with conservation heroes, documentary screenings and symposia, we create a platform for people to meet, discuss and make plans together for a better Future For Nature.

www.ffnacademy.org
ffnacademy@gmail.com
www.facebook.com/futurefornatureacademy
@FFNAcademy

www.nern.nl

NAEM 2018 Bingo – Challenges

Name: Twitter name:
Email address: Institution:

	A	B	C	D
1	Tweet a picture of yourself in front of the FFN Academy stand using #NAEMbingo and #NAEM2018	Ask someone you don't already know to tell you the most unexpected thing that has occurred in their career	Have coffee/tea with someone you don't know, and ask them about their work	Raise your hand to ask a question in a talk
2	Prepare an elevator pitch (<60 sec) about your research and give it to three people you met for the first time	Imitate David Attenborough in your talk or poster presentation	Attend last talk of a day, and sit in the front row	Take a selfie with a speaker and tweet it using #NAEMbingo and #NAEM2018
3	Approach someone you don't know after their talk to express your enthusiasm about their work	Start a discussion on how you think fundamental science can contribute to conservation	Tweet photo of you giving your talk or poster presentation using #NAEMbingo and #NAEM2018	Invite someone to your talk/poster, then follow up and ask if they have any feedback for you
4	Tweet a picture of you with 4 people, each from different institutions using #NAEMbingo, #NAEM2018	Draw a picture about someone's talk or poster, give it to them as a present and tweet it using #NAEMbingo, #NAEM2018	Email your CV to a prospective PhD supervisor, postdoc advisor or collaborator	Start a discussion about ethical publishing

NAEM 2018 Bingo – Notes

	A	B	C	D
1				
2				
3				
4				

NOTES