



NAEM 2019

Netherlands Annual Ecology Meeting

12 & 13 February 2019

Congrescentrum De Werelt, Lunteren

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Programme

Tuesday 12 February

	Main Entrance Hall				
08:30	Registration and coffee in the Lounge and setting up posters				
	Europe Hall				
10:15	Word of Welcome				
10:30	Plenary 1: "Rewilding in the face of Global Change" Throughout human history, global wildlife loss (defaunation) has disproportionately affected large animals and the functions they have in ecosystems. Rewilding aims to restore these functions through the re-introduction of missing, large wildlife species. However, rewilding can also be applied through the restoration of water level dynamics in ecosystems. In this session, we focus on the concepts, opportunities and impacts of rewilding as a restoration approach in the face of global change.				
10:30	1. Trophic rewilding – background, opportunities and challenges for megafauna-based restoration in the Anthropocene Jens-Christian Svenning, Department of Bioscience, Aarhus University, Denmark				
11:15	2. Rewilding: impact on ecosystems under global change Liesbeth Bakker, Department of Aquatic Ecology, Netherlands Institute of Ecology, The Netherlands				
12:00	Lunch in the restaurant				
	Europe Hall	America Hall	Asia Hall	Africa Hall	Vide Hall
13:30	Parallel 1a: Defaunation en rewilding	Parallel 1b: Ecological genomics - Bridging the gap between ecology and genomics	Parallel 1c: The next generation of research on biodiversity and ecosystem functioning (BEF)	Parallel 1d: From individual fitness to population dynamics	Parallel 1e: Ecology and Conservation
	<i>Conveners:</i> 1. Liesbeth Bakker (Netherlands Institute of Ecology) 2. Marjolein Sterk (Wageningen University & Research) 3. Jens-Christian Svenning (Aarhus University)	<i>Conveners:</i> 1. Chiara Bortoluzzi (Wageningen University & Research) 2. Mirte Bosse (Wageningen University & Research) 3. Per J. Palsbøll (University of Groningen)	<i>Conveners:</i> 1. Yann Hautier (Utrecht University) 2. Hans de Kroon (Radboud University)	<i>Conveners:</i> 1. Rosemarie Kentie (Royal Netherlands Institute for Sea Research) 2. Tamar Lok (Royal Netherlands Institute for Sea Research) 3. Andrew Allen (Radboud University)	<i>Conveners:</i> 1. Ignas Heitkönig (Wageningen University & Research) 2. Rascha Nuijten (Netherlands Institute of Ecology)
	This session is linked to the first plenary session on Rewilding in the face of Global Change. Throughout human history, global wildlife loss (defaunation) has disproportionately affected large animals and the functions they have in ecosystems. Rewilding aims to restore these functions through the re-introduction of missing, large wildlife species.	Ecological genomics is an emerging interdisciplinary field of studies that seeks to understand the molecular mechanisms underlying responses of organisms to their natural environments. In this symposium, we will bridge the gap between ecology and genomics by exploring the potential of ecological genomics in model and non-model organisms.	During the last three decades of research on BEF, we have accumulated evidence of the positive effects of biodiversity at small scales on ecosystem functioning. This session will highlight current and future directions in BEF research. This includes 1) scaling up the BEF relationship and mechanisms in space and time, 2) clarifying	Fitness and population dynamics are inter-related topics: fitness is about who survives and reproduces whilst population dynamics concerns how the size and structure of populations is driven by variation in demographic rates. In this session, we aim to unite long-term studies conducted at the level of individuals. By comparing	In the current time of rapid global change in climate and societies, conserving nature and natural processes has become an ever increasing challenge. In this session we (1) highlight examples of ecological research that evidently have a positive impact on the conservation of a species, habitat or ecosystem, and (2) explore avenues of future ecological and/or other

	However, rewilding can also be applied through the restoration of water level dynamics in ecosystems. In this session, we focus on the ecosystem consequences of defaunation as well as the impacts of rewilding as a restoration tool.	We will do that by exploring the benefits that ecological genomics brought to, among others, the following three areas of research: 1) the study of life history evolution and its impact on the genome architecture; 2) the genomic mechanisms of phenotypic plasticity, and 3) the genomic bases of adaptation and speciation.	the buffering effect of biodiversity on ecosystem functioning in a changing world, and 3) determining the role of multitrophic interaction in driving BEF.	factors explaining variation in survival, growth, fecundity and dispersal, we can advance our understanding of how individual fitness scales up to population dynamics.	research to contribute to more resilient conservation of nature and a sustainable society.
13:30	Rewilding: a resilience approach (Marjolein Sterk, Wageningen University & Research)	Changes in DNA methylation in relation to timing of reproduction in the great tit <i>Parus major</i> (Melanie Lindner, Netherlands Institute of Ecology)	The next generation of research on biodiversity and ecosystem functioning (BEF) (Yann Hautier, Utrecht University / Hans de Kroon, Radboud University)	From individual fitness to population dynamics: an avian perspective (Andrew Allen, Radboud University)	How past human-landscape interactions shaped island biodiversity, and why this is relevant for conservation today (Sietze Norder, University of Amsterdam)
13:50	Top-down, bottom-up and horizontal effects: an expanded framework to evaluate the need and success of rewilding (Luis Santamaría, Estación Biológica de Doñana (EBD-CSIC))	Demographic impacts of past global warming on baleen whales and their prey (Andrea A. Cabrera, University of Groningen)	Zooming out and zooming in to better predict the consequences of biodiversity change (Katie Barry, German Centre for Integrative Biodiversity Research (iDiv) Halle-Jena-Leipzig)	Unravelling the mechanisms of population phenotypic changes: Can phenotypic differences between colonisers and philopatric individuals explain population dynamics? (Marion Nicolaus, University of Groningen)	Pollinator diversity, herb layer diversity and semi-natural habitat enhance pollination service to sweet cherry (Maxime Eeraerts, Ghent University)
14:10	Defaunating synergic large herbivore functions in tropical forests (Nacho Villar, Universidade Estadual Paulista, São Paulo, Brazil)	Genome-wide data reveals strong impact of Pleistocene climate fluctuations on the demographic history of a tropical marine vertebrate (Jurjan P. van der Zee, University of Groningen)	Influence of community assembly on biomass production in a restoration context (Eva DeCock, Ghent University)	From within-host persistence to zoonotic emergence: Understanding bats as viral reservoirs (Anieke van Leeuwen, Royal Netherlands Institute for Sea Research)	To sustainable management of North Sea habitats. Studying the ecological characteristics of fishing hotspots (Karin van der Reijden, University of Groningen)
14:30	Short Break				
14:40	Mechanisms behind large herbivore grazing effects on grassland invertebrate communities (Yu Zhu, Netherlands Institute of Ecology)	Large effect loci for lifespan segregate in natural populations of <i>Drosophila melanogaster</i> (Joost van den Heuvel, Wageningen University & Research)	Large herbivores promote plant diversity not only via removal of aboveground biomass in the long term (Qingqing Chen, University of Groningen)	Demography of a stable population of crab plovers wintering in Oman (Roeland A. Bom, Royal Netherlands Institute for Sea Research)	Woody plant encroachment in African savannas: the interactive effect of anthropogenic disturbance, geology and tree functional traits (Inger de Jonge, University of Groningen)
15:00	Risks and opportunities of trophic rewilding for arthropod communities (Michiel WallisDeVries, Dutch Butterfly Conservation / Wageningen University & Research)	The genome of the live-bearing fish <i>Heterandria formosa</i> implicates a role of conserved vertebrate genes in the evolution of placental fish (Henri van Kruistum, Wageningen University & Research)	Top-down predation pressure outweighs the effect of overstorey tree species composition on herbivory levels and growth of saplings in deciduous forest fragments (Daan Dekeukeleire, Ghent University)	Are mother's cursing their sons? Prevalence of mtDNA induced sex-specific differences in survival and fertility in zoo populations (Marloes Leeflang, Zoo Antwerp Centre for Research and Conservation)	Eco-engineering dunes: Exploring the spatiotemporal effects of small-scale blowouts for dune grassland restoration (Yuki Fujita, KWR)

15:20	Building ecosystems from scratch: facilitating marsh development at the Marker Wadden archipelago (Marloes van den Akker, Radboud University)	Natural genetic variation in the response to nutrition in the fungus <i>Podospora anserina</i> (Jelle Zandveld, University of Amsterdam / Wageningen University & Research)	Modelling global consequences of megafauna extinction on top-down control in ecosystems (Selwyn Hoeks, Radboud University)	Directional breeding migration of harbour seals in the Wadden Sea (Sophie M.J.M. Brasseur, Wageningen University & Research)	Predicting climate change effects on global vegetation patterns using a trait-based approach (Coline Boonman, Radboud University)
15:40	Coffee and tea in the lounge				
	Europe Hall	America Hall	Asia Hall	Africa Hall	Vide Hall
16:00	Parallel 2a: Animals adjusting to a rapidly changing world	Parallel 2b: Nature's Followers	Parallel 2c: Urban Ecology	Parallel 2d: Fungal interactions in a changing world	Parallel 2e: Carbon and Nutrient Dynamics
	<i>Conveners:</i> 1. Bart Nolet (Netherlands Institute of Ecology / University of Amsterdam) 2. Martijn van de Pol (Netherlands Institute of Ecology) 3. Jan van Gils (Royal Netherlands Institute for Sea Research)	<i>Conveners:</i> 1. Monique de Jager (Netherlands Institute of Ecology) 2. Marijke van Kuijk (Utrecht University)	<i>Conveners:</i> 1. Dries Bonte (Ghent University) 2. Matty Berg (Vrije Universiteit Amsterdam)	<i>Conveners:</i> 1. Alena Gsell (Netherlands Institute of Ecology) 2. Silke Van den Wyngaert (IGB Leibniz - Institute of Freshwater Ecology and Inland Fisheries) 3. Hans-Peter Grossart (IGB Leibniz - Institute of Freshwater Ecology and Inland Fisheries)	<i>Conveners:</i> 1. Mariet Hefting (Utrecht University) 2. Paul Bodelier (Netherlands Institute of Ecology) 3. Elly Morriën (University of Amsterdam)
	There is ample evidence that the world is changing more rapidly than ever before as a result of direct and indirect human influence. In fact, changes are occurring so fast that we as ecologists can study the way organisms are responding to these changes. In this session, we want to show examples of animals trying to cope with these changes by behavioural, physiological or somatic changes.	Using modern technology, we have become nature's followers: we can camera trap every animal that lives in an ecosystem and gps-track individuals over long periods of time. In this session, researchers will present what they are monitoring, how and why they are doing this, and how the excessive amounts of obtained data are analysed.	Urban ecosystems cover a small but continuously increasing proportion of land surfaces, and tend to differ greatly from natural or rural areas in several biogeochemical/physical drivers of biodiversity and ecosystem functioning. Urbanisation therefore imposes a strong selection pressure and environmental filter. Because it is a global phenomenon, it provides a unique opportunity to study adaptive strategies of species towards often extreme human impacts like pollution, fragmentation and warming.	Fungi are known for their detrimental (e.g. parasitism) and beneficial (e.g. mutualism) interactions with other organisms and even for switching their interaction type when environmental conditions change. Thereby, their ecological role can greatly change, resulting in different food-web interactions and ecosystem level outcomes. The aim of this session is to highlight the ecological role of terrestrial and aquatic fungi in ecosystem processes, the diversity and variability of their interactions and their response to environmental change.	Ecosystems can be significant carbon sources or sinks depending on their management. There is a growing concern that ecosystems will increasingly function as CO ₂ -source as climate warms and nutrient enrichments increase. Concurrently, initiatives as 4p1000 claim that a slight increase in ecosystem C-sequestration could fully compensate anthropogenic increases of atmospheric CO ₂ . This session provides a platform for a wide range of studies on carbon and nutrient dynamics in the context of climate change mitigation.
16:00	A bird's-eye view: organisms coping with rapid environmental change (Ron Ydenburg, Simon Fraser University)	Village size affects occupancy of ground-dwelling animals in Suriname (Marijke van Kuijk, Utrecht University)	Urbanisation affects functional diversity of soil fauna, but the direction and strength depend on soil type (Matty P. Berg, Vrije Universiteit Amsterdam / University of Groningen)	Fungi – a key component at the base of terrestrial and aquatic food webs (Hans-Peter Grossart, Leibniz Institute of Freshwater Ecology and Inland Fisheries)	Reducing the GHG emission by peatland rewetting – An estimation for the Peelvenen using vegetation maps (Gert-Jan van Duinen, Radboud University)

16:20	Demographic and distributional responses by adult long-distance migrating shorebirds to the rapid loss of staging habitat (Ying-Chi Chan, University of Groningen)	The effect of Wild ungulate abundance on temperate forests: a camera trapping approach (Juan Ignacio Ramirez, Wageningen University & Research)	Big City Life: genotypic trait differentiation in thermal adaptation, life history, physiology, and pace-of-life in response to urbanization in <i>Daphnia magna</i> (Kristien I. Brans, KU Leuven)	Tracking trade strategies of arbuscular mycorrhizal fungi with fluorescing quantum-dots exposed to fluctuations in resource availability (Anouk van 't Padje, Vrije Universiteit Amsterdam)	Modulating greenhouse gas balance by combinations of organic amendments (Kristof Brenzinger, Netherlands Institute of Ecology)
16:40	Too darn hot: impact of global warming on trophic interactions in simulated communities (Lionel Hertzog, University of Ghent)	The effects of heat on diel activity patterns of mammals in a Neotropical forest (Cristina Lopez-Malaga, Wageningen University & Research)	Urban-associated changes in the immune system of common blackbirds in Europe (Juan Diego Ibáñez-Álamo, University of Groningen)	An integrative transcriptomic atlas of symbiosis development, nutritional status and sporocarp maturation highlights functional adaptation of ectomycorrhizal fungi (Joske Ruytinx, Universiteit Hasselt)	Impact of large mammalian herbivores on soil carbon and nutrient sequestration (Judith Sitters, Vrije Universiteit Brussel)
17:00	Short Break				
17:10	Fuelling conditions at staging sites can mitigate Arctic warming effects in a migratory bird (Eldar Rakhimberdiev, Royal Netherlands Institute for Sea Research / Lomonosov Moscow State University)	Tracking the Bewick's swan: an unprecedented insight in swan behaviour during spring migration (Rascha Nuijten, Netherlands Institute of Ecology)	On time in the urban environment: direct and systemic impact of light at night on daily activity of birds and small mammals (Kamiel Spoelstra, Netherlands Institute of Ecology)	Know your neighbour: plant neighbour identity plays a role in soil-borne fungal disease transmission in susceptible hosts (Eline A. Ampt, Wageningen University & Research)	How to measure the tree logs mass loss rate more correctly? (Chenhui Chang, Vrije Universiteit Amsterdam)
17:30	Comparing gosling growth between Arctic- and temperate-breeding barnacle goose populations (Chiel Boom, Netherlands Institute of Ecology)	Using GPS and accelerometer tracking to quantify spatiotemporal differences in foraging time among feeding specialisations (Henk-Jan van der Kolk, Netherlands Institute of Ecology)	Adaptive changes in sexual signalling in response to urbanisation (Wouter Halfwerk, Vrije Universiteit Amsterdam)	Drying-rewetting and freezing-thawing leave different legacies in soil microbial communities (Annelein Meisner, Lund University / Netherlands Institute of Ecology)	The impact of <i>Typha latifolia</i> paludiculture on nutrient dynamics and greenhouse gas emissions in rewetted peatlands (Renske Vroom, Radboud University)
17:50	25 Year of red knot numbers in the Wadden Sea explained by changing food conditions (Sterre Witte, Royal Netherlands Institute for Sea Research)	Orographic lift shapes flight routes of gulls in virtually flat landscapes (Elspeth Sage, University of Amsterdam)	Plants are favoured by our city: selection for larger and more tolerant to insect herbivore (Jiao Qu, Ghent University)	Combining targeted isolation approaches with environmental sequencing to unveil ecological interactions of aquatic chytrid fungi (Silke Van den Wyngaert, Leibniz Institute of Freshwater Ecology and Inland Fisheries)	What is the impact of palm swamp forest degradation on peat carbon fluxes in the Peruvian Amazon? (Jeffrey van Lent, Center for International Forestry Research, Bogor, Indonesia / Wageningen University & Research)
18:10	Drinks in the Lounge and from 18:30 onwards dinner in the restaurant				
19:30	Poster session 1				
21:00	Evening Programme: "Bending the Curve": Biodiversity Recovery in the Netherlands via "Het Deltaplan Biodiversiteitsherstel" (Moderators: Louise Vet and Koos Biesmeijer, board NERN) In this programme the Deltaplan Biodiversiteitsherstel will be presented and discussed. Amongst others, focus will be on how we as ecologists can contribute to the success of the Deltaplan.				

Wednesday 13 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: Full annual cycle research in ecology	Parallel 3b: Management of (overabundant) herbivore populations	Parallel 3c: Soil Ecology	Parallel 3d: Ecological consequences of rapid evolution	Parallel 3e: Governing dynamics of community assembly: from big data to best practices
	<i>Conveners:</i> 1. Magali Frauendorf (Netherlands Institute of Ecology) 2. Morgan Brown (University of Amsterdam)	<i>Conveners:</i> 1. Daan Bos (Altenburg & Wymenga ecological consultants) 2. Ronald C. Ydenberg (Simon Fraser University Burnaby, Canada) 3. E. Emiel van Loon (University of Amsterdam)	<i>Conveners:</i> 1. Davide Francioli (Wageningen University & Research) 2. Ciska Veen (Netherlands Institute of Ecology)	<i>Conveners:</i> 1. Steven Declerck (Netherlands Institute of Ecology) 2. Jacintha Ellers (Vrije Universiteit Amsterdam)	<i>Conveners:</i> 1. Edwin T. Pos (Utrecht University) 2. Marco D. Visser (Princeton University)
	Annual cycles consist of breeding and non-breeding periods that are often clearly separated in space and time, but that are biologically intricately linked. These inter-seasonal effects are poorly understood but are crucial to understand population dynamics and space use, making full annual cycle research important for effective conservation and management. This session examines how environmental conditions and individual state in one season carry over to influence the performance in the subsequent season, and what the consequences of these seasonal interactions are.	In the cultural landscape there are obvious fields of tension between human interests and highly abundant herbivores. Mitigation of problems may be achieved a.o. using technical measures, the influencing of animal behaviour, or more or less careful population management. This session aims at providing a platform for studies that test and develop theory or practical instruments for wild-life management, as well as case studies where the scientific basis and effectivity of actual management decisions are being evaluated.	In terrestrial ecosystems, soil organisms are involved in a series of important ecological processes and functions, such as nutrient cycling, support of plant growth, degradation of pollutants and buffering against acute environmental changes. In this session, we focus on the ecological and functional role that (micro)organisms play in soil ecosystems.	The potential of contemporary evolution to lead to rapid trait change is increasingly being recognized. Microevolutionary dynamics can be so fast as to affect the outcome of species interactions, geographic range shifts and the stability of populations and communities. By presenting in-depth case studies on a wide variety of organism types, this session will illustrate how rapid evolutionary change provides a pathway to a broad range of ecological dynamics.	Big data in ecology is pushing new boundaries for ecological analyses, but it also brings novel pitfalls and dangers. Global datasets offer a grand opportunity to disentangle the governing dynamics of ecosystems, but it also sets novel challenges: the need to develop efficient analytical tools and new evidentiary standards to prevent spurious correlations. How to deal with these challenges and where to go from here? How do we go from big data to best practices?
08:30	An overview of full annual cycle research in animal ecology – case study: the Eurasian oystercatcher (Magali Frauendorf, Netherlands Institute of Ecology)	A suitable evidence-base for the management of overabundant herbivores (Daan Bos, Altenburg & Wymenga ecological consultants)	Will follow soon (Gerlinde De Deyn, Wageningen University & Research)	Ecological consequences of rapid evolution (Steven Declerck, Netherlands Institute of Ecology)	The future of ecology: Big data, Big questions and Big problems (Edwin T. Pos, Utrecht University)
08:50	Individual quality mitigates environmental effects on future reproductive performance of a threatened shorebird	Fallow Deer have biodiversity on the menu (Vincent van der Spek, Waternet)	Understanding the soil microbiome in function of soil resistance and resilience (Lisa Joos, Flanders Research Institute for Agriculture, Fisheries	<i>Daphnia</i> microbiome and genotype interact to affect the assembly of the bacterioplankton (Ellen Decaestecker, KU Leuven)	Big data in Ecology may not be so big but still useful – an example from a big forest (Hans ter Steege, Naturalis Biodiversity Center)

	(Jurrian van Irsel, Radboud University)		and Food (ILVO) / Ghent University)		
09:10	Managing time in a changing world: timing of annual cycle stages under climate change (Marcel Visser, Netherlands Institute of Ecology)	A large-scale experiment to evaluate the effects of trapping on muskrat (<i>Ondatra zibethicus</i>) population development in The Netherlands (E. Emiel van Loon, University of Amsterdam)	Fine-mapping rhizosphere communities: opening Pandora's black box (Paula Harkes, Wageningen University & Research)	Intraspecific trait variation and trade-offs within and across populations of harmful algae (Dedmer van de Waal, Netherlands Institute of Ecology)	How large-scale DNA sequencing of environmental samples helps us open the "black box" of fungal community assembly in tropical, temperate, and arctic biomes (Jozsef Geml, Naturalis Biodiversity Center)
09:30	Short Break				
09:40	Full annual cycle research on individual red knots <i>Calidris canutus</i> (Theunis Piersma, Royal Netherlands Institute for Sea Research / University of Groningen / Global Flyway Network)	Managing geese through their landscape of fear? The potential effect of human disturbance on the distribution of geese (Nelleke Buitendijk, Netherlands Institute of Ecology)	Benefits of stimulating saprotrophic fungi in arable soils (Anna Clocchiatti, Netherlands Institute of Ecology)	Eco-evolutionary consequences of connectedness loss: an experimental approach (Stefano Masier, Ghent University)	How the Microbial Rare Biosphere Coexist with Dominant Species? (Xiu Jia, University of Groningen)
10:00	Favourable energy balance, but poor fitness, in Sanderlings wintering in tropical rather than temperate zones (Jeroen Reneerkens, University of Groningen)	Anthropogenic landscape of fear shapes deer space use but not browsing levels (Bjorn Mols, University of Groningen)	Soil biodiversity unraveled: the functional importance of small predators (Stefan Geisen, Netherlands Institute of Ecology)	What costs and benefits for foraging efficiency are involved in rapid evolution of learning ability? (Maartje Liefiting, Freie Universität Berlin / Vrije Universiteit Amsterdam)	Big(ger) data with DiSSCo (Niels Raes, Naturalis Biodiversity Center)
10:20	Does migration strategy influence plasticity of nonbreeding movements in a generalist seabird? (Morgan Brown, University of Amsterdam)	Oostvaardersplassen: a (too) novel ecosystem? (Han Olff, University of Groningen)	Disturbance intensity alters soil microbial community reassembly dynamics (Simone Weidner, Utrecht University / Netherlands Institute of Ecology)	Rapidly evolving zooplankton in a salinizing world: to what extent does adaptation to one salt increase tolerance to another one? (Libin Zhou, Netherlands Institute of Ecology)	Bigger isn't always better: how regression dilution distorted the perception of negative density dependence (Marco D. Visser, Princeton University)
10:40	Coffee and tea in the lounge				
	Europe Hall				
11:00	Plenary 2: "Estuarine & Coastal Ecology in the Anthropocene: challenges and opportunities" Most of the world's human population live along coasts and delta's, raising questions on how to preserve marine ecosystems despite urbanisation, and how to protect humanity from flooding. <i>Laura Airolidi</i> will highlight a framework for designing marine infrastructures that meet multifaceted goals, by offering examples of "green" engineering approaches aiming at continue and/or rehabilitate relevant ecosystem services. <i>Tjeerd J. Bouma</i> will highlight the latest insights on Nature Based Solutions for coastal defence in relation to global change processes.				
11:00	1. Discovering, understanding and sustaining marine ecosystems along increasingly artificial coastlines Laura Airolidi, Department of Biological, Geological, and Environmental Sciences, University of Bologna, Italy				
11.45	2. Sustaining intertidal ecosystems under climate change for coastal protection Tjeerd Bouma, Department of Estuarine & Delta Systems, Royal Netherlands Institute for Sea Research, The Netherlands				
12:30	Lunch in the restaurant				
13:30	Poster Session 2				

	Europe Hall	America Hall	Asia Hall	Africa Hall	Vide Hall
15:00	Parallel 4a: Estuarine & Coastal Ecology in the Anthropocene	Parallel 4b: Using small-scale data for large-scale questions	Parallel 4c: Tropical Ecology	Parallel 4d: Understanding spatial patterns in biodiversity	Parallel 4e: Host associated microbiome interactions and their implications for host ecology
	<i>Conveners:</i> 1. Karin van der Reijden (University of Groningen) 2. Laura Govers (Royal Netherlands Institute for Sea Research) 3. Oscar Bos (Wageningen Marine Research)	<i>Conveners:</i> 1. Melinda de Jonge (Radboud University) 2. Coline Boonman (Radboud University) 3. Leila Meyer (Federal University of Goiás, Brasil)	<i>Conveners:</i> 1. Marielos Peña Claros (Wageningen University & Research) 2. William Gosling (University of Amsterdam) 3. Patrick Jansen (Wageningen University & Research / Smithsonian Institution)	<i>Conveners:</i> 1. Jeroen van Leeuwen (Wageningen University & Research) 2. Stefan Geisen (Netherlands Institute of Ecology)	<i>Conveners:</i> 1. Ellen Decaestecker (KU Leuven) 2. Jie Hu (Utrecht University)
	Coastal seas, such as the North Sea, provide us with food, protection, and recreation possibilities and are valued for their ecological wealth. Simultaneously, these systems are increasingly threatened by global change, rising world populations and coastal urbanization. To conserve these ecosystems, scientific knowledge of mechanisms and processes driving coastal ecosystem degradation is essential. In this session, we provide a platform for scientific research that supports evidence-based conservation, sustainable management and habitat restoration of coastal seas.	In ecology, we try to understand the relationship between organisms and their environment at different scales: from local populations to meta-communities to global patterns in biodiversity. While research questions may change with scale, the data that is used in analyses remains the same. In this session, we focus on how small-scale data is used to answer macroecological questions, and aim to highlight the relevance of large-scale studies for improving our understanding of general ecological concepts.	This session deals with studies focused on tropical ecosystems, including terrestrial as well as marine systems. We particularly welcome talks focused on explaining the extraordinary high biodiversity, or on understanding anthropogenic impacts on this diversity.	The spatial distribution of organisms is still largely unknown, either due to lack of quantitative data in general, or to the lack of harmonization of existing data sets. Harmonization necessitates knowledge on both biological methods and spatial statistics and databases. Linking spatial patterns in organism distribution to environmental properties and management lead to further understanding of these patterns. Talks covering these issues in the spatial distribution of soil-, aboveground or aquatic organisms are welcome.	The microbiome is highly complex and flexible, and can respond rapidly to changes in host genotypes/diets or (a)biotic environmental disturbance, e.g. via chemical communication. Host associated microbiomes may thus represent an important source of metabolic flexibility for the host and comprise interactions among individuals inside a specific community. In this symposium, we aim to understand interactions between microbiomes and host genetics, microbiome mediated local adaptation, microbiome interactions at the community level and what the implications are for host ecology and ecosystems in general.
15:00	Marine conservation and restoration ecology in a changing world (Laura Govers, University of Groningen / Royal Netherlands Institute for Sea Research)	Using small-scale data for large-scale questions (Melinda de Jonge / Coline Boonman, Radboud University)	Predator avoidance and prey tracking in a Neotropical forest (Constant Swinkels, Wageningen University & Research)	Understanding (and mapping) of spatial patterns in biodiversity (Jeroen van Leeuwen, Wageningen University & Research / Stefan Geisen, Netherlands Institute of Ecology)	Eco-evolutionary dynamics and gut microbiome (Shinjini Mukherjee, KU Leuven)
15:20	Biomimicry can amplify coastal restoration success by bridging establishment thresholds for habitat-forming plants (Ralph Temmink, Radboud University)	European bees are modulated by local and landscape context interactions. (Juan Gallego-Zamorano, Radboud University)	The role of fig volatiles in pollinator specificity and fig diversity (Aafke Oldenbeuving, Naturalis Biodiversity Center)	To what extent is the current spatial distribution of organisms shaped by past environmental dynamics? (Sietze J. Norder, Universidade de Lisboa / University of Amsterdam)	Effects of warming, trophic status and host genotype on zooplankton microbiomes (Paul L.E. Bodelier, Netherlands Institute of Ecology)

15:40	Lowering settlement thresholds to increase restoration success of intertidal musselbeds (Jildou Schotanus, HZ University of Applied Sciences)	Intra- and inter-specific patterns of population density in terrestrial vertebrates (Luca Santini, Radboud University)	Mangrove Atlantis: Can mangroves keep up with extreme land-subsidence? (Celine van Bijsterveldt, Royal Netherlands Institute for Sea Research)	Disentangling causes of spatial autocorrelation in species' distributions (Konrad Mielke, Radboud University)	Prenatal transfer of gut bacteria occurs in birds: evidence from rock pigeons (Maurine W. Dietz, University of Groningen)
16:00	Short Break				
16:10	A mega-nourishment as a promising eco-friendly alternative to regular sand nourishment for the intertidal macroinvertebrate community (Emily van Egmond, Vrije Universiteit Amsterdam)	Evaluating the reliability of plant species distribution models with ecological indicator values (Marjon Hendriks, PBL Netherlands Environmental Assessment Agency)	The fate of forests in agro-forest frontier landscapes, implications for conservation (Madelon Lohbeck, Wageningen University & Research)	The Dutch Bird Atlas, citizen science delivering detailed spatio-temporal patterns: a wealth of data for ecological research (Ruud P.B. Foppen, SOVON - Dutch Centre for Field Ornithology)	Long-distance chemical interactions in terrestrial ecosystem (Adam Ossowicki, Netherlands Institute of Ecology)
16:30	Top-down pressure on a coastal ecosystem by harbor seals (Geert Aarts, Wageningen Marine Research / Royal Netherlands Institute for Sea Research)	Using airborne laser scanning to quantify fine-scale habitat structures at macroscales (W. Daniel Kissling, University of Amsterdam)	Trends in the variability of Specific Leaf Area of paramo vegetation during succession (Marian Cabrera, University of Amsterdam)	Predicting bird-mediated dispersal of wetland plants from seed traits (Casper H.A. van Leeuwen, Netherlands Institute of Ecology)	Spice it up: are biochar and chitin the salt and pepper of horticulture (Caroline De Tender, Ghent University)
16:50	The spatial distribution of benthic organisms and sand ripples over tidal sand waves: insights from a submerged camera system (Johan Damveld, University of Twente)	GLOBIO 4: a global model of local biodiversity intactness (Aafke Schipper, PBL Netherlands Environmental Assessment Agency / Radboud University)	Succession dynamics of tree and soil fungal communities in regenerating tropical rainforests are strongly influenced by regional species pool and abiotic factors (Irene Adamo, Naturalis Biodiversity Center)	Hydro- and morphodynamics affecting the spatial distribution of macrozoobenthic communities on estuarine intertidal flats (Natalie Steiner, Royal Netherlands Institute for Sea Research)	The power of the crowd: how Black Soldier Fly larvae and organic waste type influence bacterial succession in substrate and larval gut (Stijn Schreven, Wageningen University & Research)
17:30	Awards and Closing Ceremony				
18:00	Farewell drinks				
18:30	Dinner and NERN board meeting				
19:30	End / Travel Home (Shuttle available between Conference Centre and Lunteren Station)				

NAEM 2019

Presentation Abstracts

Plenary Session 1

Rewilding in the face of Global Change

Throughout human history, global wildlife loss (defaunation) has disproportionately affected large animals and the functions they have in ecosystems. Rewilding aims to restore these functions through the re-introduction of missing, large wildlife species. However, rewilding can also be applied through the restoration of water level dynamics in ecosystems. In this session, we focus on the concepts, opportunities and impacts of rewilding as a restoration approach in the face of global change.

1. Trophic rewilding – background, opportunities and challenges for megafauna-based restoration in the Anthropocene

(Jens-Christian Svenning, Aarhus University)

A large proportion of current real-world ventures named as rewilding fall under the concept of trophic rewilding, as do much discussion of rewilding. Trophic rewilding is an ecological restoration strategy that uses species introductions to restore top-down trophic interactions and associated trophic cascades to promote self-regulating biodiverse ecosystems (<http://bit.ly/rewildingPNAS>). Trophic rewilding is often focused on large-bodied animals (both herbivores and carnivores) due to their ecological and societal importance and the widespread, strong historical and recent prehistorical losses of megafauna in most regions around the world. In this presentation, I will first discuss the concept of trophic rewilding, and then outline the scientific background for trophic rewilding, integrating paleoecology and contemporary ecology. Key themes here will be the fact that megafauna-rich ecosystems have been the norm on evolutionary timescales, with the widespread modern-day megafauna-poor ecosystems being a novel situation, and the emerging evidence for the strong ecological importance of large-bodied animals. I will also discuss the current role of trophic rewilding in nature conservation and ecological restoration as well as its potential, now and in the future. Finally, I will outline key research priorities and possibilities in relation to trophic rewilding.

2. Rewilding: impact on ecosystems under global change

(Liesbeth Bakker, Netherlands Institute of Ecology)

Ecosystems worldwide are increasingly affected by human-induced global change, including over-exploitation of living systems, temperature rise, eutrophication and exotic species proliferation, resulting in a biodiversity crisis. Furthermore, human societies increasingly experience disasters as an increase in flooding events and wildfires, with further increases likely in the near future. Therefore, new thinking is needed to address these pressing societal and biodiversity conservation challenges. Rewilding could potentially offer such a new way of thinking, as it is a future-oriented process-oriented and non-static restoration strategy. Through its focus on natural processes, rewilding advocates new ways of land management, focused on restoring diversity-maintaining autonomous mechanisms in nature. By restoring more complete ecosystems, rewilding—if successful—could (i) confer greater robustness (resistance or resilience) to the pressures from global change and (ii) by restoring (more) self-managing ecosystems help reduce needs for people and domestic animals for ongoing management, which overall should release economic and human resources for other uses. By combining functions such as water storage capacity and giving room to natural processes, rewilding could contribute to finding solutions for flooding and drought problems as well as increase biodiversity. Such examples are now becoming available and will be discussed in the plenary.

Plenary Session 2

Estuarine & Coastal Ecology in the Anthropocene: challenges and opportunities

Most of the world's human population live along coasts and delta's, raising questions on how to preserve marine ecosystems despite urbanisation, and how to protect humanity from flooding. *Laura Airoidi* will highlight a framework for designing marine infrastructures that meet multifaceted goals, by offering examples of "green" engineering approaches aiming at continue and/or rehabilitate relevant ecosystem services. *Tjeerd J. Bouma* will highlight the latest insights on Nature Based Solutions for coastal defence in relation to global change processes.

1. Discovering, understanding and sustaining marine ecosystems along increasingly artificial coastlines

(Laura Airoidi, University of Bologna)

Most people in the world live in coastal cities. As coasts have become more urbanised globally, natural habitats and associated biota have been damaged, with loss of environmental quality, vital ecosystem services and livelihood. Losses are accelerating, and the current and future challenges faced by urban coastlines are diverse and substantial. Mainstream urban ecology has largely overlooked the influence of human activities on marine environments. The marine biodiversity of ports and urban waterfronts is poorly documented, and mechanistic understanding of their ecological functioning is missing. Despite their human dominated and mostly artificial nature, marine habitats along ports and urban waterfronts can still support a variety of communities and ecosystem services, making them important areas for urban conservation and ecological rehabilitation. I will introduce a conceptual framework for designing marine artificial infrastructures that meet multifaceted project goals and provide better outcomes for the society, and I will offer examples of "green" engineering approaches aiming at continue and/or rehabilitate relevant ecosystem services. I will also discuss the management and societal challenges to the rehabilitation of natural marine habitats in urban systems subjected to multiple co-occurring and potentially interacting uses and stressors, and conclude by highlighting the relevance and potential of a sustainable "blue" economy.

2. Sustaining intertidal ecosystems under climate change for coastal protection

(Tjeerd J. Bouma, Royal Netherlands Institute for Sea Research)

On the one hand, there is a growing awareness that valuable intertidal ecosystems like salt marshes, mangroves, seagrass meadows, oyster reefs, etc., have gone lost over the last decades. And to date these ecosystems remain highly threatened by continued anthropogenic impacts. On the other hand, we increasingly value these ecosystems for the ecosystem services that they provide, among others, their capacity to contribute to coastal defence in the face of climate change. To enable the usage of Nature Based Solutions for coastal defence, we need to understand the effectiveness of such ecosystems under extreme physical forcing, be able to restore these ecosystems where needed, and perhaps most importantly, understand their long-term resilience under climate change. Answering such applied questions, requires fundamental insight in how different types of estuarine organisms are affected by, and able to influence their physical environment. In this presentation I will provide an overview of some recent insights in i) how estuarine ecosystems contribute to coastal defence, ii) the main drivers of their dynamics, iii) the mechanisms behind natural establishment, iv) how we can use such insight for ecosystem restoration and v) potential management implications. I will discuss how these issues are affected by global change processes like sea level rise and enhanced wave climates.

Parallel Session 1

1a: Defaunation and rewilding

Conveners: Liesbeth Bakker (Netherlands Institute of Ecology)
Marjolein Sterk (Wageningen University & Research)
Jens-Christian Svenning (Aarhus University)

1. Rewilding: a resilience approach

Marjolein Sterk, Edwin Peeters
Wageningen University & Research

For decades we have tried to create a better world. Based on our knowledge on social-ecological systems we agreed on goals for e.g. social, economic and environmental development. Though the complexity of the world perturb the trajectories to these goals. And even the goals will never be reached. Increasingly, cracks are appearing in the capacity of communities, ecosystems, and landscapes to provide the goods and services that sustain our planet's well-being. The response from most actors has been for "more of the same" that created the situation in the first place: more control, more intensification, and greater efficiency. With a rewilding-approach nature managers seek to generate space for self-organizing and adaptive ecosystems including humans. This paradigm shift from a command-and-control management to ecosystem-based management implies that we have to reconsider our future visions. A resilience thinking approach investigates how these interacting systems of people and nature can best be managed in the face of disturbances, surprises and uncertainty. We define resilience as the capacity of a system, be it an individual, a forest, a metropole or an economy, to deal with change and continue to develop in a just safe operating space.

2. Top-down, bottom-up and horizontal effects: an expanded framework to evaluate the need and success of rewilding

Luis Santamaría, Juan Giralt, Pablo Fernández-Méndez
Estación Biológica de Doñana (EBD-CSIC)

Throughout human history, global wildlife loss (defaunation) has disproportionately affected large animals and the functions they have in ecosystems. Rewilding aims to restoring these functions through the re-introduction of missing, large wildlife species (or suitable proxies of those already extinct). Rewilding initiatives in place show, however, a strong emphasis on the re-introduction of large herbivores, aimed at generating desirable effects such as mesoherbivore control, changes in vegetation structure and increases in plant diversity – which may cascade to other groups, such as invertebrates. This bias towards large herbivores reflects a combination of social convenience (other groups, such as predators, are often less acceptable for local stakeholders) and a biased perception of top-down processes as the main drivers of ecosystem structure and function. Current ecological theory suggest, however, that ecosystems are regulated by the interplay between top-down and bottom-up processes; and horizontal processes (e.g. intra-guild competition) are also dependent on these two controllers. Ignoring such interactions may push the system into undesirable socio-ecological states that hamper rather than promote ecosystem functions, services and resilience. We build on available examples of unintentional and intentional introductions of wild and domestic, large herbivores to exemplify some of these consequences. Given the high levels of uncertainty involved, rewilding initiatives should adhere explicitly to an adaptive management framework if they sincerely aim at being successful.

3. Defaunating synergic large herbivore functions in tropical forests

Nacho Villar, Tadeu Siqueira, Valesca Zipparro, Fabiano Farah, Pedro Jordano and Mauro Galetti
Universidade Estadual Paulista, São Paulo, Brazil

Defaunation of large-bodied herbivores from ecosystems has a strong influence on the regulation of plant diversity. Yet for forest ecosystems the mechanisms behind such process are poorly understood. The Janzen-Connell (JC) model of diversity suggests that natural enemies such as seed predators suffice to generate diversity amongst plant communities in forest ecosystems, without accounting for the possible synergic effects of seed dispersal by mutualist frugivores. We conducted a long-term multisite landscape-scale exclusion experiment across gradients of defaunation in the hyperdiverse Atlantic Forest of Brazil, where most large herbivores are also frugivores. We examined experimentally how two functionally distinct large generalist mammalian herbivore species (the lowland tapir, a hypergeneralist browser and seed disperser, and white-lipped peccary, a hypergeneralist seed and seedling predator) affect spatiotemporal patterns of diversity of seedling communities in tropical forests. Our results suggest synergic effects of both herbivore functional types on the regulation of diversity in space and time. In combination, both herbivores increased beta diversity of dominant plant species and reduced alpha diversity of rare species, contradicting some of the predictions of the JC model. We propose that mechanistic models of herbivore regulation of plant diversity need to take into account synergistic effects of predation and seed dispersal.

4. Mechanisms behind large herbivore grazing effects on grassland invertebrate communities

Yu Zhu, Ciska Veen, Liesbeth Bakker
Netherlands Institute of Ecology

Grasslands host a high biomass and diversity of invertebrates, which have special significance in structuring the food web and maintaining ecosystem functions. Grassland is also a managed ecosystem, which provides food for abundant mammalian domestic and wild herbivores. In the Netherlands, a lot of native and domestic herbivores were reintroduced into many small nature reserves following the idea that the presence of large herbivores provides more opportunities for natural processes to take place and therefore make ecosystems more complete and diverse. However, invertebrates as an essential part of the food webs usually are ignored in the rewilding process, and the knowledge on the mechanisms by which large herbivore grazing affects invertebrate communities is largely missing. To fill this gap in our understanding, we compared the biomass and abundance of invertebrates of several trophic levels within and outside long-term herbivore exclosures at four grassland locations in the Netherlands. We also measured vegetation and microclimate parameters to disentangle the cascading effects of the large herbivores across different trophic groups of invertebrates.

5. Risks and opportunities of trophic rewilding for arthropod communities

Michiel WallisDeVries, Roel van Klink
De Vlinderstichting / Dutch Butterfly Conservation, Wageningen University & Research

Trophic rewilding is a restoration strategy focusing on the restoration of trophic interactions to promote self-regulating, biodiverse ecosystems. It has been proposed as an alternative to traditional conservation management in abandoned or defaunated areas. Arthropods constitute the most species-rich group of eukaryotic organisms, but are rarely considered in rewilding. Here, we first present an overview of direct and indirect pathways by which large herbivores and predators affect arthropod communities. We then review the published evidence of the impacts of rewilding with large herbivores on arthropods. We find that systematic monitoring is rare and comparison with a relevant control treatment is usually lacking. Nevertheless, the available data suggest that when the important process of top-down control of large-herbivore populations is missing, arthropod diversity tends to decrease. To ensure that rewilding is supportive of biodiversity conservation, we propose that if natural processes can only partially be restored, substitutes for missing processes are applied. We also propose that boundaries of acceptable outcomes of rewilding actions should be defined a priori, particularly concerning biodiversity conservation, and that action is taken when these boundaries are transgressed. To evaluate the success of rewilding for biodiversity, monitoring of arthropod communities should be a key instrument.

6. Building ecosystems from scratch: facilitating marsh development at the Marker Wadden archipelago

Marloes van den Akker, Leon Lamers, Liesbeth Bakker, Han Olff
Radboud University

The Marker Wadden can be seen as an iconic example of wilderness engineering: it is a large constructed archipelago of freshwater mud flats and marshes build for nature development. The islands are located in Lake Markermeer, one of the largest freshwater lakes in Western Europe. Due to land reclamation and the construction of dikes and dams, Lake Markermeer barely has any natural shores left. Moreover, its water is very turbid because of continuous resuspension of accumulated sediment by wind and waves, resulting in an impoverished food web with low numbers of algae, zooplankton, and a decrease in fish and bird species. The Marker Wadden aims to increase the productivity of the benthic and pelagic food webs around the islands by creating soft shorelines, sheltered areas where sediment can settle and by creating highly productive marshes. As a novel ecosystem, the Marker Wadden provide great opportunities to examine the driving mechanisms behind early establishment, succession, community assembly and landscape formation. My current research focuses on how the abiotic starting conditions interact with biota and how this shapes the environment. Water table and soil organisms heavily influence the physical conditions of the soft sediment which was used as a building material. Moreover, *Phragmites australis* seems to play an important role in the soil biogeochemistry and biogeophysics, which may influence the further establishment of species and thus the assembly of communities. However, the main factor shaping the ecosystem appears to be herbivory by geese, which greatly limits the development of productive marshes.

1b: Ecological genomics – Bridging the gap between ecology and genomics

Conveners: Chiara Bortoluzzi (Wageningen University & Research)
Mirte Bosse (Wageningen University & Research / VU University Amsterdam)
Per J. Palsbøll (University of Groningen)

1. Changes in DNA methylation in relation to timing of reproduction in the great tit *Parus major*

Melanie Lindner, Heidi M. Viitaniemi, Irene Verhagen, Veronika N. Laine, Marcel E. Visser, Kees van Oers & Arild Husby.
Netherlands Institute of Ecology

Timing of reproduction has major fitness consequences and is phenotypically plastic, so that lay date adaptively shifts with annual environmental variation. DNA methylation is a key regulatory mechanism known to temporarily alter the expression of phenotypes in response to environmental conditions. Here, we examine short-term variation in DNA methylation in a selection line for lay date in great tits using red blood cell samples collected throughout the breeding season. We used a reduced representation bisulfite sequencing approach and the resulting methylation call information to identify differentially methylated sites between four reproductive stages within the breeding season. Most promising findings included genes encoding for Steroidogenic factor 1 (NR5A1) and Steroidogenic acute regulatory protein (STAR). Moreover, differentially methylated sites within the promoter region of NR5A1 showed an increase in methylation level after lay date, consistent with a potential upregulation of those genes before and during egg-laying. These findings suggest that short-term variation in DNA methylation throughout the breeding season influenced timing of reproduction in the great tit. Future work should experimentally test how blood DNA methylation patterns relate to changes in gene expression levels in this and other tissues (hypothalamus, gonads) for candidate genes identified.

2. Demographic impacts of past global warming on baleen whales and their prey

Andrea A. Cabrera, Elena Schall, Martine Bérubé, Lutz Bachmann, Simon Berrow, Peter B. Best, Phillip J. Clapham, Haydée A. Cunha, Luciano Dalla Rosa, Carolina Dias, Kenneth P. Findlay, Tore Haug, Mads Peter Heide-Jørgensen, Kit M. Kovacs, Scott Landry, Finn Larsen, Xênia Moreira Lopes, Christian Lydersen, David K. Mattila, Tom Oosting, Richard M. Pace, Chiara Papetti, Angeliki Paspatis, Luis A. Pastene, Rui Prieto, Christian Ramp, Jooke Robbins, Conor Ryan, Richard Sears, Eduardo R. Secchi, Monica A. Silva, Gísli Víkingsson, Øystein Wiig, Nils Øien, Per J. Palsbøll
University of Groningen

The demography of baleen whales and their prey during the past 30 thousand years was assessed to understand the effects of past rapid global warming on marine ecosystems. Mitochondrial and genome-wide DNA sequence variation in eight baleen whale and seven prey species revealed strong, ocean-wide demographic changes that were correlated with changes in global temperatures and regional oceanographic conditions. In the Southern Ocean baleen whale and prey abundance increased exponentially and in apparent synchrony, whereas changes in abundance varied among species in the more heterogeneous North Atlantic Ocean. The estimated changes in whale abundance correlated with increases in the abundance of prey likely driven by reductions in sea-ice cover and an overall increase in primary production. However, the specific regional oceanographic environment, trophic interactions and species ecology also appeared to play an important role. Somewhat surprisingly the abundance of baleen whales and prey continued to increase for several thousand years after global temperatures stabilized. These findings warn of the potential for dramatic, long-term effects of current climate changes on the marine ecosystem.

3. Genome-wide data reveals strong impact of Pleistocene climate fluctuations on the demographic history of a tropical marine vertebrate

Jurjan P. van der Zee, Marjolijn J.A. Christianen, Mabel Nava, Tadzio Bervoets, Sietske van der Wal, Jessica Berkel, Leontine E. Becking, Per J. Palsbøll
University of Groningen

Climate fluctuations associated with the glacial cycles of the Pleistocene have been important drivers of population expansions and declines in temperate species. However, less is known about tropical species, in particular in the marine environment. The present study reconstructed the demographic history of the hawksbill turtle (*Eretmochelys imbricata*), a critically endangered tropical marine vertebrate and keystone species in coral reef ecosystems, using genome-wide data. Assuming a mutation rate of 1.2×10^{-8} per site per generation and a generation time of 24 years, trajectories of effective population size (N_e) through time were constructed using the site-frequency spectrum estimated from genome-wide markers (triRADs). Our results show hawksbill turtles rapidly expanded during marine isotopic stage 11 (~400,000 years ago), which is considered the longest and warmest interglacial during the last 500,000 years, declined during the last glacial period (~110,000 to 10,000 years ago) and expanded again during the Holocene (~10,000 years ago to present). These findings demonstrate a strong impact of glacial

cycles on the demographic history of hawksbill turtles, possibly through large-scale changes in the amount of coral reef habitat throughout the Pleistocene.

4. Large effect loci for lifespan segregate in natural populations of *Drosophila melanogaster*

Joost van den Heuvel, Bas Zwaan.

Wageningen University & Research

We study genetic variation for lifespan in the fruitfly *Drosophila melanogaster*. Starting from a large outbred founded from 6 European populations, we experimentally evolved flies and have produced long-living populations (N=12), which are divergent for correlated traits such as development time, compared to their controls (N=12, short-lived populations) and sequenced them to be able to discover candidate loci for lifespan. After this an initial validation test we found three large effect loci that associated with lifespan, each explaining >8% (together explaining 22%) of the phenotypic variation. Furthermore, a high degree of epistasis and genotype by environment interactions (with larval nutrition) were found for these loci. In a second validation step we monitored individuals and founds that other life history traits also associate with the loci. In cooperation with other *Drosophila* groups we sampled and sequenced many European populations. As expected, most divergent candidate loci in natural populations are more similar to short-lived populations, compared to long-lived populations. Furthermore, large effect loci are present in very low frequencies in natural populations but are maintained. These data suggest that large effect loci for lifespan and other life history traits occur in natural populations, but their expression depends on genetic background and environment.

5. The genome of the live-bearing fish *Heterandria formosa* implicates a role of conserved vertebrate genes in the evolution of placental fish

Henri van Kruistum, Joost van den Heuvel, Joseph Travis, Ken Kraaijeveld, Bas J. Zwaan, Martien A.M. Groenen, Hendrik-Jan Megens and Bart J.A. Pollux

Wageningen University & Research

The fish family Poeciliidae present an interesting case on the evolution of complex traits. While almost all species of this family bear live young, there is marked variation between species in the way they provision their offspring during the pregnancy. Some species retain eggs after fertilization without any additional maternal provisioning (lecithotrophy), while others show variable amounts of post-fertilization maternal provisioning (matrotrophy). Here, we investigate the genomic basis underlying variation in maternal provisioning during embryonic development by comparing the genome of the placental fish *Heterandria formosa* to the genomes of three non-placental species, all from the family Poeciliidae. Using comparative evolutionary analyses, we found 17 genes that were positively selected exclusively in *H. formosa*, as well as five gene duplications exclusive to *H. formosa*. Eight genes evolving under positive selection in *H. formosa* have a placental function in mammals, most notably endometrial tissue remodelling or endometrial cell proliferation. We hypothesize that natural selection acting on genes involved in these processes may have played a key role in the evolution of the placenta in *H. formosa*. However, to what extent these genes regulate the development of the placenta in *H. formosa* will require further investigation.

6. Natural genetic variation in the response to nutrition in the fungus *Podospora anserina*

Jelle Zandveld

University of Amsterdam / Wageningen University & Research

Life-history traits (LHT) are much affected by dietary manipulations. For example, dietary restriction (DR), a decreased nutrient intake without malnutrition, increases lifespan and reduces reproduction in many species, including the fungus *Podospora anserina*. However, *how* DR extends lifespan is still not exactly understood. As LHT's respond often gradually to environmental change, we predict to acquire more mechanistic information when measuring G*E effects using a full reaction norm. By measuring the lifespan and reproduction response to seven concentrations of dietary glucose we constructed gradual reaction norms in more than 60 wild-derived strains, and uncovered considerable (natural) genetic variation in the fungus' diet response. Firstly, we observed a significant correlation between the general lifespan and the response to glucose, showing an overlap between mechanisms mediating the lifespan *response to diet* and the mechanisms involved in general lifespan *determination**. Secondly, on intermediate diets a reduced reproduction was not always associated with lifespan extension, indicating that decoupling of these LHT's (that often trade-off) can be achieved. We discuss the potential of combining natural variation with a gradual reaction norm to improve our understanding genetic mechanisms mediating life-history plasticity to diet, and more general to other environmental interventions that affect an organism's life-history.

1c: The next generation of research on biodiversity and ecosystem functioning (BEF)

Conveners: Yann Hautier (Utrecht University)
Hans de Kroon (Radboud University)

1. The next generation of research on biodiversity and ecosystem functioning (BEF)

Yann Hautier, Hans de Kroon
Utrecht University / Radboud University

During the last three decades of research on BEF, we have accumulated evidence of the positive effects of biodiversity at small scales on ecosystem functioning. This session will highlight current and future directions in BEF research. This includes 1) scaling up the BEF relationship and mechanisms in space and time, 2) clarifying the buffering effect of biodiversity on ecosystem functioning in a changing world, and 3) determining the role of multitrophic interaction in driving BEF.

2. Zooming out and zooming in to better predict the consequences of biodiversity change

Kathryn Barry, Christian Wirth, Liesje Mommer, Jasper van Ruijven, & Alexandra Weigelt
German Centre for Integrative Biodiversity Research (iDiv)

Humans are propelling drastic environmental changes leading to biodiversity loss at regional and global scales. Locally, higher species richness often improves the ability of ecosystems to function. Thus, continuing biodiversity loss may have devastating consequences for ecosystem functioning. The potential consequences of biodiversity loss underpin biodiversity-ecosystem functioning research in local-scale experiments. Yet, the effects of biodiversity loss on ecosystem functioning depend on components at multiple scales. First, zooming out - at regional scales, meta-community processes determine ultimate species loss. Second, zooming in - at the local scale, the mechanisms that enhance ecosystem functioning in more diverse systems determine the effect of species loss on ecosystem functioning. Here, we synthesize across a conceptual study, a meta-analysis of biodiversity experiments, and a scale manipulation in a natural grassland. These results combined emphasize that zooming-out to larger spatial scales and zooming in on how biodiversity affects ecosystem functioning both fundamentally alter the implications of species loss for ecosystem functioning.

3. Influence of community assembly on biomass production in a restoration context

Eva DeCock, Iris Moeneclaey, Safaa Wasof, Stephanie Schelfhout, Margot Vanhellemont, Jan Mertens, Kris Verheyen, An De Schrijver, Lander Baeten
Ghent University

Biodiversity is declining worldwide. Loss of biodiversity affects the ecosystems' functioning and thus also its capacity to deliver the goods and services that we all need and use. After two decades of research on the relationship between biodiversity and ecosystem functioning (BEF), it is widely accepted that more biodiversity leads to more stable and higher levels of ecosystem functioning. However, most of previous research focuses mostly on species richness and does not account for community assembly, i.e. the underlying processes that determine both the species composition and local biodiversity of a community. To combat the loss of biodiversity, damaged ecosystems need to be repaired and managed, i.e. ecosystem restoration. Restoration traditionally only focuses on a community perspective (biotic components and target plant species), without explicitly considering the ecosystem processes and the community assembly processes. Building on the similarities between BEF research and ecosystem restoration, we apply the Community Assembly and Functioning of Ecosystem (CAFE) framework by Bannar-Martin et al. (2018), Ecology letters on data from a grassland restoration experiment to test the effects of community assembly on ecosystem functioning. We focus on biomass production.

4. Large herbivores promote plant diversity not only via removal of aboveground biomass in the long term

Qingqing Chen, Jan. P. Bakker, Juan Alberti, Christian Smit, and Han Olff.
University of Groningen

Herbivorous arthropods play a key role in the survival and growth of trees. With increasing tree species diversity, herbivory on a focal tree mostly decreases. Such patterns of associational resistance are generally explained by decreasing resource concentration or increasing top-down control in diverse forests. In this study, we experimentally investigated the effects of overstorey species composition and top-down control on herbivory levels of tree saplings in fragmented forests. In 53 research plots in northern Belgium we planted saplings of three focal tree species (beech, pedunculated oak and red oak). On a subset of these saplings, we excluded insectivorous birds by using nets and then monitored herbivory levels and measured the growth. Using structural equation models, we show that excluding birds leads to higher herbivory levels on all sapling species. In the case of beech and red oak, this increased herbivory leads to a reduction in growth. Effects of the concentration of the same tree species in the overstorey are only present in Pedunculate oak when birds are excluded. More-over, on this

species, we find stronger top-down control effects closer to the forest edge. These results underpin the importance of multitrophic interactions for driving sapling growth in diverse forest stands.

5. Top-down predation pressure outweighs the effect of overstorey tree species composition on herbivory levels and growth of saplings in deciduous forest fragments

Daan Dekeukeleire, Irene M. van Schroyen Lantman, Lionel Hertzog, Martijn Vandegehuchte, Diederik Strubbe, Pieter Vantieghem, An Martel, Kris Verheyen, Dries Bonte, Luc Lens.
Ghent University

It is generally assumed that large herbivores promote local plant diversity via removal of aboveground biomass and thus reducing competition for light or reducing dominance. However, these results are mainly derived from short-term experiments from different grassland ecosystems. Here we use a unique 46-year cattle grazing and mowing experiment to test whether the effect of grazing on plant diversity is entirely attributed to removal of aboveground biomass. We compared the changes in plant diversity, community composition and dominance structure, between grazing and mowing, as mowing is similar in removing aboveground biomass by grazing, but without having the additional mechanisms. Over time, grazing significantly increased plant diversity compared with mowing. In addition, mowing induced accumulative change in community composition and promoted new dominant species 20 years after the start of the experiment. Our long-term experiment demonstrates that the effect of herbivores on plant diversity cannot solely.

6. Modelling global consequences of megafauna extinction on top-down control in ecosystems

Selwyn Hoeks, Mark Huijbregts, Michela Busana, Mike Harfoot, Jens-Christian Svenning, Luca Santini
Radboud University

Large-bodied mammals, also referred to as megafauna, have suffered severe population declines and extinctions since the Pleistocene. These species are known to exert important top-down effects in ecosystems, consequently their extinction may have triggered trophic cascades. However, investigating these dynamics empirically presents a number of challenges, due to the large temporal and spatial scales at which these dynamics act. Here, we apply a global mechanistic model to investigate the effects of megafauna removal from undisturbed ecosystems. We designed different scenarios in order to disentangle the functional role of mega-herbivores and mega-carnivores in top-down control. Our preliminary results show that megafauna removal can trigger large shifts in the relative sizes of the various trophic levels and the energy flows amongst them. In particular, the loss of large carnivores leads to the increase of meso-predators, and the loss of herbivores to a large increase in autotroph biomass and large changes in yearly biomass fluctuations. The magnitude of these impacts, however, appears to be largely dependent on the underlying environmental characteristics such as seasonality and the overall primary productivity. Our results support theoretical expectations and suggest that ecosystems have been severely modified and are still changing as a result of the decline and extinction of large-bodied mammals.

1d: From individual fitness to population dynamics

Conveners: Rosemarie Kentie (Royal Netherlands Institute for Sea Research)
Tamar Lok (Royal Netherlands Institute for Sea Research)
Andrew Allen (Radboud University)

1. From individual fitness to population dynamics: an avian perspective

Andrew M. Allen, Rosemarie Kentie, Tamar Lok
Radboud University

Avian studies are classic examples of long-term studies conducted at the level of individuals, where a common aim is to improve our ecological knowledge of a species, and thereby understand the consequences for survival, growth, fecundity and dispersal. As the planet enters a biodiversity crisis, there is an increased urgency to understand the drivers behind the dynamics of species populations, i.e. what underlying factors are causing species populations to increase or decrease. Answering these questions relies upon studies conducted at the level of individuals, which identify factors that affect survival or reproduction, and then scale up the results to population processes. We will introduce this session "From individual fitness to population dynamics" by describing our own research on three different avian species, the Eurasian Oystercatcher, the Black-tailed Godwit and the Eurasian Spoonbill, all of which are classic examples of long-running research projects. Interestingly the Spoonbill has had a contrasting population trend in the Wadden Sea compared with the Oystercatcher and the Godwit, and thus our aim is to unite species-level studies and by comparing factors explaining variation in the demographic rates of individuals, we can advance our understanding of how individual fitness scales up to population dynamics.

2. Unravelling the mechanisms of population phenotypic changes: Can phenotypic differences between colonisers and philopatric individuals explain population dynamics?

Marion Nicolaus, Rob Bijlsma, Richard Ubels, Christiaan Both
University of Groningen

Individual animals commonly leave their natal or current breeding patch to settle in a new breeding area ('dispersal'). These movements are essential for most species to persist in changing environments and/or expand their range. Strikingly, one recurrent finding in dispersal studies is that dispersers and non-dispersers of the same species or population differ consistently in a suite of morphological, behavioural and/or life-history traits ('dispersal syndromes'). Such covariation may emerge as a result of divergent selection on dispersers and non-dispersers or as plastic changes occurring during/after settlement. Therefore, it is expected that populations in newly established areas exhibit a change in means of traits associated with dispersal over time. Using data from a wild pied flycatcher (*Ficedula hypoleuca*) population established 11 years ago and of known pedigree we investigate if 1) colonizers (immigrants of unknown origin) differ phenotypically from locally born individuals 2) if studied traits harbor substantial genetic variation (i.e. they are heritable and have the potential to evolve under selection) and 3) population mean morphological and life-history traits (presumably associated with dispersal) change over the years. Using multivariate animal models, we then establish whether population changes are due to selection on phenotypes (i.e. micro-evolutionary change) and/or phenotypic plasticity.

3. From within-host persistence to zoonotic emergence: Understanding bats as viral reservoirs

Cara E. Brook, Mike Boots, Kartik Chandran, Andrew P. Dobson, Andrea L. Graham, Bryan T. Grenfell, Melinda Ng, Anieke van Leeuwen
Royal Netherlands Institute for Sea Research / Utrecht University / Princeton University

Bats have gained notoriety in recent years for their roles as purported reservoir hosts for several of the world's most virulent emerging human diseases, which they appear capable of hosting without experiencing any evident morbidity or mortality. In humans, transmissible, pathologic infections will require large host populations and high birth rates for persistence, but bats are known to maintain otherwise-virulent viral pathogens in isolated island populations with discrete, annual birth pulses. Such patterns have led to the hypothesis that bats maintain zoonotic viruses as persistent within-host infections. Recent evidence suggests that bats employ several unique molecular pathways, which could facilitate endemic maintenance of infections, including mitigation of immunopathologic inflammation and constitutively primed innate antiviral immune responses. To investigate immune mechanisms which could support or deter within-host persistent infections in individual bats, we developed and analyzed a theoretical model of bat viral defense, testing scenarios of induced and constitutive immunity, and then fit our model to empirical time series generated from tissue culture experiments carried out in bat cell lines expressing these divergent immune phenotypes. Our within-host work suggests that persistent viral infections may be supported under both induced and constitutive assumptions of immunity through hosts maintaining a balance between rates of within-host viral replication and acquisition of antiviral immunity. We find that induced immune assumptions favor slower, and constitutive immune assumptions favor faster rates of both viral replication and antiviral acquisition. When viewed from an

epidemiological, host population perspective, faster viral rates may pose greater hazards for cross-species pathogen emergence into spillover hosts.

4. Demography of a stable population of crab plovers wintering in Oman

Roeland A. Bom, Jan A. van Gils, Kees Oosterbeek, Symen Deuzeman, Jimmy de Fouw, Andy Y. Kwarteng, Rosemarie Kentie
Royal Netherlands Institute for Sea Research / Utrecht University

Coastal areas of the Arabian Peninsula and East-Africa provide essential breeding and wintering habitat to a large number of shorebirds. These coasts are rapidly changing under increasing human pressure. In contrast to shorebird populations in other parts of the world, the status of shorebirds breeding and wintering in this part of the world remains largely unknown. To understand if shorebirds can keep up with their changing environment, we studied population dynamics of the crab plover *Dromas ardeola*, a species endemic to the shores of the Indian Ocean. We used survey and demographic data from 2011-2015 collected at Barr Al Hikman in the Sultanate of Oman which is the most important wintering area for crab plovers. Observed and expected population change were estimated independently in a Bayesian framework. Survey data showed that the population of crab plovers was stable. Demographic values (survival and fecundity estimated from colour-ringed birds and juvenile percentages respectively) indicated most likely a decreasing population. We discuss possible explanations for this apparent mismatch, and argue that the population of crab plovers at Barr Al Hikman receive second-year immigrants each year. Our study largely support the IUCN listing of crab plover as stable, but further population-wide monitoring is required.

5. Are mother's cursing their sons? Prevalence of mtDNA induced sex-specific differences in survival and fertility in zoo populations

Marloes Leeftang, Philippe Helsen
Zoo Antwerp Centre for Research and Conservation

Mitochondria are the powerhouses of the cell and as such influence a great deal of fitness traits, ranging from fertility to the process of aging. Although parents contribute equal amounts of nuclear DNA to their offspring, in general mitochondrial DNA is exclusively transmitted via the mother (maternal inheritance). As a result, mitochondria that negatively affect male fitness will never be selected against. This can lead to an accumulation of male-harming mutations in the mitochondrial DNA, a theory labelled "Mother's Curse", affecting males and ultimately the entire population. Previously, signs of Mother's Curse have been seen in both humans and livestock (e.g. reduced male fertility and aging). We were particularly interested in whether similar signals can be found in captive breeding programmes. To do this, we analysed a total of sixteen populations through their studbooks, with a focus on the sex-specific difference in aging and fertility. While no significant differences were found for the fertility analysis, our results indicate the survival of males is affected in mitochondrial lineages within several of the sixteen studbooks. Results of our study will be important for the maintenance of healthy populations and safeguarding their genetic diversity.

6. Directional breeding migration of harbour seals in the Wadden Sea

Sophie M.J.M. Brasseur, Peter J.H. Reijnders, Roger Kirkwood, Geert Arts
Wageningen University & Research

Migration plays a central role in the spatial dynamics of many mobile species, though until now migration had not been identified in the harbour seal (*Phoca vitulina*). In the Wadden Sea however, regional differences in pup production led to the hypothesis of an annual breeding migration. Seasonal migration of pregnant females between areas with low pup numbers (the Netherlands and Denmark) and high pup numbers (Germany) could explain the elevated pup production in Germany. Between 2007 and 2016, 225 harbour seals were tracked using GPS data-loggers in the Dutch Wadden Sea. A total of 44 females were tracked during the breeding period, and 27 of these were identified as breeding. Twelve (44%) breeding females remained within 10 km of the catch site but thirteen (48%) females migrated in an easterly direction towards Germany prior to the breeding season. Most (78%) adult females tracked after the breeding period moved in the opposite direction, (i.e. westerly), suggesting a return migration to the feeding grounds. Migration distance varied significantly among individuals and may explain why such migrations have not been noticed previously. Further study of the movements of these highly individual animals may provide new insights in the population development and genetics.

1e: Ecology and Conservation

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

1. How past human-landscape interactions shaped island biodiversity, and why this is relevant for conservation today

Sietze Norder, Harry Seijmonsbergen, Jun Lim, Kenneth Rijdsdijk
Universidade de Lisboa / University of Amsterdam

Human activities fundamentally alter ecosystems and species distributions from local to global scales. However, this is not only a recent phenomenon. On many locations around the globe, human impacts on biodiversity became significant long time ago. Volcanic oceanic islands are ideal “microcosms” for analysing the dynamics of past human impacts because the start of ecological processes and first human contact can be clearly defined. However, between islands there exist large differences regarding the rate and magnitude at which their ecosystems are affected by human activities. Here, we reconstruct the history of human impact on several islands and compare their ecological outcomes. Our findings show that present-day biodiversity patterns are the outcome of the way humans have interacted with the abiotic landscape over several centuries and sometimes millennia. However, similar human activities can lead to vastly different ecological outcomes as a result of contrasting abiotic environments. And, divergent societal trajectories might lead to diverse outcomes in similar environments. This highlights that human-modification of the landscape can potentially have a positive impact on the conservation of nature. We conclude that an appreciation of the dynamics of human-landscape interactions in the past provides a reference point for future nature conservation.

2. Pollinator diversity, herb layer diversity and semi-natural habitat enhance pollination service to sweet cherry

Maxime Eeraerts, Guy Smagghe, Ivan Meeus
Ghent University

We previously uncovered that intensive agriculture reduces pollinator diversity and pollination services to sweet cherry (*Prunus avium*) in Flanders, Belgium. Therefore, we have built on prior results to determine how landscape composition regulates pollinator diversity and pollination services to agricultural crops. Although approximately 80% of all flower visitors were managed honey bees, fruit set of sweet cherry was only clearly linked to pollinator species richness and wild pollinator abundance. We also found that semi-natural habitat, more so than intensive agriculture, regulates pollinator diversity. Most studies to date only incorporate a single gradient of one land use type in such assessments (intensive agriculture or semi-natural habitat). Yet, to clear up this relationship our experimental setup included independent gradients of both semi-natural habitat and intensive agriculture around the study orchards. We also found that flowering herbaceous plants in the herb layer between the cherry trees, next to landscape composition, have an additional beneficial effect on pollinator diversity. Our study provides further evidence why to establish diverse pollinator populations in agricultural landscapes. We also conclude that measures to promote pollinator diversity can be taken both on the landscape scale as well as on the orchard scale by farmers.

3. To sustainable management of North Sea habitats. Studying the ecological characteristics of fishing hotspots

Karin van der Reijden, Niels Hintzen, Laura Govers, Adriaan Rijnsdorp, Han Olff.
Conservation Ecology Group. Groningen Institute for Evolutionary Life Sciences

Bottom trawl fisheries negatively affect benthic habitats, with varying impact between different habitats. In addition, fisheries often show highly aggregated patterns, which are stable over time. The structuring mechanisms behind these stable fishing hotspots, however, are not well understood. In this study, we show that the three dominant Dutch demersal fisheries target very specific benthic habitats, which are relatively rare. Beam-trawls targeting sole are mainly active in the Southern North Sea, and therein more specifically the depressions between sand ridges. Fisheries for Norway lobster and plaice show different preferences. Logically, preferred habitats are coupled to distribution patterns of target species. We thus show that fishermen exactly know where to catch their target species, and with that, they indirectly know the habitat-requirements of these species. Moreover, we demonstrate that benthic habitats are subjected to unequal fishing pressures. Fisheries are currently managed by species-specific catch limitations (quota), and by fisheries-specific effort restrictions. The spatial distribution of fishing activity, however, is only marginally managed. So are multiple intensively fished hotspots located within Natura 2000 areas. We conclude that for effective protection of specific and rare habitats, management should include the spatial distribution of both benthic habitats and their users.

4. Woody plant encroachment in African savannas: the interactive effect of anthropogenic disturbance, geology and tree functional traits

Inger de Jonge, Ruth Howison, Michiel Veldhuis, Han Olff
University of Groningen

Woody plant encroachment in savanna ecosystems has raised widespread concerns about the potential impact on ecosystem services. While there is increasing consensus on the relative importance of fire, herbivory and soil properties on this phenomenon across biogeographic regions, predictions on grass-woodland transitions remain relatively poor on regional and local scales. Satellite-imagery of the Serengeti-Mara ecosystem in East-Africa have revealed substantial grazing by livestock inside protected areas, leading to far-stretched fire suppression. We used a combination of high-resolution remote sensing data and field surveys to assess the impact of anthropogenically induced fire suppression on tree basal area change and how this varies locally across parent-materials, landforms and tree community structures. The results show that woody plant encroachment is fastest on granite-gneissic substrates with recent volcanic ash deposition while there is no encroachment on granite rock substrates. Furthermore, encroachment is fastest on low-catenal landforms, which coincides with a community-level shift in traits associated with fire-resistance strategy. These results imply that soil properties and geomorphology affect local susceptibility to drivers of woody plant encroachment. Understanding local vegetation change within savanna ecosystems is critical to make effective decisions on management practices to ensure a steady flow of ecosystem services to people and wildlife.

5. Eco-engineering dunes: Exploring the spatiotemporal effects of small-scale blowouts for dune grassland restoration

Yuki Fujita, Pieter Stuyfzand, Camiel Aggenbach
KWR

Coastal dune grasslands are naturally dynamic systems with a mosaic of different ages, primarily driven by aeolian activities and succession. In the last decades, however, the aeolian activities are weakened due to changes in management and high atmospheric N deposition, causing a decrease in biodiversity. Creating or reactivating small-scale blowouts is a way to mimic the natural process of aeolian activity, yet their spatial and temporal impacts have been hardly quantified. In order to make an effective design of blowouts for dune grassland restoration, we evaluated the effects of blowouts on soil and vegetation in Dutch coastal dunes. Our study showed that the sand deposition from blowouts brings positive effects to vegetation by increasing soil pH, helping species adapted to base-rich environment to establish in acidified dunes. The area that a blowout can influence is ca. 3.3 times larger than the size of the blowout. The spatial extent of the influenced zone is determined by several factors, such as exposure to winds, calcite content of the deflation zone, and degree of decalcification of the surrounding area. The comparison between the active and stabilized blowouts indicated that the effects of the blowouts can remain decades after the stabilization of the blowout.

6. Predicting climate change effects on global vegetation patterns using a trait-based approach

Coline Boonman, Mark Huijbregts, Luca Santini
Radboud University

Dynamic Global Vegetation Models are used to quantify future changes in vegetation. Current models link plant functional types (PFTs) to climate, assuming that all species within a PFT respond similarly to different kinds of change, and that relationships remain similar among species. Trait-based models can reduce the inflexibility of using PFTs, as they 1) include among and within species variation, and 2) reduce uncertainty of model predictions, because vegetation processes are more realistically modelled. This results in more reliable models and predictions, making trait-based modelling especially suitable for predicting future changes in plant communities. In this study, we aim to quantify the effect of climate change on global terrestrial biome distributions, and indicate areas of major change. First, we predict current distributions of plant height, specific leaf area, and wood density using ensemble forecasting. Trait community means are related with climate variables and soil properties using four different models. Second, we cluster trait combinations to biomes using a Gaussian mixture model. Effects of climate change on future plant traits are predicted under different climate scenarios, which resulted in a change of predicted biome distributions. Locating future biome changes can help allocate large-scale conservation efforts with regard to climate change effects.

Parallel Session 2

2a: Animals adjusting to a rapidly changing world

Conveners: Bart Nolet (Netherlands Institute of Ecology)
Martijn van de Pol (Netherlands Institute of Ecology)
Jan van Gils (Royal Netherlands Institute for Sea Research)

1. A bird's-eye view: organisms coping with rapid environmental change

Ron Ydenberg
Simon Fraser University

Other than climate change, examples of rapid large-scale change in the environment include intensified agriculture, urbanization, the expansion of protected areas, land use changes, the widespread recovery and wholesale removal of top predators, changes in available food resources, and others. This session focuses on phenotypic (behavior, physiology, morphology) changes induced in populations of organisms made (or alleged to have been made) in response to these anthropogenically-induced changes. After an overview, I'll briefly describe the work of my lab group on opposing directional changes in wing morphology of two long-distance migrant sandpiper species in the decades following the DDT ban, and demonstrate how increasing predation danger underlies these changes.

2. Demographic and distributional responses by adult long-distance migrating shorebirds to the rapid loss of staging habitat

Ying-Chi Chan, Tamar Lok, Suet-Wah Chung, Lee Tibbitts, Shen Zhang, Chris Hassell, Theunis Piersma
University of Groningen / Royal Netherlands Institute for Sea Research

Facing habitat destruction, mobile animals can remain at original habitat which would result in higher densities, or move to alternative habitats of lower quality. If the amount of habitat is a limiting factor, negative fitness consequences are expected from density-dependence effects, which can result in population declines. This easy-to-understand process is hard to document in wild populations facing real problems. We study this process in a long-distance migratory shorebird, the bar-tailed godwit (*Limosa lapponica menzbieri*), facing rapid habitat loss at their main refueling area during their migration, which is the mudflats in the Yellow Sea. We found from satellite imagery that between 2007 and 2018, reclamation occurred in nine out of our 12 study sites, resulted in about 40% of mudflat area being converted to land. During this period, survival of this population was high and decreased since 2011. To examine distributional changes, we compared locations of godwits satellite-tracked in 2015-2018 to those in 2008. At sites where substantial amount of mudflats remained after reclamation, godwits shifted seawards into deeper mudflats, where the mudflats are exposed for shorter time for them to forage. Sites with almost all of the mudflat reclaimed are not visited by 2015-2018 birds anymore. While godwits' distribution in the Yellow Sea have changed in response to loss of mudflat, in 2015 to 2018, godwit usage remained positively related to mudflat area. While the shifting to unused deeper mudflats might represent one way that birds can buffer habitat loss in 2008, both the survival trend and the positive mudflat area-usage relationship suggest the population is limited by the amount of mudflats in the Yellow Sea. A severe population decline is expected if there is any further loss in mudflats in the Yellow Sea.

3. Too darn hot: impact of global warming on trophic interactions in simulated communities

Lionel Hertzog, Julia Tiede, Jan Engel
University of Ghent

Global warming is predicted to lead to a decline in ectotherms body mass due to increased metabolic costs under warmer temperature. However, warmer temperature will also translate into higher mobility for these organisms which could partially offset higher metabolic costs by increasing trophic interactions. Here, I will present results on an Individual-Based Model explicitly modelling individual movement, metabolic rate and predator-prey interactions all of these processes depending on body mass and air temperature. Nine different scenarios of air temperature are compared both with increasing average temperature (from +1.5 to +5°C) but also with extreme heat events (5 to 10 consecutive days of +5 to +10°C above normal). Simulations were ran on 64 virtual communities varying species richness, individual density and carnivore proportions. Early results show a stronger effect of increased average temperature compared to extreme heat ways on individual survival. Further analysis will explore trophic efficiency, the trade-off between metabolic costs and food intake, but also changes in the predator-prey interaction network under global warming. Together these results will provide some theoretical insights into potential ectotherm physiological and behavioural responses to global warming.

4. Fuelling conditions at staging sites can mitigate Arctic warming effects in a migratory bird

Eldar Rakhimberdiev, Sjoerd Duijns, Julia Karagicheva, Cees Camphuysen, Vogelringstation
Castricum, Anne Dekinga, Rob Dekker, Anatoly Gavrilov, Job ten Horn, Joop Jukema, Anatoly
Saveliev, Mikhail Soloviev, Lee Tibbitts,, Jan van Gils, Theunis Piersma
Royal Netherlands Institute for Sea Research / Lomonosov Moscow State University

Under climate warming, migratory birds should align reproduction dates with advancing plant and arthropod phenology. To arrive on the breeding grounds earlier, migrants may speed up spring migration by curtailing the time spent en route, possibly at the cost of decreased survival rates. Based on a decades-long series of observations along an entire flyway, we show that when refuelling time is limited, variation in food abundance in the spring staging area affects fitness. Bar-tailed godwits migrating from West Africa to the Siberian Arctic reduce refuelling time at their European staging site and thus maintain a close match between breeding and tundra phenology. Annual survival probability decreases with shorter refuelling times, but correlates positively with refuelling rate, which in turn is correlated with food abundance in the staging area. This chain of effects implies that conditions in the temperate zone determine the ability of godwits to cope with climate-related changes in the Arctic.

5. Comparing gosling growth between Arctic- and temperate-breeding barnacle goose populations

Chiel Boom, Henk van der Jeugd, Boas Steffani, Kjell Larsson, Götz Eichhorn
Netherlands Institute of Ecology

Gosling growth patterns are shaped by selection pressures and constraints specific to the breeding and rearing grounds. Furthermore, Arctic-breeding geese have to evade the breeding grounds in time for their long-distance travels to the wintering grounds. Therefore, breeding in different environments is expected to result in adaptation to local environmental conditions and migratory lifestyles. Over the past decades an originally arctic- breeding long-distance migrant, the barnacle goose (*Branta leucopsis*), expanded its breeding range southwards. Nowadays, barnacle geese also breed successfully in temperate regions, thereby shorting their migratory journeys or giving up migration altogether. During the breeding period, temperate-breeding geese (and their goslings) experience different environmental conditions compared to their arctic-breeding counterparts. We have gathered gosling growth data from arctic (Barents Sea) and temperate (Baltic, North Sea) barnacle goose populations, of which the North Sea population is no longer migratory. We found differences in growth rates between the three populations, with the highest growth rates occurring in the arctic migratory population and the lowest in the temperate resident population. In our presentation we will address these differences and highlight the importance of the environmental factors that may have shaped these patterns.

6. 25 Year of red knot numbers in the Wadden Sea explained by changing food conditions

Sterre Witte, Theunis Piersma, Romke Kleefstra, Allert Bijleveld
Royal Netherlands Institute for Sea Research

Changing food conditions likely result in changing population sizes of those that rely on this food. For migratory animals a declining food availability, even at one of several foraging areas along their journey, could have far reaching impacts. The extent to which migratory populations show responses to changes in food abundance on long timescales (decades rather than seasons or a few years) still warrants study. This study examines how the population size of non-breeding Red Knots (*Calidris canutus*) varies with food availability in the Dutch Wadden Sea. In this area, Red Knots specialise on bivalve prey and it has been suggested that they occupy the foraging area to capacity. Previous research has given us the methods to 'translate' abundances of intertidal bivalves into the number of red knots that can be supported by an area. We analyse a 25-year long time series on yearly prey availability and high-tide roost counts, to better understand the relation between benthic communities and knot populations. We then evaluate whether it is possible to predict bird population dynamics from prey abundances.

2b: Nature's Followers

Conveners: Monique de Jager (Netherlands Institute of Ecology)
Marijke van Kuijk (Utrecht University)

1. Village size affects occupancy of ground-dwelling animals in Suriname

Marijke van Kuijk, Martin van Oosterhout, Monique de Jager, N. Hanoeman, B. Hoffman
Utrecht University

Many animal species are severely affected by human activities. Local communities that hunt wildlife for subsistence are assumed to have substantial negative effects on the abundance of ground-dwelling animal species. To examine this effect, we monitored animal populations around four villages in South Suriname using camera traps. We used cropland area surrounding the villages as a measure of village size and as a proxy for hunting pressure. For different animal groups, we analyzed occupancy in relation to the distance to the village and explored differences in day and night occupancy. Our results show that ground-dwelling birds were negatively affected by cropland area size close to the village but not further away. Carnivores and caviomorphs had a higher occupancy when the cropland area was larger. We also found that the difference between night- and day-occupancy increases with cropland area size for caviomorphs (higher activity at night around villages with larger cropland areas), especially closer to the villages, while the opposite was true for ungulates. These results clearly indicate that the occupancy and activity patterns of ground-dwelling animals are indeed affected by the presence of people, yet in this study not all species groups are negatively affected by human activities.

2. The effect of Wild ungulate abundance on temperate forests: a camera trapping approach

Juan Ignacio Ramirez, Patrick Jansen, Jan den Ouden, Xuqing Li, Palma Lacobelli, Natalie Herdoiza, Lourens Poorter
Wageningen University & Research

Herbivory has a strong top-down control on the structure and dynamics of forests and the effects of this mechanism are exacerbated by an ungulate population increase in the northern hemisphere. The dose-response relationship between wild ungulates and recruitment in temperate forests, however, remains poorly documented. Here, we combined camera trapping and vegetation surveys to quantify the dose-effect relationship in temperate mixed forests at the Veluwe, the Netherlands. At ten sites that widely ranged in ungulate abundance and composition, we used camera traps to quantify ungulate utilization and vegetation surveys to measure eleven forest response variables. We used Generalized Linear Mixed Models to assess the dose-response relationship. Camera-trap estimates determined that ungulate abundance increases the incidence of browsing time per day. With increasing *Cervidae* abundance, there was a decrease of tree species richness, tree diversity, litter thickness and an increase in sapling density. Whereas with increasing *Suidae* abundance there was a decrease in understory shrub cover and litter thickness. Our results suggest that the dose-response between ungulate abundance and different forest components are non-linear, following a reversed asymptote. Yet, the shape of the dose-response may vary according to biotic and abiotic factors of each study location.

3. The effects of heat on diel activity patterns of mammals in a Neotropical forest

Cristina Lopez-Malaga, Patrick Jansen
Wageningen University & Research

Global warming is considered as one of the most important threats to biodiversity due to its potential negative effects on species fitness and survival. For endotherms such as mammals, one way to cope with changing temperatures, theoretically, is through behavioural strategies such as shifting their activity patterns as to avoid the hottest parts of the day. In this study, we test whether heat affected activity patterns in the predicted manner for 11 Neotropical forest mammals in Panama across a range of body mass. Activity patterns were measured with camera traps after correcting for a critical bias: passive infrared sensors (PIR) and thus detection rates are – like animal activity – influenced by environmental temperature and humidity. We found that most species had shifted activity patterns and lower activity levels during hot days, but this was significant only in 3 of 11 species, partially supporting the predictions. The method developed in this study allows using camera traps to assess behavioral responses of mammals to temperature across a wide range of systems.

4. Tracking the Bewick's swan: an unprecedented insight in swan behaviour during spring migration

Rascha Nuijten, Bart Nolet
Netherlands Institute of Ecology

Rapid technological developments make it possible to not only track the location of individual animals, but also to observe their behaviour remotely by including an accelerometer in the tracking device. This can yield important insights in the ecology of the species. In this study we followed individual Bewick's swans (*Cygnus columbianus bewickii*) with GPS-GSM collars with built-in accelerometer and water sensors to track their migration in very much detail.

After groundtruthing the sensor data using observations in captivity, we developed detailed time budgets for all tracked individual swans during their spring migration in 2017 and 2018. The swans showed considerable variation between individuals and years. The water sensor gave us an unprecedented insight in the times and locations that the swans relied on aquatic resources to fuel their migration. This allowed us to compare these important areas for the swans with current protected areas along the migratory route and draw valuable conclusions for management and policy makers.

5. Using GPS and accelerometer tracking to quantify spatiotemporal differences in foraging time among feeding specialisations

Henk-Jan van der Kolk, Bruno Ens, Kees Oosterbeek, Willem Bouten, Andrew Allen, Magali Frauendorf, Thomas Lameris, Eelke Jongejans, Martijn van de Pol
Netherlands Institute of Ecology

Fitness payoffs of feeding specialisation vary with environmental conditions, but the underlying behavioural mechanisms, such as foraging time patterns, are poorly understood. Bio-logging is a promising tool to study payoffs of feeding specialisation as it enables behavioural comparisons among individuals over a wide range of environmental conditions. Using UvA-BiTS GPS trackers, we combined GPS and accelerometer tracking in oystercatchers (*Haematopus ostralegus*). Accelerometer measurements were calibrated to classify behaviour. We then quantified individual variation in foraging time and its spatiotemporal allocation. Individuals vary widely in foraging time (3.7-6.5 hours per tidal period) and long foragers have lower inferred survival. Visually-hunting worm specialists foraged more during day-time tides and complemented intertidal foraging with grassland foraging when intertidal flat exposure was limited, particularly during well-illuminated nights. Shellfish specialists increased total foraging time in cold weather, whereas foraging time of worm specialists decreased as grasslands became inaccessible. Our results imply that worm specialists are most sensitive to cold snaps and day-time disturbance, while shellfish specialists are most sensitive to conditions that affect the intertidal exposure time (bad weather and sea-level rise). Such mechanistic knowledge is crucial for making reliable predictions on how heterogeneous populations respond to environmental change.

6. Orographic lift shapes flight routes of gulls in virtually flat landscapes

Elspeth Sage, Willem Bouten, Bart Hoekstra, Kees Camphuysen, Judy Shamoun-Baranes
University of Amsterdam

The atmosphere is a landscape of complex aerial processes that numerous taxa have to navigate and which, thanks to the advancement of GPS tracking and remote sensing data, may now be studied on increasingly fine spatial and temporal scales. Specifically, sources of atmospheric uplift such as orographic lift are often strongly influenced by landscape features and may be regularly utilised by birds who have a strong knowledge of their aerial environment in order to save energy. We investigate the degree to which large gulls (*Larus fuscus*, *Larus argentatus*) utilise fine scale orographic lift created by upward deflections of wind moving over landscape features in the virtually flat landscape of North Holland. Using high resolution accelerometer measurements and GPS tracking data collected over multiple years, flight behaviour is analysed with respect to orographic uplift, modelled using high resolution digital elevation models and wind data. The relationship between available orographic uplift and flight behaviour demonstrates that gulls have an advanced knowledge of their aerial surroundings and the benefits to be gained from them, utilising orographic lift even when generated by features as small tree lines.

2c: Urban Ecology

Conveners: Matty P. Berg (Vrije Universiteit Amsterdam / University of Groningen)
Dries Bonte (Ghent University)

1. **Urbanisation affects functional diversity of soil fauna, but the direction and strength depend on soil type**

Astra Ooms, Andre Dias, Raoul van Oosten, Jacintha Ellers, Hans Cornelissen, Matty P. Berg
Vrije Universiteit Amsterdam / University of Groningen

Urbanisation affects available habitat space and soil conditions and has been shown to lead to a decline in soil invertebrate diversity. However, the magnitude and direction of urbanisation effects might depend on abiotic factors, and this context dependency could mediate the detrimental impact of urbanisation. Here we tested whether and how urbanisation affects isopod richness and functional trait composition and if this relationship depends on habitat soil type. We recorded the distribution of 18 isopod species and some key traits (body size, drought resistance), together with information on soil type (peat, clay) and amount of built-up area in a 500 km² area in and around the city of Amsterdam, the Netherlands. We analysed the relationship between functional diversity and environmental factors based on data for each single 1 km² grid cell across a rural-urban landscape gradient. The relationship between isopod diversity and level of urbanisation strongly depended on soil type. Species richness was negatively associated with the amount of built-up area when rural soils contained clay, while for rural soils with peat, highest species richness was found at intermediate levels of urbanisation. The percentage built-up area showed a strong positive correlation with drought resistance and body size. These results suggest that soil type heterogeneity introduces an important, but often overlooked context dependency in the effect of urbanisation on soil biodiversity. However, functional traits show predictable patterns irrespective of soil context and is an important tool for understanding effects of environmental change on biodiversity.

2. **Big City Life: genotypic trait differentiation in thermal adaptation, life history, physiology, and pace-of-life in response to urbanization in *Daphnia magna***

Kristien I. Brans, Robby Stoks, Luc De Meester
KU Leuven

A key feature of urban areas is the urban heat-island effect. Evidence on adaptive evolution to this anthropogenic warming in freshwater habitats is limited. We conducted large-scale common garden experiments to test for genetic differentiation in a suite of traits between urban and rural populations of the water flea *Daphnia magna*. Compared to rural *Daphnia*, urban animals shifted along the slow-to-fast Pace-Of-Life axis coinciding with early maturation times, smaller size at maturity, higher fecundity and higher intrinsic population growth rates. Stress physiological responses show urban animals have a higher energy budget (fat, protein, and carbohydrates), but limited upregulation of antioxidant enzyme activity. Remarkably oxidative damage did not differ between the two genotype sets, suggesting urban *Daphnia* evolved more efficient antioxidant defense mechanisms. An integrative analysis indicated all traits were significantly structured by an underlying Pace-of-life Syndrome in the urban, but not rural genotype set. We hypothesize in city ponds differential selection regimes shift energy allocation to align stress physiological coping-mechanisms to life history evolution in the direction of fast life, evoking a strong pace-of-life syndrome. These results add up to the recent evidence that urban *Daphnia* evolved a higher heat tolerance, indicating urbanization drives the evolution of increased stress resistance.

3. **Urban-associated changes in the immune system of common blackbirds in Europe**

Juan Diego Ibáñez-Álamo, Olivia Sanllorente, Robert L. Thomson, José I. Aguirre, Maike Versteegh, Alazne Díez-Fernández, Jordi Figuerola, Bruno Faivre, B. Irene Tieleman
University of Groningen

Urbanization is a globally conspicuous landscape change that will likely accelerate in the future. This human-induced process imposes important ecological modifications on organisms inhabiting cities including changes in the diseases and parasites encountered. However, we still know very little on how urban environments impact their immune system. Previous studies offer contrasting results that are based on single immune parameters with no spatial replication. We investigated whether common blackbirds (*Turdus merula*) living in cities or in natural (forest) habitats show differences in their innate and adaptive immune system. We collected information from 10 blackbird populations paired two by two (urban vs forest) across a wide geographical area in Europe to allow generalization of our results. We found urban-associated increases in haptoglobin and haemagglutination, while other immune parameters (ovotransferrin, haemolysis, nitric oxide and white blood cells) did not show significant differences between urban and forest blackbirds. Despite the overall reduction in parasitic pressure (i.e. ecto and endoparasites) in urban habitats, our results show that some urban-associated immune changes (e.g. haemagglutination) are mediated by *Plasmodium* infection. Our findings suggest complex and multi-faceted immune changes associated with urbanization that cannot be simply explained by changes in parasitic

4. On time in the urban environment: direct and systemic impact of light at night on daily activity of birds and small mammals

Kamiel Spoelstra, Marcel E. Visser
Netherlands Institute of Ecology

Evidence showing negative impact of urbanization on ecosystems is accumulating. Artificial light at night is one of the strongest expressions of anthropogenic activity and effects vary from direct mortality to disruption of species' natural behaviour. A frequently reported consequence of light at night are changes in the daily timing of activity. The occurrence of such changes may be expected, as the natural light/dark cycle is a powerful cue for time of day. In the field, we tested whether activity of bats and mice directly changes by the presence of experimental light. In the lab, we tested whether changes in activity patterns in great tits (*Parus major*) by light at night are caused by direct responses or by changes in how the master circadian clock is synchronized to the 'normal' light/dark schedule. The results of these studies reveal moderate to strong changes in the temporal organization of activity. However, these changes appear to be a direct response to light, and in case of the great tits, these changes clearly do not relate to changes in the internal circadian clock. The presence of direct responses implies that species can be flexible with adapting their activity when exposed to light at night.

5. Adaptive changes in sexual signalling in response to urbanisation

Wouter Halfwerk P. Alex Trillo, Ximena E. Bernal, Rachel A. Page, Michael J. Ryan, Jacintha Eilers
Vrije Universiteit Amsterdam

Human-created landscapes such as cities are replacing natural habitats at an evolutionary unprecedented scale and pace forcing many species to adapt. Animal communication signals serve crucial functions to attract mates and defend territories and experience divergent selection pressures between natural and urbanized areas with population- and/or species-level consequences. Animal signals across a wide range of taxa have shown to respond rapidly to various features of urbanization, including noise and light pollution. However, we lack knowledge whether such habitat-dependent signal change is adaptive in terms of mate attraction on the one hand and predator and parasite avoidance on the other. Here we show how the selection pressures operating on the mating display of the túngara frog (*Physalaemus pustulosus*) differ dramatically between urban and forest environments and how this may have selected for urban males that are more attractive to females. Playback experiments in 11 paired forest and urban sites situated around the Panama Canal revealed that calling males attract fewer predators and parasites and experience stronger competition for fewer females. Furthermore, we found urban males to call more conspicuous and to be more attractive to females than their forest counterparts. A common garden approach revealed that urban frogs can immediately adjust their calls to match the ecological requirements of the forest, but that forest frogs do not match urban frogs when placed in an urban environment. Our findings demonstrate that urban environments can drive signal evolution, in particular when sexual and natural selection pressures are operating in the same direction. We argue that the observed differences in signal flexibility may have important eco-evolutionary consequences.

6. Plants are favoured by our city: selection for larger and more tolerant to insect herbivore

Jiao Qu, Dries Bonte, Martijn Vandegehuchte
Ghent University

Accumulating evidence is emerging that species can adapt to urban environments through the evolution of phenotypic plasticity. To test for consistency of phenotypic divergence of plant-herbivore interactions in relation to urbanisation at different spatial scales, common garden herbivory-controlled experiment was conducted with *Arabidopsis thaliana* which seeds were collected from urban-rural areas. We found trichome remarkably reduced herbivory, but herbivory did not affect plant growth. Plant biomass and trichome and herbivory as well highly depended on genotypes, while no genotype-dependency was found for herbivore growth. Compared to rural genotypes, urban genotypes with less trichome grew larger, and showed differences in herbivory and herbivore growth as well. Plants allocated more in root growth and produced less trichome with urbanisation at 200m scale. The study demonstrates urbanisation leads to the evolution of larger plants that were less resistant but more tolerant to herbivory. Besides, differences among genotypes were expressed at small spatial scales, indicating fast and local adaptive dynamics in response to rather immobile herbivores. Our study suggests adaptive phenotypic divergence of rural and urban genotypes, and highlights that also functional interactions are subject to urban evolution, likely impacting future ecological dynamics in the city.

2d: Fungal interactions in a changing world

Conveners: Alena Gsell (Netherlands Institute of Ecology)
Silke Van den Wyngaert (Leibniz Institute of Freshwater Ecology and Inland Fisheries)
Hans-Peter Grossart (Leibniz Institute of Freshwater Ecology and Inland Fisheries)

1. Fungi – a key component at the base of terrestrial and aquatic food webs

Hans-Peter Grossart

Leibniz Institute of Freshwater Ecology and Inland Fisheries

Microbes (Bacteria, Archaea, and Fungi) are the most diverse and numerous organisms on earth and represent essential components of every ecosystem since occupying almost every trophic position and niche space. Here, I will mainly focus on the role of fungi as biochemical engineers responsible for the mobilization and mineralization of non-living OM in terrestrial and aquatic ecosystems, which influences exchange of carbon (mainly CO₂ and CH₄) between the biosphere and the atmosphere. However, microorganisms also form the basis of the decomposer food web, supporting a wide diversity of detritivorous invertebrates and protists, and in turn, a wide range of vertebrate and invertebrate predators. Despite fundamental differences in the physical structure of terrestrial and aquatic systems, I will highlight several similarities across these systems. These ecosystems favor the dominance of fungi and fungal-based arthropod communities. Fungi are large and biochemically complex in relation to bacteria, making them more resistant to consumers; increased environmental heterogeneity selects for a highly complex fungal-based food web. Under these conditions, the microbial community is structured predominantly by bottom-up control, and microbial growth and activity are limited by the accessibility of organic nutrients (e.g., from plants). As ecosystems become more homogeneous and the abundance of POM generally decreases in relation to DOM (e.g., deep lakes and open oceans), this selects for a metabolically active, bacterial-dominated community being more top-down controlled. Here, I will highlight the multiple roles of fungi as well as their interactions with other food web components in terrestrial vs. aquatic ecosystems. In particular, I will focus on similarities but also differences between both habitats that lead to systematic differences in the importance and ecological role of fungi in the respective food webs.

2. Tracking trade strategies of arbuscular mycorrhizal fungi with fluorescing quantum-dots exposed to fluctuations in resource availability

Anouk van 't Padje, Gijsbert Werner, Matthew Whiteside, Toby Kiers

Vrije Universiteit Amsterdam

The arbuscular mycorrhizal symbiosis is characterized by underground networks of plants and fungi trading resources. While it has been shown that fungal and plant individuals are able to preferentially allocate resources to higher quality partners, the trade dynamics governing these markets are unknown. A defining feature of markets is that prices fluctuate: an influx of resources is predicted to drive a drop in value, while resource scarcity drives an increase. We tested this by manipulating external phosphorus conditions, creating events mimicking economic 'crashes' and 'booms'. We either severed a section of the network or exposed a section of the network to a pulse of phosphorus to drive a change in its value. We documented changes in fungal trade strategies over three weeks by tracking phosphorus tagged with fluorescing quantum-dots of three colours from different phosphorus pools across the network. We found that loss of phosphorus in the crash treatment was compensated by increased transfer from other parts of the network. While initially there was no difference in the exchange rate between the treatments, we found that the network in the boom treatment was eventually able to capitalize on the influx of resources, gaining more carbon per phosphorus transferred by day twenty-one of the experiment. Our work demonstrates the flexibility of mycorrhizal trade strategies across space and time.

3. An integrative transcriptomic atlas of symbiosis development, nutritional status and sporocarp maturation highlights functional adaptation of ectomycorrhizal fungi

Joske Ruytinx, Annegret Kohler, Shingo Miyauchi, Sebastian Wittulsky, Maira de Freitas Pereira, Frédéric Guinet, Clément Pellegrin, Jean-Louis Churin, Carine Put, François Le Tacon, Yohann Daguerre, Claire Veneault-Fourrey, Francis Martin

Universiteit Hasselt / Institut National de la Recherche Agronomique Université de Lorraine

Forest ecosystems are of primary importance in carbon cycling. A balanced nutrient supply and adaptability to a range of environmental conditions contribute to tree health and productivity. Through associations with ectomycorrhizal (ECM) fungi, trees are able to colonize, establish and survive in a wide range of soils. Proper functioning of ECM fungi implies the differentiation of structures within the fungal colony. A symbiotic structure is dedicated to nutrient exchange and the extramatricular mycelium explores soil for nutrients. Eventually, sporocarps develop to assure last stages of sexual reproduction. The aim of this study is to understand how an ECM fungus uses its gene set to support functional differentiation and development of specialized morphological structures. We performed RNAseq analyses on different developmental stages of *Laccaria bicolor* – *Populus tremula* x *alba* ECM and associated extramatricular mycelium, sporocarps and free-living mycelium under various conditions of N, P and C supply. Genes regulated in ECM with a putative role in plant-fungal interaction could be identified and

sorted from genes with a distinct expression profile and with a putative role in hyphal aggregation or in N – P and carbon homeostasis. The results of this study direct future functional genetics research in order to better understand how ECM fungi fulfil their important role in changing forest ecosystems.

4. Know your neighbour: plant neighbour identity plays a role in soil-borne fungal disease transmission in susceptible hosts

Eline A. Amp, Jasper van Ruijven, Jos Raaijmakers, Aad Termorshuizen, Liesje Mommer
Wageningen University

Biodiversity loss has a major impact ecosystem functioning, including primary productivity. This can be caused by effects of biodiversity loss on soil-borne pathogen pressure. However, the underlying mechanisms explaining how plant diversity can affect soil-borne fungal pathogens are yet unknown. Root density of host species is hypothesized to be an important factor. We demonstrate that plant neighbour identity is an additional factor that may dilute or amplify disease transmission. We investigated the spread of the soil-borne plant fungal pathogen *Rhizoctonia solani* through monoculture rows of seedlings in two susceptible host species: the forbs *Leucanthemum vulgare* and *Plantago lanceolata*. In addition, we planted other, so called 'barrier' seedlings, in between the rows to assess the effect of neighbour identity on fungal disease spread. We found significant effects of barrier plants on disease spread. *P. lanceolata* neighbours amplified disease spread in host rows of *L. vulgare*, while the other neighbour species (*L. vulgare* and two grass species) diluted disease spread in both host species. Our findings provide proof of principle that plant neighbour identity affects belowground fungal disease dynamics. Future research will focus on understanding the mechanisms underlying the effects of neighbours on disease risks in diverse plant communities.

5. Drying-rewetting and freezing-thawing leave different legacies in soil microbial communities

Annelein Meisner, Aimee Classen, Joseph Nesme, Samuel Jacquoid, Anders Prieme
Lund University / Netherlands Institute of Ecology / University of Copenhagen

Terrestrial ecosystems will experience altered frequency and intensity of drying-rewetting and freezing-thawing cycles due to climate change. These fluctuations affect soil moisture availability, which is an important driver of soil microbial activity. However, the question remains if the legacy of one type of fluctuation influences the microbial response to the other. We hypothesized that a freezing-thawing and drying-rewetting cycle have similar effects on the soil microorganisms. Three microcosm experiments were performed using grassland soil. In the first experiment, soil was exposed to a freezing-thawing or a drying-rewetting cycle. The second and third experiment consisted of two phases. In the first phase, soil microcosms were exposed to similar treatments as in experiment one. In the second phase, soil microcosms were exposed to a drying-rewetting or a freezing-thawing cycle. We measured soil respiration and composition of bacteria and fungi using amplicon sequencing. We observed a larger CO₂ pulse upon rewetting than upon thawing. The legacy of drying-rewetting affected the composition of bacteria and fungi and CO₂ emissions upon the second freezing-thawing cycle. In contrast, the freezing-thawing legacy did not affect the response of soil microorganisms to drying-rewetting. Our results suggest that drying-rewetting has more influence on soil microbial communities than freezing-thawing.

6. Combining targeted isolation approaches with environmental sequencing to unveil ecological interactions of aquatic chytrid fungi

Silke Van den Wyngaert, Keltor Rojas-Jimenez, Lars Ganzert, Christian Wurzbacher, Ramsy Agha, Kensuke Seto, Hans-Peter Grossart, Maiko Kagami
Leibniz-Institute of Freshwater Ecology and Inland Fisheries

Chytrids are a diverse group of true zoospore fungi. The recent molecular discovery of a large diversity of undescribed, so called "dark matter", chytrids has raised awareness on their important, but so far understudied ecological role in aquatic ecosystems. Many chytrid species have been morphologically described as parasites on almost all major groups of phytoplankton. However, the majority of these parasitic chytrids has rarely been isolated and lack DNA sequence data. This severely limits the use of environmental DNA and other molecular approaches to study their biogeography, ecological interactions and host specificity. In this study we applied several targeted approaches i.e. cultivation, single cell isolation and in situ baiting, to obtain DNA sequences of phytoplankton and pollen associated chytrids from the oligo-mesotrophic lake Stechlin. In parallel, we collected weekly to biweekly samples from the pelagic, spanning more than a year, for high throughput DNA sequencing. With the results of our targeted isolation approaches we were able to "illuminate" a substantial part of the "dark matter" chytrid community and their ecological interactions in Lake Stechlin. Chytrid community composition and function displayed a clear seasonal pattern. We provide empirical evidence that parasitic chytrids dominate the community during diatom spring blooms, whereas the subsequent clear water phase, coinciding pollen fall, is dominated by saprophytic pollen-degrading chytrids. However, we also highlight that BLAST searches with chytrid sequences from this study provided only a few sequence matches with culture isolate or environmental sequences in the database, suggesting highly specific and locally-adapted host-chytrid interactions.

2e: Carbon and nutrient dynamics

Conveners: Mariet Hefting (Utrecht University)
Elly Morriën (University of Amsterdam)
Paul Bodelier (Netherlands Institute of Ecology)

1. Reducing the GHG emission by peatland rewetting – An estimation for the Peelvenen using vegetation maps

Gert-Jan van Duinen, John Couwenberg, Christian Fritz
Stichting Bargerveen / Radboud University

Drainage of peatlands and peat extraction causes biodiversity losses, as well as emission of the carbon stored during the development of the mire ecosystem. To restore the two main remnants of the former raised bog system Peel, in the Southern part of the Netherlands, hydrological restoration measures have been carried out, including two recent LIFE+ projects. These projects also aim to restore the ecosystem service of carbon storage and sequestration. In addition, transformation of drained and fertilized farmland on peat stops emission of the strong greenhouse gas N₂O. The effects of these measures on the greenhouse gas (GHG) emission are estimated, using existing vegetation maps and the approach of Greenhouse Gas Emission Site Types (GEST-approach, developed by Couwenberg et al., 2011). This methodology is based on the indicative value of vegetation types for specific water level regimes and GHG fluxes. To each site type GHG fluxes are assigned using published GHG emission values from sites with a similar vegetation and water level. No complicated or expensive additional GHG measurements are needed. The estimated reduction is 5,000-10,000 tons CO₂ equivalents per year in the Deurnsche Peel and Mariapeel (reduction 20-40%) and 1,400-2,600 tons in the Groote Peel (reduction 12-24%).

2. Modulating greenhouse gas balance by combinations of organic amendments

Kristof Brenzinger, Sytske M. Drost, Gerard Korthals, and Paul L. E. Bodelier
Netherlands Institute of Ecology

Agricultural intensification can lead to the loss of soil methane uptake capacity and additionally leads to enhanced emission of nitrous oxide by lowering the reduction of N₂O to N₂. Especially the use of mineral fertilizer and manure over the last 150 years in agricultural fields is known to influence the GHG emission, but to increase agricultural yields fertilizers are required. Recently, it was shown that a few organic fertilizers are able to stimulate CH₄ uptake from agricultural soils in margins comparable to forest soils. Managing organic fertilizer application (by using newly discovered organic amendments or combining organic amendments) to maximize this effect and to minimize emission of other greenhouse gasses (CO₂, N₂O) at the same time, offers possibilities to increase sustainability of agricultural processes. However, it is necessary to make sure that these modifications do not burden the plant yield. We screened different organic amendments as single application or in combination to observe their influence on the carbon and nitrogen cycle as well as on the plant yield. Our results indicate that a combination of a not to N-rich (2-3%) organic amendment with compost gives the overall best benefit in terms of sustainability.

3. Impact of large mammalian herbivores on soil carbon and nutrient sequestration

Judith Sitters, Jasper Wubs, Liesbeth Bakker, Tom Crowther, Ciska Veen, Duncan Kimuyu, Harry Olde Venterink, Truman Young
Free University Brussels

Soils are important reservoirs of carbon (C) and nitrogen (N) and they are facing considerable alterations due to human activities, including changes in the populations of large mammalian herbivores. As herbivores can alter the balance between ecosystem C and N uptake and release, changes in their abundance could potentially feed back to the climate. We examined the responses of soil C and N to mammalian herbivore removal in (i) 21 grasslands under ambient and elevated nutrient availabilities, and (ii) a long-term (20 yr) experiment manipulating the presence and absence of wild herbivores and cattle in an African savanna. Results show that in general herbivores will increase soil C and N sequestration under elevated nutrient availabilities, but that this impact is contingent on climatic conditions and the type of herbivore. For example, the impact of cattle on soil C and N contrasted sharply to the impact of wild herbivores. Cattle decreased soil C and N while wild megaherbivores, such as elephant, increased these pools and could even reverse the negative effects of cattle. The results of these studies highlight the importance of including herbivores, and especially the type of herbivore, within global models predicting land-atmosphere interactions under future climate change.

4. How to measure the tree logs mass loss rate more correctly?

Chenhui Chang, Richard van Logtestijn, Hans Cornelissen

Vrije Universiteit Amsterdam

Tree decomposition exerts a crucial role in global carbon and nutrient cycles, the decay rate significantly influences the system stability. Wood density has been used as an important proxy for measuring decay rate, whereas it can be easily underestimated due to the volume depletion as decay advanced. Therefore, exploring a better way to measure the mass loss of tree logs is important. Ten typical European tree species were collected from two contrasting sites. The bark and wood mass loss rate were measured using different methods after 4 years decomposition. The results showed the modified method improved a lot in improving the accuracy of calculating the mass loss rate. The modified result showed that bark always decomposed faster than wood, and bark mass loss contribute to half of the total mass loss of log at the first 4 years decomposition. Using our modified method greatly improved the contribution of the tree logs to global carbon and nutrient cycles by decomposition.

5. The impact of *Typha latifolia* paludiculture on nutrient dynamics and greenhouse gas emissions in rewetted peatlands

Renske Vroom, Fuju Xie, Jeroen Geurts, Alfons Smolders, Leon Lamers, Christian Fritz

Radboud University

Drainage of peatlands for agricultural use leads to substantial losses of carbon (C) and nutrients to the environment. To restore multiple ecosystem services of peatlands while maintaining productive land use, paludiculture, the cultivation of perennial crops on wet or rewetted peatlands, is a promising, much more sustainable alternative. Paludiculture crops thrive under waterlogged conditions that stimulate nutrient removal and convert serious drainage-induced C losses to C sequestration. Uncertainty remains, however, if and to what extent paludicrops affect nutrient cycling and emissions of the potent greenhouse gas methane (CH₄). We studied greenhouse gas emissions and nutrient cycling in the paludicrop *Typha latifolia*. Effects of nutrient loading and water level were studied in the field and in controlled mesocosm experiments. Nitrogen addition stimulated biomass production and nutrient uptake by *T. latifolia*. In mesocosms, CH₄ emissions remained very low (<1 mg CH₄ m⁻² day⁻¹), despite the labile C pool in the extensive belowground biomass and organic N sources. In field conditions, however, CH₄ emissions were substantially higher (on average 177 mg CH₄ m⁻² day⁻¹) at a high water table (+20 cm). Our findings show that the effectiveness of paludiculture as a climate measure hinges on smart water management and crop choices.

6. Palm swamp forest degradation in the Peruvian Amazon – effects on soil carbon fluxes.

Jeffrey van Lent, Kristell Hergoualc'h, Julio Grandez, Mariela Lopez, Louis Verchot, Oene Oenema, Jan Willem van Groenigen

Wageningen University & Research

Tropical peat swamp forests (PSF) are among the most carbon-dense ecosystems worldwide. Depending on its management, they may represent an important carbon sink or source. Most studies on soil carbon (C) fluxes in PSF have been conducted in Southeast Asia, where drainage and conversion has led to dramatic environmental impacts. Here, we report on the degradation of *Mauritia flexuosa*-dominated PSF in the Peruvian Amazon, with recurrent harvesting of fruit-bearing adult female individuals from undrained natural stands. Four consecutive years of monitoring indicated that harvesting of palms on the microscale resulted in lower heterotrophic respiration rates at hummocks, but site-scale fluxes were >85% based on fluxes from hollows. Degradation further resulted in lower palm and dicot tree stem densities, reducing the site-scale litter input. Combined, the heavily degraded site was an estimated net C source (-7.1 ± 0.2 Mg C ha⁻¹ yr⁻¹), while the intact and medium degraded sites remained close to zero (-0.2 ± 0.4 and -0.7 ± 0.2 Mg C ha⁻¹ yr⁻¹, respectively). Our study shows that unsustainable harvesting practices in *M. flexuosa*-dominated peat swamps disrupt its soil C sequestration potential, and simultaneously suppresses an important non-timber forest product essential to the livelihoods of communities living in the Amazon.

Parallel Session 3

3a: Full annual cycle research in ecology

Conveners: Magali Frauendorf (Netherlands Institute of Ecology)
Morgan Brown (University of Amsterdam)

1. An overview of full annual cycle research in animal ecology – case study: the Eurasian oystercatcher

Magali Frauendorf, Andrew Allen, Bruno Ens, Henk-Jan van der Kolk, Kees Oosterbeek, Simon Verhulst, Eelke Jongejans, Hans de Kroon, Martijn van de Pol
Netherlands Institute of Ecology / Centre for Avian Population Studies

Annual cycles consist of breeding and non-breeding periods that are often clearly separated in space and time. However, they are biologically intricately linked, since the conditions and selective pressures during each period are likely to affect individual performance during subsequent periods. This makes it much more difficult to understand how global change (like climate or land-use) influences ecology and conservation and emphasizes the importance of full annual cycle research. This session covers various aspects of full annual cycle research on different species. We start with an example of the oystercatcher, where we investigated how winter body condition influences reproductive success. We first extended an existing winter body condition index, integrating information on body mass with a range of physiological variables and assessed its effect on the survival of 340 colour-banded adults in the period 2001-2018. Using structural equation models, we quantified how the condition index related to the reproductive performance of 60 oystercatchers monitored in the subsequent breeding season. Results indicate, there is a positive carry-over effect (COE) of winter condition on the reproduction. Adults with higher condition lay earlier in spring, which in turn leads to more fledglings. We suggest COEs play an important role in explaining variation in individual performance and thereby help to clarify the relative importance of various environmental threats acting at temporal and spatial differences.

2. Individual quality mitigates environmental effects on future reproductive performance of a threatened shorebird

Jurrian van Irsel, Magali Frauendorf, Bruno Ens, Martijn van de Pol, Karin Troost, Hans de Kroon, Eelke Jongejans, Kees Oosterbeek, Andrew Allen
Radboud University, Nijmegen

An emerging research field focuses on how environmental effects experienced by an individual in one season carry-over to impact survival or reproduction in a subsequent season. An important consideration is how individual sensitivity to adverse environmental conditions may vary with individual quality. We investigated carry-over effects of breeding Eurasian Oystercatchers (*Haematopus ostralegus*) and defined individual quality according to reproductive success (successful, failed, and non-breeders). Successful breeders had higher survival than failed and non-breeders, and severe winters and low available biomass of cockles had a stronger impact on the survival of failed and non-breeders compared with successful breeders. Successful breeders were also more likely to remain successful in the next year and were better able to cope with adverse conditions. After winters with low cockle biomass, successful breeders had a higher probability than failed or non-breeders of being a successful breeder the next year. A concerning result is that successful breeders appear less able to buffer adverse environmental conditions in recent years, which may have important consequences for future population viability. Our study underlines how carry-over effects vary amongst individuals and is an important consideration for studies investigating carry-over effects.

3. Managing time in a changing world: timing of annual cycle stages under climate change

Barbara M. Tomotani, Marcel Visser
Netherlands Institute of Ecology

Long-distance migrants have complex annual cycles. Their life-cycle events, such as moult, migration and reproduction, have to be fitted into one year, leading to trade-offs between the timing of these events. Climate change has led to shifts in seasonal timing and, using our long-term data, we show that these shifts differ for different life-cycle events of the pied flycatcher, leading to mismatched life-cycle timing. We studied the temporal organization of the entire life-cycle in a large field-laboratory experiment: does the timing of a given stage in the annual cycle affect the timing of subsequent stages. A second test is whether fledglings, which were shifted in their hatching time, adjust their first-year annual cycle stages when they were born earlier or later. Shifts in the termination of breeding in males did not affect the onset of other stages (incl. their time to migrate) and thus increased their moult-breeding overlap as a time-saving strategy. Fledglings shifted their moult date with their hatch date but not their timing of migration. As a whole, migration seems to be the main time-constrained stage. This understanding of carry-over effects of life-cycle timing is crucial to understand how migrants are affected by their warming world.

4. Full annual cycle research on individual red knots *Calidris canutus*

Theunis Piersma, Eva Kok, Chris Hassell, Ying-Chi Chan, He-Bo Peng, Julia Karagicheva, Dmitrii Dobrynin, Eldar Rakhimberdiev, Paul Howey, Lee Tibbitts, Yvonne Verkuil
University of Groningen / NIOZ Royal Netherlands Institute for Sea Research / Global Flyway Network

There are good biological reasons for some birds to breed in one part of our planet and spend the rest of the year at another. Long-distance migrating shorebirds breed in the Arctic combine their reproductive activities on the tundra with a life on soft-sediment seashores, flying as far south as the Sub-Antarctic. Such shorebirds show a range of trophic specializations and among them the red knot *Calidris canutus* combines visual hunting for surface-living arthropods on the tundra with probing for hard-shelled prey on intertidal sedimentary flats. As suitable habitats are rare and widely dispersed across the globe, the long migration flights of red knots may be considered a consequence of their ecological specialization. Enabled by the new availability of very small solar-powered satellite tags, in this study we analysed the complete tracks of eight red knots *C. c. piersmai*, marked in February 2018 in coastal NW Australia, back and forth to the tundra breeding grounds on the New Siberian Islands, Russia. We will try to illuminate the critical features of this remarkable annual cycle in comparisons with what we know of the subspecies of red knots in other parts of the world, and review evidence for cross-seasonal interactions.

5. Favourable energy balance, but poor fitness, in Sanderlings wintering in tropical rather than temperate zones

Jeroen Reneerkens, Tom Versluijs, Tamar Lok, José Alves, Mark Boorman, Teresa Catry, Colin Corse, José Granadeiro, Kirsten Grond, Gunnar Thor Hallgrímsson, Pedro Lourenço, Yaa Ntiamoa-Baidu, Alfred Nuoh, Peter Potts, Job ten Horn, Theunis Piersma
University of Groningen

Evolutionary theories of seasonal migration generally assume that costs of longer migrations are balanced by benefits at the non-breeding destinations. We studied time budgets, intake rates, diet composition, food availability, thermoregulation costs and three components of fitness of High Arctic Sanderling *Calidris alba* at six non-breeding sites ranging in latitude between England (55° N) and Namibia (25° S). Birds at tropical sites had more favourable energy budgets, with more profitable trophic conditions and lower thermoregulation costs. Surprisingly though, survival probabilities were considerably lower in tropical West-Africa (Mauritania: 0.74 and Ghana: 0.75) than at three European sites (0.84, 0.84 and 0.87) and in Namibia (0.85). Sanderlings also more often stayed in the tropics during the first possible breeding season and occurred 5-16 days later at the last stop-over site during northward migration than birds wintering further north or south. Namibia-wintering Sanderlings tracked with solar geolocators staged in West-Africa during southward but not during northward migration. Migrating Sanderlings defy long distances but may end up in non-breeding locations with poor fitness prospects. We discuss that despite favourable wintering conditions, spring fuelling in the tropics is constrained.

6. Does migration strategy influence plasticity of nonbreeding movements in a generalist seabird?

Morgan Brown, Willem Bouten, Emiel van Loon, Cornelius Jan Camphuysen, Judy Shamoun-Baranes
University of Amsterdam

Behaviour can be a plastic trait, but learning and maintaining a large behavioural repertoire can be costly. The degree of behavioural plasticity shown by an individual should therefore be proportional to need. One factor that may influence degree of plasticity is migration strategy. Individuals within a population can differ considerably in how far they migrate from their breeding sites, resulting in differences in variability of environmental conditions and resources experienced throughout an annual cycle. For example, the range of environmental conditions experienced throughout the year becomes more stable the further you migrate. Disconnect between breeding and wintering areas also increases with migratory distance, causing a shift from reliance on flexible local environmental cues to highly consistent photoperiod cues for predicting optimal migration times. Lesser Black-backed Gulls (*Larus fuscus*) are a generalist species who exhibit a range of migration strategies within a single population. We GPS-tracked > 100 individuals from 5 European breeding colonies over multiple annual cycles. We examine the effects of breeding status, size, and colony on non-breeding behaviour, while examining the postulate that as migration distances increases, within-individual variation in behaviour will decrease. We discuss whether variability in annual cycle conditions can carry over to influence behavioural repertoire.

3b: Management of (overabundant) herbivore populations

Conveners: Daan Bos (Altenburg & Wymenga ecological consultants)
Ronald C. Ydenberg (Simon Fraser University Burnaby)
E. Emiel van Loon (University of Amsterdam)

1. A suitable evidence-base for the management of overabundant herbivores

Daan Bos

Altenburg & Wymenga ecological consultants

The title of this talk is the obvious plea for evidence-based management. The talk itself provides a recipe. What elements of information should ideally be collected to choose the right alternative? Using a decision framework proposed by Booy et al. (2017) we have evaluated alternative strategies for the management of overabundant muskrat populations, presented here as a case in point. But, why should these muskrat be considered overabundant?! From what perspective? In this contribution we recall a view on the topic of overabundance by Caughley (1981), and illustrate that view using the subjects from the presentations to follow. It will be made clear that often, decisions have to be made using incomplete knowledge. Thus, we consider what elements of the desired evidence-base should have highest priority.

2. Fallow Deer have biodiversity on the menu

Vincent van der Spek, Mark van Til

Waternet

In the Amsterdam Dunes (3400 ha), a Natura 2000 dune system along the Dutch west coast, an illegally introduced Fallow Deer (*Dama dama*) population grew vastly over the years. Monitoring shows that in 2016 the population had grown to 4000 adults – over one deer per hectare. The population curve showed no signs of evening out. In the meantime, ecologists, foresters and visitors reported a worrying decline in biodiversity. As a non-territorial ungulate without natural enemies, food is the limiting driver behind population dynamics, which had a huge effect on edible plants (and organisms depending on these plants). But how about data to support this expert judgment? We have an excellent citizen science network: volunteers have been collecting standardized monitoring data of a large array of species groups, over a long period of time. Alongside small scale experiments, foreign literature and expert judgement, the running monitoring proved to be a vital source for (independent) experts to proof biodiversity was indeed at stake. A large pile of reports shows that (as a group) all but one species group suffered from overgrazing. This formed the basis of population control that has taken place since autumn 2016.

3. A large-scale experiment to evaluate the effects of trapping on muskrat (*Ondatra zibethicus*) population development in The Netherlands

E. Emiel van Loon, Daan Bos & Ron C. Ydenberg

University of Amsterdam

The muskrat *Ondatra zibethicus* is an invasive species in Europe. An extensive control programme has been in effect for decades in The Netherlands, because muskrat burrowing can compromise the integrity of dykes. Historical data demonstrate a correlation between the annual trapping effort invested and the change in number of muskrats trapped relative to the previous year. We report on an experiment that manipulated trapping effort, in order to better specify the relation between effort and catch. The experiment ran for three years (2013 – 2016) in a stratified random sample of 117 5*5 km 'atlas squares' from the national grid. In these experimental atlas squares trapping effort was manipulated by 30% relative to the preceding three years. Results were evaluated by competing linear mixed models of the catch per unit effort (CPUE). Relative to the control treatment, CPUE fell in the increased effort treatment and rose in the decreased effort treatment. Confidence intervals for these effect sizes, however, enclose zero. The analysis also revealed that CPUE was strongly influenced by that in the preceding three years ('history'), and in the surrounding atlas squares ('neighbourhood'). The strength of these effects was unanticipated. The results obtained here will help to inform a proper public debate and more effective allocation of control effort.

4. Managing geese through their landscape of fear? The potential effect of human disturbance on the distribution of geese

Nelleke Buitendijk

Netherlands Institute of Ecology

In recent decades, several geese species have gone from vulnerable to highly abundant, causing damage to agricultural land along their flyway. While conservation of these species remains relevant, it is also important to minimize damage. One management approach is to scare geese away from sensitive fields, concentrating them in special accommodation areas. This can be seen as an attempt to influence their landscape of fear. For this to work, the geese need to experience human disturbance as predation risk. Furthermore, the cost associated with this risk should outweigh benefits of foraging outside accommodation areas, where competition will be lower and food quality may be higher. Here we review

studies that have looked at human disturbance as predation risk, bringing together knowledge from different species and locations. This will help to formulate predictions about the effective management of geese through scaring and accommodation areas, which in turn can be tested using past and current disturbance studies.

5. Anthropogenic landscape of fear shapes deer space use but not browsing levels

Bjorn Mols, Evert Lambers, Dries P.J. Kuijper, Christian Smit
University of Groningen

Human-wildlife conflicts as a result of increasing deer numbers and expanding ranges pose challenges to managers worldwide. Current population management practices fail to mitigate impacts of high deer numbers on agriculture, forestry, ecology, public health and traffic. Moreover, there is a broad societal call for preventive, non-lethal population management. We tested if deer space use can be steered with zonation of recreation, hunting activities and spatial planning of hiking trails. We measured deer space use by conducting pellet-group counts and assessed browsing levels on planted tree saplings close to and far away from walking tracks, across areas with different recreation and hunting regimes. Deer dropping counts were lower in the proximity of tracks, except for in refuge areas (no hunting & no recreation). At a larger scale, deer pellet-group numbers were highest in refuge areas, and not different between recreation and hunting areas. While we found strong effects on deer space use, these effects did not cascade down to the vegetation as browsing levels were not different close and far from walking tracks, nor between areas with different recreation and hunting regimes. Our study indicates that humans affect deer space use, but that this does not lead to measurable differences in browsing levels.

6. Oostvaardersplassen: a (too) novel ecosystem?

Han Olff
University of Groningen

Europe sees a growing interest in re-establishing ecosystems with a dominant role of natural processes. The Oostvaardersplassen ecosystem in the Netherlands has been a unique example of the creation of a novel ecosystem through embankment of former lake, and introduction of free ranging populations cattle, horses and red deer. In addition, various grazing geese species frequently visit the area. The populations numbers of the large herbivores in this area have developed in a spontaneous way, where population densities are regulated by food availability during winter, by predation. Due to political sensitivity to societal protest regarding the animal welfare aspects of this management, and concerns about changes in various breeding bird species, this management was terminated in December 2018 and replaced by a regular culling regime controlling densities far below carrying capacity of the ecosystem. We report on the details of the dynamics of the herbivore assemblage (growth, mortality) in relation to vegetation change during the last 30 years, and compared this to savanna ecosystems in Africa that do contain large predators. With the growth of the total herbivore density in the Oostvaardersplassen, we found the smaller herbivores to increasingly outcompete the largest herbivore in the system, and explain this by associated changes in vegetation structure, food availability and overall population densities. This will be contrasted to dynamics of African savannahs, where larger predators especially control the smaller herbivores, giving a competitive advantage to larger herbivores, with important implications for vegetation dynamics and ecosystem functioning. We discuss the implications of these findings for rewilding strategies and the establishment of novel grazing ecosystems in a setting of cultural/agricultural landscapes, where protected area size and neighbouring land use often restrict the range of species that is introduced.

3c: Soil Ecology

Conveners: Davide Francioli (Wageningen University & Research)
Ciska Veen (Netherlands Institute of Ecology)

1. Multifunctionality of soil biodiversity in natural and agro-ecosystems

Gerlinde de Deyn
Wageningen University & Research

It are exciting times to be a soil ecologist as soils are at the basis of a sustainable future for life on land. During the last decades it became increasingly clear that natural soils are incredibly rich in (microscopic) life, most of which we cannot yet culture. We also start to realize the importance of diverse soil life for governing many ecosystem functions, yet at the same time we see that soil biodiversity is under threat due to intensive land use. The good news is that these adverse effects can be counteracted by developing new ways of operating, based on ecological principles. In this light both natural and agricultural systems have much to offer to increase our understanding of plant-soil interactions and their impact on key ecosystem functions such as primary productivity, greenhouse gas mediation and disease suppression.

2. Understanding the soil microbiome in function of soil resistance and resilience

Lisa Joos, Caroline De Tender, Lieven Clement, Jane Debode, Bart Vandecasteele
Flanders Research Institute for Agriculture / Ghent University

Soil accommodates a large diversity of microorganisms that drive vital soil processes such as degradation of organic matter and cycling of nutrients. Unfortunately, soils are threatened by land use intensification and climate change. It is a challenge to understand how these disturbances affect the soil microbiome and if those changes are reflected in the resistance and resilience of soil. In this work, soils of five field trials with a specific history of organic fertilizer application, soil tillage and/or crop rotation are evaluated for their physicochemical properties and soil microbiome (fungal and bacterial communities). Additionally the temporal variability of the soil microbiome is investigated (1) to understand how rapid the soil microbiome responds to agricultural practices or environmental changes and (2) to determine the representativeness of samples taken on a given time point. On a monthly basis over a period of one year, samples were taken from two of those five field trials. In general, the soil microbiome was affected by land use and environmental changes. We further hypothesize that the soil microbiome plays an important role in determining the soil resistance and resilience and therefore can be used, at least partially, to assess the soil quality.

3. Fine-mapping rhizosphere communities: opening Pandora's black box.

Paula Harkes, Afnan Suleiman, Sven van den Elsen, Martijn Holterman, Eiko Kuramae, Johannes Helder
Wageningen University & Research

The most intensive interactions between microbes and plants take place at the rhizosphere, which is the interface between plant roots and their surrounding soil. Understanding the functioning of the rhizobiome in its full complexity requires powerful tools to map the inhabitants of this community. Combining the DNA and RNA profile can provide useful information about stimulated fractions within your population at the instant of measuring, resulting in an improved interpretation of ecosystem functioning. Here we monitored the bacterial, fungal, protists and nematode community in the rhizosphere of barley under three distinct soil management regimes, for two developmental stages of the crop, in two different locations. Total DNA and RNA was isolated (in-house protocol) from rhizosphere samples - 104 rhizosphere samples, for each sample DNA and cDNA was analysed separately. First of all, very significant difference was seen at the active (cDNA) and resident community (DNA). Also a location effects was observed for all four organismal groups. Superposed on the location effects, clear effects of organic, integrated and conventional could be pinpointed. To the best of our knowledge this is the first time four mayor key organismal groups players of the soil food web are simultaneously mapped in order to obtain insight in the effects of soil management practices.

4. Benefits of stimulating saprotrophic fungi in arable soils

Anna Clocchiatti, Marlies van den Berg, Maria Hundscheid, Emilia Hannula, Wietse de Boer
Netherlands Institute of Ecology

Saprotrophic fungi are crucial for soil functioning in (semi-)natural ecosystems. On the contrary, their biomass is low in arable soils. This is ascribed to the use of chemical fertilizers, pesticides and tillage practices. The restoration of saprotrophic fungal biomass could support the functioning of arable soils, by improving soil aggregation, nutrient retention and by contributing to a disease-suppressive microbiome. This study investigates how to enhance the growth and activity of saprotrophic fungi in the farmland. Organic materials of different quality were amended to an arable sandy soil. Wood sawdust of broadleaf tree species and paper pulp resulted in the highest increase of fungal biomass, as compared to waste materials, composts, plant residues and conifer sawdust. Moreover, the fungal community

shifted towards a higher proportion of saprotrophic fungi, at the expense of potential plant-pathogens. High-C materials caused N immobilization. This was compensated by the addition of mineral N, which had no immediate negative effect on saprotrophic fungi. Secondly, ¹³C pulse-labelling was applied to carrot seedlings grown on a sawdust-amended soil. PLFA/NLFA-SIP showed that sawdust increases the biomass and activity of saprotrophic and arbuscular mycorrhizal fungi in the rhizosphere. This study serves as a basis for the use of wood sawdust as a sustainable soil improver.

5. Soil biodiversity unraveled: the functional importance of small predators

Stefan Geisen

Netherlands Institute of Ecology

Soils host the vast majority of biodiversity on the planet. Soil organisms are key for ecosystem functioning by controlling nutrient fluxes and plant performance. These roles are fundamentally influenced by protists, the smallest microbial predators. However, the diversity and more importantly function of protists is largely unknown. Here I will provide a short overview of recent advances that revealed an enormous taxonomical diversity of soil protists. These recent findings have also started to shift our perspective of the functional importance of protists in soils that is much wider than previously assumed and include key roles influencing ecosystem functioning. Using three studies I will showcase the importance of protists as (1) structural elements shaping bacterial communities that drive bacterial rarity, (2) most sensible bioindicators in an agricultural study in China and (3) key microbiome hubs shaping plant vegetation in the Brazilian Cerrado. Together I will use protists to exemplify that it is essential to take a more complete (=ecological...) perspective on soil biodiversity including predators to increase our understanding on soil biodiversity-driven ecosystem functions rather than focusing on single, commonly studied groups of the soil microbiome.

6. Disturbance intensity alters soil microbial community reassembly dynamics

Simone Weidner, Joost Keuskamp, Hylke Kortenbosch, Wu Xiong, Rong Li, Alexandre Jousset, George Kowalchuk

Utrecht University / Netherlands Institute of Ecology

Soil microbial communities are essential for soil fertility. However, they are under increasing pressure of disturbances linked to anthropogenic activity and climate change, causing high levels of microbial mortality in soils. Subsequent recovery dynamics may importantly shape microbial community structure with potentially long-lasting effects on soil functioning. We mimicked die-off events of varying intensity by re-inoculating sterilized soil with its own serially diluted microbial extract. We explored post-disturbance effects at three levels of integration: soil microbial community composition, assembly on plant roots and functioning of bacterial isolates. Nine weeks after inoculation microbial biomass had recovered. Dilution negatively affected potential growth rate, but increased carrying capacity. Increasing disturbance thus appears to select for yield, as opposed to growth, strategists. Dilution also decreased bacterial diversity, whilst increasing soil bacterial community variability. Dilution effects on the bulk soil bacterial community were propagated to subsequent rhizosphere communities, decreasing rhizosphere bacterial diversity. Further, we found a decline in the production of public goods by bacterial isolates with increasing dilution (siderophore production, antibiotic production). Together, our results show that die-off events reshape soil microbial communities. Disturbances caused by anthropogenic activity and extreme weather events may thus have long-lasting legacy effects on ecosystems even after apparent recovery.

3d: Ecological consequences of rapid evolution

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

1. Ecological consequences of rapid evolution

Steven Declerck, Jacintha Ellers
Netherlands Institute of Ecology

In ecology, species have long been treated as entities with fixed traits because rates of evolutionary adaptation were supposed to be much slower than the rate of ecological dynamics. Ecologists now increasingly come to realize that microevolutionary change can take place at ecological time scales and as such influence contemporary ecological dynamics. In contrast to phenotypic changes due to macro-evolutionary processes such as speciation and radiation, microevolutionary trait shifts may seem relatively insignificant. However, they can strongly determine the performance of contemporary populations and their interactions with the biotic and abiotic environment. This is especially relevant in the context of human-induced impacts, which cause unprecedented rates of change in the biotic and abiotic environment of organisms. Global warming, urbanization, pollution may all cause rapid adaptive shifts in traits of species, and we are only just starting to link this to their ecological dynamics. In this talk, we will give an overview of this exciting new field of research and introduce the talks of the session that provide nice examples of how rapid evolutionary dynamics may affect ecological trajectories.

2. *Daphnia* microbiome and genotype interact to affect the assembly of the bacterioplankton

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

Using a metabarcoding approach, we show that gut microbiome and environmental bacterioplankton are shaped by the same factors, and that host genotype and its associated gut microbiome influence the structure of the surrounding bacterioplankton in the freshwater crustacean *Daphnia magna*. In a first experiment, in which different *Daphnia* genotypes were placed in identical environments, both the gut microbiome and the bacterioplankton showed a genotype- and diet-dependent taxonomic composition. Overall, the gut microbiome strongly differed from the bacterioplankton in taxonomic composition and was characterized by a lower α -diversity, suggesting a selective rejecting of bacteria from the regional species pool. In a second microbiome transplant experiment, the assembly of both the gut microbiome and the bacterioplankton was strongly impacted by host genotype and the inoculum to which the *Daphnia* were exposed. Together, these results indicate strong interactions between *Daphnia* genotypes, their gut microbiome and free-living microbial communities, which may affect eco-evolutionary dynamics in freshwater systems. More in particular, we illustrate how *Daphnia* genotypes can modify the composition of bacterioplankton and the way in which changes in the genetic structure of *Daphnia* populations can play a structuring role in bacterial communities.

3. Intraspecific trait variation and trade-offs within and across populations of harmful algae

Karen Brandenburg, Sylke Wohlrab, Uwe John, Anke Kremp, Jacqueline Jemey, Bernd Krock,
Dedmer Van de Waal
Netherlands Institute of Ecology

Intraspecific trait diversity can promote the success of a species, as complementarity of functional traits within populations enhances its competitive success, and facilitate resilience to changing environmental conditions. A high intraspecific diversity may support evolutionary selection of beneficial traits and associated genotypes, and can be maintained through intraspecific trade-offs. Harmful algal blooms are genetically and phenotypically diverse proliferations of phytoplankton populations that form a major threat to the structure and functioning of coastal ecosystems. We assessed intra-specific trait variation and trade-offs of 15 clones of the harmful algal bloom species *Alexandrium ostenfeldii* from Baltic Sea and Dutch populations. Key traits that were determined included growth rate, cell size, elemental composition, nitrogen uptake kinetics, toxin production and allelochemical potency. We demonstrate substantial variation in all traits both within and across populations, particularly in nitrogen affinity, which was even comparable to interspecific variation across phytoplankton species. We furthermore found intraspecific trade-offs between maximum nitrogen uptake rate and affinity, and between defensive and competitive traits. The observed high trait variation may facilitate development, resilience and the evolution of harmful algal blooms under dynamic environmental conditions.

4. Eco-evolutionary consequences of connectedness loss: an experimental approach

Stefano Masier, Dries Bonte
Ghent University

Habitat fragmentation and connectivity loss are between the main effects of human activity, both having an impact on population dynamics and ecology. It is however complex to disentangle their actual effects in natural populations. In our experiment we studied how differently connected patch networks influence the dynamics of experimental metapopulations of two-spotted spider mites (*Tetranychus urticae*). To remove spatial structure, we implemented reshuffling on some of the replicas. We monitored the population size in every patch for ~18 generations; at the end of the experiment, we also tested for evolved differences. Our results show how connectedness affects population dynamics at global and local scale and the decoupled effect of kin structure. We also highlight differences in evolved traits: starvation resistance, intrinsic growth rates and dispersal timing were all impacted by global connectedness. Local connectedness affected intrinsic growth rate: as reshuffling did not cancel the effect, we propose epigenetic mechanisms as a possible explanation. We show how, even in a simple lab experiment, the dynamics of a metapopulation can be more intricate than what is usually assumed. We also demonstrate how theory can sometimes be misleading, as biological systems are able to self-adapt and rescue themselves up to a certain extent.

5. What costs and benefits for foraging efficiency are involved in rapid evolution of learning ability?

Maartje Liefing
Freie Universität Berlin / Vrije Universiteit Amsterdam

Understanding how variation in complex behavioural traits is maintained and how selection acts on these different phenotypes is a major challenge in evolutionary biology. Learning is most likely the fastest way to adjust phenotype to changing environments and natural variation in this ability (e.g. in the speed and accuracy with which information can be learned and memorized) exists in most species. This creates the potential for the selection of certain learning abilities in response to specific environmental conditions. Learning ability in a parasitoid wasp indeed responded readily to selection in an earlier study. It is commonly assumed that a specific learning ability is the net result of the trade-off between costs and benefits, but only recently have the first ecological studies on this subject been ventured. We therefore further explored natural variation in learning ability in a parasitoid wasp in the light of relevant costs and benefits regarding foraging efficiency.

6. Rapidly evolving zooplankton in a salinizing world: to what extent does adaptation to one salt increase tolerance to another one?

Libin Zhou, Shuai-Ying Zhao, Steven Declerck
Netherlands Institute of Ecology

Freshwater organisms are increasingly exposed to higher levels of salinization, due to rising sea levels, increased evaporation, fertilization, industrial pollution and road salts. Stress due to salinization does not only involve increased osmotic pressure but, depending on salt chemical identity, also toxicity by salt ions. The objectives of our study were to test if evolutionary adaptation to one type of salt alters the potential to cope with other types of salts? For this we performed a laboratory evolution experiment subjecting replicate populations of the rotifer *Brachionus calyciflorus* to low and high NaCl treatments. In a subsequent common garden experiment, genotypes of these populations were exposed not only to NaCl but also to CaCl₂ and NaSO₄. In each of these treatments, salt levels were gradually increased until populations realized zero net population growth. Zero growth osmolarities showed that adaptation to NaCl increases the ability of populations to cope with toxicity due to calcium but not to sulphate ions. To conclude, our results suggest that in a metapopulation context evolutionary adaptation to one salt type may facilitate colonization of patches that are salinized by other types of salts, but this outcome will largely depend on salt chemical identity.

3e: Governing dynamics of community assembly: from big data to best practices

Conveners: Edwin T. Pos (Utrecht University)
Marco. D. Visser (Princeton University)

1. The future of ecology: Big data, Big questions and Big problems

Edwin T. Pos
Utrecht University

We are in the midst of a sixth mass extinction with newspapers reporting every other day about the consequences of climate change with regard to biodiversity loss. Undeniably, biologists are facing greater challenges than ever, and hence is it more important than ever to efficiently utilize all tools at our disposal to tackle these problems across multiple scales. In this information age, big data is such a powerful tool, one that is becoming more and more readily available across taxonomic, spatial and temporal scales. Here, we will focus on how big data aids in the understanding of community assembly, and helps unravel the drivers of diversity. Today, we are able to study the process of community assembly from the micro to global scales using many different technologies. In this first talk we take a birds-eye view of big data, big questions and perhaps even bigger problems to pave the way for the remainder of the session where we will look at some successful examples of using big data on different levels of organisation to understand community assembly but also emphasize methods of getting big data and its caveats. The session provides a glimpse into the future of ecology. It highlights how classical approaches to answering questions in ecology are changing in light of the availability of big data, but also how this brings new challenges and pitfalls.

2. Big data in Ecology may not be so big but still useful – an example from a big forest

Hans ter Steege
Naturalis Biodiversity Center

The Amazon, our largest and richest tropical forest, covers an area of 5.7 million km². At the moment spatial ecological data for the Amazon is concentrated in two big data sets, the ATDN plot inventory (1952 plots, over a million trees) and the combined herbaria of the world (1/2 million unique collections). While considered big data by some, this data fits easily in a database. The coverage of the big data is small; the plot data together covers just 0.0000035% of the area and there is only 1 tree collection per 10km². Yet with this 'limited' data the major patterns, richness and threat can be assessed with some level of accuracy. Combining wider data may allow better estimates of species richness across all forests in South America and further.

3. How large-scale DNA sequencing of environmental samples helps us open the "black box" of fungal community assembly in tropical, temperate, and arctic biomes

József Geml, Irene Adamo, Fabiana Canini, Joliese Teunissen, Luis Morgado
Naturalis Biodiversity Center

Fungi represent one of the largest groups of living organisms. They play key roles in determining the structure and functionality of terrestrial ecosystems, drive plant diversity and productivity, and are crucial for ecosystem resilience towards disturbance. The vast majority of fungi are invisible to the naked eye and/or cannot be cultured. Consequently, the proper characterization of highly diverse fungal communities and the discovery a significant portion of yet unknown species, orders, and even classes and phyla have only recently become possible with the advent of high-throughput DNA sequencing of environmental samples. In particular, DNA metabarcoding, the simultaneous identification of multiple species from an environmental sample, has revolutionized fungal ecology and diversity studies. In this talk, we give an overview of how large-scale DNA sequence data and site metadata can be used to assess to which biotic and abiotic environmental variables drive fungal community assembly in different biomes. Examples include evaluating the influence of environmental drivers on fungal community composition along natural gradients (e.g., elevation, slope aspect) as well as in response to anthropogenic disturbance (e.g., deforestation) and climate change. The emerging pattern is that most fungi have high habitat specificity and tend to respond quickly to changes in environmental conditions. Therefore, fungi have a promising potential as indicators of habitat quality in biological monitoring programs that can inform decision-makers with respect to land use strategies that foster the sustainable preservation of diverse and resilient ecosystems with a wide range of ecosystem functions. However, routine and scalable use of these methods will require standardized acquisition and handling of such big datasets.

4. How the Microbial Rare Biosphere Coexist with Dominant Species?

Xiu Jia, Francisco Dini-Andreote, Joana Falcão Salles
University of Groningen

Our planet teems with microorganisms, which often present a skewed abundance distribution in a local community, with relatively few dominant species co-existing alongside a high number of rare species, i.e. the microbial rare biosphere. Recent studies have demonstrated that rare taxa not only serve as limitless reservoirs of genetic and functional diversity but also perform a disproportionate level of

functions. However, most of our current knowledge of microbial community is based on dominant species; relatively little is known about the ecological mechanisms mediating the structure of rare biosphere, i.e. speciation, dispersal, selection, and drift. To fill this gap, we investigated which processes contribute to the soil microbial rare biosphere persistence and dynamics across space and time on the salt marsh chronosequence located on the island of Schiermonnikoog, the Netherlands. Using high-throughput 16 cDNA sequencing, we observed that the species composition of rare biosphere was different from that of dominant biosphere. In the rare biosphere, most species were permanently rare, whereas only a small fraction of the rare biosphere was conditionally rare and transiently rare. To further explore which mechanisms contribute the observed pattern, we disentangled the ecological processes by combining phylogenetic community structure with ecological null model analysis. We found that homogenizing selection was the predominant ecological process contributing to the variation of the rare biosphere structure, suggesting that most rare species persist in low abundance due to their special life-history strategies or ecological trade-offs. Together, these results elucidated how the highly diverse microbial rare biosphere is assembled, which will promote a better understanding of the main processes underpinning the huge diversity found in microbial communities.

5. Big(ger) data with DiSSCo

Niels Raes and the DiSSCo consortium
Naturalis Biodiversity Center

Many recent groundbreaking biogeographical, macroecological and biodiversity studies rely on digitized and georeferenced specimen data from natural history museums and herbaria that is available today. Currently, GBIF, the most important data infrastructure for biodiversity data holds 149 million records of preserved specimens. Within Europe, however, it is estimated that all collection institutes collectively hold 1.5 billion specimens or 55% of the global collection, meaning that only a small percentage of the European collection is digitally available. Furthermore, biodiversity data that is digitally available is still incomplete and inadequately connected. Recognition of the importance of digital biodiversity data for scientific research and evidence based policy decisions has resulted in the acceptance of DiSSCo <<http://dissco.eu>>, the 'Distributed System of Scientific Collections' on the European Strategy Forum on Research Infrastructures (ESFRI) roadmap. DiSSCo will mobilise and harmonise natural science collection data and make them available as one big linked science cloud, linking historical collection data with data emerging from new techniques (e.g. whole genome sequences, proteomics, metabolomics) using permanent and persistent identifiers. In this presentation I will showcase the DiSSCo framework and architecture, and illustrate the potential and added value of DiSSCo for future ecological studies with a number of worked examples.

6. Bigger isn't always better: how regression dilution distorted the perception of negative density dependence.

Marco D. Visser
Princeton University

Coexistence theory has long predicted that for species to coexist, intraspecific competition should be stronger than interspecific competition. Over the past two decades plant community ecology has assembled a growing body of evidence, using datasets on unprecedented scales, that intraspecific competition is indeed stronger than interspecific competition. This year community ecologists have proclaimed victory: we have successfully proved the basic tenets of coexistence theory, and our theory is now ready to be applied to managing our ecosystems and biological reserves. In the face of the biodiversity crisis, policy makers need solutions to solve critical environmental problems today based on the best available science. Is this, therefore, a timely success story for the use of big data? Here I explore the insidious nature of a well-known statistical inference bias called regression dilution. Regression dilution causes an underestimation of the strength of dependency between two variables when the predictors are error-prone proxies (EPPs), i.e. contain errors. This type of bias has contaminated a large body of studies focused on conspecific negative density-dependence (CNDD). Because of the nature of the bias, CNDD is often overestimated, and in some cases, can be erroneously detected, even when absent. This bias can vary significantly between rare and abundant species and thereby generates spurious trends and mislead the ecological interpretation of the pattern. The examples explored here suggest that this bias has been pervasive and has permeated the ecological community in such a way that the perception of CNDD has been distorted. I end by asking what evidentiary standards are needed in the analysis of big data? And whether community ecology, in combination with big data, is truly ready to be applied to environmental problems.

Parallel Session 4

4a: Estuarine & Coastal Ecology in the Anthropocene

Conveners: Karin van der Reijden (University of Groningen)
Laura Govers (University of Groningen / Royal Netherlands Institute for Sea Research)
Oscar Bos (Wageningen Marine Research)

1. Marine conservation and restoration ecology in a changing world

Laura Govers, Eric S. Higgs, Eeke P. Haanstra, Han Olff
University of Groningen / Royal Netherlands Institute for Sea Research

The global degradation of coastal ecosystems in an age of rapid environmental change calls for the reassessment of conservation and restoration proxies that often refer to pre-disturbance states. In addition, current game changers in the field of conservation - the increasing valuation of ecosystem services on a landscape-scale, cutting edge interdisciplinary technological innovations and collaborations and growing investments in conservation - call for a novel, more flexible approach to marine conservation and restoration. In this session, we illustrate the leading position of marine conservation science in the Netherlands by presenting an interesting range of talks that addresses coastal restoration and conservation issues in our nearby, heavily modified coastal seas. From innovative restoration projects on salt marshes and tidal mussel beds, to an eco-friendly sand nourishment project, to recovery of a top-predator in the Wadden Sea to novel methods to map the North Sea floor; these talks illustrate current advancements in the field of conservation science in an ever-changing world.

2. Biomimicry can amplify coastal restoration success by bridging establishment thresholds for habitat-forming plants

Ralph Temmink, Greg S. Fivash, Christine Angelini, Wouter Lengkeek, Karin Didderen,
Leon P.M. Lamers, Tjeerd J. Bouma, Tjisse van der Heide
Radboud University

Coastal ecosystems provide flood protection and biodiversity services, but are declining worldwide. Restoration of these degraded ecosystems has proven challenging, because success depends often on overcoming establishment thresholds resulting from habitat modifier-generated density and/or patch size-dependent self-facilitating feedbacks. To bridge these thresholds, modified restoration designs were recently proposed to harness self-facilitation. However, this transplant-hungry approach is impractical for systems with limited source populations. We propose a new restoration concept in which habitat modifiers are transplanted within biodegradable structures that mimic self-facilitating feedbacks. Using salt marshes as a model system, we tested whether newly developed potato waste-derived BESE-elements can promote wave attenuation and sediment stabilization feedbacks to support *Spartina anglica* (cordgrass) transplants. We manipulated establishment conditions of cordgrass transplants using BESE-structures to mimic cordgrass' above or belowground self-facilitating feedbacks at high and low intertidal elevations. Our experiment revealed that at higher elevation, aboveground BESE-elements strongly increased cordgrass transplant survival and lateral expansion by locally increasing the sediment bed level and possibly reducing wave and current stress on the plants. At low elevation, physiological plant stress was insufficiently ameliorated by BESE-elements. We conclude that the use of temporary establishment structures to mimic self-facilitation feedbacks is a promising approach for restoring coastal ecosystems.

3. Lowering settlement thresholds to increase restoration success of intertidal musselbeds

Jildou Schotanus, Edwin Paree, Jacob J. Capelle, Johan van de Koppel, Tjeerd J. Bouma
HZ University of Applied Sciences

Restoration of intertidal mussel beds may help to counteract the increasing erosion of mudflats in soft-bottom systems. However, settlement thresholds caused by hydrodynamic stress and predation pressure may impede successful transplantation of mussels. We tested if we could artificially lower mussel settlement thresholds by using (1) wave breakers in front of mussel beds, (2) attachment substrates such as oyster shells and nets and (3) anti-predation fences to reduce predation by crabs. The wave breakers and the provision of attachment substrate showed to have a positive effect on mussel survival. The anti-predation fences did not keep out the crabs but did work as a blockage for mussels to get washed away. There is thus potential for combining these kinds of protective measures to restore intertidal mussel beds at wave exposed mudflats. abstract.

4. A mega-nourishment as a promising eco-friendly alternative to regular sand nourishment for the intertidal macroinvertebrate community

Emily van Egmond, Peter M. van Bodegom, Matty P. Berg, Jeroen Wijsman, Lies Leewis, Gerard Janssen, Rien Aerts
Vrije Universiteit Amsterdam

Globally, sandy beaches are subject to coastal squeeze due to erosion. Soft-sediment strategies, such as sand nourishment, are increasingly applied to mitigate erosion effects, but have negative impacts on beach flora and fauna. As a more eco-friendly alternative to regular beach nourishment, a mega-nourishment has been constructed along the Dutch coast by depositing 21.5 Mm³ of sand (the Sand Motor), from which sand is gradually redistributed by natural processes over a 20-year period. We evaluated the development of intertidal macroinvertebrate communities in relation to this mega-nourishment, and compared it to those at beaches subject to regular beach or no nourishment. We found that a mega-nourishment resulted initially in a higher macroinvertebrate richness, but a lower macroinvertebrate abundance, compared to regular beach nourishment. The macroinvertebrate community at a mega-nourishment did not converge to a community similar to those at unnourished beaches. Beach areas at the mega-nourishment sheltered from waves harboured a distinct macroinvertebrate community compared to typical wave-exposed sandy beach communities. Thus, a mega-nourishment temporally creates new habitat for intertidal macroinvertebrates by enhancing habitat relief of the sandy beach. We conclude that a mega-nourishment may be a promising coastal defence strategy for sandy beaches in terms of the intertidal macroinvertebrate community.

5. Top-down pressure on a coastal ecosystem by harbor seals

Geert Aarts, Sophie Brasseur, Jan Jaap Poos, Jessica Schop, Roger Kirkwood, Tobias van Kooten, Evert Mul, Peter Reijnders, Adriaan D. Rijnsdorp & Ingrid Tulp
Wageningen Marine Research / Royal Netherlands Institute for Sea Research

Historic hunting has led to severe reductions of many marine mammal species across the globe. After hunting ceased, some populations have recovered to pre-exploitation levels, and may have regained their prominent position as top predator in marine ecosystems. Also the harbor seal population in the international Wadden Sea grew at an exponential rate following a ban on seal hunting in 1960's, and the current number ~38,000 is close to the historic population size. Here we estimate the impact of the harbor seal predation on the fish community in the Wadden Sea and nearby coastal waters. Fish remains in fecal samples and published estimates on the seal's daily energy requirement were used to estimate prey selection and the magnitude of seal consumption. Estimates on prey abundance were derived from demersal fish surveys, and fish growth was estimated using a Dynamic Energy Budget model. GPS tracking provided information on where seals most likely caught their prey. Harbor seals hauling-out in the Dutch Wadden Sea fed predominantly on demersal fish, e.g. flatfish species (flounder, sole, plaice, dab), but also on sandeel, cod and whiting. Although harbor seals acquire the majority of prey further offshore in the adjacent North Sea, and only spend 14% of their diving time in the Wadden Sea, seal predation was still estimated to cause an average annual mortality of 43% of the remaining fish in the Wadden Sea and 60% in the nearby shallow coastal waters (<20m). There were however large sources of uncertainty in the estimated impact of seals on fish, including the migration of fish between the North Sea and Wadden Sea, and catchability estimates of the fish survey sampling gear, particularly for sandeel and other pelagic fish species. Our estimate suggested a considerable top-down pressure by harbor seals on demersal fish. However, predation by seals may also alleviate density-dependent competition between the remaining fish, allowing for increased fish growth, and partly compensating for the reduction in fish numbers. This study shows that recovering coastal marine mammal populations could become an important component in the functioning of shallow coastal ecosystems.

6. The spatial distribution of benthic organisms and sand ripples over tidal sand waves: insights from a submerged camera system

Johan Damveld, Karin van der Reijden, Chui Cheng, Leo Koop, Lisa-Rose Haaksma, Cameron Walsh, Karline Soetaert, Bas Borsje, Laura Govers, Pieter Roos, Han Olff, Suzanne Hulscher
University of Twente

Shallow shelf seas are important areas for both engineering and ecology. Their seabeds consist of rhythmic bed patterns of various dimensions. Meso-scale features such as sand waves migrate several meters per year, possibly exposing pipelines and cables to wind farms. On a smaller scale, sand ripples influence the roughness of the seabed, which is an important parameter in morphological models. At the same time, the bed of coastal seas are covered by large communities of benthic organisms, living on top and within the seabed. A wide range of human-related activities in these areas put an increasing pressure on the long-term stability of the marine ecosystem. In order to increase our understanding of the complex seabed system, we study the spatial relationships among benthic habitats, sand waves and ripples. To this end, we present results gathered from video transects over sand waves in the North Sea. These data reveal that both epi- and endobenthos are significantly more abundant in sand wave troughs, compared to their crests. Furthermore, in sand wave troughs ripples are less abundant and more irregularly-shaped. Finally, we demonstrate that submerged camera systems are a quick and effective method in studying benthic spatial patterns in relation to small- and meso-scale seabed morphology.

4b: Using small-scale data for large-scale questions

Conveners: Melinda de Jonge (Radboud University)
Coline Boonman (Radboud University)
Leila Meyer (Federal University of Goiás)

1. Using small-scale data for large-scale questions

Melinda de Jonge, Coline Boonman, Leila Meyer
Radboud University

The conveners will introduce the topic of the session. Here, we focus on the application of small-scale data for large-scale questions. We will also give an overview of the research of each of the conveners of this session.

2. European bees are modulated by local and landscape context interactions

Juan Gallego-Zamorano, Ron Corstanje, Andy Purvis, Adriana De Palma
Radboud University

Local land management as well as landscape characteristics, can have beneficial effects on bee populations and the pollination services they provide. However, the effects of the interactions between both local (e.g. different farming practices) and landscape scales (e.g. landscape configuration) on bee abundances are still relatively unknown. We used abundance data at the local-scale, to provide the first continental-scale assessment of how the interactions between local and landscape characteristics impact bees. We showed that bee responses to local pressures are significantly influenced by the landscape context (including habitat heterogeneity, the number of accessible floral resources, and the functional connectivity in the landscape). We also demonstrated that in land uses with a moderate intensity of use, abundance of bees can be bolstered when the surrounding landscape offers favourable conditions for nesting, feeding and reproduction. Lastly, we observed a similar response in intensively-used croplands but only for domesticated bees.

3. Intra- and inter-specific patterns of population density in terrestrial vertebrates

Luca Santini, Nick Isaac, Luigi Maiorano, Gentile Francesco Ficetola., Samuel Pironon, Mark Huijbregts, Chris Carbone, Wilfried Thuiller
Radboud University

Macroecology has traditionally focused on the drivers and patterns of species' distribution. However, how spatial environmental variation influences species population density for a large range of organisms at a broad spatial scale has received little attention. Here we used >18K georeferenced population density estimates for terrestrial vertebrates to answer three questions relevant to macroecology and conservation: 1) What are the environmental predictors of population density in terrestrial vertebrates? 2) Can we predict population density? 3) Does abundance distribution decline from the centre to the edge of species ranges? We found that, beside species traits, environmental conditions explain an important component of the variation in population density across species and conspecific populations. Species traits, resource availability and climatic stability have a different influence on the population density of the four groups of terrestrial vertebrates. Our models can be used to predict the average species population density over large areas and be used to explore macroecological patterns and inform conservation analyses, but require caution in their application and interpretation. Finally, we found the abundance distribution within species ranges to be largely inconsistent with several definitions of the abundant-centre hypothesis, suggesting this remains an appealing speculation with little and variable empirical support.

4. Evaluating the reliability of plant species distribution models with ecological indicator values

Marjon Hendriks, Wim Ozinga, Arjen van Hinsberg, Mark Huijbregts, Stephan Hennekens, Joop Schaminée, Jürgen Dengler, Aafke Schipper
PBL Netherlands Environmental Assessment Agency

Species distribution models (SDMs) are routinely applied to assess current and future species distributions at large spatial scales. Confidence in SDMs is typically achieved by means of cross-validation, but this may provide overly optimistic estimates of the models' predictive ability due to a lack of independence of the testing data set. Here we evaluated the robustness and ecological plausibility of European-scale SDMs of 1,383 terrestrial plant species against independent ecological indicator values (EIV), which indicate the preferences of plant species for key environmental conditions. For each species we first extracted indicator values for climate, soil, land use and nitrogen deposition from the SDMs, using the median values from within their projected distributions. We then compared these modelled indicator values and the EIVs across the species by means of bivariate correlations and a redundancy analysis (RDA). We found reasonable agreement between modelled and independent ecological indicator values for large-scale climatic gradients, but much less so for nitrogen deposition and more heterogeneous and fine-grain characteristics related to land cover and soil properties, notably pH. This scale-dependency of the environmental responses requires careful consideration when establishing and applying large-scale SDMs.

5. Using airborne laser scanning to quantify fine-scale habitat structures at macroscales

W. Daniel Kissling, Zsófia Koma, Meiert Grootes, Christiaan Meijer, Ruud Foppen, Henk Sierdsema, Arie Seijmonsbergen and Willem Bouten
University of Amsterdam

Local habitats are of key importance for the distribution and abundance of animal species, but quantifying high-resolution 3D vegetation structure at macroscales remains challenging. Here, we present the eEcoLiDAR project which currently builds an eScience infrastructure for ecological applications of point clouds derived from Light Detection and Ranging (LiDAR). We use available multi-terabyte point cloud datasets (derived from airborne laser scanning), high performance computing as well as existing and newly developed open source software tools to derive country-wide LiDAR metrics at high resolution (10-100 m grid cells). These LiDAR metrics allow to quantify 3D habitat and vegetation structure at unprecedented detail, incl. vegetation height, vegetation coverage, horizontal and vertical vegetation distribution as well as terrain properties. First applications of species distribution models (SDMs) with LiDAR metrics and nationwide bird atlas data show the potential to reveal fine-scale habitat niches of bird species, incl. wetland and reedbed birds for which currently available land cover maps are insufficient to describe their habitats. Our project demonstrates how advancements in ecoinformatics and macroecology can improve our understanding of the relationship between organisms and their environment, especially via providing fine-scale (high resolution) habitat data across broad spatial extents.

6. GLOBIO 4: a global model of local biodiversity intactness

Aafke Schipper, Jelle Hilbers, Johan Meijer, Laura Antão, Ana Benítez-López, Melinda de Jonge, Luuk Leemans, Eddy Scheper, Rob Alkemade, Jonathan Doelman, Sido Mylius, Willem-Jan van Zeist, Mark Huijbregts
PBL Netherlands Environmental Assessment Agency / Radboud University

Biodiversity is facing unprecedented and increasing anthropogenic pressures, including habitat loss and fragmentation, climate change, hunting and pollution. Global biodiversity models are indispensable for quantifying and comparing the effects of these pressures as well as evaluating policies aimed at halting biodiversity loss. The GLOBIO model quantifies impacts of various anthropogenic pressures on biodiversity intactness worldwide, based on pressure-impact relationships that are parameterized with site-level monitoring data. In this presentation, we will first show recent updates made to the GLOBIO model, which now runs at a higher spatial resolution, contains a new module for downscaling land use data, and includes updated pressure-impact relationships for climate change, land use, habitat fragmentation, nitrogen deposition and hunting. We will then show the results of a case study where we assessed the implications for future biodiversity intactness of three global socio-economic development pathways, ranging from a sustainability pathway to a fossil-fuelled development scenario. Based on these results we will identify hotspots of projected biodiversity change as well as underlying pressures and drivers, which in turn can be used to formulate recommendations for policy measures aimed at safeguarding biodiversity.

4c: Tropical Ecology

Conveners: William Gosling (University of Amsterdam)
Marielos Pena Carlos (Wageningen University & Research)
Patrick Jansen (Wageningen University & Research)

1. Predator avoidance and prey tracking in a Neotropical forest

Constant Swinkels & Patrick A. Jansen
Wageningen University & Research

Predator-prey interactions are important factors in ecosystems. Two key questions are whether prey avoid predators and whether predators track their prey. One approach to address these questions in field situations is to monitor the proximity of animals in space at the same time, using GPS. One limitation, however, is that only a limited subset of all animals can be followed so that actual proximity might be greater, which could lead to wrong conclusions. We studied whether prey animals avoid predators and predators follow prey in a novel way; by measuring proximity in time at the same place, using camera-trapping data from the tropical moist forest of Barro Colorado Island, Panama. We fitted Cox mixed effect models to measure temporal proximity of predators and prey, and used random permutations to generate null distributions for significance testing. We found that predator passage prolonged the time until prey appeared, suggesting predator avoidance by prey, while prey passage did not shorten the time until predators appeared, suggesting no prey tracking by predators. We conclude that a Eulerian approach to studying predator-prey is a viable and non-invasive alternative to GPS tracking.

2. The role of fig volatiles in pollinator specificity and fig diversity

Aafke Oldenbeuving, Jacques van Alphen, Edward Allen Herre
Naturalis Biodiversity Center

Fig trees (genus *Ficus*; around 800 spp. globally) are an important food source for many frugivores in all tropical ecosystems. At any given site, each fig species is usually pollinated by one or two species of fig wasp that identify their proper host by the figs' species-specific volatile blends. Despite the extraordinary high specificity observed, increasing evidence suggests that host shifts within the fig genus and hybridization are also quite common. Therefore, speciation and diversity in figs reflects a balance between the wasps' extreme host-specificity (e.g. ensuring prezygotic isolation) as well as by the breakdown of it (e.g. hybridization followed by genetic introgression). In this talk I explore the role the composition and recognition of species-species fig volatiles play in speciation processes in figs. I summarize the current consensus on host-specificity mechanisms and show data collected in the tropical rainforest in Panama. I have simultaneously monitored the volatile blends and the pollinator communities present in four sympatric fig species, two pollinated by host specific wasp species and pollinated by two generalist species. The results further elucidate how fig volatiles generally result in the fig wasps' specificity but sometimes promote host-shifts.

3. Mangrove Atlantis: Can mangroves keep up with extreme land-subsidence?

Celine van Bijsterveldt, B. van Wesenbeeck, R. Pribadi, M. Helmi, C. Böhm, T. Heuts and T. Bouma
Royal Netherlands Institute for Sea Research

A large portion of the world's population lives near the coast, deltas and estuaries. Big cities near the coast are increasingly under threat from processes as sea level rise and subsidence. The coastline of North Java, Indonesia, for instance is subsiding rapidly with rates up to 30 cm per year near big cities as Jakarta and Semarang. At the same time large scale coastal erosion occurs along these coasts due to failing conventional coastal protection and intensive land-use in the form of aquaculture. Governments now look into using mangroves for restoration of the sediment balance and protection of the coastline. We therefore wondered: Will mangroves be able to keep up with land subsidence? We measured subsidence, sedimentation and erosion rates at 9 mangrove sites with increasing distance from Semarang city, on the coast of North Java, Indonesia. At each site, we investigated mangroves' response to subsidence, sedimentation and erosion through a combination of "forensic forestry" on dead mangrove trees and monitoring of living trees. Here we present results that show how mangroves can potentially keep up with subsidence thanks to various acclimation mechanisms.

4. The fate of forests in agro-forest frontier landscapes, implications for conservation

Madelon Lohbeck, Mathieu Decuyper, Miguel Martinez-Ramos, Frans Bongers
Wageningen University & Research

Most of the world's remaining tropical forest is located inside human-modified landscapes. We study an agro-forest frontier landscape in Chiapas, Mexico where colonization took place from the '70. We used a unique combination of long-term forest monitoring plots and Landsat-based, multi-temporal remote sensing techniques. Most of the remaining forest is still high-diversity mature forest, 30% is regrowth forest and 15% is plantation forest. Mature forest has seen dramatic declines in the first decades after colonization, and have become increasingly fragmented and degraded. Median forest regrowth age initially increased and is now decreasing which may indicate land scarcity. Secondary forests today rarely persist longer than 8 years, which allows restoring most of carbon stocks, but restricts restoring soil fertility and biodiversity. The last decade has seen an increase in palmoil plantations, which contribute little to conservation. The large variation in forest dynamics trajectories across the 38 villages can be partially explained by geology, accessibility, population density and tenure. Understanding the socio-cultural conditions under which forests persist is important for informing policy measures. This study warrants continued degradation and the need for improved conservation measures adapted to socio-cultural realities.

5. Trends in the variability of Specific Leaf Area of paramo vegetation during succession

Marian Cabrera & Joost Duivenvoorden
University of Amsterdam

Paramo succession is driven by the functional structure of the community. We hypothesized that plant communities in the mid-successional stages are characterized by a larger intraspecific variability than in early or late successional stages. Our gradient represented plant communities from semi-natural areas to early successional stages after agriculture. We counted all vascular species in 136 plots of 1x1m. We collected from each species registered in each plot at least 15 leaves to account for the intraspecific variability of the specific leaf area (SLA). We measured plant height as a proxy of the ontogenetic state of the plant community. Our regression model showed that late successional plant communities had lower intraspecific variability in SLA than early and mid successional communities. We reject our hypothesis of mid successional communities having higher trait variability. Early successional plant species had higher intra and intraspecific SLA variability, however, paramo conditions select for more conservative plant strategies, and species with high SLA values experience high costs.

6. Succession dynamics of tree and soil fungal communities in regenerating tropical rainforests are strongly influenced by regional species pool and abiotic factors

Irene Adamo, Edgar Ortiz-Malavasi, Robin Chazdon, Priscila Chaverri, Hans ter Steege, József Geml
Naturalis Biodiversity Center

Studying regenerating tropical forests can give fundamental insights into the successional dynamics of community composition and functional diversity following land-use change. In general, most conservation studies have been focusing on vascular plants and animals, while data regarding the successional changes in the diversity and composition of fungi in secondary tropical forests are virtually absent. Here, we compared fungal richness and β -diversity and community composition along forest successional gradients in two regions of the Osa Biological Corridor in Costa Rica. In addition, we tested if fungal and tree communities from the same plots showed similar successional trends. We observed no correlation between fungal and tree richness: forest succession had no influence on total fungal richness and we observed no correlation between fungal and tree species richness, while tree species richness was significantly higher in the primary forest than in regenerating forests of various ages. Conversely, β -diversity measures were significantly smaller in primary forest communities than regenerating secondary forests in both trees and fungi. This suggests, that after greater stochasticity in community assembly in the early stages of secondary forest succession, both tree and fungal communities tend to converge on a set of taxa with competitive advantage in old-growth forests. However, regional differences in climate and edaphic factors had greater influence on fungal and tree community composition than forest succession, emphasizing the importance of the regional species pool.

4d: Understanding spatial patterns in Biodiversity

Conveners: Jeroen van Leeuwen (Wageningen University & Research)
Stefan Geisen (Netherlands Institute of Ecology)

1. Understanding (and mapping) of spatial patterns in biodiversity

Jeroen P. van Leeuwen, Stefan Geisen

Wageningen University & Research / Netherlands Institute of Ecology

The knowledge on spatial patterns differs between groups of organisms ranging from comparably well-known birds via plants and snails to basically unknown patterns in benthic communities and soil biodiversity. In this session we will cover all of these groups, starting with a conceptual overview. Two important components in the understanding of spatial patterns are the availability of quantitative and qualitative data and harmonization of existing data sets. Harmonization necessitates knowledge on both biological methods and spatial statistics and databases. We will explain the process with soil nematodes as an example, as they are the most abundant animals in the world, and play a key role in ecosystem processes. Understanding the spatial patterns in nematode community distribution and linking these to soil properties and soil management could therefore lead to increased soil multi-functionality. The process of collecting and harmonising data to be able to understand the occurring patterns is not limited to soil biodiversity. It can also be identified in research focusing on island biogeography, birds, plants, and organisms living on intertidal flats.

2. To what extent is the current spatial distribution of organisms shaped by past environmental dynamics?

Sietze J. Norder, W. Daniel Kissling, E. Emiel van Loon, Kenneth F. Rijdsdijk

Universidade de Lisboa / University of Amsterdam

During the late Quaternary, climatic oscillations have resulted in major fluctuations in sea level and, correspondingly, changes in island area and isolation. We quantified sea-level driven changes in paleogeography of 178 islands worldwide and stored these new data in the Palaeo-Island and Archipelago Configuration (PIAC) database. Our online database shows that oceanic islands are dynamic entities: they emerge and submerge; they shrink and expand; they split and merge. The data also underlines that the present-day situation is exceptional: for most of the late Quaternary, islands were larger than today, and less isolated. We assessed the role of past archipelago configurations in shaping the present-day distribution of endemic land snails and angiosperms. This was done by fitting linear mixed models for different archipelago configurations using the number of endemic and (non-endemic) native species as a response. Consistent across both taxa, we found that especially patterns of single-island endemic species are related with past environmental dynamics. Long-lasting configurations have left a stronger imprint on their distribution than extreme archipelago configurations that persisted for only a few thousand years. In understanding the spatial distribution of island biota it is essential to consider longer-lasting past environmental conditions, rather than the current situation alone.

3. Disentangling causes of spatial autocorrelation in species' distributions

Konrad Mielke, M. Busana, T. Claassen, T. Heskes, M.A.J. Huijbregts, K. Koffijberg, A.M. Schipper
Radboud University

Species' distributions are typically characterized by spatial autocorrelation. This is caused by a combination of spatial autocorrelation in the abiotic environment and biotic interactions among conspecifics. Failing to adequately account for either of the two sources of autocorrelation in species' distribution modelling may lead to spurious conclusions on species' habitat preferences. We developed a method based on generalized linear mixed models (GLMMs) that accounts for both causes of spatial autocorrelation simultaneously. Our method relies on repeated observations of presences of individuals in the same environment and disentangles the two causes of spatial autocorrelation by including an explicit model term for each one of the two. We tested our method on artificial species' distributions and found that it outperforms auto-logistic regression, which is commonly used to account for spatial autocorrelation in species distribution modelling. Additionally, we applied our method to disentangle both sources of autocorrelation in the distribution of the corncrake (*Crex crex*), a migratory bird species, in the Rhine River floodplains in the Netherlands. In this talk, I will elaborate on the problem at hand, the approach that we employ to solve it and show preliminary results.

4. The Dutch Bird Atlas, citizen science delivering detailed spatio-temporal patterns: a wealth of data for ecological research

Ruud P.B. Foppen, Henk Sierdsema, Christian Kampichler, Chris van Turnhout, Erik van Winden
Sovon (Dutch Centre for Field Ornithology)

The new Dutch Bird Atlas describes the distribution of more than 300 bird species occurring in the Netherlands in the breeding season and in winter in the period 2013-2015. Thanks to the contribution of more than 2000 volunteer observers spending approximately 190.000 hours in the field mainly following a strict protocol with counts in a fixed grid we could compile detailed distribution maps for many bird species. Geostatistical models (Random Forest) were used to predict relative abundance on a 1x1 km basis. We also produced difference maps, either showing change in occurrence on a 5x5 km basis compared to previous atlas periods (around 1975 and around 2000) or maps showing a change in occupancy on a 1x1 km basis over a 15 year time period. These maps and the underlying data provide an excellent opportunity for analyses addressing ecological and conservation oriented questions. We see many potentials in, for instance, 'comparative analyses' unraveling the underlying (pressure) factors that determine either abundance loss or gain as indicated by the spatial patterns.

5. Predicting bird-mediated dispersal of wetland plants from seed traits

Casper H.A. van Leeuwen
Netherlands Institute of Ecology

The spatial distribution of organisms is often directly linked to their dispersal capacity through suitable habitat. Plants and small invertebrates in wetland ecosystems importantly rely on wind, water or more mobile animals for their dispersal. Hence, understanding spatial distributions of wetland organisms requires assessing the relative importance of their key dispersal mechanisms. Seeds of wetland plants can have plumes or air sacks that suggest wind and water as important dispersal mechanisms. However, still little is known about which seed traits determine seed survival during passage of the digestive system of animals. This talk introduces a new biological method to study the relationship between seed traits and survival of digestion by animals – using waterbirds as model system because they are known to ingest, transport and egest many plant seeds. We exposed seeds of 48 different wetland plant species to the digestive processes in the avian digestive system *in vitro*, and studied how seed traits such as size, shape, hardness and imbibition determined survival. This method advances traditional approaches with living animals, which suffer from ethical issues and many confounding factors. This talk contributes to our mechanistic understanding of how plant traits determine their spatial distributions.

6. Hydro- and morphodynamics affecting the spatial distribution of macrozoobenthic communities on estuarine intertidal flats

Natalie Steiner, Claudia Morys, Lodewijk de Vet, Bram van Prooijen, Tom Ysebaert
Netherlands Institute for Sea Research / Delft University of Technology

The spatial distribution of marine macrozoobenthic communities is significantly influenced by abiotic factors. In particular the parameters grain size, organic matter content and salinity are considered as reliable variables to predict the occurrence of species. In coastal areas, especially on intertidal flats, additional hydro- and morphodynamical factors like emersion duration, current velocity, wave intensity and seabed level changes are indicating a major effect on the species distribution. To acquire a more detailed understanding of the morpho- and hydrodynamical impact on the species composition, we conducted a high-resolution sampling campaign of the benthic community and the abiotic properties along intertidal flats. Thereby, 4 transects with similar salinity, emersion duration and sediment properties, but different morpho- and hydrodynamical characteristics, were sampled in the Eastern and Western Scheldt. These estuarine systems are of particular interest, since they harbour highly productive habitats, which provide essential ecosystem functions and services. At the same time, the abiotic and biotic conditions of the Eastern and Western Scheldt are constantly changing, due to large-scale human interferences. Considering this rapid alterations, the present study enhances the understanding of the morpho- and hydrodynamical impact on the spatial distribution of benthic communities, a crucial prerequisite for sustainable management and conservation measures.

4e: Host associated microbiome interactions and their implications for host ecology

Conveners: Ellen Decaestecker (KU Leuven)
Jie Hu (Utrecht University)

1. Eco-evolutionary dynamics and gut microbiome

Shinjini Mukherjee, Ellen Decaestecker, Robby Stoks, Emilie Macke, Luc De Meester
KU Leuven

The field of eco-evolutionary dynamics has gained a considerable momentum in recent years with respect to our understanding of responses of populations, communities and ecosystems to human-induced environmental change. Phenotype is core to understanding eco-evolutionary dynamics and there is increasing appreciation that gut microbiome-mediated responses, in interaction with the host genotype, strongly contribute to phenotypic plasticity. Given the crucial impact of gut-microbiome on host ecology and evolution, it might be considered an important piece, currently missing in the eco-evolutionary dynamics theory. Furthermore, eco-evolutionary dynamics at the scale of the microbiome itself might be key to understanding the assembly of the gut microbiome and its consequences for host phenotype. This leads us to propose the concept of hierarchical eco-evolutionary dynamics a) at the microbiome level within host individuals and b) its cascading feedbacks at the level of host populations, communities and ecosystems. We will here outline the plausible mechanisms by which evolution might impact community trajectories and functions of gut microbiome. Next, we discuss various feedback loops of eco-evolutionary processes within individual and among host population and communities and highlight the relevance of studying these processes.

2. Effects of warming, trophic status and host genotype on zooplankton microbiomes

Md Sainur Samad, Femke van Beersum, Slawek Cerbin, Steven Declerck, Hyo Jung Lee, Kimberley Lemmen, Marion Meima-Franke, Libin Zhou, Annelies Veraart, Dedmer B. van de Waal, Paul L.E. Bodelier.
Netherlands Institute of Ecology

Zooplankton is a crucial component of aquatic food webs and maintaining clear water conditions. It has been proposed that zooplankton-associated microbes provide numerous beneficial services to their "host", like nutrient acquisition, stress protection and detoxification. However, there is still a lack of understanding concerning the factors that determine zooplankton microbiome composition and its effects on their hosts. Furthermore, it is unknown how the zooplankton microbiome differs from bacterioplankton and phytoplankton associated microbes. In this presentation we present data from field sampling campaigns in artificially warmed lakes, long-term enclosure experiments with temperature and nutrients treatments as well as laboratory incubations in which free-living, phytoplankton and zooplankton associated microbiomes are assessed separately. In field, outdoor-mesocosm and lab incubations zooplankton microbiomes were consistently different from free-living and phytoplankton-associated microbiomes, suggesting zooplankton specific selection or colonization factors. Next to temperature and nutrients, zooplankton genotype was a significant factor in microbiomes composition suggesting again specific microbial colonization mechanisms or host specific conditions affecting microbiome composition.

3. Prenatal transfer of gut bacteria occurs in birds: evidence from rock pigeons

Maurine W. Dietz, Joana F. Salles, Bin-Yan Hsu, Cor Dijkstra, Ton G.G. Groothuis, Marco Van der Velde, Yvonne I. Verkuil, B. Irene Tieleman
University of Groningen

Gut bacteria are vital for proper postnatal development of most organs and the immune and metabolic systems of their hosts, and likely also important for prenatal development. Prenatal transfer of gut bacteria from mother to offspring is shown in four mammalian species including humans, yet 92% of the vertebrates are oviparous. We hypothesize that also oviparous vertebrates such as birds, prenatally transmit gut bacteria. We investigated this in captive rock pigeons (*Columba livia*) by comparing the microbiome (bacterial community) of the very first faeces of 21 neonates with the cloacal microbiome of 5 females. Neonatal faeces contained a well-established and diverse microbiome. Its composition resembled the female cloacal microbiome, as indicated by multiple shared phyla, orders, families and genera. While females shared only 0.3% of the 1030 female OTUs, neonates shared 16.1% of the total number of OTUs present (2881) with females, and 45.5% of their core microbiome. These findings suggest that prenatal gut bacterial transfer does occur in birds. Our results support the hypothesis that gut bacteria may be important for proper prenatal development. Prenatal transfer presents a potential heritability pathway of gut bacteria in vertebrates, which may be subjected to natural selection as part of the host-microbiome complex.

4. Long-distance chemical interactions in terrestrial ecosystem

Adam Ossowicki

Netherlands Institute of Ecology

Chemical interactions and communication contribute greatly to an ecosystem's functioning and stability. Hence, the understanding of belowground inter-kingdom (bacteria, protists, fungi, plants) chemical interactions is crucial for assessing the functioning of a soil ecosystem. Plant- and microbe-derived compounds play an important role in belowground interactions, e.g. in signalling and interference competition. Both plants and microorganisms produce and secrete a wide variety of primary and secondary metabolites including volatile and non-volatile compounds. In my talk, I will present our recent discovery of the ecological role of volatile compounds in long-distance belowground plant-microbe interactions and how pollutants (such as microplastics in soil) can affect these interactions.

5. Spice it up: are biochar and chitin the salt and pepper of horticulture

Caroline De Tender, Bart Vandecasteele, B. Mesuere, Peter Dawyndt, S. Ommeslag, C. Lieven, Eiko Kuramae, Jane Debode
Ghent University

We showed that biochar, the rest product of biomass pyrolysis, promotes the growth and disease resistance of strawberry when it is amended to the growing medium. This effect is not mediated by a higher nutritional value of the growing medium: no changes in physicochemical characteristics are observed. The number of plant growth promoting rhizobacteria are increased, indicating that growth promotion might be induced by changes in the plant's microbiome. Likewise, we've shown that chitin, a rest product from the fisheries industry, induces plant growth without additional fertilization of the growing medium. The application of chitin-rich crab shell flakes to the growing medium of lettuce leads to an increase in lettuce growth, a higher amount of plant-available N in the growing medium and the massive growth of a specific fungus: *Mortierella*. Based on our findings, we expect that both biochar and chitin induce plant growth & health by a change in the rhizobiome. Application of these new amendments might reduce the impact of horticulture on the environment and contribute to a circular-based economy.

6. The power of the crowd: how Black Soldier Fly larvae and organic waste type influence bacterial succession in substrate and larval gut.

Stijn Schreven, Hugo de Vries, Gerben Hermes, Giacomo Zeni, Hauke Smidt, Joop van Loon, Marcel Dicke
Wageningen University & Research

The detritivorous larvae of the Black Soldier Fly (*Hermetia illucens* L.) are used to convert organic waste into insect biomass for animal feed. The waste type can influence the larval gut microbiota. Conversely, the larvae can increase substrate aeration and pH, inhibit Gram-negative bacteria and change volatile blends. It is unclear, however, how diet type and larvae interact to influence microbiota dynamics in substrate and larval gut. To this end, we sampled substrate and larval gut bacterial communities over time in three diets (chicken feed, chicken manure and *Camelina sativa* oilseed cake) with four larval densities (including control without larvae). 16S rRNA gene amplicons, covering the V5-V6 region, were sequenced with Illumina HiSeq, processed using the NG-Tax pipeline and analysed in R. Substrate bacterial communities differed between diets and were impacted differently by the presence or absence of larvae, yet differences among larval densities were small. Only in chicken manure the larval gut microbiota differed significantly from its substrate counterpart. Although diet type determined the majority of the substrate microbiota, our findings suggested that larvae significantly altered the course of bacterial succession in substrate, and – depending on the diet – harboured a gut community significantly different from their feeding substrate.

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	Session
1	Annegreet Veeken	Using palaeoecology and functional traits to examine long-term ecosystem functioning in agricultural landscapes	Parallel 1c
2	Daan Bos	Bio-economic model of Muskrat control	Parallel 3b
3	Julia Karagicheva	Why time is relative for birds	Parallel 2a
4	Evert Lambers	The Deer Hunter - Effects of hunting and recreation on deer distribution and browsing behaviour	Parallel 3b
5	Irene van Schroyen Lantman	Tree diversity and forest edges - (in)direct impact on diet specialization in the garden cross spider	Parallel 2a
6	Fabiana Canini	Vegetation and soil chemistry strongly influence soil fungal richness and community composition in Western Greenland	Parallel 3c
7	Luc De Bruyn	Citizen science and wild bee monitoring	Parallel 2b
8	Azkia Nurfikari	Closing the loop: use of insect waste-streams for biocontrol of soil-borne diseases and fertilization	Parallel 3c
9	Víctor Martín	Functional connectivity across habitat types by a highly mobile waterbird	Parallel 2b
10	Stefanie Vink	Plant species identity and functional group drives fungal communities after 3 years of soil conditioning	Parallel 3c
11	Luis Santamaría	Doñana's Long Term Monitoring Program: Merging classical and novel monitoring technologies	Parallel 2b
12	Raoul Van Oosten	Experimental evolution of amphipods to drought stress, and the consequences thereof for salt marsh dynamics	Parallel 3d
13	Bert Dijkstra	Urbanisation of the Oystercatcher	Parallel 2c
14	Tim Grandjean	The entrapment of Posidonia oceanica seagrass species in the Mediterranean Sea	Parallel 4a
15	Rinus Dillerop	Adapting to city life (Eurasian Oystercatcher)	Parallel 2c
16	Beatriz Marin Diaz	Saltmarsh elevation, age and grazing as predictors for cliff erosion	Parallel 4a
17	Bregje van der Bolt	Rate-induced tipping in a population of cyanobacteria	
18	Janne Nauta	Trophic cascades and the resilience of intertidal flats to sea level rise	Parallel 4a

#	Name	Poster title	Session
19	Coline Boonman	'Predicting climate change effects on global vegetation patterns using a trait-based approach	
20	Annieke Borst	On the interplay between habitat complexity, surface area and food availability	Parallel 4b
21	Chiu Cheng	Surfing the sand waves: Macrobenthos living high or low on the seafloor?	
22	Melinda de Jonge	Conditional Love? Testing the Stress Gradient Hypothesis on a European-scale using Joint-SDMs	Parallel 4b
23	Arne van Eerden	Where to build your nest? Which factors determine nest-site selection in the Seychelles warbler?	
24	Irene Adamo	Successional dynamics of functional groups of fungi in regenerating tropical rainforests.	Parallel 4c
25	Annelies van Ginkel	Top-down or bottom-up? Help wanted with SEM	
26	Celine van Bijsterveldt	"Mangrove Atlantis: Can mangroves keep up with extreme land-subsidence?"	Parallel 4c
27	Juan Miguel Giralt Rueda	Plant - ungulates dynamics in Mediterranean areas with high inter-annual variation in plant productivity	
28	Juan Gallego-Zamorano	Habitat loss of tropical mammals due to land use and hunting pressure	Parallel 4c
29	Max Gräfnings	One small step for mankind, one giant leap for intertidal seagrass restoration	
30	Joliese Teunissen	Diversity, classification and ecological function of foliar and wood fungi in tropical trees as revealed by DNA metabarcoding	Parallel 4c
31	Alena Gsell	Host-specific chytrid infections of phytoplankton modify the outcome of resource competition	
32	Lucas Gomes	Spatio-Temporal variability of habitat quality in a biodiversity hotspot in Brazil	Parallel 4d
33	Martijn Hammers	Helpers delay parental senescence	
34	Geerten Hengeveld	Measuring forest resilience	
35	Hui Jin	Phytoplankton and sestonic stoichiometry dynamics in Marker Wadden	
36	Lisa Joos	Understanding the soil microbiome in function of soil resistance and resilience	
37	Yvonne Kahlert	Spatial and Temporal variability of food web composition during early succession	
38	Lise Klunder	Impact of an artificial structure on the surrounding benthic community composition in the North Sea: assessed by a morphological and molecular approach	
39	Zsofia Koma	Quantifying 3D vegetation structure in wetlands using national-wide Airborne Laser Scanning	
40	Koosje Lamers	The role of dispersal in adaptation to climate change: an experimental approach	
41	Giulia Leone	Trophic transfer of microplastics from fish to grey seal pups	

#	Name	Poster title	Session
42	Keli Li	Drought legacy effects on plant soil-feedbacks of range expanders and related natives	
43	Qian Li	Pollination and biological control service in Korla pears	
44	Isabelle van der Ouderaa	Small-scale habitat creation by shellfish reefs	
45	Anouk van 't Padje	Tracking trade strategies of Arbuscular Mycorrhizal fungi	
46	Karen De Pauw / Pieter Sanczuk	Effects of forest microclimate on understorey plants: an experimental approach	
47	German Perez	Abiotic and biotic factors that shape the community structure, physiology and activity of methane oxidizers in freshwater systems	
48	Matti Pisman	Pollination of apple orchards in Flanders: Pollination gap and potential role of wild bees	
49	Maarten Postuma	Epigenetics and inbreeding in <i>Daphnia magna</i> ?	
50	Luca Santini	Applying habitat and population density models to land cover time series to inform IUCN Red List assessments	
51	Yanjun Song	Hydraulic strategies compared across 26 coniferous species using a common garden experiment in the Netherlands	
52	Michiel Verhofstad	Nature restoration in an anthropogenic landscape	
53	Jip de Vries	Quantifying multiple stress experienced by macroinvertebrate communities in lowland streams	
54	Qi Wang	Yield and resource use in maize/peanut intercropping in Northeast China	
55	Safaa Wasof	It depends on the soil biota: phosphorus fertilization does not always increase biomass in mixed grassland communities; evidence from a mesocosm experiment	
56	Elke Wenting	Stoichiometric variation in mammals	
57	Dianneke van Wijk	Smart Nutrient Retention Networks for good water quality and sustainable nutrient use	
58	Casey Yanos	Population Structure of Threespine Stickleback Along the Swedish Baltic Coast	
59	Lars Zandbergen	Pathogen and non-pathogen interactions in urinary tract infections	
60	Jelle Zandveld	'Experimental evolution of nutrient-dependent reproduction in <i>Drosophila</i>	
61	Wei Zhang	Phylogenetic, morphological and ecological divergence in <i>Brachionus calyciflorus</i> , a newly described hybridizing species complex	
62	Lixia Zhao	The shaping role of self-organization: linking vegetation patterning, plant traits and ecosystem functioning	

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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. There will be a first (€ 300,-), second (€ 200,-) and third (€ 100,-) prize. 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 2018 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 (€ 300,-), second (€ 200,-) and third (€100,-) prize. 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

NOTES

This image shows a single sheet of white paper with horizontal ruling lines. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.