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Abstracts for oral presentations, alphabetical by presenting author, presenting author underlined:

Understanding perceptions of Nature based Solutions (NbS) in Lima and Bogota

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Half of the population of the world lives in cities, and projections mention that by 2050 almost 70% of the world will be urbanized (FAO, 2018). Hence, there is a need to pay more attention for further environmental-friendly developments and its considerations like the ones acknowledged under the term of Nature-based Solutions (NBS) to achieve sustainable cities. The International Union for Conservation of Nature (IUCN) defines NBS as actions taken to protect, sustainably manage and restore natural or modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing well-being and biodiversity benefits. The challenges that NBS can potentially tackle include unsustainable urbanization, human health issues, degradation and loss of natural capital, climate change, etc. (European Commission, 2018).
In this context, Lima (9,320,000 inhabitants) and Bogota (7,800,000 inhabitants) ought to identify and put forward a plan to consider the benefits that NBS can potentially provide (INEI, 2018). Given the fact that there is no much information available of this matter, the findings of my thesis show interesting results to look closely into consideration in the Peruvian context. The presentation will focus in exposing what the literature believes on NbS and compare it to the context of Lima and Bogota. Moreover, the presentation will deliver the results of the interviews made to the local authorities to both cities which included the main Municipalities, The Ministry of the Environment, UN FAO, GIZ, local districts, NGOs, etc. Furthermore, it will conclude outlining the most crucial aspects Lima and Bogota needs to address and potential solutions for policy makers.

Long-term ecological effects of a biological invasion in a subarctic watercourse

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Invasions of non-native species constitute a large challenge for nature management. A successful invader may become a predator or prey or a serious competitor for food and habitat, thereby affecting the native community. Most invasions are, however, detected long time after the fact, making assessment and documentation of any ecological impact difficult. Hence, few studies have been able to assess the long-term ecological impacts and responses of an invasion in details. The present study addresses the long-term invasion effects of vendace Coregonus albula, a non-native fish species, which in the early 1990s invaded the subarctic Pasvik watercourse, northern Norway and Russia. The arrival and establishment of this planktivore specialist induced large impacts on the zooplankton community with adverse knock-on effects on the sibling whitefish Coregonus lavaretus population. Following a transient boom-and-bust phase in the early stages of the invasion, the vendace has become a dominant pelagic fish species in the watercourse with key ecological roles as both predator, prey and competitor and with large consequences for the lacustrine food web. The resulting, long-lasting changes in the native zooplankton and fish communities have important implications for ecosystem function and services.

Estimating insect community biomass changes by using uncorrected data from traps – how you may get it all wrong

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In a recent publication that has become influential with massive attention in the media, Hallmann et al. (2017) report that biomass of flying insects has decreased by 75% in protected areas in Germany over the course of the last 27 years. However, the estimates are based on malaise trap data, which may be significantly biased by body mass, resulting in overestimation of large bodied species. For example, for pitfall traps it has previously been shown that around 75% of the sampling error is correlated with body mass and that this can give seriously misleading results when testing key ecological hypotheses using uncorrected trap data. Unpublished work done by us shows that a similar bias exists also for flying insects when caught by window traps. If this bias is not corrected for when estimating changes in biomass of multispecies insect communities, the results may be highly misleading. For example, if biomass declines for large bodied species but increases for small ones so that there is no net change in overall biomass, large declines can still be estimated when using uncorrected trap data. Similarly, a large decline in biomass caused by declines of small bodied species can pass largely undetected if biomass of large species is unchanged or increases slightly. The biases in data from insect traps have been known and discussed in the literature for more than 50 years, and a method exist to correct for the bias associated with body mass in multispecies datasets. Still, the issue is often left unaddressed, leading to potentially misleading results. If insect ecology is to progress as a science giving key advice to policy makers, this practice must stop.

SURROUND – the dynamics of urban green infrastructure and its impact on ecosystem services

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The fact that well-functioning ecosystems are crucial for human societies have been increasingly focussed in spatial planning during the last decades. We realize that human well-being depends on sustainable urbanisation, which implies development of urban areas where people thrive and economy is healthy, but where environmental degradation is evaded. In particular, we acknowledge the importance of urban areas' green infrastructure for biodiversity, access to recreational areas, cultural heritage and landscape qualities. The prevailing planning paradigm over the last 30 years has prescribed urban compaction, to reduce the urban sprawl and reduction of non-developed areas. The paradigm partly departs from the NAMIT research project (1988-92) that performed thorough mapping of green infrastructure in in four small – medium sized urban areas; Horten, Malvik, Trondheim east and Sogndal. As a part of the interdisciplinary Miljøforsk project SURROUND Sustainable urbanisation requirements of small and medium sized urban settlements and their surroundings (2018-2020) we will re-map these four urban areas and their surroundings. The project employ historical and recent maps and aerial photos as well as contemporary sources of information to reveal landscape changes. We focus on the change in green infrastructure over time and between the urban areas and their surroundings, and also record fine-scale changes in green infrastructure (ground cover and trees) in one of the urban areas, Sogndalsfjøra. The data allows exploration of the past and present urban ecosystem service potential (e.g. biodiversity, cultural heritage, run-off capacity and pollen availability). The linkages between urbanisation drivers, ecosystem services and sustainability governance can be explored, and through this, the SURROUND project aims to increase the understanding of requirements for sustainable urbanisation in small and medium sized urban areas and their surroundings.

Increased vascular plant growth leads to a larger microbiota and an altered microbial food web in high Arctic peatlands

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Herbivorous grazing reduces the ratio of vascular plants to mosses in Arctic peatlands, leading to reductions in the soil carbon and nutrient availability. The link between altered soil conditions due to vegetation changes and the resulting effects on the size and properties of the soil organic carbon degrading (SOC) microbiota is not known. Here we have investigated the plant communities, the soil composition and the microbiota of 20yr fenced exclosures compared to grazed sites using metagenomic, metatranscriptomic, metabolomic, antibody staining and enzymatic methods in combination with plant classification. Our results showed that an increased abundance of vascular plants within the fenced sites corresponds to increases in the soil content of complex polysaccharides, monosaccharides and amino acids. Furthermore, DNA and RNA quantification demonstrated that a three times larger and twice as active (transcription) microbiota had established in the rhizosphere of the fenced sites. Corresponding to the increased soil content of polysaccharides, the relative and absolute abundance of transcripts for polysaccharide degrading enzymes and the potential activity of these enzymes were significantly higher in the fenced sites. While the overall microbial community composition remained the same, we found considerably higher relative abundances of fungal, protist and metazoan transcripts and genes in the fenced sites. Together with the increasing masses of DNA and RNA this shows that both the relative and absolute abundance and activity of these microbes are higher in the fenced sites. A substantial fraction of the fungal increase were due to saprotrophic fungi within the order Helotiales (Ascomycota) and the order Agaricales (Basidiomycota) that transcribed genes for the degradation of broad ranges of plant polymers including cellulose, hemicelluloses and pectins. Additionally, we saw an increase in the gene transcription and abundance of predatory eukaryotes (Entomobryomorpha), which based on their transcription profile are involved in both plant and microbial polymer degradation. We conclude that greater densities of vascular plants due to reduced herbivore grazing increases the pools of polysaccharides and dissolved organic nitrogen and carbon through the decay of a richer plant biomass and root exudation. These inputs allow the establishment of broad substrate range fungal decomposers of Helotiales and Agaricales, and an overall larger microbial biomass that is food for Entomobryomorpha and other predatory eukaryotes, possibly leading to a faster microbial loop.

Insect-fungi interactions in dead wood – what do we know and where to go next?

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Fungi and insects may interact in a number of ways; fungi can provide insects with nutrients and essential elements, detoxify plant defenses in recently dead wood and protect, or in contrast, attack and digest insects. Insects at the other side might affect fungi through grazing or spore dispersal. In addition, both insects and fungi have the capacity to change the wood substrates, indirectly modifying their common habitat with consequences for the other part.
With the exception of ectosymbiotic relationships, most interactions between insects and fungi in dead wood is surprisingly understudied. For instance, several recent studies indicate

that insect-vectored dispersal might be an important complement to wind dispersal also for non-mutualistic saproxylic fungi, potentially providing targeted dispersal to suitable substrates. Hopefully, these interactions will be expanded on in the near future, providing guidance for conservation of forests biodiversity.
Insect-fungus interactions in dead wood are an essential component of forest ecosystems, potentially influencing species richness, wood decay and nutrient cycling. At present, these aspects are hardly been investigated. Thus, including functional aspects of insect-fungus interactions should be a major priority in future research. Insect-fungi interactions have recently been summarized in an extensive review by the authors.

Urban bees and resource use – changes in resource use within season and indications of resource partitioning between wild and domesticated pollinators

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Within a city, "small green lungs" including private gardens and parks, patches of wild nature and peri-urban forest, contain flowers that require pollination provided by insects, and in return provide pollen and nectar resources. Recently, the importance of wild and domesticated pollinators and their function has been in focus. Combined with a trend in urban agriculture, urban beekeeping has become a popular activity. A concern is whether domesticated pollinators and wild bees use the same resources, and whether they compete or play complementary roles in maintaining plant biodiversity. We collected pollen from beehives within Oslo in 2017, between June-September. We used eDNA-sequencing to assess the different plant groups visited by domesticated bees. We found that the resource use of domesticated pollinators is skewed towards typical garden plants, often rich in resources. It also shows sharp shifts in pollen composition along the season. However, there is variation among hives in both plant-groups and the amount of pollen gathered, indicating that placement of the beehive has impact on resource use and the level of pollinating services by domesticated pollinators. Due to the low detection of native plant species within our data, we argue that domesticated bees and wild pollinators may use different resources in the urban area. This underpins previous studies showing that domesticated pollinators tend to use "high resource" areas with dense cover of plants flowering at the same time, while wild bees use to a larger extent native plants and can utilise smaller patches with sparser flower resources. However, there is some overlap in resource use, and pollinator observations indicate that honey bees are the dominant bee species in Oslo. Further research should quantify the proportion of wild bees' foraging resources in urban areas competed for by honey bees, with the aim of making recommendations for beekeeping in urban areas.

Ecosystem nitrogen responses to simulated spring goose disturbance and summer warming in three high Arctic plant communities

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Higher summer temperatures are strongly affecting terrestrial nutrient cycling in tundra ecosystems. However, the extent to which tundra nutrient cycling is modified by warmer summers may be modulated by plant-herbivore interactions. Moreover, temperature- and herbivore-induced effects on nutrient cycling are likely to depend on ecosystem characteristics, such as productivity, nutrient, and soil moisture conditions, which in turn show strong inter-annual variability. In Svalbard, pink-footed goose population has dramatically increased, raising the issue of how tundra nutrient cycling may be affected by perturbations linked to spring foraging by geese (grubbing) combined with warmer summers. By simulating grubbing and summer warming in a two-year fully-factorial experimental set-up, we explored how these drivers may interact in determining nitrogen (N) concentration in different ecosystem components ([organic] soil, moss, and vascular plant components) in three high Arctic plant communities distributed along a soil moisture gradient: mesic, moist, and wet. N-concentrations strongly differed between plant communities and experimental seasons (2016 and 2017). Moss and vascular plant N-concentration was higher in wet communities. Soil N-concentration was higher in 2016, whilst vascular plant N-concentration was higher in 2017. Grubbing strongly reduced soil N-concentration in wet communities in both experimental years, but in moist and mesic communities the effect depended on year: increased in 2016 and decreased in 2017. Mosses were relatively unresponsive, although warming tended to decrease their N-concentration in 2016. Vascular plants showed the strongest responses to treatments. Warming consistently reduced vascular plant N-concentration in all communities in both years. In 2017, grubbing increased vascular plant N-concentration in all communities. However, grubbing interacted with warming in 2016 by strongly increasing vascular plant N-concentration in wet communities. Despite Arctic environments are characterized by slow ecosystem process rates, these results suggest that grubbing by geese and higher summer temperatures have the potential to affect ecosystem nutrient cycling at a much shorter time scale than previously acknowledged.

Understanding decision-making from the animal perspective: The case for complex integrative models

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Choice is fundamental for the behavior of all animals. The organism must trade priority across its various needs, such as those supporting growth, survival, and reproduction. However, in naturally complex environments this task incurs huge computational costs. Therefore, most models in behavioral ecology assume that animals do not include all proximate complexities and use simple decision rules specific to current contexts. We posit that this does not solve the complexity challenge: it just transcends to the next level: how do animals identify the context and decide which simple rule to use? Thus, the underlying physiological, cognitive and behavioral machinery should not be ignored. We developed a general modeling framework based on a cognitive and behavioral architecture enabling the organism to make predictions about the future and behave autonomously. It has three essential aspects: (a) the focus on the autonomous individual, (b) the need to limit, as much as integrate, information from the environment, and (c) the importance of goal-directed in addition to stimulus-driven cognitive and behavioral control. The resulting simulation models integrate cognition, decision-making and behavior in the whole integrated phenotype including the genome, physiology, hormonal system, perception, emotions, motivation and cognition. This provides an avenue for understanding the adaptive economics and evolution of decision-making and behavior from the point to view of the animal.

Breeding phenology of a pied flycatcher population in southern Norway – and how we can make this knowledge useful for policy

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The timing of recurring life-history events, or phenology, has important consequences for natural populations. One key phenological event is the timing of breeding. Recent studies have revealed that timing of reproduction has advanced in many species breeding in seasonal environments, and these responses have been linked to increasing spring temperatures. Yet, the advancement may not be similar at all trophic levels. This may cause mismatches between peaks of resource availability and the timing when those resources are needed. As a consequence, these mismatches may reduce individual fitness and population sizes. This may be especially problematic in migratory birds, which need to time both their arrival and breeding phenology to the peak of food availability. We studied breeding phenology in a pied flycatcher population in southern Norway during a 30-year period (1985-2014). We investigated trends in phenology and how these were related to arrival from migration and environmental variables. Our results indicate that breeding phenology has advanced approximately five days during the study period, which is in line with the advancement in arrival phenology. However, this has not resulted in a general reduction in reproductive output, although late-breeding birds have clearly lower success than early breeders. In addition to our results, we discuss how to use a single-population study to increase the chances of making an impact on policy and decision-making. We reflect on the usefulness of long-term series of data and how long-term, single-population studies may be combined with other studies on the same species in other areas, with studies on other species, and with studies on different trophic levels, to provide an integrated

ecosystem view that may be more relevant for policy.

The role of snow in plant-soil ecosystems on Svalbard

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The duration of snow cover and depth of snow are extremely important in cold climates and contribute to determining many aspects of the growing and non- growing season. We have been studying the role of snow on Svalbard using snow fences since 2006 to experimentally manipulate snow depth and melt date. Together with manual snow removal and summer warming, we created a range of climatic scenarios at the plot level, in which we could investigate plant, soil, microbial and invertebrate responses. We will give an overview of some of our findings in this presentation.

Using multitrait matrices to analyze the effects of trade-offs on individual fitness

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It is increasingly recognized that the incorporation of Life History Trade-Offs (LHTOs) into evolutionary demography models requires the decomposition of the trade-offs into genetic and individual components. This is fundamental in order to understand how trade-offs are related to fixed and dynamic components of individual heterogeneities and generate variance in individual trajectories. Therefore, embedding such LHTOs into Population Projection Matrices (PPMs) usually requires three traits: a Life-History Determining (LHD) trait (e.g. age or stage), a fixed trait incorporating the genetic trade-off and a dynamic trait modeling the individual component. This has proved a complex exercise until the recent advent of Multitrait Population Projection Matrices (MPPMs). Recent developments of Trait-Level Analysis (TLA) tools for MPPMs now allow studying the demographic and evolutionary consequences of each component of a LHTO. Here, we illustrate this by constructing and analyzing an evolutionary demography model that implements both individual and genetic components of the Costs of Reproduction (CoR), the trade-off between current/early reproduction and future/later fitness. In particular, we explain and describe the use of the TLA to measure the effects of such an LHTO on individual fitness. In order to yield such computations, we provide novel calculations for R0 and its variance for age-structured models with/without fixed and with/without dynamic heterogeneity.

Ecosystem drivers and adaptive management of a critically endangered arctic fox population

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The arctic fox is critically endangered in Fennoscandia due to overharvesting in the beginning of the last century and ongoing tundra ecosystem changes. As part of the Norwegian Environment Agency's arctic fox conservation program, the project "Arctic fox in Finnmark" was initiated in 2004 to document the state of the arctic fox in eastern Finnmark, in the very North East of Norway, and investigate needs for conservation. This project has now become part of the arctic fox module (Varanger) of the Climate Ecological Observatory for Arctic Tundra (COAT), a monitoring program based on the principles of adaptive monitoring, and evolved to be a good example of ecosystem-based adaptive monitoring. A synthesis of the results from the projects first 11 years identified two fundamental drivers for the lack of recovery and further decline of the Arctic fox: 1) An increasing irregularity of lemming cycles likely driven by a changing winter climate and 2) an increasing abundance of red foxes, which are subsidized by carrion of semi-domestic reindeer. During this first part of the project red fox culling was carried out as an experiment. Results showed, however, that culling at the levels realized in eastern Finnmark was not sufficient to allow arctic foxes to recover. The reasons for this may either be too low initial numbers making the population vulnerable to stochatic events, that red fox culling alone is not a sufficient conservation action or that the ecosystem in eastern Finnmark is not suitable for arctic fox anymore. For the next phase of the project, a new management action has been introduced with release of captive bred arctic fox pups and supplemental feeding. According to the principles of adaptive management, the success of these interventions will be assessed in an ecosystem perspective.

Climatic forcing and individual heterogeneity in Willow ptarmigan

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The current dramatic change in the world's climate is affecting global biodiversity both directly and indirectly. To understand and potentially mitigate effects on wildlife populations, information about

exposure and sensitivity to climate change, as well as the individual's capacity to adapt through phenotypic plasticity and eco-evolutionary processes are crucial. However, lack of detailed, long term data sets is often hampering scientific progress on the latter. Here, by utilizing the power of legacy data, we benefited from a unique 17-year time series of individual based life-history data on willow ptarmigan (Lagopus lagopus) in Dovrefjell National Park, Norway, from the years 1978-1994. Based on these data, we examined how individual heterogeneity and climate variation together determines annual reproductive success. We conducted in-depth analyses of the relative importance of inter-individual heterogeneity and stochastic weather events during spring and early summer, and to which extent there were any interactions between individual state variables such as age and body condition, making the individuals respond differently to climatic conditions. Finally, we tested the hypothesis that there were different strategies among individuals in terms of allocation of resources to breeding, and that fluctuating climatic conditions result in a fluctuating selective pressure. We discuss the findings in light of future climate predictions and large-scale patterns in ptarmigan abundance and distribution.

Assessing ecosystem functioning when standard biological assessments fail to detect change

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Habitat restoration in streams and rivers is increasingly applied to systems that have lost geomorphic features due to habitat simplification. Although the major goal of habitat restoration is to improve biodiversity, most biological assessments to date have found limited improvement on instream richness and diversity in restored streams. Thus, scientists and stakeholders have raised concerns on the biological potential of such restoration efforts. However, ecological processes have been little assessed, despite being promising tools for bioassessment and biomonitoring. We assessed how distinct stream restoration efforts affected an important ecological process, litter decomposition, and the functional composition of the litter-associated detritivore community in 20 stream reaches in a boreal forest catchment. Streams ranged from no restoration to restored and reference streams. Restoration efforts were quantified using a continuous measure of habitat heterogeneity at each stream, instead of analysing the restoration efforts dichotomously. We found that litter decomposition was positively related to habitat heterogeneity. This result was associated with shifts in the functional composition of detritivores. The most obligate litter consumers dominated streams showing higher habitat heterogeneity (mostly restored and reference streams), whereas less obligate litter consumers dominated more homogeneous streams (mostly the channelized streams). Our results show that habitat restoration, through improvements on habitat heterogeneity, can enhance litter decomposition by affecting the functional characteristics of the detritivore community. Furthermore, we show that measures of ecosystem functioning not normally assessed in biomonitoring and bioassessment programs have potential to indicate changes in the ecosystem that remain undetected through the lens of standard assessment tools.

Spatial scaling in population synchrony and life history strategy in marine fish

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Spatial synchrony in population dynamics is crucial in ecology, as it for example affects the extinction probability of species and the rate at which diseases or invasive species can spread. We know that processes like dispersal, environmental forcing and trophic interactions play an important role in driving synchrony across populations. However, we still have little understanding of how life history interacts with these processes to influence the observed spatial synchrony. To bridge this gap, we studied whether the extent of spatial synchrony (i.e. spatial scaling) in population dynamics could be predicted by a species' position along the slow-fast continuum. We compiled information on life history traits (i.e. generation time, population growth rate, mortality rate and their indices of variation) from eight populations of marine fish species, and measured how well these described variation in the spatial scaling of abundance, growth rate and environmental noise in population fluctuations. We found that all the traits associated with a slower pace of life (long generation times, slow growth and low mortality) predicted an increase in the spatial scaling of abundance and growth rate. More importantly, we could show that this pattern was not caused by the spatial pattern of environmental noise in population dynamics. This could mean that, for example, the probability of global extinction could increase among slower-lived species and that sampling resolution may be especially important when studying fast-lived populations. These results illustrate the importance of life history on spatial dynamics and brings us closer to establishing a relationship that expands across species and ecosystems. Given current ecological challenges, like habitat fragmentation and climate driven invasions or disease outbreaks, the presented pattern could provide important management and sampling design guidelines for the future.

Closing the knowing-doing gap – a workflow for knowledge provision

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The gap between scientists and decision-makers has been well documented. Despite this there has been little progress in actually closing this gap. Here we present 5 key areas where small changes in workflow would allow scientists to better provide support to decision-makers. We advocate a combination of the principles of evidence synthesis and structured decision making.
1) Question setting/formulation: Question setting is often seen by scientists as being in the

realm of the decision-maker and by decision-makers as being in the realm of scientists. To avoid miscommunication all stakeholders need to be involved in the co-development of questions.
2) Evidence synthesis: All available evidence (e.g. scientific articles, unpublished reports, indigenous knowledge, expert opinion, etc.) needs to be formally synthesized. This is not simply a matter of collating evidence but also a formal assessment of the quality of the evidence. Evidence synthesis can be rapid whilst retaining rigor.
3) Experimental design (if needed to supplement Step 2): Rather than focusing on understanding underlying mechanisms decision-makers are generally focused on determining what works and for what cost/benefit. Scientific experimental design needs to reflect this. Existing methods (e.g. from medicine) should be explored further in ecology.
4) Decision-theoretic systems models: Scientific models need to (where appropriate) take in to account the wider decision context. Decision-theoretic systems models allow the uncertainties across the whole problem context to be fully expressed and mathematically accounted for.
5) Adaptive management and model updating: Dynamics in the available knowledge and the decision context need to be incorporated in to the workflow.
We will illustrate the workflow using published and unpublished examples of our work.

Life-history shapes vulnerability to changes in the frequency and intensity of extreme weather events

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Extreme weather events are becoming more frequent, severe and/or widespread as a consequence of anthropogenic climate change. While the economic and ecological implications of these changes have received considerable attention, the role of evolutionary processes in determining organismal responses to these critical challenges is currently unknown. Because of this knowledge gap in how organisms adapt to rare selection events like these, our ability to identify populations or species that may be at particular risk of extinction from this phenomenon is severely compromised. We develop a theoretical framework that explores how alternative pathways for adaptation to rare selection events can influence population-level vulnerabilities to future changes in the frequency, scope, and intensity of environmental extremes. We begin by showing that difference in organisms' life histories and their prior exposure to extreme events can shift the balance between additive and multiplicative properties of fitness accumulation, favoring different evolutionary responses to identical environmental phenomena. We then demonstrate that these different adaptive outcomes lead to predictable differences in population-level vulnerabilities to rapid increases in the frequency, intensity or scope of extreme weather events. Specifically, we show that when the primary mode of fitness accumulation is additive, evolution favors ignoring environmental extremes and lineages become highly vulnerable to extinction if the frequency

or scope of extreme weather events suddenly increases. Conversely, when fitness accumulates primarily multiplicatively, evolution favors phenotypes that cope well with historical extremes and lineages tend to become instead highly vulnerable to sudden increases in extreme intensity. Our findings address a critical gap in our understanding of the potential consequences of rare selection events and provide a relatively simple rubric for assessing the vulnerabilities of any population of interest to changes in a wide variety of extreme environmental phenomena.

The handbook for standardised field measurements in terrestrial global change experiments

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Global change is a worldwide threat to biodiversity and ecosystem structure and functioning. We urgently need better understanding of the direction and magnitude of the changes, the underlying drivers and mechanisms, and the ecological consequences. An increasing number of past and ongoing global-change experiments are creating new opportunities for meaningful and high-quality generalization and improved process understanding. However, there are significant challenges related to data unavailability and/or incompatibility across studies; compromising opportunities for data re-use, syntheses, and upscaling. Many of these challenges are related to a lack of an established “best practice” for how to measure key impacts and responses across experimental global-change projects. This negatively impacts our current understanding of complex processes and mechanisms in terrestrial ecosystems related to global change.
One way to overcome these challenges is to facilitate coordination and standardisation of methods and sampling protocols across global-change studies. Here we provide a handbook for standardised field and laboratory methods for terrestrial global-change experiments. We provide guidance on which response variables to measure and which methodologies to use to facilitate second-order output such as data re-use, syntheses, and upscaling. Further, we make suggestions on the measurement and collection of data that are critically needed for adequate understanding of processes, for synthesising efforts across experiments, and for model-experiment interactions. Our intention is that this handbook will be widely used in order to stimulate standardised data collection and further collaboration between terrestrial global change projects across scientific disciplines, in order to increase our general understanding of ecosystem responses to climate and global change.

Bridging ecology-science with decision making - despite different understanding of the science-policy interface

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Objectivity in science is crucial in our society; an ideal impossible to realize completely for ecological decision-making, but always to be respected and desired. Several (e.g. Brundtland, 1997) have stated that; “there is no other basis for sound political decisions than the best available scientific evidence.” However, ‘good’ policy does not necessarily comes from ‘good’ science. Further, what is THE best management practise also depends on several governance issues. Therefor, "emerging good management" is probably a better term, taking on board both new knowledge, as well as interpretation of legal framework and "emerged policy".
Obstacles like e.g. the incomplete knowledge of ecology, insufficient studies on several aspects of biodiversity contra dictionary results and disagreement between scientist, needs to be acknowledged, and incorporated into management strategies. All of these obstacles both can and should be defeated in order to achieve the ideal of an objective and evidence based nature management. However, despite uncertainties, ecological complexities and EIA that not answer all aspect of impacts, it is a demand in our society for taking decisions (as good as possible).
Emerging good (management) practise as basis for decisions with ecological impacts, imply at least the following to foster a good science-policy interface:
1) Acknowledge that ecological science can improve environmental policy
2) To integrate the best available knowledge and techniques into guidelines, as basis for ecological management planning.
3) Common understand and use of the same terms and frameworks; where “interpreters” and generalisations might be needed.
4) The most important issues in politics must be recognized by scientists; e.g. scaling, cause-impacts and social economy.
5) Expert judgement is often needed, where guess work should be avoided but based on a common understanding and be transparent by use of management tools.
Relevant examples will be given from integrated water management and experiences with sustainability indicators (ecological status).

The ecological effects of red deer herbivory in boreal forest: long-term studies at Svanøy, Western Norway

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[1]Høgskulen på Vestlandet

Fifty to 100 years ago, you would hardly meet a red deer in the Norwegian forest. Today they are present in large numbers and have become an important ecological factor. But how does this large mammal affect its main habitat, the boreal forest? We used a combination of experiments (exclosures) and a natural disturbance gradient (herbivory intensity) to investigate various ecological effects of red deer herbivory.
We predicted that red deer herbivory would cause: 1) plant species richness to peak at intermediate disturbance level; 2) woody and herbaceous plants to be losers and grasses, ferns and bryophytes to be winners; 3) herbivorous beetles to be more negatively affected than predatory or detrivorous beetles, and that most beetles species would be losers; 4) the abundant key plant Vaccinium myrtillus had lower abundance, smaller size, less reproductive output, and fewer insects feeding on it; and that 5) plant and insect communities would be homogenized (i.e. reduced beta diversity) in forest browsed by red deer.
Our results verified many of our predictions, for example we found a unimodal relationship between herbivory intensity and plant richness; that woody plants were losers when red deer was present; that ground-dwelling beetles were affected by large mammal herbivory; that Vaccinium myrtillus and the insects feeding on it indeed was negatively affected; and that red deer may sometimes homogenize communities. On the other hand, plant richness peaked at the highest natural levels of herbivory intensity, more plant and beetle species were winners than losers, herbivore insects did not always select for the unbrowsed Vaccinium myrtillus, and beetle communities were more heterogeneous at high herbivory intensity. We discuss the results in relation to ecological theory and wildlife management.

Norsk rødliste for naturtyper

Henriksen, Snorre[1], Mathisen, Ingrid Ertshus

[1]Artsdatabanken

Andre utgave av Norsk Rødliste for naturtyper ble lansert i november 2018. Den viser at ingen naturtyper gått tapt siste 50 år i Norge eller på Svalbard. Åtte naturtyper er kritisk truet CR, 23 er sterkt truet EN, 44 sårbar VU og 39 er nær truet NT. Eksempler på kritisk trua naturtyper er Slåttemark, Arktisk steppe og Jordpyramide.
Vurderingene omfatter all naturtyper og landformer i Norge, bortsett fra sterkt endra natur. Rødlista er dermed den eneste fullstendige arealdekkende oversikten over tilstanden og utviklingen for natur i Norge. Rødlista for naturtyper viser hvilken risiko naturtypene i Norge har for å gå tapt, hvis de rådende forhold vedvarer
I Norge er det landbruk, klimatiske endringer, habitatpåvirkning på ikke landbruksarealer og forurensning som påvirker flest naturtyper negativt. Landbruk inkluderer jordbruk, skogbruk, skogreising, buskap, og opphørt drift.
Mange naturtyper er rødlistet fordi mer enn 20 % av totalarealet har gått tapt. Eksempler er Eksponert blåskjellbunn og Semi-naturlig eng.

Det er forringelse, forårsaket av abiotiske faktorer, som er den vanligste årsaken til at naturtyper blir rødlistet. Hvis mer enn 20 % av totalarealet til naturtypen er blitt forringet av abiotiske faktorer som for eksempel jordbruk, skogbruk, veiutbygging eller tråling kan naturtypen bli rødlistet.
Forringelse, forårsaket av biotiske faktorer har vært utslagsgivende for at 31 naturtyper har blitt rødlistet. Det vil si at mer enn 20 % av totalarealet til naturtypen er blitt påvirket negativt av biotiske faktorer som for eksempel gjengroing og fremmede arter.
Rødlista er utarbeidet av Artsdatabanken i samarbeid med en rekke eksperter fra vitenskapelige institusjoner. Vurderingene omfatter all natur i Norge, bortsett fra sterkt endra natur. Naturtypene vurderes etter en internasjonal metodikk utviklet av Den Internasjonale naturvernunionen, IUCN.

Havet blir til mens du ror: Hvordan kunnskap og kartdata skaper kystsoneplanene

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Gjennom historien har kysten hovedsakelig vært en allmenning hvor transport, fiske og annen bruk har eksistert sammen. Fordi fiskeoppdrett krever permanente anlegg som fortrenger annen, vokste behovet for planlegging i kystsonen fram parallelt med akvakulturnæringens framvekst på 1970 og 1980-tallet. Plan- og bygningsloven, som regulerer arealplanleggingen både på sjøen og på land, krever at alle berørte skal kunne medvirke i planleggingsprosessen, og kystsoneplanene blir laget med bakgrunn i kartdata som dokumenterer de forskjellige myndigheters og berørte parters interesser.
Denne presentasjonen gjør rede for forskning på hvordan forskjellige kartdata som blir spilt inn eller innhentet i sammenheng med kystsoneplanlegging har forskjellig påvirkningskraft i planleggingsprosessene. Undersøkelsene ble gjennomført ved gjennomgang av kystsoneplanene for ti kommune og intervjuer med seks planleggere. Resultatene indikerer at kartdataenes autoritet varierer systematisk etter hvilket tema det dokumenterer, etter geometrien i datasettet, og etter om datasettet dokumenterer et lovhjemlet tema eller ikke. Tema som det ikke eksisterer kartdata for kommer ikke med i kystsoneplanene. Fordi arealplanlegging er et kommunalt ansvar kan lokale prioriteringer som ikke har støtte i dokumentasjon, likevel få forrang framfor andre dokumenterte interesser eller hensyn.

Experimental exclusion of invertebrates influences saprotrophic fungal community and wood decay rate in the field

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Decomposition of dead wood is a major component of the Earth's carbon flux, but still we know very little of the dynamics of saprotrophic communities within wood. Invertebrates and fungi are the most important eukaryotic decomposers of dead wood, both in terms of number of species and effect on decay rate. Within their shared habitat, invertebrates and fungi interact in numerous ways, but the significance of these interactions for community composition and decay rate is poorly known. We therefore conducted an exclusion experiment to test the effect of invertebrates on fungal decomposer communities in dead wood, repeated at 30 sites in two landscapes, and measured wood density to assess effect on decay rate.
Invertebrates were excluded from recently cut logs by cages with a 1 mm mesh net, and fungal communities in caged logs were compared to logs accessible to invertebrates by DNA metabarcoding analyses. Accessible logs included control logs, cage control logs and positive control logs. We found that exclusion of invertebrates had a significant effect on fungal community composition. For example, the wood decay fungi Trametes versicolor and T. ochracea were significantly more abundant in accessible logs than in caged logs. The strongest effect on fungal community composition, however, was attributed to differing baseline conditions in the individual trees. When accounting for these baseline differences, caged logs had significantly higher wood density than control logs after two years, indicating lower rates of wood decay in caged logs.
Further studies, spanning several years, are required to fully understand the influence of invertebrates on fungi and wood decay. However, our results indicate that invertebrates influence both the composition of saprotrophic communities in dead wood and their decomposition function, which is vital to all forest ecosystems.

What happens in a mire after restoration?

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Mire is defined as an area of land with moisture-demanding vegetation which forms peat.
Today, intact mires cover approximately 28 000 km 2 (about 9 %) of Norway, but a further 7000 km 2 are degraded or destroyed. Mires have been threatened for a long time, and many mires are damaged by ditches and/or peat extraction. Ecological restoration is necessary to restore and halt the loss of nature and restore ecosystem services.
In 2015, the Norwegian Environment Agency, started a project with the goal of restoring 18 ditched mires. Monitoring was established at three sites; Kaldvassmyra (Trøndelag), Aurstadmåsan og Midtfjellmåsan (Akershus). In 2016 and 2017, Aurstadmåsan and Kaldvassmyra, respectively were

restored by plugging ditches. Both mires are ombrotrophic raised bogs. We reanalysed these two mires in 2018.
At Aurstadmåsan, data indicates almost no difference between data collected in 2015 and 2018. The mire is seemingly not wetter, as transects are still dominated by tussock vegetation and species such as Sphagnum capillifolium and S. fuscum. It was impossible to see if the water level has raised following plugging, as the summer of 2018 was extremely dry in this part of Norway.
At Kaldvassmyra, water was at ground level. The plugs are high, and it could be that water levels are somewhat too high. This may have resulted in flooding of ombrotrophic vegetation by minero-trophic water. The data indicates that the vegetation already has responded to the increased moisture, with less hummock vegetation, and more lawn and carpet vegetation in 2018 compared to 2015. In and around the ditches we observed revegetation of peat mosses, especially S. fallax. This species indicates minerotrophy, and perhaps increased nutrient availability due to disturbance following the restoration. These unexpected changes are visible after only one year.

Recolonization and succession of a subtidal hard-bottom epibenthic community in Smeerenburgfjorden, NW Svalbard

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Rapid changes of Arctic marine ecosystems in recent years have drastic consequences for the structure and function of benthic communities. Exploring the resilience of Arctic benthos to perturbations and climate change requires a solid understanding of key ecological processes and must be conducted over appropriate time scales due to the slow growth and recruitment of many Arctic benthic organisms. This study addresses the successional pattern of a hard-bottom benthic community in Smeerenburgfjorden (NW Svalbard) after a perturbation as well as the functional traits involved in the different stages of recolonization. The time series was initiated in 1980 by clearing the substrate free of organisms on a rock wall at 15 meters depth, which subsequently was photographed annually by SCUBA divers. The structure of the community was investigated with traditional taxonomic analyses, whereas the function was examined via functional traits analysis. We found that the recovery rate at community level following the clearing mirrored previous observations of slow recolonization in polar benthic systems. It took ten years for the cleared substrate to be covered by living organisms comparable to the control area, whereas the convergence of the cleared and controls community compositions appeared to take over two decades. All recolonizers were representative of the local community, generally comprising of slow growing and long-lived taxa. The community-weighted mean traits displayed a decrease in body size and longevity in response to the clearance manipulation, and a small increase in

mobility, grazing and predatory feeding habits. As anthropogenic climate change is expected to open up large areas of coastal hard-bottom habitat for colonization in the Arctic, and promote species invasions and altered ecological interactions, long-term monitoring is crucial to our understanding of the succession of these communities.

Moose, trees, and Norwegian Society – providing the science backing for sustainable ecosystem management

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Communication is both a challenge and a strength of ecosystem-based management. Managing entire ecosystems, more so than for single species/resources, implies balancing ecological, social and economic factors. The scientific community is challenged by having to communicate rather specific findings to solve problems arising in a very complex socio-ecological landscape. Assuming that knowledge generation is not the bottleneck for increased sustainability in nature management today, we argue that increased synthesis making and coordinated science communication is low hanging fruit to achieve the same. This effort is necessary so that our use and coexistence with nature does not become too much shaped by strong social or economic interests or research bias. Achieving this requires very broad knowledge and an overview that no single person, or discipline, possess. We therefore need to work interdisciplinary, despite our different methods, terminology, and traditions. Here we present a new tool and an online platform that makes use of an interactive socio-ecological map, where experts from multiple scientific fields come together to collate and create the knowledge base needed for informed decision-making. We will demonstrate the use, virtues and challenges with this tool. Our case study is the Norwegian boreal forest ecosystem based around the central actors ‘moose’ and ‘trees/forest’. The ultimate goal of this project is to make relevant science available and understandable to decision makers and society as a whole, and to create a legitimate and holistic synthesis of knowledge that can be used in the service of sustainable management.
Link to web-page: https://moose-trees-wolf.org/

Atlantic cod in warming waters: Resistance against and tolerance towards infections are affected by water temperature

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Sustainable management of marine resources requires extensive knowledge of the health status of the species of interest. The environmental temperature has profound effects on marine aquatic organisms and plays a critical role in species distribution and abundance. Particularly during the warmer seasons, variations in habitat temperature may introduce episodes of stressful temperatures which the organisms must adapt to and compensate for to maintain physiological homeostasis. The marine environment is changing and predicted raises in water temperatures will affect numerous marine species. Translocation of pathogens will follow migration of species and alternations in physical environmental parameters may have impact on the virulence of pathogens, as well as the hosts immune responses. While pathogenicity of many true pathogens is expected to increase following climate induced temperature stress, the influence of environmental stressors on the occurrence and severity of opportunistic infections is unknown. Here we describe how thermal stress in the cold-water species Atlantic cod (Gadus morhua) influenced the fish immune responses against the opportunistic intracellular bacterium Brucella pinnipedialis. Following experimental infection at normal water temperature (6°C) and sub-optimal temperature (15°C), cod cleared the intracellular bacteria more rapidly at the higher temperature. The overall immune response was faster and of higher amplitude at 15°C. However, a significant number of cod died at this temperature despite efficient clearance of infection. An increased growth rate not affected by infection was observed at 15°C, confirming multiple energy demanding processes taking place simultaneously. Serum chemistry revealed that general homeostasis was influenced by both infection and increased water temperature, highlighting the cumulative stress responses (allostatic load) generated by simultaneous stressors. Our results suggest a trade-off between resistance and tolerance to survive infection at sub-optimal temperatures and raise questions concerning the impact of increased water temperatures on the energetic costs of immune system activation in aquatic ectotherms.

Spatial covariation of competing species in a fluctuating environment

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Environmental fluctuations and spatial processes can both have strong impacts on the dynamics and distribution of natural populations. Understanding how stochastic fluctuations in the environment influence populations in a spatial setting is essential for successful management and sustainable harvesting, and is a central topic in ecology. However, most studies to date have focused on

populations of single species, and we lack knowledge of how species interactions and dispersal together influence responses to environmental fluctuations. We have therefore developed a new analytical model for understanding patterns of covariation in space between interacting species. Key properties of this model will be presented along with results showing how the covariance between competing species depends on the strength of competition, and on the similarity between species in their responses to the environment. It will be shown that the influence of competition is strongly dependent on the rate of dispersal in the system. Results will be presented both for the covariance between two species in a single point, and for the distances over which two competing species covary. These results have implications for our understanding of stochastic population dynamics and community processes and how they can be expected to respond to environmental change.

Temporal trends of persistent organic pollutants in Barents Sea polar bears (Ursus maritimus) in relation to changes in feeding habits and body condition

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Persistent organic pollutants (POPs) reach the Arctic ecosystems from lower latitudes mostly via air and ocean currents. They biomagnify through Arctic food webs and reach considerably high concentrations in top predators such as polar bears (Ursus maritimus). Although many of these compounds have been banned or restricted for decades, concentrations in Arctic biota still remain high. Trends of POP concentrations in biota are affected by various factors, including dietary source and climate change. Because of retreating sea ice polar bears can be forced to feed at lower trophic levels or consider terrestrial food sources, potentially leading to a decreased uptake of contaminants. Temporal trends of persistent organic pollutants (POPs: PCBs, OH-PCBs, p,p'-DDE, HCB, β-HCH, oxychlordane, BDE-47 and 153) in relation to climate-associated changes in feeding habits and body condition in adult female polar bears (Ursus maritimus) from the Barents Sea subpopulation were examined over 20 years (1997-2017). All 306 samples were collected in the spring (April). Both stable isotope values of nitrogen (δ 15 N) and carbon (δ 13 C) from red blood cells declined over time, with a steeper trend for δ 13 C between 2012 and 2017, indicating an increasing intake of more terrestrial and lower trophic level prey. Body condition, based on morphometric measurements, did not significantly change between 1997 and 2005, and increased significantly between 2005 and 2017. BDE-153 and β-HCH concentrations in plasma were stable over time, whereas Σ 4 PCB, Σ 5 OH-PCB, BDE-47 and oxychlordane declined linearly. Plasma concentrations of p,p'-DDE and HCB, however, declined until 2012 and 2009, respectively, and increased thereafter. Climate-related changes in feeding habits and body condition did not significantly affect POP trends. The study indicates that changes in diet and body condition were not the primary driver of POPs in polar bears, but were controlled in large part by primary and/or secondary emissions of

POPs.

The research-management nexus: Fashioning research projects to meet multiple publics

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The management of ecosystem resources requires policy and regulations that are appropriate to the ecosystem, useful for management authorities and legitimate from the point of view of end users. In addition, management officials have work within the laws, policy and management goals set by national authorities. In navigating all of these, having enough of the right kind of knowledge about the resource to be managed is essential. Current thinking suggests that a close partnership among end users, management authorities and researchers is essential in producing this knowledge. This paper is a case study of the CHASES research project on sea trout, in the context of the Norwegian management system for salmonids, in which local authorities and river-bank owners have particularly large responsibility for local resources. In the CHASES project, three groups have worked closely together: local management authorities, an important interest group (The Norwegian Association of Hunters and Fishers Anglers, NJFF) and researchers from CHASES. This paper examines how local authorities use scientific knowledge in their decision-making and to what degree and how CHASESs' research responds to both national priorities and the needs of local consumers (authorities and end users) of its research. The paper will be based on survey data and interviews with authorities, members of the interest group and CHASES researchers.

An analysis of what ecological shortfalls paleoecological data is most suited to address: the case of ancient DNA of plants

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Ecological shortfalls beset all modern ecological studies: we have incomplete information about species identities, distributions, evolutionary history, functional roles, population dynamics, abiotic tolerances, and ecological interactions. A limiting aspect of many ecological studies to properly address these gaps in our knowledge is the short timeframe, they are rarely longer than a decade, and often inferences are made from only a few years-worth of data. Paleoecological proxies, including pollen, DNA and macrofossils, can remedy this lack of temporal breadth, providing information about distributions, population dynamics, abiotic tolerances and evolutionary history back in time. Functional roles and ecological interactions of plants in the past can be inferred based on our knowledge from today, along with the assumption of the principle of uniformity of nature. Yet, addressing shortfalls, particularly population dynamics, depends on reliable abundance

information, while others are dependent on relevant spatiotemporal and taxonomic resolutions which can be challenging to acquire with paleoecological data.
In this study, we look into which ecological shortfalls paleoecological studies are most suited to resolve, exemplified by ancient DNA of plants. Detection of plants from ancient DNA (aDNA) is a proxy that can provide good taxonomic depth and breadth, particularly as databases and laboratory procedures improve. We address the typical spatiotemporal and taxonomic resolutions of both plant community aDNA research and modern ecological vegetation research, with emphasis on study design, and discuss the implications in the context of addressing ecological shortfalls. A careful consideration of these knowledge gaps opens up opportunities for integration between paleo- and modern ecology.

Biotic and abiotic drivers of ptarmigan population dynamics in Svalbard

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The Svalbard rock ptarmigan Lagopus muta hyperborea is the only terrestrial bird species that resides in the archipelago throughout the year. It is the most popular game species in Svalbard, but the impact of ongoing climate change on its populations is likely to exceed that of harvesting. Untangling the main factors driving population dynamics is important to predict how the species will respond to future changes. This is a difficult task, in spite of the relative low complexity of the Svalbard food web. We intended to shed some light on what determines ptarmigan population dynamics in Svalbard. We developed a-priori hypotheses on the direction of impact of several potentially important factors, both biotic and abiotic. We predicted the ptarmigan population growth rate to be positively influenced by warm conditions at hatching, but negatively influenced by heavy rainfall events at hatching. We expected fluctuations in snow seasonality in terms of early snowmelt and late winter onset to negatively affect ptarmigans, by causing trophic and/or molting mismatch. We also expected rain-on-snow to have a negative effect by making food less available through rain-generated crust-ice layer. Eventually, we hypothesized climate-induced fluctuations of alternative food sources for the arctic fox, such as reindeer carrion, to determine variation in fox predation rates on ptarmigans, and thus predicted a negative impact of high carrion availability. We used data from a point transect distance sampling monitoring of territorial males carried out in April for the period 1998-2017. We fitted a hierarchical distance sampling model to the data in a Bayesian framework. This approach allows explicit modeling of spatial variation in abundance while accounting for detection probability.

Moose patch-scale browse selection of pine in relation to wolf presence in Scandinavia - do tri-trophic cascades exist in anthropogenically altered landscapes?

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Following functional extinction in the 1960's in Scandinavia, the wolf (Canis lupus) population has partly recovered. In this context, it is interesting to study the behavioural responses of their main prey moose (Alces alces), in landscapes managed for commercial forestry. The primary winter forage of moose is Scots' pine (Pinus sylvestris) and moose browsing damage may lead to substantial economic losses for the timber industry. Previous research has shown that wolf predation risk for moose is higher in open areas and young forests, likely due to a higher risk of detection by wolves. Young forest stands also contains the most moose forage potentially causing a trade-off between foraging and predation risk. In this study, we carried out a survey of moose winter browsing pressure, forage availability and moose pellet group density across a range of habitat types, in moose wintering areas without and without resident wolf packs in southeast Norway. We hypothesise that in the areas with wolf establishment, moose will select pine to a larger degree in more closed forests to reduce predation risk as compared to areas without wolves. Previous research also showed that predation risk for an individual moose is higher in areas with low and high moose density, as compared to areas of intermediate moose density. Thus, our second hypothesis is that in areas with wolf present, moose selection for browse in young forest within the wintering area will be higher at low predation risk. Our results may have implications for moose browsing impacts on timber production.

Decades of release from sheep grazing render no changes in local plant species richness, but a significant species turnover within regions of different species pool size

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Current environmental changes may pose a threat to global biodiversity, having detrimental consequences for the functioning of ecosystems and the provision of ecosystem services. However, some recent studies suggest that there is globally no evidence of local biodiversity loss through time, and that current biodiversity trends are rather characterized by species replacements within a community. In order to understand ongoing biodiversity trends, one must regard local diversity in relation to its main shaping forces though, which are 1) the local habitat productivity, 2) the disturbance regime and 3) the species pool size.
Here, we investigated local plant diversity within tundra landscapes. We conducted a quasi-experimental study, in which we assessed local vascular plant species richness (alpha) with respect to contrasting habitat productivity. We stratified our sampling to valleys, which were either currently used as rangelands for sheep (Ovis aries L.), or released from sheep grazing for several decades. In addition to alpha diversity, we also investigated the community distinctness in our study (beta

diversity). We followed this approach by conducting two case studies, applying the same sampling design in regions with comparably small (north, north-west Iceland) and comparably large (northern Norway) species pool size.
In Iceland, results showed that local richness is mainly driven by contrasts in landscape topography. Decades of a release from sheep grazing had no impact. Besides higher local vascular plant species richness in general, we found similar effects of topography and release from grazing in Norway. However, the release from sheep grazing was the best predictor of beta diversity in both case studies. This major change in disturbance regimes does thereby not reflect in changes of local species richness, but a turnover towards species with potentially different functionality.

Impacts of fishing and hydropower production on brown trout in Norway – Lessons from size-structured population models

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Many wild populations of migratory salmonid fishes are threatened by human exploitation, habitat alteration (especially as a consequence of hyrdoelectric power production), and climate change. Because of the high ecological, cultural, and economical value of such populations, some parts of their life history have been studied intensely. However, to predict human and environmental impacts on salmonid population dynamics, integrative models accounting for the entire life cycle are needed. Using data from a unique long-term study from a landlocked population of migratory brown trout in Eastern Norway, we estimated the relationships between individual body size and vital rates at different life-stages (growth, cause-specific mortality, developmental transitions, and fecundity) and subsequently linked them to population dyanimcs in an Integral Projection Model (IPM). Analysis of this model provides detailed insights into the relative importance of different vital rates and underlying individual- and environmental factors on population dynamics. Furthermore, it allows investigating the effects of changes in management strategies (e.g. fishing regulations, hatchery practices, hyrdoelectric dam operation) on the abundance and size distribution of the trout population, highlighting the sheer potential of long-term individual-based monitoring data and quantitative sturctured population models for management and conservation.

Is the Nowegian pollinator strategy policy-relevant?

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In October 2015, three MPs representing the Christian Democrats (KrF) asked the ruling government, a coalition between the Conservative (Høyre) and the Liberalist (FrP) parties, to build a pollinator strategy. Both ruling parties voted against it. Being a minority Government, losing the vote with 50 to 51, they still had to do it. This does not suggest a strong focus on the strategy. On June 29 th 2018 The Ministry of Agriculture and Food released the Norwegian Pollinator Strategy. At first glance, this is good news for bees and other pollinators. However, the process leading to the strategy document and the ambitions outlined within, give reasons for concern. Building a strategy to conserve an ecosystem function makes suggests that Ecology is policy-relevant, but only if ecologists are invited to participate in the development of the strategy. Here I will describe the process leading to the Norwegian Pollinator strategy, and how the involved Ministries tackled the challenge. In particular how they involved the national research community. I will also emphasize the importance of scientists questioning the science basis for the strategy. Finally, I will discuss the intentions behind building the strategy in the first place, and illustrate how that may affect its potential impact. I have been critical to the strategy all along, but I will end with some positive notes on the strategy's potential for conserving bees and other pollinators and the ecosystem functions and services they provide.

Biodiversity informatics in ecological sciences: current, past and future

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Over the past decade, there has been an increasing awareness of scientific culture and conduct, including a call for more open and transparent research processes. A key element in the open science movement is a rapid change in access to scientific data, driven by both a cultural and a technological revolution. With a strong focus on digitization of public services in society at large, there is also a concurrent shift in mentality towards open government data and an expectation that public data services are efficient and highly interconnected. We should expect the same efficiency and interoperability from information services for ecological datasets, fostering a transparent and reproducible knowledge base that supports management actions and policy development. In this talk we highlight some of the benefits and challenges related to the open data movement for ecological and environmental research, and how biodiversity informatics is a key player that facilitate transparent knowledge-based management of the worlds biota. We discuss the current technological and governance systems that exist on a national and international biodiversity informatics scene, and conduct a horizon scan related to future developments within the field. Current global aggregators of biodiversity data such as the Global Biodiversity Information Facility (GBIF) have currently been expanding datastreams from mainly presence-only occurrence data

towards data models offering support for quantitative ecological and time series data, as well as integration with other data streams from e.g. molecular genetics infrastructures. Biodiversity informatics currently offers an increasing set of tools and practices for improved data management that is so far underutilized in the ecology community. In addition to technical implementation, there is a need for both cultural changes and data management capacity building for ecologists to equip the society with an open and transparent knowledge from the field.

Utvikling av nytt forvaltningssystem for norsk natur. Presentasjon av fagsystem for økologisk tilstand.

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Norsk handlingsplan for naturmangfold har som et hovedmål at økosystemene skal ha god tilstand for å kunne bevare biologisk mangfold og levere økosystemtjenester (Meld. St. 14 (2015-2016)). Et ekspertråd ble oppnevnt for å foreslå et fagsystem som skal måle økosystemenes tilstand. Fagsystemet omfatter marine og terrestriske økosystemer som ikke dekkes av vannforskriften. Eksisterende klassifiseringssystemer ble lagt til grunn i arbeidet, og Ekspertrådet har videreutviklet dette for vårt formål. Syv ulike egenskaper som karakteriserer økologisk tilstand er identifisert: Primærproduksjon, fordeling av biomasse mellom trofiske nivå, diversitet av funksjonelle grupper, viktige arter og biofysiske strukturer, arealvurderinger knyttet til arters overlevelse, endringer i artssammensetning, og abiotiske faktorer. Ved god økologisk tilstand skal disse egenskapene ikke avvike vesentlig fra intakt natur. Intakt natur defineres som natur som ikke er vesentlig endret som følge av post-industrielle og gjennomgripende menneskelige påvirkninger. Foredraget vil gi en kort introduksjon til fagsystemet, samt gi en omtale om hvordan fagsystemet testes med reelle data i utvalgte pilotområder. En rekke institusjoner er involvert i arbeidet.

Global distribution of ecosystems suitable for extensive grazing: causes and spatial patterns

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Extensive grazing is optimal land use for areas where herbivorous have always food limited and where the vegetation is therefore dominated by grazing tolerant plants. Theoretically, such ecosystems should prevail in areas with low primary productivity, i.e. in areas where the minimum

herbivore density required by predators to survive and to reproduce exceeds the maximum herbivore density that the vegetation can sustain. In these ecosystems, periodically intense herbivory pressure is an integral part of the nature, favoring grazing tolerant plants and promoting their evolution.
In rough outlines, the above summarized conjecture was formulated by Oksanen et al. int heir 1981 "Exploitation Ecosystems" article, but in this article the underlying model was treated as an abstraction, and its parameters were not connected to the realities of terrestrial food web interactions. Consequently, the authors proposed that there is a uniform and globally valid primary productivity threshold at which terrestrial three trophic level cascades are replaced by two trophic level dynamics, i.e. by a strong herbivore-plant interaction. By explicitly relating model parameters to traits of terrestrial nature, we found that this part of the conjecture is grossly erroneous. The threshold can be expected to be much higher in strongly seasonal ecosystems, where only a small fraction of the energy fixed by plants is available for herbivores in winter and where cold temperatures eliminate alternative energy sources, which augment predators in persistently warm environments.

Changes in species associations with climate change

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With climate change altering aquatic ecosystems worldwide, many species will see their habitat space constricted. At the same time, other species will be able to arrive in areas previously uninhabitable for them due to temperature restrictions. New species assemblages will not only alter the structure of the ecosystem, it will also alter their function. Moreover, climate change will in itself likely change the way species interact with each other. As such, it is rapidly becoming crucial not only to monitor and forecast changes in species assemblages, but also to monitor and forecast changes in environmental impacts on species to species co-occurrences. Here, we build a joint species distribution model to gauge changes in freshwater fish interspecies associations with rising temperature. We used a space-for-time approach with a dataset containing presence-absence information from 2825 lakes spanning a latitudinal gradient from 55 to 72 o N in Fennoscandia, with 32 regularly-occurring fish species. There where several changes in species associations along climate gradients. We illustrate how results enables predictions of a) where species were likely to be able to disperse into novel environments and b) what the effect of those species arrival on local species would be.

Land cover determines richness of threatened and alien species in an urban municipality

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Species richness is frequently modelled for a limited number of species, either globally or for a local area, including relatively labor-intensive data gathering. For policy makers, a spatial extent of municipality level, richness of large species assemblies across taxa, and habitat categorization used by multiple administrative bodies are more useful for forming the base of management decisions. We aim to use the plethora of species records are now freely available through online databases, and detailed maps of land cover to investigate what land cover factors affect the distribution and richness of threatened and alien species across a urban-rural municipality.
We used GBIF records to build spatially explicit GLS models to predict richness of all species, threatened (red-listed) species and alien (black-listed) species in 500m*500m grid cells across Trondheim municipality, Norway, a region spanning a steep urban-rural gradient.
We show that land cover is an important factor determining species richness for the three investigated groups. We also find that alien species are positively associated with human-modified urban land cover, whereas the most characteristic habitat type associated with threatened species is coastal areas. Threatened species are also positively associated with areas characterized by large amounts of cultivated land, even more so than overall species richness. All species are positively affected by increasing habitat heterogeneity, the relative effect is however stronger for threatened species than for alien ones.
For future management, these results point to a need to ensure protection of coastal areas and management focused on high levels of habitat heterogeneity on a 500m*500m scale, if threatened species are to be favored. Likewise, urban areas should be carefully monitored to assess the spread of alien species.

The Microbial Methane Filter: Reducing CH 4 emissions in High Arctic peatland soils

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Northern peatlands store large amounts of the Earths carbon. Increased thawing due to higher temperature in the Arctic releases larger amounts of this carbon, which is metabolized to methane (CH 4) by anaerobic Archaea. However, Methane Oxidizing Bacteria (MOB) act as a biological filter, reducing CH 4 emissions to the atmosphere. The key enzyme for CH 4 oxidation is methane monooxygenase, partly encoded by the gene pmoA. This gene can be used as a molecular tool in ecological studies to identify MOB. In Arctic peat lands with a neutral pH, Methylobacter tundripaludum and closely related species are key MOB.
In this study we aimed to understand how altered soil parameters such as temperature and CH 4 concentration impact the activity and community structure of

these Arctic MOB. We addressed the biological CH 4 filter in grazed peat land soils compared to peat land soils protected from grazing. We combined in situ measurements with ex situ CH 4 oxidation activity measurements using microcosms. Additionally, we assessed the active MOB community by sequencing pmoA transcripts.
Our results show that a removal of plants caused by grazing, alters the CH 4 cycle by change in water level, decrease in oxygen (O 2) and thus an increase in CH 4 production. However, microcosm studies comparing grazed and exclosed peat soils show that MOB are able to respond to increased CH 4 concentration by increased CH 4 oxidation. When looking at elevated CH 4 concentration and elevated temperature, we could also see that increased CH 4 has a strong influence on CH 4 oxidation activity accompanied by changes in the active MOB community. We found different abundances of Methylobacter strains or the exchange of different Methylobacter strain consortiums in response to altered CH 4 concentration.
In conclusion, our studies documented that the Arctic CH 4 filter is able to respond rapidly to changed environmental conditions and can mitigate increased CH 4 emissions in Arctic peatlands.

Soil carbon in boreal forest under European beech and Norway spruce

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Boreal forest soils are the largest terrestrial carbon (C) pool, and play an important role in mitigating climate change. Previous studies have revealed variances in soil C under different dominating tree species. European beech has been replaced with Norway spruce across Europe due to forest management. Generally, spruce forest has been found to store more soil C than beech forest. In boreal regions, where beech has its northern distribution, there is a lack of knowledge on how beech and spruce differs in impact on forest soil C. We have therefore compared the vertical distribution of soil C in a natural beech forest with that of a spruce forest planted on former beech forest and a spruce forest planted on former spruce forest, in South East Norway. Analyses of biochemical parameters and fungal biomass were done along fine-scaled soil profiles, covering both the organic and mineral layers. Overall, we found fungal biomass to be significantly greater in beech forest soil compared to both spruce forests. However, there were no significant differences in total C storage of the organic or mineral soil layer between the forests. Soil C, nitrogen (N), and C/N ratios were forest type and soil depth dependent, whereas forest type had an effect on the vertical distribution of condensed tannins and fungal biomass. Our results suggest that the presence of beech or spruce as the dominant tree species has an effect on the vertical distribution of soil properties, while there is no major difference when comparing the whole soil profile. This contradicts the current understanding that spruce forest store more soil C than beech forest. We posit that various site factors in boreal forest ecosystems may override the tree species effect on forest soil C stock.

eDNA as a tool for fisheries stock assessments and ecosystem management

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An ecosystem approach to fisheries management must be based on extensive data on the status and dynamics of marine ecosystems and on estimates of abundance of fisheries stocks. However, current fisheries independent survey methods are expensive and labor intensive, and in many cases inadequate for determining indices of stock abundance in areas encompassed by marine sanctuaries or having other restrictions (e.g. untrawlable habitat). Methods for mapping and monitoring marine ecosystems have not kept pace with demand, generating a pressing need to develop methods that can provide more accurate information about the resources that are being assessed. Advances in genetics and genomics, encompassing a variety of technologies and tools, now give us the power to augment existing data collections, fill data gaps in existing survey methodologies, and augment or in some cases possibly replace current methodologies with more robust and cost-effective methods. The USA - Norway eDNA Science Consortium was initiated in 2018 to bring together bi-lateral expertise for identifying challenges and potential solutions associated with implementation of eDNA as a monitoring tool for knowledge-based ecosystem management and fisheries stock assessments. The goal of this consortium is to develop a strategy for future implementation of eDNA for fisheries management, leveraging resources and international expertise to addresses concerns of stakeholders. We present here research priorities and plans to achieve outcomes identified from these round table discussions. These meetings attempted to address the major aspects of using eDNA as a tool for fisheries stock assessments, including:
best practices for sampling, sample processing and data analysis
description of case studies where eDNA can generate/improve knowledge
performance of interlaboratory calibration studies
development of standard reference material
sharing of biological and genetic resources across national borders
initiation and execution of bi-lateral field activities testing eDNA implementation
effective communication of eDNA results

Tracking the past using the present: does sedimentary ancient DNA capture the dominant vegetation growing around a lake?

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Effects of past climate on vegetation have typically been assessed using pollen and macrofossils as proxies. In recent years, these proxies have been supplemented by use of sedimentary ancient DNA (sedaDNA). However, the degree to which inferences from sedaDNA reflect the actual flora has not been addressed properly. Thus, we wanted to assess catchment area of a lake as a predictor of sedaDNA. More specifically, we hypothesized that the dominant species of the most abundant habitat types in the contributing area of a lake will be the most abundant species in the sedimentary DNA. Furthermore, we hypothesized that species abundance relations in the contributing area will be reflected in the sedaDNA. To address these hypotheses, we assessed the contributing area surrounding the ECOGEN lakes, characterized landscapes and habitat types/vegetation types in the contributing area including species abundances of the most common species and functional groups. We will compare abundances of species in the contemporary vegetation to that of their abundance in the contemporary sedaDNA of each lake to assess how well sedaDNA capture the current vegetation growing around different lakes.

On time to include a seascape and ecological engineering approach when building structures into the sea?

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To protect marine biodiversity, it's on time to change the traditional way of planning and forming structures placed into the sea, both by including a landscape perspective (as ordinary for terrestrial planning), and by choosing design and materials that promote marine life. Landscape architects have rarely access to marine topographical maps. This makes it impossible to consider the marine landscape when designing buildings and infrastructure in

the sea. Additionally, artificial structures in the sea have traditionally been built with straight edges and smooth surfaces, creating desert-like marine habitats. We here demonstrate a pilot study where we through an interdisciplinary approach have designed underwater urban tidalscapes, as well as a design for testing a variation of eco-engineering methods to increase habitat complexity and biodiversity in an urban subtidal and tidal study area; the former industrial Port of Oslo (Norway). To promote natural colonization of marine organisms onto established building constructions, smooth surfaces are modified with holes and cavities to become more suitable settlement substrates. Underwater tidal gardens and landscape structures, built from local stone minerals, are designed to provide authentic habitats for the marine organisms. Native habitat-forming taxa are suggested to be transplanted into the tidal scape structures to accelerate the formation of a natural ecosystem. The project includes collaboration between landscape architects, social scientists, geologists, oceanographers, marine biologists, city planners and developers. The goal in the short term is to design and test interventions that enhance algae and animal diversity in Oslo's urban foreshore area. In longer term, we want to stimulate the use of a landscape perspective and ecosystem engineering in the marine environment in Norway.

Recovery of soil micro-arthropod communities after cessation of experimental environmental change

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Changes in environmental conditions can push ecosystems into alternative states that differ in species composition, species abundance, and thereby ecological processes and functioning. However, we often do not know whether these responses to environmental change are permanent, or if communities can and will recover after environmental variables return to their original level. Here, we present the results of our study on the recovery of the micro-arthropod community (Collembola and Acari) in a Dryas-heath community at Finse, Southern Norway. We resampled the study site for Collembola and Acari (Oribatida, Astigmata, Prostigmata, and Mesostigmata) nine years after cessation of warming and nutrient addition treatments and assessed the communities' ability to recover. Because an earlier study shows that the vegetation in this system has not recovered, particularly when herbivores are excluded, we expected a similar lack of recovery in the micro-arthropod communities. However, our initial results show that micro-arthropod (notably Collembola and predatory Mesostigmata) abundance has recovered from the strong initial responses to the treatments with nutrient addition. Contrastingly, for Collembola and Oribatida community composition, we found no clear indications of recovery and grazing did not clearly stimulate recovery. The results of this study show that arthropod communities can quickly recover in terms of abundance, but that environmental manipulation can have long-lasting legacy effects on the composition of alpine micro-arthropod communities.

Mapping tourist interactions with nature in the Arctic inside and outside protected areas

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Understanding where and how tourists interact with the natural environment is an important step towards quantifying the environmental impact of tourism and identifying opportunities to improve sustainable management of natural resources. In the Arctic, as in many parts of the world, interactions with the natural world are an important part of the tourist experience and are often recorded in photographs. Using Google's Cloud Vision algorithm, we analysed the content of over 800,000 geotagged Arctic photographs on Flickr. We identified the types of nature most photographed and mapped hotspots of tourist-nature interactions across the Arctic; generating fine-scale maps of different types of nature tourism across the Arctic. Almost all (91.1%) of users took one or more photograph of biotic nature, and such photos account for over half (53.2%) of Arctic photos on Flickr. We find that tourists are slightly more likely to photograph nature inside protected areas after accounting for their inaccessibility, but that the vast majority of Arctic tourist-nature interactions occur outside protected areas.

Forest condition indicators and management practices define sustainability standards: A case study of the Native Forest Law in Argentina

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We use a case of native forest management in Argentina to illustrate an approach to operationalize indicators of forest ecological condition linked to criteria of sustainable use in compliance with national regulations. The Forest Law (Nº 26331 of "Minimum Standards of Environmental Protection of Native Forests") aims to protect native forest biodiversity and to promote the sustainable use of ecosystem services (ES). Ten criteria (targeting native biodiversity, soil and water protection, forest provisioning services and social objectives) were stablished for land zoning in three forest conservation categories. However, the use of Criteria and Indicators (C&I) for sustainable management at the local level has not yet been implemented, leaving much uncertainty about acceptable levels of use. A previous study revealed that there are trade-offs within some provisioning ES such as forage and firewood, and between provision and maintenance and regulation ES such as forage and biodiversity (Rusch et al. 2017). Using a BBN model, we assess the probability of maintaining the system within high ecological condition quality after 40 years, with different

management options (grazing, logging and planting of trees), starting from two initial forest conditions. Starting from a forest condition with little human intervention, all levels of use will decrease the ecological condition compared to the reference state, although combinations of management practices will attain different levels of environmental quality, income and provisioning services. In contrast, starting from an initial state of open forest under silvopastoral use, certain combination of practices can improve environmental quality, and at the same time, maintain provisioning services within the time horizon of the study. We conclude that sustainable use standards much be understood considering the initial condition of the forest, and that different measures (e.g. set-aside or protected areas, direct payments to land-owners (PES), and technical assistance) are suitable to achieve different sustainability solutions.

A bird's-eye view for bryophytes when building nests: selected choices or random picking?

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Birds reproductive success is dependent on the building quality of their nests but until recently it was believed that nest building behavior reflected nothing more than genes or instinct alone. This view has now been challenged because the nest building seems to be a learning process. However, data on nest composition is scarce, hampering our understanding of how nests achieve their various functions. Those studies that have examined the composition of nests rarely detail the species composition of bryophytes, a material that usually dominates in the nests of passerine birds such as Blue Tits (Cyanistes caeruleus) and Great Tits (Parus major). We know even less whether bird species have preferences for certain bryophyte species for building material or whether they just pick species randomly. Therefore, our aims are to detail the species composition of bryophytes in nests of Blue Tit and Great Tit, and to examine whether Great Tit has preferences for certain bryophyte species as nest material.
We determined the bryophyte species composition in 49 nests of Blue Tit and 53 nests of Great Tit in a forest at Bogstadvannet, nearby Oslo. We also collected data of the forest floor species composition of bryophytes in 167 plots surrounding a sub-set of the nests of the Great Tit.
Both the bird species used 15 species of bryophytes and mainly the same species as building material but in different amounts. Pleurozium schreberi, Rhytidiadelphus squarrosus were those species used in largest amounts of both bird species. The Great Tit had species preferences as three bryophyte species, all considerably branched, where found in significantly larger amounts in nests than in the forest floor vegetation: Pleurozium schreberi, Rhytidiadelphus squarrosus and Sanionia uncinata. In contrast, many common bryophyte species of the forest floor were avoided, among them several sparsely branched taxa. Even though the Great Tits have preferences they normally fly less than ten metres to collect materials and the local bryophyte vegetation is partly

reflected in the nest's composition, indicating a possible trade off between nest material quality and time and energy invested in nest building.

Effects of flow regime on benthic algae and macroinvertebrates - a comparison between regulated and unregulated rivers

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Natural fluctuations in flow are important for maintaining the ecological integrity of riverine ecosystems. However, the flow regime of many rivers has been modified. We assessed the impact of water chemistry, habitat and streamflow characteristics on macroinvertebrates and benthic algae, comparing 20 regulated with 20 unregulated sites. We found no consistent differences in benthic algal or macroinvertebrate structural and functional traits between regulated and unregulated sites, in spite of differences in flow regime. When regulated and unregulated sites were pooled, overall flow regime affected macroinvertebrate species assemblages, but not indices used for ecosystem status assessment or functional feeding groups. In contrast to macroinvertebrates, overall flow regime did not affect benthic algae. Our results indicate that overall flow regime affected the species pool of macroinvertebrates from which recolonization after extreme events may occur, but not of benthic algae. When individual components of flow regime were analyzed separately, high June (i.e. three months before sampling) flow maxima were associated with low benthic algal taxon richness, presumably due to scouring. Macroinvertebrate taxon richness decreased with lower relative minimum discharges, presumably due to temporary drying of parts of the riverbed. However, recolonization after such extreme events presumably is fast. Generally, macroinvertebrate and benthic algal assemblages were more closely related to water physico-chemical than to hydrological variables. Our results suggest that macroinvertebrate and benthic algal indices commonly used for ecological status assessment are applicable also in regulated rivers.

Cue identification in phenology: how good are our statistical tools?

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Changes in the timing of life history events are a widespread consequence of climate change. In order to establish how this phenology is likely to change over time we need to identify the environmental cues which drive phenological events. Cue identification is achieved with statistical testing of candidate cues through mechanistic or regression-based approaches. As the number of methods used to

generate predictions increases, assessing the predictive accuracy and congruence of different approaches has become necessary. We tested the predictive ability of five commonly applied statistical methods for cue identification. We explored how the timing and aggregate statistic of the identified cue changed based on the statistical method used, the number of years of data included, and the timespan of the data. We achieved this by applying all methods to an illustrative dataset of mean annual clutch initiation timing in wild great tits (Parus major), spanning 55 years. Predictive capacity of each method was assessed using cross validation. We found that the identified critical window of cue sensitivity is consistent across most methods but differs markedly for the relative sliding window. The accuracy of predictions varied across our dataset. Predictions preceded observations for the first few decades of our study but lagged observed timings in the most recent years, potentially indicating a shifting cue-phenology or cue-proxy relationship. The precision of predictions (prediction intervals) ranged from approximately one to two weeks. These findings suggest that the current statistical toolkit in phenology varies in precision and accuracy based on the method and data used. Phenological studies should not assume a static cue-phenology relationship through time, should compare results from different methods, and cross validate results for predictive analyses. All results should be interpreted with caution, particularly from relative sliding time window analysis, as this method can identify biologically unrealistic cues.

Urban biodiversity: measurement and modelling challenges for a policy-relevant ecology

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Moving towards policy-relevant ecology requires efforts aimed at understanding and accounting for interactions between humans and the natural environment. The home base of ecology has always been the natural environment. The hotspots of human activities and economies, however, are the cities. Urban environments, with dense human populations, intensive and highly diverse land use, transportation networks, etc. offer great opportunities for studies of interactions between humans and nature. Many cities are situated in areas with high biodiversity and thus constitute both human and biodiversity hotspots.
I will present some ongoing work on biodiversity in Oslo, which harbors the highest human population and the highest biodiversity in Norway. This work has several aims of importance to policy-relevant ecology, including quantification of rare biodiversity elements (species, ecosystems), modelling effects of human pressures, and defining and estimating states and reference values for assessments of ecological condition and ecosystem accounts. I will illustrate opportunities and challenges related to these aims based on analyses of biodiversity surveys and open biodiversity data from several projects and sources (including URBAN-EEA and GBIF). For instance, rare (and thus often highly valued) biodiversity elements are not easily captured in standard surveys and are often over-represented (with unknown bias) in open occurrence data, but can be captured with probability-

based sampling. A preliminary statistical model for limestone-associated plant species in Oslo suggests that the occurrence of these species is determined by a combination of ecological conditions and human land use. With such models we can estimate the current state of this biodiversity element across Oslo, and assess the magnitude of human impact. This may serve as a starting point for defining and estimating reference states and building biodiversity and ecosystem accounts. All of this does, however, involve uncertainties at several levels, which also constitute an important challenge for policy-relevant ecology.

Biome-wide patterns and drivers of Arctic herbivores functional and phylogenetic diversity

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Communities are assembled from species that evolve or colonise a given region, and persist in the face of abiotic conditions and interactions with other species. Phylogenetic diversity characterises the evolutionary and colonisation history of a community, while functional diversity is indicative of abiotic and biotic conditions.
Understanding the forces shaping patterns of functional and phylogenetic diversity will help understand how ecosystems respond to environmental changes.
We tested whether geographic, abiotic or trophic factors drive biome-scale spatial patterns of functional and phylogenetic diversity in vertebrate herbivores across the Arctic tundra biome. Trophic interactions with plants and predators had a central role in determining diversity patterns of the herbivore guild. Hence, rapid ongoing environmental changes in the Arctic are likely to affect herbivore diversity and the herbivore guild functioning.

Brain volume variation in four morphs of Arctic char (Salvelinus alpinus L.) in Lake Tinnsjøen

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Adaptive radiation is the diversification of species occupying different ecological niches. Knowing the maximum time frame of colonization in postglacial lakes offers a unique opportunity to study morphological traits specialized for niche adaptation in polymorphic fish species. Niche-specific characteristics could influence brain size variation in char morph, associated with behaviour and sensory modality. To what extent is this pattern reflected in the brain of the char morphs? We

identified four morphs of Arctic char (Salvelinus alpinus): the Piscivore, the Planktivore, the Dwarf and the Abyssal in one of the largest lakes in Norway, Tinnsjøen. In my study, I measured six different brain regions in each of the morphs. I focused mainly on the olfactory bulb and the optic tectum, and the corresponding size of the olfactory organ and the eye, as an approximation for smell and sight
perception, respectively. I used recursive partitioning methods (decision trees and random forest) to determine which important parameters led to the segregation of the four different morphs. The differences present in morphs could be adaptations to niches or alternatively, reflect environmentally induced phenotypic plasticity or potentially genetic constraints for radiation to a given niche. These findings contribute to a better understanding of the adaptive radiation in Arctic char populations. The four morphs could diverge into species given enough time due to the ecological speciation process.

Red List updates and dynamics of red-listed species over time - effects on site selection based on occurrences of red-listed species

Gjerde, I., Sætersdal, M., Grytnes J.A. and Tingstad, L.[1] (2018) and

Tingstad, L.[1], Grytnes, J.A., Sætersdal, M. and Gjerde, I. (manuscript)

[1]Tidligere (når arbeid ble utført): Universitetet i Bergen og NIBIO. Nåværende arbeidssted: NINA

Communities of species are not static, neither in space nor time. As species distributions change over time, sites selected for conservation may not necessarily continue to serve their original purpose in capturing target species.
In these studies, we first investigated the effects of Red List updates on the long-term robustness of fine-scale site selection. We used records of red-listed species from six forest areas in Norway and four consecutive updates of the Norwegian Red list and performed an initial site selection using two different selection strategies. The ability of the selected sites to capture redlisted species of later issues was measured. In boreal forest, the mean proportion of red-listed species captured was reduced by 18 % during the study period, whereas no such effect was found in hemi-boreal forest, where increased clustering compensated for changes in target (redlisted) species. This could mean that, at finer spatial scales, alternatives to using occurrences of target species in site selection should be considered.
For redlisted species, both continuous updates of the Red list and the dynamics of the red-listed species themselves pose challenges to site selection and its effectiveness. For the second study, we used species data from inventories 17 years apart to estimate turnover of species. We estimated how the spatio-temporal dynamics of red-listed species affected the rank order of sites regarding species richness. Results revealed substantial species dynamics between the two inventories, which led to a considerably different rank order of sample plots in 1998 vs in 2015.
Lastly, we combined the results from our two studies, and looked at the combined effect caused by both Red List updates and the spatio-temporal dynamics of the species over time. Our results suggest that a moderate expectancy to the effectiveness of fine-scale set-asides selected based on snapshot occurrences of target species is warranted.

Adaptive management of increasing goose populations; the European framework

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Several arctic-breeding goose populations wintering in Europe have increased dramatically in numbers over the previous decades. This is due to a number of factors, such as the establishment of protected areas, improved feeding conditions on farmland in the non-breeding season, and, more recently, a warmer climate improving foraging conditions and especially breeding conditions in the Arctic. More geese have led to increasing conflicts with agricultural interests along their flyway, and there are also signs of negative goose impacts on the arctic tundra. With this as a background, a European Goose Management Platform has been established under the auspices of the Agreement on the Conservation of African-Eurasian Migratory Waterbirds. An adaptive framework is implemented for management plans for four goose species, and in the present talk the plan for Pink-Footed Goose (Anser brachyrhynchus) will be presented. Generally, the link between monitoring, research and management is vital in these processes, and stepwise deleting uncertainties, modelling, transparency, communication, building trust and social learning are all of importance in order to successfully implement the objectives with the corresponding actions. We will demonstrate the usefulness of an adaptive framework when managing wildlife species causing conflicts among several stakeholder groups. Moreover, the most common challenges will be presented, as well as solutions to overcome these.

Assessing ecological state by combining plant community data with Ellenberg and Grime indicator values

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Nature conservation and management need good metrics for assessing the ecological state of ecosystems. A common metric is the presence or absence of one or a few indicator species. However, multiple species data or entire species compositions express ecological function in a more robust and general manner than single species occurrences and may thus constitute an advantageous alternative.

This would be especially useful in systems where effective single species indicators are sparse and/or insufficiently sensitive to deterioration of the ecological state. We are developing a method for ecological state assessment combining plant community data with Ellenberg indicator values for environmental conditions and Grime indicator values for plant strategies, and have investigated whether these plant indicators successfully assess the ecological state of field survey data sets from five Norwegian ecosystem types: semi-natural grasslands, coastal grasslands, heathlands, mires, and forests. Our method makes use of a reference-state species composition for each ecosystem type, based on Nature in Norway (NiN 2.1).
We calculated community-weighted averages of Ellenberg and Grime indicator values and the distributions around them for all community data sets and then compared the distributions of field survey data and their corresponding reference data. Our results show that indicator distributions from field survey data of ecosystems in deteriorated ecological state clearly deviate from their respective reference distribution, whereas field surveys from ecosystems in good ecological state show significant overlap with their reference. Our approach thus promises high potential for robust assessment of ecological state.
Further development of the methodology should include: (i) collecting sufficient field data sets, existing or new, from nature in poor and good ecological state across all ecosystem types in Norway in order to validate the methodology and set empirically based quantitative limits in the reference for good ecological state; and (ii) extension of the Ellenberg-/Grime-framework to functional traits.

Trade-offs modify ecosystem biomass structure along trophic gradients

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Community-level data in macro-faunal ecology from diverse sets of environments, including marine and freshwater systems, show predator-to-prey biomass ratios that decrease with increasing prey biomass, consistently and worldwide. Analogous observations for parasite-host abundances in microbial communities exist, but efforts to link these observations under a common theoretical framework remained unattempt. We show how a simple principle rooted in marine microbial ecology has the potential to explain these consistent patterns. It suggests that trade-offs between resource competition and defense against top-down control with associated costs may shape food webs across all scales. We discuss how this framework links linking parasitism to predation and guides us towards a unifying theory of ecology.

Uncertainty and Maximum likelihood when fitting a Latent Variable Model with Correspondence Analysis

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Community ecologists commonly utilize dimension reduction techniques to find unobserved ecological gradients that influence the composition of a community. After finding the ecological gradients, taxa at locations can be ordered by their dissimilarity. The composition of the ecological gradients is usually contributed to a variety of environmental drivers or biotic interactions. Community data requires a family of the exponential distribution to adhere to the correct mean-variance relationship of data, albeit measured as counts, presence-absence, percentage cover or ordinal classes, per taxa at locations. For decades, community ecologists have relied on ordination methods to fit their data to the species packing model. One of the most popular methods in community ecology, Correspondence Analysis (CA), offers an approximate solution to a Latent Variable Model (LVM).
LVMs are a type of multivariate mixed-effects model with an unstructured random effect. The random-effect is estimates as a column-specific response to a row-specific (continuous) latent variable. However, unlike LVMs fit with e.g. maximum likelihood (ML), CA does not quantify the uncertainty of parameters, and only reaches the ML-solution under certain conditions. As a result, both are commonly disregarded when utilizing CA.
In this study, I explore the consequences of not taking the uncertainty of parameters and the ML-solution into account, in the application of CA.

How mat-forming lichens affect microclimate and decomposition in an alpine ecosystem

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Mat-forming lichens are an important component of alpine and arctic vegetation, where they often cover large areas. Despite their abundance, little is known about how lichens influence ecosystem processes inside and underneath mats. We set up a lichen transplantation experiment in Finse, alpine Norway, to study the effects of different mat-forming lichens and their traits on soil temperature and moisture, and decomposition rates of plant litter. We used four lichen types with contrasting traits such as reflectance and water-holding capacity: Alectoria ochroleuca, Cetraria islandica, Cladonia rangiferina/stygia and Flavocetraria nivalis, and bare soil. We recorded soil temperature and moisture and measured mass loss of two plant litter types after one year in the field. We found that lichens insulated the soil: both mean soil temperature during the growing season and number of freeze-thaw cycles were significantly reduced under lichen mats compared to bare soil, and C. rangiferina/stygia had lower soil temperature and less freeze-thaw cycles compared to other lichens. Interestingly, decomposition rate was lower under A. ochroleuca than under F. nivalis, but this does not correspond with lichens' impact on microclimate. We propose that insulation by lichen mats is the result of their water-holding capacity; lichens with high water holding

capacity have higher insulation capacity, while reflectance does not affect soil conditions. Second, we propose that lichens are associated with different microbial communities and/or microbial biomass, which have a larger effect on decomposition than soil conditions. Our findings show that lichens affect microclimate and decomposition by different mechanisms.

Wild reindeer population dynamics in Hardangervidda National Park

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Hardangervidda National Park is the largest mountain plateau in Europe. The main purpose of the National Park is to protect a section of a valuable high mountain plateau and its cultural environment, while securing living areas for the largest stock of Wild Reindeer in Europe. Wild reindeer are considered keystone species of the circumpolar region, but are also important for their economical and recreational value for hunters and landowners. Thus, a loss of this herd is negative, particularly for the landowners who are selling hunting permits. Reindeer populations are on the decline worldwide, and although these declines are not well understood, they have been linked to climatic variation, disease, and human interference. Reindeer are dependent on a short summer season to gain body weight, thus, any factors that reduce their ability to feed are detrimental to their winter survival. Such factors are insect harassment, which is worsened by warmer summers, and a shift in the timing of greening, which can reduce the spatial variability of plant phenology, causing a decline in calf production. Snow cover is also an important factor determining quantity and access to winter fodder. When snow thaws and refreezes to cause icy layers, the snow pack can become impenetrable by reindeer. Thus, warmer winters can be a serious problem for reindeer searching for suitable winter fodder, particularly later in the winter season. Climatic and anthropogenic factors do interact, and it has been suggested that reindeer with access to good winter conditions are regulated by hunting, and those with access to poor conditions are regulated by bottom-up processes. It is, however legitimate to ask if the introduction of wild carnivores would benefit the regulation of the reindeer population in the area defined as a national park by politicians.

How to ensure flower resources for pollinators by appropriate management practices in species rich hay meadows

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Globally, almost 90% of all flowering species are estimated to benefit from pollinators and 5 to 8 % of the global food production depend on pollinators, making it one of the most important ecosystem

services. However, pollinator populations are declining worldwide.
Semi-natural grassland is one of the key habitats for pollinators in Norway because it provides nesting sites and high diversity of flower resources throughout the season making it important to safeguarding these habitats. However, there is a need for better knowledge of the interaction between management, floral resources through the season and pollinator abundance in this habitat. The aim of this project is to study the effect of heterogeneous management in semi-natural grasslands on floral resources and pollinator diversity. We surveyed bumblebee species and floral resources for pollinators in ten permanent plots in 12 semi-natural hay meadows of high biological diversity.
The hay meadows in the study had three management regimes. A) Five hay meadows were mowed at two different times: one part mowed in late July and one part mowed in mid-August. B) Four hay meadows were mowed at once in end of July. C) Three hay meadows were mowed in mid-August after our last survey. We surveyed all the meadows three times during the season: 1. end of May/start of June, 2. mid July, 3. mid-August.
Preliminary results suggest that the most appropriate management practice to sustain pollinator densities in semi-natural hay meadows is to mow parts of the hay meadows at different times. The flowering stages of the different plant species in the semi-natural grasslands succeed each other and by always allowing some flowers to remain, this yields floral resources for the pollinators during the whole season.

Abstracts for poster presentations, alphabetical by presenting author, presenting author underlined:

Evaluating the effectiveness of National Implementation Plans under Stockholm Convention in the Arctic; Case-studies of Canada and Norway (CANO)

Abbasi, Golnoush[1], Borch, Trude[2], de Leon, Fe[3]

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Once chemicals are emitted to the environment, they can cause adverse effects to ecosystems, animals and humans. Some chemicals undergo long-range transport (LRT) to remote areas, such as the Arctic. The LRT chemicals persistent organic pollutants (POPs) have been added to the list of chemicals to be reduced or eliminated under the Stockholm Convention (SC). Member countries to the SC are required to develop national implementation plans (NIPs) to reduce or eliminate release of intentionally and unintentionally produced POPs. Norway and Canada, both Arctic countries and Parties to the SC, generate POPs regionally and also receive them through LRT. Thus, regulatory and non-regulatory actions taken by these countries to reduce or eliminate POPs, at national and international levels, affect the amount of POPs that potentially reach and accumulate in the Arctic. The overall objective of this study is to use Norway and Canada as case-studies to improve our understanding of how NIPs can influence the achievement of SC objectives.

Year-to-year variation in the production of batatasin-III and caffeic acid in Empetrum nigrum along a climatic gradient

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Empetrum nigrum is a plant common in northern ecosystems with the capacity to produce allelopathic compounds which, among other effects, inhibit seed establishment and germination. Some of the most studied compounds regarding this effect are batatasin-III and phenolic acids, among them caffeic acid, which account for a large proportion of the leaf's biomass. Five random sites were established following a climatic gradient, and first year shoots were collected in August

from 2010 to 2016. The plant's antioxidant effect was studied for plant performance, with possible relation to allelopathy, and shoot length was measured for trade-offs between secondary metabolite production and growth. The effect of environmental variables on the production of batatasin-III and caffeic acid was assessed, and the plant's antioxidant activity and shoot growth were studied in accordance to the metabolite production and weather conditions. High concentrations of batatasin-III were found in sites with low temperature and/or high number of freezing days. Nevertheless, a positive relation between yearly temperature and production of batatasin-III was found at site level. Caffeic acid and antioxidant activity were positively related, although none of the environmental variables studied explained their pattern. Shoot length was related to yearly air temperature, but not to the production of batatasin-III or caffeic acid. In conclusion, this study suggests that an increase in yearly temperature is likely to lead to an increase in batatasin-III production at the site level, but that no increase in growth would be expected for first year shoots. No impact of weather conditions on concentration of caffeic acid or antioxidant activity was found.

Disentangling the impact of wild and domestic herbivores on aboveground productivity in savannahs

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The plant productivity in savannah ecosystems has been shown to depend on temporal and spatial patterns in precipitation. However, herbivore pressure also varies spatially and temporally and consequently influences savannah productivity. Human driven land-use change is altering the dominant herbivores in savannahs from highly mobile assemblages of wild herbivores to less mobile and typically higher densities of livestock. This shift in herbivory impact is likely to affect the temporal patterns in productivity of savannahs.
This study quantified the impacts of livestock and wildlife grazing on net aboveground productivity and herbivore consumption inside wildlife protected areas in the Serengeti National Park, Tanzania, and adjacent livestock dominated pasturelands. This was achieved by harvesting vegetation using moveable exclosures and paired open plots. Herbaceous biomass was destructively measured seven times within a 15 months period. Additionally cumulative rainfall between harvest periods was determined from satellite images.
Preliminary results show that in wet periods there was higher productivity in pastures than in protected areas, where production exceeded consumption. In dry periods the productivity decreased dramatically in pastures and slightly less in protected areas and nearly all biomass was consumed in both land uses, with a higher proportion consumed in pastures. This study demonstrates the relatively high productivity of pastures outside the Serengeti national park in wet periods. However, periods of drier climate reduce the pastures capability to remain productive compared to the vegetation in protected areas. The lack of drought resistance in pasture vegetation may adversely affect the livelihood in local communities outside Serengeti.

Patterns and determinants of the distribution of arctic and boreal forest herbivores in dimensions of species diversity, functional diversity and phylogenetic diversity

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The world's biodiversity is under increasing pressure due to several factors including climate change and land-use change. Despite this, there remain substantial knowledge gaps in the understanding of spatial patterns and drivers of biodiversity on a global scale. Herbivores play a substantial role in determining patterns of biodiversity due to their strong interactions with primary producers and predators, and there is increasing evidence that herbivores moderate climate-change driven transitions between Arctic tundra and boreal forest ecosystems. In this study, we investigate patterns of vertebrate herbivore assemblages in terms of species, phylogenetic and functional diversity across the Arctic tundra and boreal forest biomes, and ask which drivers are the most influential in determining these patterns? For the phylogenetic assessment, five highly conserved mitochondrial markers were employed to construct the phylogenetic tree. The functional trait matrix was constructed with expert insight as well as an extensive literature search. Species richness information was obtained from existing distribution ranges. Environmental drivers of the patterns of species, phylogenetic and functional diversity will be assessed to address whether abiotic or biotic factors primarily drive patterns across the boreal-tundra ecotone. This approach has potential to be an important asset in understanding global biodiversity patterns and drivers, as well as to provide further insight into general biodiversity dynamics across the susceptible forest-tundra transition.

Transforming Citizen Science for Biodiversity

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Citizen science - the collection and analysis of data by members of the general public- is increasingly used by scientists because of its potential for completing datasets in many research areas (e.g. ecology,
wildlife management). Recent digital developments have vastly extended the potential for input from citizens, making them contributors in studies addressing biodiversity issues. Applications such as Artsobservasjoner, iNaturalist and eBird have made it easy for the public to report sightings of species, which are shared through infrastructures such as GBIF. However, the large amount of data obtained and the lack of a standardized methodology creates several challenges when trying to make inferences from the data. Also, the widespread mistrust existent in such data often hampers the

communication of results from citizen science projects (e.g. publication in peer review Journals). These issues are tackled by the project "Transforming Citizen Science for Biodiversity" which aims to (1) encourage citizens to collect more representative data, (2) help scientists correctly interpret and use this data, and (3) provide information back to the citizens about how the data they have collected is being used. Doing this will transform how ecological analyses are done, turning the current linear system of collection and use of data into a virtuous cycle where the value of data collected by citizen scientists is enhanced through improved methods for analysis and presentation. Improving how citizen science is done is also a way to enhance social participation. Our project aims to build online visual tools to help the report of results produced by citizen science projects, as well as, to demonstrate both the value of the information collected by the citizen and identify locations where data collections needs to be improved.

Microbial biodiversity along High-Arctic environmental gradients

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Microbial response to climate change could drastically alter the carbon exchange from high-Arctic soil microbiomes. One effect of climate change in High-Arctic is an altered precipitation regime and/or increased evaporation during summer, resulting in either a positive or negative soil moisture balance, depending on region and topography. This change in water availability is likely to affect the microbial community composition and their contribution to the functioning of these ecosystems. In the project we investigate the effect of two moisture gradients in Svalbard's tundra soil on the microbial community and highlight how moisture impacts the diversity of taxa linked to the carbon cycle, emphasizing taxa related to the methane (CH 4) cycle. Soil samples were collected from three moisture levels within the gradients and at two depths (0-1 cm and 5-10 cm). Total DNA was isolated from the soil samples and used for high-throughput amplicon sequencing of the 16S rRNA gene. Preliminary results show that the communities are greatly dominated by the Proteobacteria (60-74%) phylum, and most abundant in all moisture levels and depths are members of the Alphaproteobacterial order Rhizobiales. Moreover, the Actinobacteria, which are known to occupy key steps in organic carbon degradation are clearly more abundant in drier soils and in the deep layers. In turn, this may also have an impact on the CH 4 cycle. This study is a part of the BiodivERsA project CLIMARCTIC (http://www.climarctic.ugent.be), which aims to assess the effect of climate change on the microbial diversity and function of high-Arctic soils, wetlands and lake sediments.

TransPlant: an international effort to study climate change effects on alpine plant communities.

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Using whole-community transplants of intact extant communities into new sites that have climates matching future predictions for the region is a greatly informative way of empirically assessing alpine vegetation responses to climatic change. It allows assessment of the net effects of climate change, including both direct climate responses and effects of new species interactions, on the community structure and development. At the same time, variation in geography and other environmental variables can be controlled for. So far, transplant studies have been performed in numerous locations around the world, mostly focusing on the effects of climatic warming. Results show that alpine plants in warmer climates are subject to strong competition from new interactions with lowland species, which greatly reduced their performance.
TransPlant aims to further the insights of such experiments by taking a meta-analysis approach. Combining data from our elaborate network of existing transplant studies worldwide allows us to relate general patterns of colonization and extinction to functional traits of the component species, soil properties, and local climatic variables. Moreover, trait-based analyses will allow us to predict ecological processes and responses across species, systems, and spatial scales. This will greatly improve our understanding of climate change impacts on mountain vegetation, uncover underlying mechanisms, and demonstrate how these vary with ecological and environmental settings on a global scale.
TransPlant already has an extensive network of collaborators and sites (including Mountain Invansion Network MIREN; SEEDCLIM - The role of seeds in a changing climate; MicrObs - Microbial Observatory; and individual sites) spanning a wide range in the northern hemisphere, mostly in north America, Europe and Asia. However, we would be very happy to invite more gradients into our network, so feel free to contact us!

Modelling of Spatial Dynamics

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Spatial models that incorporate dynamic processes are needed to predict the current and future distributions of plant populations, communities and ecosystems. Traditional, correlative distribution studies have often modelled local, current, realized distributions without making general predictions about future changes. Important ecological

processes that shape distributions, like biotic interactions and dispersal, are understudied and poorly represented in models. New and dynamic ways of modelling are emerging, based on realistic interaction and dispersal mechanisms that need to be developed further and integrated across population, community and ecosystem levels. The main aim of this PhD project is to better understand the spatial dynamics of plants across biodiversity levels, through a combination of theoretical and empirical work. The project has four parts: Part I is a literature review of spatial dynamics modelling in plant ecology aimed at identifying theoretical and empirical knowledge gaps. Part II explores population-level spatial dynamics in fragmented habitats, focusing on dispersal patterns and using functional traits. Part III will revolve around community-level spatial dynamics in response to climate change, and finally in Part IV ecosystem-level spatial dynamics will be modelled along the forest-tundra ecotone. The long-term goal of the PhD project is to contribute to a theoretical, model-based framework of spatial dynamics across the population, community and ecosystem levels of organization. The framework will focus on traits and allometric scaling to allow for generalization across model targets and scales, and to unify the project parts into a coherent thesis.

Environmental conditions and population density affect age at first recruitment in a long-lived bird breeding in the high-Arctic

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The age at which an individual reproduces for the first time will, according to life history theory, affect its fitness due to a variety of costs and benefits linked to different strategies. In long-lived species, the age at recruitment is found to vary greatly within and among species and populations, and the consequences of this among-individual variation is of high interest. However, there is a lack of empirical work attempting to disentangle external causes of variation in this key life-history trait. We present a long-term study with capture-recapture data (1991 to 2017), monitoring a population of high-Arctic breeding barnacle geese located in Kongsfjorden, Svalbard. To improve the mechanistic basis for understanding how climate and among-individual variability influence barnacle goose population dynamics, we attempted to disentangle the causes of age at first successful reproduction, which varies considerably across individuals and years. By the use of multistate models, we tested for age-dependent and external effects on the probability to recruit goslings for the first time, specifically analyzing the effect of population densities, and timing of spring. Our results show how important external forces are when attempting to explain variation in age at first successful reproduction. Probabilities to recruit goslings each year were highly variable within each age class of female barnacle geese, strongly depending on the timing of spring, with increasing population densities causing an additional delay in females of age two. With

a high-Arctic study system, our research has implications on understanding effects on a warming climate together with population dynamic feedback on a key life history trait.

Change in arthropod communities following a mass death incident of reindeer at Hardangervidda

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Decomposition of dead material is a vital part of ecology, and an important process in every ecosystem. Dead animals (carrion) represent more than 1% of the organic matter input in some terrestrial ecosystems, and is likely to play a major part in sustaining species that specialize on scavenging. The highly nutrient rich carcasses may also have cascading effects and influence none-scavenging species communities. In the present study, we have investigated the change in arthropod communities two years after of a mass death incident of reindeers at Hardangervidda, Norway. We compared arthropods caught in pitfall traps and sticky traps in the mass death site with a nearby control site where no carcasses were present. Even though differences in initial decomposers such as blow flies were not observed, the total abundance of arthropods were almost doubled in the carcass site two years after the mass death. Predators such as carabids and spiders were particularly numerous, but also scavengers such as beetles in the family Silphidae were abundant. The highest abundance within the carcass site was found in close proximity to the highest cadaver densities. These results show that large carcasses may alter the arthropod fauna for years in an alpine community, with potential cascading effects.

The battle of the mountains: Will a supplemental fed arctic fox population lead to less red fox activity at Finse mountain plateau?

Grevskott, Ragnhild Thorseth[1], Eide, Nina Elisabeth, Rød-Eriksen, Lars, Landa, Arild and Jensen, Henrik

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There are many conservation situations where significant management actions are necessary to enable recolonization of a species after local extinction. The arctic fox (Vulpes lagopus) is a threatened species in Scandinavia. Intra guild competition with the red fox (Vulpes vulpes) is considered one of the main threats for their distribution. To restore a viable arctic fox population, several conservation efforts have been implemented, namely; a captive breeding and release reintroduction programme, supplemental feeding and red fox culling. Over the last

decade, these actions have led to growth in the Scandinavian arctic fox populations. This study examined if re-establishment of the arctic fox population leads to less red fox activity when the arctic fox is provided with exclusive access to supplemental food. The study was conducted at Finse mountain plateau, where arctic foxes has been released since 2009. Species activity was recorded using movement-triggered wildlife cameras at feeding stations. Preliminary results suggest a negative relationship between arctic and red fox activity. The outcome of this study will likely give a better understanding of the ability of the arctic fox to recolonize an area. If the arctic fox is capable of recolonizing areas in the presence of red fox, supplemental feeding could be done without red fox culling, which is a rather costly and controversial measure. Such knowledge is of high relevance for the future arctic fox conservation management in Scandinavia.

INCLINE: Indirect climate change impacts on mountain plant communities

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Climate change is causing species to move to higher elevations, shifts that are now happening at increasing rates. Species move in asynchrony, creating the potential for novel interactions between species that have not previously co-occurred. This may be particularly detrimental to alpine biodiversity, because plant-plant interactions in alpine habitats are often facilitative, whereas the lowland species that now colonize the alpine habitats come from lowland communities characterized by competitive interactions. Asynchronous range shifts may thus shift both the magnitude and the net outcome of alpine species interactions from facilitative to increasingly more competitive. Novel interactions could therefore have large impacts on alpine species, community, and ecosystem responses to climate change. The consequences of

said novel interactions under climate change are the focus of the INCLINE project.
While novel interactions arise because lowland species migrate into alpine areas, not all lowland species are the same, the species differ in their competitive effects; reflected in traits related to competitive performance, like light interception or growth rate. We utilize this variation among the potential novel competitors in a field experiment where we combine warming with single-plant transplants of two groups of lowland species: species with traits similar to the alpine community vs. species that introduce novel, competitive traits into the alpine community.
INCLINE will assess impacts of warming and novel interactions on 1) the species composition and functional trait dynamics of the alpine plant communities, and 2) population dynamics of selected alpine plant species. The first will yield insights into direct and indirect consequences of climate change for biodiversity, and community assembly and functioning. The latter will provide a mechanistic understanding of the specific demographic drivers and rates of change in species abundances of alpine species.

Communicating uncertainty of scientific studies: focusing on 50 shades of gray rather than an accept and reject world

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Evidence from most studies are based on a black and white requirement of statistical significance, completely neglecting the uncertainty. This deterministic thinking is problematic because statistical significance on its own tells nothing about the magnitude of the effect, its practical significance, and the uncertainty around this evidence, thereby resulting in a high chance of making an interpretation mistake or taking the wrong decision. Through examples, we highlight the problems when assessing scientific evidence under a deterministic thinking and suggest how we can move from this black and white razor blade to a continuous gradient of 50 shades of grey, which allows for a more holistic assessment of evidence. We propose judging scientific evidence by focusing on the uncertainty around the evidence. We show how uncertainty can be presented and assessed with confidence intervals using an example from weather forecasting, by calculating the risks of Type S (sign) and Type M (magnitude) errors using an example from survival analysis, and by evaluating the reliability and validity of the results obtained using an example from wildlife management. We hope to raise awareness and prompt researchers to build better study designs, take better measurements, and make better use of statistics for inferring and judging scientific evidence.

The impact of climate, land-use and woody plant cover on carbon storage across the Serengeti ecosystem

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Savannahs are considered great carbon (C) sinks, however total ecosystem C storage in savannahs are understudied and roughly estimated. Savannahs are increasingly exposed to anthropogenic disturbances; wild areas are turned into pastureland, leading to changes in spatial processes of fire and herbivory. These land-use changes in combination with climate change have the potential to alter coexistence of trees and grasses as well as savannah ecosystem C storage. We aim to answer how interactions between changing land-use, climate and woody plant cover affect terrestrial C-pools, namely: woody, herbaceous, deadwood and soil, in the Serengeti ecosystem, Tanzania. We ask whether abiotic variables (rainfall and soil texture) or biotic variables (land-use and woody plant cover) explain most of the variation in C storage across the Serengeti ecosystem. We quantified terrestrial C storage, both inside wildlife protected areas subjected to fire, and neighbouring pastureland with no fire. Sampling sites span several spatial gradients. Rainfall ranges from 600 to 1000 mm year -1 ; soil texture in the northwest is dominated by clay, north by sand, and southeast by silt; tree densities vary, from shrub dominated pasturelands to wildlife protected areas with more mature large trees. Our study will increase knowledge of savannah ecosystem C storage and the variables driving it; this knowledge is crucial to implement correct management of these ecosystems.

Status and trends of grassland plant diversity in Trondheim

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Urbanization is considered to be an important driver for loss of biodiversity. Fragmentation and degradation of habitats as a result of urban development has been shown to have a negative effect on the biodiversity in urban landscapes. As well as experiencing urbanization, Trondheim municipality is also experiencing agricultural development, leading to an intensification of the usage of available greenspaces. This can have a negative effect on the remaining semi natural grasslands in the municipality. As a contribution to improve the local management, we assessed the current state of biodiversity of vascular plants in semi natural grasslands close to the city centre of Trondheim. The study included grasslands classified as open firm ground (OFG) and home field grazing (HFG) within the urban part of Trondheim. In total the study includes 66 areas categorized as HFG, and 1531 areas of OFG. Field data, in the form of soil samples, species lists and area descriptions, was collected in summer 2018. Preliminary results indicate that a substantial part of the visited areas are not managed to their full potential in terms of biodiversity. Of the areas of HFG visited, 34% were overgrown with

shrubs and tall herbs, indicating a high nutrient level, and 13% were in late succession stage, inhabiting typical forest species. Only 32% displayed the characteristics of healthy diverse semi natural grasslands and only 19% were used for grazing. Species lists collected for this project, combined with existing lists from the areas, resulted in a total species list consisting of 271 vascular plant species. Both red listed and alien species were observed at the study sites. Based on the collected field data we aim to improve the understanding for which conditions that needs to be met to achieve grasslands with a high degree of biodiversity.

Effects of red deer (*Cervus elaphus*) browsing on plant diversity in boreal forests

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The red deer population in boreal forests in Norway is increasing. This has resulted in negative effects on forestry, agriculture and higher number of traffic accidents. In addition, their impact on natural ecosystems are also substantial. This raise a range of management issues, and we need more knowledge about how the red deer affects the forest to make good decisions. Red deer are classified as mixed feeders, as they mainly select graminoids and herbs during summer, but browse during the winter season. They are therefore expected to negative affect grazing intolerant plants both in the tree layer and the field layer. In this project we will use data from permanent vegetation plots that have been monitored over 9 years in 10 experimental sites in Tingvoll. Each homogenous site consists of an exclosure (20x20 meters) and a browsed control. We predict that removing red deer will cause a shift in species composition towards grazing intolerant species. The general expectations are higher alfa, but lower beta diversity in grazed areas, and the opposite effect for exclosed areas.

Seed dispersal of boreal plant species through endozoochory

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Many plants are dispersed by animals through endozoochory. Studies have been conducted on plant-animal seed dispersal relationship in temperate and tropical ecosystems, but few have been done in boreal forest. We hypothesize that animal species will differ regarding which plant species they disperse. Through collecting animal scats, and germinating and identifying viable seeds in them, we quantify the dispersal niches of large vertebrates of the boreal forest. The study includes brown bear (*Ursus arctos*), red fox (*Vulpes vulpes*), pine marten (*Martes martes*), moose (*Alces alces*), mountain hare (*Lepus timidus*), Eurasian

beaver (*Castor fiber*), black grouse (*Tetrao tetrix*) and capercaillie (*Tetrao urogallus*). All these animal species disperse seeds through endozoochory, but omnivores (brown bear, marten, red fox) disperse larger quantities than herbivores. Ericoid plant species are most commonly dispersed, in addition to graminoids, forbs, and fleshy-fruited Rosaceae species. The brown bear and the red fox dispersed mostly fleshy-fruited ericoid species while the fox has a broader niche, also including grasses and Rosaceae species. In scats from mountain hare and moose, few seedlings germinated, except some forbs and ericoids. The galliformes black grouse and capercaillie differed in what they disperse, with black grouse dispersing mostly bilberry (*Vaccinium myrtillus*) and rushes, and capercaillie dispersing more lingonberry (*Vaccinium vitis-idaea*) and grasses.
Differences in habitat use among the dispersers and their feeding preferences may explain the observed niche differentiation. Omnivores prefer fleshy fruits (adaptations for endozoochory) and dispersed large numbers of their seeds, whereas herbivores disperse fewer seeds, predominantly graminoids and forbs. Herbivores may forage more specifically on plants, and incidentally consuming their seeds conforming the 'foliage is the fruit' theory. A combination of seed traits and the morphology of the digestive system of the dispersers can further determine which seeds can pass the digestive system unharmed and have the potential to germinate and establish.

Physical properties of snow guide the movements of lemmings under the snowpack

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Lemmings are key species in arctic ecosystems and fluctuations in their populations can have dramatic effects on many predators that depend upon them for their survival. During the long arctic winter, lemmings stay active under the snowpack and they dig burrows through the snow to access the vegetation on which they feed. Presence of depth hoar, a friable type of snow that can develop in the Arctic snowpack, is thought to help lemming digging through the snow and reduce its energy expenditure. However, the impact of snow conditions on lemming's movement in the snowpack is still poorly documented. The aim of this study is to better understand how the snow physical properties affect lemming's behavior in the snowpack.
In 2017, we sampled 11 snow pits in Bylot Island, Nunavut, where we observed attacks on lemmings though the snowpack by arctic foxes. We found and characterized 35 lemming tunnels and we measured snow properties (i.e. density and thermal conductivity) in different snow layers.
A strong positive relationship ($R^2 = 0.70$, $n = 35$) was found between the height of burrows and the height of the depth hoar, showing that lemmings had a strong preference to dig through the depth hoar layer. In 2017, a melt-freeze layer was often found at the ground layer of the snowpack and the

density of this layer was significantly higher than the density of the depth hoar layer, where lemmings dug their burrows. Those results suggest that lemmings choose to dig in low density snow layers when moving, even if it is not at the ground level where food is most accessible. Our results suggest that snow physical properties play a key role on lemming movements under the snowpack. Understanding how lemmings interact with their winter habitat is important to anticipate their response to climate change in the Arctic.

Use of Lidar data for assessing effects of moose browsing on boreal forest succession

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The Norwegian moose population density is currently very high compared to historic levels. Since the moose is a selective browser, it affects species composition in boreal forests. This raises a range of management issues, and to make good decisions we need knowledge about how the moose affects the forest. Airborne remote-sensing technology gives us a new perspective compared to ground based and traditional methods, and can be used to investigate how herbivory affects forest structure. In this project we use Light Detecting and Ranging (LIDAR) data to examine how moose exclusion influences canopy height and forest structural complexity. Our experiment consists of 36 experimental exclosure sites and paired open plots, in Trøndelag (15), Telemark (13), Akershus (6) and Hedmark (2). We predict that canopy height and complexity will be greater in moose exclosures than open plots. Finally, we will compare our results to traditional field-based measurements and assess both limitations and the potential for using LIDAR in experimental forest ecology.

Density Dependence and Individual Condition affects Age-Specific Survival in a Metapopulation of Water Voles (*Arvicola amphibius*)

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Understanding how demographic rates vary over time in fluctuating populations is of great importance for evolutionary ecology and conservation biology. Extensive work has been done on fluctuating rodent populations, especially in boreal ecosystems, where rodent population fluctuations are known to be a driving mechanism. However, there is still a need for more work on natural populations and in particular, on metapopulations. Here we use a state-space formulation of a Cormac-Jolly-Seber model to estimate the effect of local population densities and individual condition on age-specific survival in a metapopulation of

water voles (*Arvicola amphibius*). Starting the spring of 2016, we have been conducting a capture recapture study with biannual field seasons, in our study system of 13 islands off the coast of northern Norway. We show that survival of age-classes differ over time, and among sites in the metapopulation. We find that population density and individual condition can affect age-specific survival. Population density had a season-dependent negative effect on survival in both juveniles and adults, while individual condition only show a positive effect on adult survival. We demonstrate how survival rates vary over time, and among sites, laying the foundations for extensive future work on population fluctuations and spatial synchrony.

Nestling diet of High Arctic snow buntings

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The warming climate of the Arctic has been shown to affect different species and populations in diverse ways. Migratory birds reproducing in the Arctic might benefit from a extension of the summer growth season, as for example shown in pink-footed goose (Anser brachyrhynchus) on Svalbard. This is however not always the case: The northernmost breeding passerine bird, the snow bunting (Plectrophenax nivalis), is a typical migratory species that is provisioning its offspring with invertebrates. Long-term research of the snow bunting population in Adventdalen (Longyearbyen, Svalbard) has shown an advance towards an earlier start of breeding and a simultaneous reduction of reproductive success during the last two decades. To evaluate the changes in prey availability and a potential miss-timing between the peak of invertebrate availability and the main nestling period, this ongoing study identifies the preferred nestling diet of snow buntings and the variation in arthropod abundance over the breeding season. For this, pitfall trap sampling of the invertebrate community and collection of nestling faeces were carried out in the 2018 breeding season of the Adventdalen snow bunting population. The identification of invertebrate taxa in the pitfall traps showed dominance of Araneae and Chironomidae in the early season, while later Muscidae constituted the largest fraction. The faeces samples are currently analysed with the molecular techniques of DNA-barcoding and next-generation sequencing and the newest results will be presented at the conference. It is expected that the nestling diet will be primarily composed of the same taxa found by the pitfall trap sampling, but might show different compositions indicating preference towards certain taxa.

Investigating the effect of experimental warming on traits, abundance, diversity and composition of bryophytes in an alpine biodiversity hotspot

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Climate is getting warmer and the impact of these changes are usually most visible in more extreme environments, such as in alpine ecosystems. Bryophytes are one of the most important primary producers the alpine ecosystem, but they are still poorly studied. We registered bryophyte species composition in experimentally warmed plots (open top chambers) and in control plots with ambient temperature. In addition, we sampled the most common species in each plot and measured various functional traits (e.g. water holding capacity and chemical content). From these measurements we calculated community weighted traits. We hypothesized that warming lead to a decrease in overall bryophyte cover. We further hypothesize that there is a shift in functional traits towards those associated with higher water retention with experimental warming. We found that warming decreased bryophyte cover with ≈28 %. Further we found an increase in litter in the warmed plot and a negative correlation between litter and cover bryophytes. Increased litter is thus a possible explanation for the decrease in bryophyte cover in the warmed plots.
Trait analysis revealed a significant negative trend in shoot weight with simulated experimental warming. This response can be largely explained by species turnover and does not seem to vary intraspesifically. Therefore, our first hypothesis was supported. The bryophytes move towards resource conservation could be explained by competition with other parts of the plant community or by the increased heat-stress of the warming. For our second hypothesis, we found support with a significant decrease in bryophyte cover in the warming chambers.

Teatime for termites: More people and livestock increase termite-driven litter decomposition in a savannah ecosystem

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[1]NTNU

Plant litter decomposition is a fundamental process underlying nutrient cycling and ecosystem productivity. Rates of decomposition in savannah ecosystems are dependent on both microbes and termites. However, little is known about how the balance between these decomposers is influenced by increasing anthropogenic dominated landscape. Here, we address this knowledge gap by investigating the contribution of microbes and termites to litter decomposition across three savannah land-uses: agricultural, pastural and wild protected areas around the Serengeti National Park, Tanzania. We use a selective mesh approach to contrast the impact of microbes and termites of decomposition to global standard litter types: labile green tea and recalcitrant rooibos tea, also known as the Tea Bag Index. Teabags were buried across different land-uses in both contrasting rainfall regions and during wet and dry seasons.
We found that microbes decompose the labile green tea to a far higher degree in the wet season and wet region, and that termites do not affect the decomposition of the labile litter. Nevertheless, the

decomposition of the recalcitrant rooibos tea is highly affected by termites, especially dominating the decomposition in dry season and dry regions where microbial activity is low. In addition, their contribution is highest in both agricultural and pastural areas, in dryer conditions. These findings highlight the importance of termite mediated decomposition in dryer savannah conditions in an increasingly anthropogenic dominated landscape.

Antarctic seabirds' hunt for krill in the Southern Ocean - Flexibility is the key for Antarctic petrels

Tarroux, Arnaud[1], Cherel, Yves, Fauchald, Per, Kato, Akiko, Love, Oliver, Ropert-Coudert, Yan, Spreen, Gunnar, Varpe, Øystein, Weimerskirch, Henri, Yoccoz, Nigel Giles, Descamps, Sébastien

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Flying seabirds feeding on Antarctic krill Euphausia superba are among the key elements of the Southern Ocean's marine ecosystem. Some, like the Antarctic petrel Thalassoica antarctica, are extremely mobile and can thus constitute highly informative indicator species, sampling their environment over thousands of km. There is need for better insight into their relationship with the feeding habitats they traverse during their foraging trips in the Southern Ocean. This study investigates the consequences of flexible foraging tactics used by breeding Antarctic petrels hunting for prey in the dynamic, ice-covered, Southern Ocean. We focus on the potential effects of various foraging tactics on their body condition using multiple physiological indicators.

How will climate change impact carbon storage in coastal heathlands of Western Norway?

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Climate models project that Western Norway will experience warmer temperatures with more frequent and extreme drought periods during the 21 st century. Such climatic changes are likely to alter many vital ecosystem processes, such as plant CO 2 sequestration and soil carbon storage, which ultimately may lead to a shift in ecosystem function. In Western Norway, coastal heathlands contain relatively large amounts of soil carbon due to their cold and wet climate, resulting in low microbial decomposition rates relative to plant productivity. In a warmer and drier climate, the carbon balance of coastal heathlands could be particularly vulnerable to changes, potentially shifting these ecosystems from being net sinks of atmospheric carbon to net sources. Here, we measured seasonal variation in ecosystem CO 2 -fluxes from above- and belowground sources in a coastal heathland site near Lygra/Bergen, Norhordland. To investigate how extreme drought events may affect future carbon dynamics in this ecosystem, we constructed an experimental drought gradient, manipulating

rainfall inputs by 0, 50, and 90% using rainout shelters. Bryophytes constitute a major functional group in coastal heathlands and bryophyte water holding capacity and soil insulation properties could potentially mediate effects of drought stress on ecosystem carbon balance. To investigate the role of bryophytes in a drier climate, we also removed bryophyte cover in a factorial setup within our drought gradient. Preliminary results show that moss cover has a strong positive effect on soil respiration during the growing season. However, with increasing drought severity regime, the moss effect on soil respiration declined drastically, suggesting that mosses may not be able to counteract extreme drought scenarios projected for the future. Ultimately the results from this study will be part of increased understanding of drought effects on the coastal heathlands but also to piecing apart how carbon storage in other similar ecosystems will react to projected changes.

Can we predict heathland drought tolerability by measuring and comparing non-destructive traits on Calluna vulgaris?

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Severe droughts might have large impacts on oceanic ecosystems with high and evenly distributed annual precipitation. Such droughts took place along the Norwegian coast in winter 2014 and again in spring and summer 2018 and led to dieback or reduced growth and reproduction in several plant species. Coastal heathland is a widespread semi-natural landscape in Norway, with high national and international conservation interests. The key species Calluna vulgaris has earlier showed strong responses to drought events, but with large between sites variation that can possibly be explained by land use history.
We measured non-destructive traits on more than 500 marked Calluna vulgaris individuals each year for three growth seasons (2016-2018) in order to evaluate growth responses to natural and experimental drought. The non-destructive traits included stem diameter, standing and stretched height above bottom layer, and length of annual shoots. The data collection was done in a full factorial design with three levels of drought across the three main successional phases in coastal heathlands and in two different regions (Hordaland and Nord-Trøndelag/Nordland).
Here we present the impact of the land use history on growth responses to short and long term drought in Calluna vulgaris and we highlight the differences between southern and northern Norway.

Abstracts for poster presentations, NHF:

Physiological responses to thermal stress in the cold-water coral Lophelia pertusa from Arctic and boreal reefs

Dorey, Narimane[1]
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Ocean acidification: how do scientists view and handle uncertainties?

Karlsson, Marianne[1]
[1]NIVA

Photoperiodic constraints on mesopelagic fish distribution: implications for high-latitude pelagic ecosystems

Langbehn, Tom[1]
[1]Universitetet i Bergen

Could long term shift in cod phenology be linked to terrestrial greening and coastal browning

Frugård, Anders[1]
[1]Universitetet i Bergen

Impact of different kinds of risk on appetite, allocation, and growth in fish

Weidner, Jacqueline[1]
[1]Universitetet i Bergen

Spawning time fidelity of spring and autumn spawning herring, *Clupea harengus*

Østgaard, Hedda[1]
[1]Universitetet i Bergen

H_2O_2 effects on potential macroalgal culture species *Palmaria palmata* and *Ulva lactuca*

Åsnes, Helga Øen[1]
[1]Universitetet i Bergen

Understanding the microbial food web. A basis for knowledge-based marine management

Tingstad, Larsen, Våge, and Tsagaraki

title unknown

Vohnnahme, Tobias[1]
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