AMAP/EU-PolarNet Stakeholder Workshop on Research Needs on Arctic Biology and Terrestrial Ecosystems

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Abstracts

Research needs on terrestrial ecosystems and their living resources; impact of climate change

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Climate change impacts many species and their ecological functions simultaneously, often through indirect pathways through food webs. While the food webs are complex, certain species or groups of functionally similar species (functional groups) have key roles in tundra ecosystems. Many of such key species/groups are also either harvested, or provide crucial resources (habitats, food) for harvested animals. Thus, ecosystem-based research that focuses on species interactions within food webs, together with climate impact pathways, is important for devising informed management strategies in a changing environment. Furthermore, many processes in arctic ecosystems are slow, inherently variable, and respond to climate change with time-lags. Therefore, ecosystems cannot be understood and managed efficiently unless slow processes are unraveled by means of long-term data. Yet, there are very few sites in the arctic that have implemented ecosystem-based long-term research on climate impacts on tundra food webs.

Research needs on Arctic Biology and Biodiversity

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In the Arctic climate-induced changes in cryosphere link rapid climatic, ecological, social and economic change, this creates critical new challenges for biodiversity monitoring and research. Evaluating the needs for monitoring and research in this context represents a major challenge; rapidly changing conditions set the stage for new or transformed drivers of change, increased potential for driver interactions and a wider range of actors influencing decision-making. This increases the risks that certain stakeholder needs remain unrepresented or important drivers of change remain unaddressed.

Research and monitoring concerning biodiversity has multiple objectives, which are often loosely defined and differ between different actors and stakeholders who produce, process and use knowledge and information. A first step to guiding future arctic biodiversity research is developing a better understanding of how stakeholders conceive systems and arctic futures. This will inform our research and monitoring needs for decision-making and stewardship. Where the production and use of information and knowledge appears biased toward the concerns of certain stakeholders, conflicts may emerge.

Biases in the relative representation of different drivers of change, sources of knowledge and system components can greatly affect our perception of how arctic biodiversity-related systems function. Without a full evaluation of these biases, misconceptions may develop during both formal and informal syntheses. How we view systems can affect the inclusion of different types of information and knowledge in our analysis of biodiversity related systems. Ecological frameworks focus on ecological components and influences or external drivers, meanwhile socio-ecological frameworks include social and economic factors including governance

structures, different actors and culture within their system conception. While both approaches have been used to understand biodiversity-related issues, these disciplines remain quite distinct. Deciding when and where each approach is relevant is key to a more balanced approach to information and knowledge production for biodiversity stewardship and finding new approaches which cut across disciplines could greatly advance our ability to tailor our research to stakeholder needs.

This includes ensuring evaluation of the impacts of drivers of change is not limited to drivers and responses which are simple to enumerate. This may be a particular concern in relation to digital technologies (e.g. satellite imagery), in addition to making use of these technologies we must consider what drivers may be missed due to incompatibility with these analytical frameworks. Greater uptake of digital technologies in research may risk a lack of focus on social drivers of biodiversity change. Similarly as upscaling becomes an increasing prevalent aim it is important not to undervalue the local studies of biodiversity and the investigation of context dependency.

Monitoring makes an important contribution to many biodiversity-related objectives and here like in other facets of biodiversity-related monitoring and research there is a need to understand stakeholder objectives. I will present my findings from semi-structured interviews assessing the needs pan-arctic wildlife monitoring. These findings highlight the importance of the process of monitoring as well as the information outcomes. Ensuring that biodiversity research not only generates useful information and knowledge, but also represents a process that drives learning and social benefits may be a key objective for biodiversity-related research and monitoring for arctic stewardship.

Research challenges in Sápmi in the light of climate change and cumulative effects

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The sámi reindeer herding is depending on weather conditions and large grazing areas linked together. Climate change can cause grazing areas to be unavailable, for example raining on snow events. Different activities claiming land area by constructions or via disturbance as movements and sound, such as wind power parks, logging, mines, dogsledding and snowmobiles, impact the reindeer negatively. Disturbance in the grazing area can cause the reindeer to avoid good grazing grounds. For example logged areas in connection to wetlands can affect the potential to use the wetland when the alternative food resources and shelter is removed. It is therefore important to have a holistic approach to the effects on grazing grounds caused by industrial- and other activities' expansion and intrusion of land area. As such, the effect of climate change and land claiming activities causes a cumulative negative effect for the reindeer and sámi reindeer herding.

Changes in the nature can be the combination of external factors as e.g. climate change and the on-going land-use. The importance to understand the history and the on-going land-use is therefore decisive to identify the effect of e.g. climate change and the effect of land-use. The indigenous knowledge is based on the combination of social and natural aspects and is tested over generations. Accordingly, the indigenous traditional knowledge provides a holistic overview in both space and time, compared to academic science where the research often is limited to local effects during a specific time period. Bringing together these two sources of knowledge develop a more sufficient and deep understanding. Hence, cross-disciplinary sharing of knowledge early in the research planning is crucial. However, to be able to both conduct relevant research and redistribute the research findings to whom it concerns the system of how knowledge is shared and owned need to be organized.

Summary of research needs on Arctic freshwater biodiversity: Observations from the Arctic Biodiversity Congress

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Arctic freshwater ecosystems are threatened by climate change and human development that can affect freshwater biodiversity. Such effects will change not only the distributions and abundances of aquatic species, but also the lives of Arctic Peoples that are dependent on the freshwater ecosystem services. A strategic goal of future biodiversity monitoring efforts of Arctic freshwaters should be harmonization efforts among Arctic countries with adequate sampling across representative ecoregions to support the detection of spatial and temporal trends. Biodiversity trends must also be related better to the underlying drivers of ecological pattern. Future monitoring should consider emerging approaches such as environmental DNA methods, community and citizen science efforts, and make better use of remote sensing tools. In addition, Arctic countries should make efforts to document and preserve data from short-term research projects, research expeditions, industrial, university and government programs. Considering the rapid changes occurring in Arctic ecosystems, there is an urgent need for the Arctic countries to continue building baseline databases, such as that produced by the CBMP-Freshwater of CAFF, to aid the assessment of future biodiversity change.

Research needs on Arctic freshwater systems and freshwater biology; impact of climate change

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Lakes and rivers are mirrors of the landscape. Water quality and biodiversity of lakes and rivers closely reflect catchment geology, vegetation cover and anthropogenic activities such as land-use change, industrial development, and diffusive and point source pollution. These stressors put constraints on species assemblages and the ecosystem services they provide. For example, Northern lakes are subjected to dramatic declines in nutrient concentrations as a consequence of ongoing, climate-driven shifts in large-scale catchment processes that contribute to reductions in nutrient run off such as (i) the observed changes in tundra vegetation cover, a.k.a. the *"Greening of the Arctic"* mediated by elevated N-mineralization and increased nutrient uptake by rooted plants, (ii) the more efficient trapping of P that originates from soil pH increases, and (iii) low and declining trends in N-deposition over northern hemisphere. The concerted action of these large-scale changes contributes to the gradual transformation of lakes and rivers towards even more oligotrophic conditions and a further increase in the predominance of N_2-fixing cyanobacteria in the base of their food webs. As cyanobacteria provide a poor food source for consumers, these changes will have repercussions on grazing invertebrates and higher trophic levels, and ultimately on the food supplies for northerners.

Projected climate regime alterations will change the abiotic templates of northern freshwaters, potentially causing wide-ranging ecological shifts. For example, Arctic freshwater biodiversity will respond to warming through range expansion of southern eurythermic species and losses of stenothermic species. Landscape alterations due to large-scale permafrost thawing, e.g. when lakes and rivers on ice are drained, will dramatically decrease the limnicity of landscapes and the connectivity of freshwaters, having major implications for biodiversity and fish production. Efforts should therefore be made to understand how landscape modifications affect the biological assemblages of lakes and rivers and key ecosystem services such as productivity. Moreover, we should improve our knowledge of the drivers of biodiversity (e.g. nestedness and turnover) in Arctic freshwaters, as richness and biodiversity metrics disregard qualitative aspects of biodiversity (i.e. which species) and provide poor information on biodiversity. Here the further development of DNA-barcoding techniques can help to provide better estimates of the species richness of complex groups such as chironomids (midges) and benthic diatoms that play key roles in Arctic freshwater ecosystems. Arctic countries should put these and other important research questions high on their agenda.

Access to data of high quality is key for future assessments of change in Arctic ecosystems. Hence, Arctic countries should develop joint efforts to secure existing monitoring efforts and expand on these to cover the entire circumpolar region, likely according to a hub-and-spoke principle. Existing Arctic networks, such as INTERACT, could play a key role in the performance of monitoring and the collection of background information using various sensors and remote-sensing approaches. Also, the engagement of indigenous peoples' organizations and their traditional ecological knowledge of the environment could supplement and strengthen the systematic collection of data. Arctic countries should also invest in the establishment of joint data base infrastructure for research and monitoring data.

Research needs on ecological consequences of a climate driven fragmentation of terrestrial and aquatic species communities in the Arctic

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The terrestrial Arctic, in contrast to most other major terrestrial biomes on Earth, is a marginal biome surrounding an ocean basin. Hence, with a warming climate there is no continental land mass for species to move northward to. Therefore, if global warming forces Arctic species further north, their distribution ranges will be increasingly more fragmented along the Arctic coastline and on Arctic islands. This process has occurred previously. Data from previous warming events suggest that many arctic species had relict distributions during the past inter-glacials. Past and present connectivity within arctic environments have thus played important roles in structuring arctic species communities, both genetically and ecologically. There are well-documented negative effects of fragmentation on genetic variation within and between populations, although the consequences of a loss of genetic variability largely depends on the genetic composition of the organisms that become fragmented and locally isolated. In addition, genetic variation is most likely to have consequences on evolutionary time scales, which may not be entirely relevant for management and utilization of environmental resources. However, recent work has also highlighted the importance of fragmentation for the ecological function of species communities. These studies suggests that the degree of isolation between animal and plant populations could have profound effects on local ecosystem processes and on the supply of ecosystem services. These effects are primarily caused by fragmentation driven declines in species richness. However, fragmentation could also influence ecosystem function in other ways, for instance by causing a temporal mismatch between ecologically important events such as plant flowering and pollinator activity. Although not comprehensive, a literature search suggests large biases in our scientific knowledge of the evolutionary and ecological effects of fragmentation in terrestrial and aquatic organisms in the Arctic. Of 43 studies that directly addressed fragmentation in non-marine arctic organisms, most studies where on terrestrial organisms, and with a geographic bias towards the North American Arctic and Greenland. There was also a taxonomic bias towards mammals, and almost half of the studies were evaluating various forms of genetic variation. Notable was an apparent lack of studies on invertebrates, except for arthropods, a lack of studies on fragmentation effects on pathogens and epidemiology, and a lack of studies on ecological interactions. I argue that a better understanding of the ecological effects of fragmentation may be crucial for our ability to manage and utilize Arctic ecosystems in the face of the challenges posed by climate change.