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nordia geographical publications

Editorial

Addressing global change in northern environments: insights from spatial data and analysis

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While change is a fundamental characteristic of the natural world, it is now universally recognized that humans are also potent agents of accelerated change, altering ocean, atmospheric and terrestrial environments and associated ecosystems from the micro to the global scale. This is particularly true of northern environments, where climate warming over the last five decades is almost four times the global mean (IPCC 2021; Rantanen *et al.* 2022), and where infrastructure development (Hjort *et al.* 2022), natural resource extraction (Hovelsrud *et al.* 2011), socio-economic transformations (Hovelsrud *et al.* 2011; Serreze *et al.* 2021) and widespread pollution (Turetsky *et al.* 2020) have compounded ecological responses leading to acute biodiversity loss and ecosystem degradation (ACIA 2005; Bjerke *et al.* 2017).

These abrupt changes cut through the entire northern biosphere with knock-on impacts to its ecosystems, biodiversity, indigenous livelihoods and overall sustainability. They are evidenced across high latitudes into the Boreal regions (Westerveld *et al.* 2023), including marine (Sumata *et al.* 2023) and coastal environments (Irrgang *et al.* 2022), terrestrial space (Myers-Smith *et al.* 2011) and peatlands (Fewster *et al.* 2022; Könönen *et al.* 2022) as well as freshwaters (Koch *et al.* 2022; Lau *et al.* 2022) from specific species responses (Antão *et al.* 2022) to large scale biotic interactions (McKinney *et al.* 2022). Changes in northern environments also have far-reaching impacts on lower latitudes through, for example, regional moisture uptake and atmospheric circulation (Bailey *et al.* 2021), the global carbon cycle (Schuur *et al.* 2015) and committed sea-level rise due to deglaciation (e.g. Box *et al.* 2022).

Acknowledging the role of human-induced change in northern environments is key to shaping strategies for conservation, sustainable resource management and mitigating the detrimental impact of human activity on natural systems. To address these prescient challenges requires a unique set of analytical skills and a new toolbox capable of linking

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and interrogating diverse datasets from multiple interdisciplinary sources on a variety of spatial and temporal scales.

The aim of this theme issue in Nordia Geographical Publications is to bring together research and advancements that explore the challenges and opportunities posed by global change in northern environments, with a specific focus on spatial data and analysis. This theme issue presents three research articles and four essays that address the specific challenges that northern environments face in this new era of abrupt change.

In the research article, Tuija Maliniemi *et al.* highlight a major ecological shift in northern boreal forests: the decline of lichens and the expansion of dwarf shrubs over multiple decades. These shifts suggest a transition to moister conditions driven by succession and climate change while the long-term reindeer grazing is a key factor in lichen decline, a trend that may be exacerbated by shrub growth. Finally, Maliniemi *et al.* raise concerns about the potential local disappearance of lichens if the decline persists.

In his research article, Marek Kazprzak takes us to Wedel-Jarlsberg Land, Svalbard, where he explored extreme events and how their origins can be studied with limited temporal data, by adding field observations, measurements and GIS analysis. He presents two new landforms that originated from such extreme events - an alluvial fan and a potential landslide.

In their research article "The Causes and Consequences of 21st Century Global Sea Level Rise on Morecambe Bay, U.K." Holly Watson and Alun Hubbard investigate the contemporary causes and consequences of global sea level rise (SLR) via literature. They present three scenarios of SLR and relate them to local flood projections to show how floods are going to roam the shores of Morecombe Bay. The study highlights the need for land management strategies and action that is required to tackle imminent changes in sea levels.

In the first Discussions and interventions text, Alix Varnajot and Élise Lépy reflect on their experiences from a ship-time fieldwork on an expedition cruise ship to the geographic North Pole and through the Arctic Ocean. Their essay focuses on science-tourism nexus onboard cruise vessels. These vessels offer platforms of opportunities not only for natural scientists but human scientists as well but what sacrifices or strategies need to be considered before boarding?

A discussion text from Janne Alahuhta *et al.* that brings freshwater plant ecology to the surface. They reveal how freshwater plants are essential for ecosystem stability, water quality, and carbon cycling, yet their responses to environmental change remain poorly understood. Thus, there is a need for more extensive research to understand their biodiversity and ecological roles.

Helena Tukiainen and Maija Toivanen present a welcome introduction to and summary of the maturing sub-discipline of geodiversity. Focusing on the Rokua UNESCO Global Geopark in northern Finland as a case study, their paper reviews the early origins and development of geodiversity, and how it is embedded in the key concepts of geoheritage and conservation. Finally, they discuss the current debates and the future directions this research might take.

Finally, Marek Kazprzak and Alun Hubbard discuss the 2024 spring floods in Ostrobothnia and how climate change may not act to simply reduce snowmelt-driven flood risk with warmer winters but could also shift and intensify them. As Arctic temperatures rise, unpredictable warm spells are driving more variable ice conditions that could yield more frequent and severe flooding, even outside of spring. While Finland's civil response was effective, future resilience will depend on improved forecasting, adaptive planning, and continual real-time learning from events like this.

The theme issue unites multiple viewpoints about global change effects on northern environments through spatial data and analysis studies. The articles in this theme issue illustrate the complex environmental transformations occurring throughout Arctic regions. By exploring Arctic cruise-based fieldwork, ecological transitions in boreal forests, freshwater plant responses, geodiversity, sea-level rise, and extreme flooding in Finland and extreme events in High Arctic, the articles highlight both the complexity and urgency of understanding environmental shifts in high-latitude regions. Although these discussion and research articles cover very broad ground and specific topics, there are also significant commonalities that can be drawn between them that provide pointers to a new generation of scientists who are set to tackle the challenges of rapid natural and social change head on. Despite them all being concerned with environmental change – focusing on the north - the message from some have more optimistic in outlook than others with well documented examples of good practice and effective, pragmatic management. Despite this, there is an overall key message highlighting the future challenges in preserving and adapting to change. Whether it will happen through the implementation of new strategies for the mitigation of flooding under changing temperature and precipitation patterns or through the measures required to preserve the natural geodiversity and unique ecosystems services they support.

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