COAT CASE STORY

Vegetation and tundra disturbance monitoring in Svalbard – Year 1

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Long time series are important for understanding changes in nature. Despite extensive research on vegetation in Svalbard, long-term monitoring has been lacking. But we can now present "Year 1" of Svalbard vegetation monitoring within COAT – Climate-ecological Observatory for Arctic Tundra.

The Svalbard tundra is changing: increases in summer and winter temperatures and precipitation; in goose and reindeer abundance; in the depth of the active layer; in permafrost degradation and the related disturbance of the land surface – these and other change factors are all intertwined. The COAT vegetation monitoring aims to understand how these changes affect vegetation and what consequences that effect has for the rest of the food web. With publication of central concepts, successful implementation of infrastructure, and fruitful development of methods – all undertaken during the first few years – we are moving forward.

To understand the pathways of causes and consequences, monitoring is best run in an adaptive, ecosystem-based framework. We have made a conceptual model to enhance understanding of how the ecosystem may change, and have tailored our measurements to detect expected changes. In this article we focus on the impacts of the pink-footed goose on vegetation particularly in moss tundra.

Spotting tundra disturbance from above

Geese typically disturb small patches of tundra vegetation. Such patches can, however, be very numerous and spread over large areas. Intensive goose activities can disrupt the vegetation layer, exposing erosion-prone bare soil. But even at lower intensities, where their activities leave some vegetation intact, grazing geese make changes to the tundra surface.

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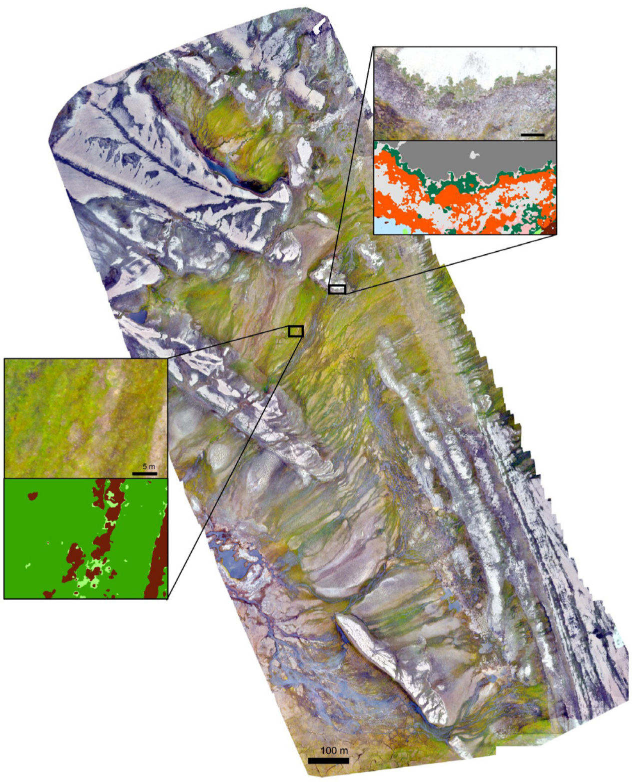
Goose grazing activity creates disturbance that may be small in size but occurs very frequently and presumably influences an increasing area of tundra vegetation.

Goose disturbance is particularly prevalent in the spring when the tundra surface is moist after snow melt and the geese that have migrated to Svalbard to breed graze intensively. The nature of goose disturbance – local patches, frequently in wetlands and moss tundra – makes it hard to obtain relevant data with good coverage.
Quantifying disturbance from imagery has not been very common in High Arctic tundra research; the technology is relatively new but is developing rapidly. We have developed protocols and methods for use in Svalbard to classify tundra vegetation affected by different types of disturbances, including that from geese. Aerial images taken with unmanned aerial vehicles (UAVs) seem very promising and relatively cost-effective in capturing images on suitable spatial scales to study this important ecological interaction. We have established UAV flight sites overlapping with ground-based field work sites, thus combining different, complementary methods to monitor both vegetation and the drivers of its change.



In COAT we focus on using the most efficient measurement method for each occasion, implementing new technologies and methods when needed. We collect aerial imagery using an eBeeX UAV and then use very precise differential GPS to ground-validate the imagery. This combined with field measurements provides a complementary dataset that reliably quantifies the goose activities and their impact on vegetation. Photo Isabell Eischeid / Norwegian Polar Institute

One method can't meet all needs

Combination of many methods is needed in the vegetation monitoring, as demonstrated in the goose example. We want to quantify the impact of goose activities on vegetation, and while we have found that UAV-based imagery provides data of good quality with adequate landscape coverage, the weather does not always allow UAV flights and we cannot detect everything from the images. While we use photos to quantify the area impacted on mountainsides and valley floors, we also do counts along transect lines. These allow us to distinguish in greater detail the frequency of different types of goose disturbance (e.g. removal of mosses or whole plants with root, exposure of bare soil). Moreover, to understand whether goose disturbance causes changes in vegetation composition over time, we count plant species and plant groups in permanent plots where geese either graze freely or are kept out (exclosures). To obtain data on goose abundance, we use nest surveys, population models, and automatic cameras, in addition to counting faeces and signs of animal activity at the permanent measuring stations.
We have set up a system of measurement stations at multiple locations in Nordenskiöld Land and on Brøggerhalvøya (Brøgger Peninsula). As of 2020, a network of 48 field sites has been established, equipped with automatic cameras, vegetation plots, and transects for field data collection. We fly the UAV over a selection of these sites and process satellite imagery to obtain an even broader understanding of the changes taking place.
Eighteen more sites will be established in 2021, all located on Brøggerhalvøya. Here, near the Ny-Ålesund Research Station, extensive research and monitoring has been conducted since the 1960s. This rich trove of historic and contemporary data allows us to combine our vegetation monitoring with research and monitoring on numerous other ecosystem variables and expands the types of hypotheses we can formulate and questions we can ask. For example : How are the vegetation changes we observe linked to changes in the local reindeer population?

Together we are stronger

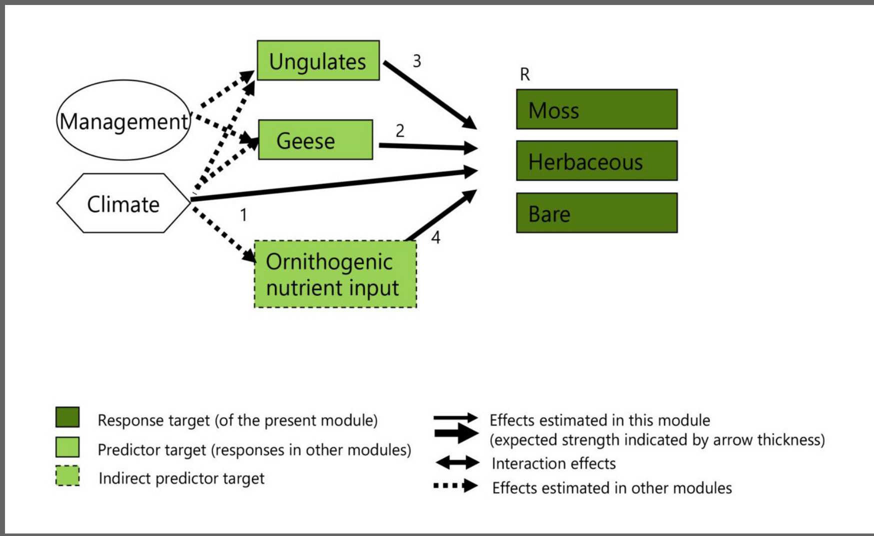
Researchers in the Climate-ecological Observatory for Arctic Tundra, a substantial part of the Fram Centre terrestrial flagship and the SIOS initiative (Svalbard Integrated Arctic Earth Observing System), started this vegetation monitoring making use of the conceptual model and a combination of well-known field methods, field experiments and technology to analyse images from the tundra landscapes. The monitoring data will feed into national programs like

MOSJ (Environmental monitoring of Svalbard and Jan Mayen) and are expected to contribute to circumpolar comparisons of ecosystem change within the Circumpolar Biodiversity Monitoring Program of CAFF (Conservation of Arctic Flora and Fauna) as well as providing input to international goose management plans. The vegetation data provided by this COAT "moss tundra module" also provides essential predictor variables to those COAT modules that focus on herbivores. The team working on vegetation monitoring is multi-disciplinary and brings in expertise from ecology, remote-sensing, climatology and plant–herbivore interactions.

Further reading:

Ravolainen V (2020) Vegetation monitoring in Svalbard – implementation plan. Norwegian Polar Institute. Brief Report 54, https://brage.npolar.no/npolar-xmlui/handle/11250/2658124

Ravolainen V, Soininen EM, Jónsdóttir IS, Eischeid I, Forchhammer M, van der Wal R, Pedersen ÅØ (2020) High Arctic ecosystem states: Conceptual models of vegetation change to guide long-term monitoring and research. Ambio 49: 666-677, https://doi.org/10.1007/s13280-019-01310-x



Conceptual model depicting expected impacts of herbivores and fertilisation on moss tundra vegetation. Climate change is expected to impact vegetation in moss tundra directly via surface warming and changed precipitation and snow/ice conditions in the winter, but also via increased population size of geese and reindeer in Svalbard. Figure adapted from Ravolainen et al 2020. Used under Creative Commons licence http://creativecommons.org/licenses/by/4.0/

Acknowledgement

Many colleagues are involved in the vegetation monitoring and contribute with their valuable specialist knowledge about the system and other scientific methods. We owe special thanks to professor René van der Wal (Swedish University of Agricultural Sciences), professor Ingibjörg Svala Jónsdóttir (University of Iceland), professor Mads Forchhammer (University Centre in Svalbard), senior scientist Hans Tømmervik (Norwegian Institute for Nature Research), Jakob Assmann (Aarhus University), and many others, for making it possible to start a monitoring programme that comprehends so many variables, locations, methods and ecological questions.

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