Climate change: reflections in the reindeer community

Dr Brage Bremset Hansen explains how a better grasp of the population dynamics of reindeer can help us to understand current climate change impacts and predict future effects.

What is your expertise with regards to climate change science, and how has this led to your current cross-disciplinary project "Predicting effects of climate change on Svalbard reindeer population dynamics: a mechanistic approach" (REINCLIM)?

As an MSc and PhD student I examined interactions between vegetation and wild reindeer in Svalbard, with emphasis on foraging behaviour. I soon learned these were dependent on fluctuations in the environment. During many years of field work I observed quite dramatic changes in my main study area, Ny-Ålesund. For instance, glaciers were melting, sea-ice on the fjords became less frequent, summers were becoming warmer and longer and winters rainier, and my scientific interests turned towards studying how these rapid changes affect the tundra ecosystem, especially the reindeer.

There were so many unanswered questions at that time. I realised that if the different groups working with reindeer joined forces, and we included experts from other fields such as climatologists, plant ecologists, biostatisticians and snow geophysicists, we could perform some really interesting and novel investigations.

Why are reindeer regarded as an ecological keystone species?

In many Arctic tundra areas reindeer are the only large herbivores. They can be highly abundant and account for a large percentage of the region’s animal biomass. Most populations migrate long distances and thereby spread their ecological impact, but in Svalbard, with no place to migrate, the reindeer are sedentary. This means they have a huge impact on the vegetation through grazing and trampling effects year-round, changing the vegetation composition. This of course affects other herbivores through their food sources. Furthermore, the reindeer carcasses constitute important food for the arctic fox (and gulls), which in turn is an important predator of many bird species, including migratory geese. The reindeer directly and indirectly impact many tundra species at different trophic levels.

Can you share the aims and objectives of REINCLIM?

Our aim is to better understand and predict how reindeer are influenced by climate change, both now and under future climate scenarios. To achieve this, we take advantage of our multidisciplinary expertise and unique long-term time series data of the environment, vegetation and reindeer.

When predicting climate effects, it is extremely important to account for fluctuations in age structure in the population. We now have a 20-year-long time series from mark-recapture data (see below) and some novel modelling tools. Because we also have the necessary expertise and environmental data – such as snow and ice measurements and plant growth – we can analyse how climate change actually operates on the reindeer.

Could you give an insight into some of your modelling techniques?

We have developed a so-called integrated population model, which combines individual mark-recapture data with population counts and harvesting data within a Bayesian model framework, and accounts for observation error, environmental and demographic stochasticity and age structure. From this model we obtain estimates of age-specific population sizes, survival and fecundity over time.

We are currently extending this modelling work to estimate climate and density effects, and the end result will include projections of future population sizes after plugging in various local climate scenarios provided by our partners at the Norwegian Meteorological Institute.

Your team consists of experts from climate, geophysics, remote sensing, biostatistics, and plant and animal ecology. Are there challenges associated with integrating such diverse backgrounds?

The main challenge lies in ‘speaking the same scientific language’. Also, scientists from different disciplines have diverse perspectives on what are the most important data to collect, on what spatial and temporal scales they should be collected, and so on. Through annual two-day workshops with all the participants present, as well as more frequent sub-meetings across research groups, we have been able to keep a common focus on the main goals for this particular project.

Conversely, technical problems in developing the rather complex integrated population model have presented a challenge. We use multiple sources of data input and the heavy computer simulations might crash unless every detail is correct in the computer scripts. Dealing with these challenges would not be feasible without the Centre for Biodiversity Dynamics’ expertise in biostatistics.

A BRIEF GUIDE TO MARK-RECAPTURE

A portion of the population is captured and marked, then released. Another portion is later captured (or just sighted) and the number of marked individuals within the sample counted. The number of marked individuals within the second sample should, given a decent sample size and some other assumptions, be proportional to the number in the whole population. By dividing the number of marked individuals by the proportion of marked individuals in the second sample, an estimate of the total population size can therefore be generated. However, in reality proper estimations usually require more complex modelling.
IN POLAR REGIONS, the amplified response to a warming planet is manifest as a visible drama of receding ice and the threatened existence of numerous species of flora and fauna. Recently, the Intergovernmental Panel on Climate Change (IPCC) concluded in high confidence that both the Arctic and Antarctic are extremely vulnerable to current and projected levels of climate change. These findings are concerning as these regions in turn play a central role in regulating the global climate.

Although these changes in climate are known to affect the population dynamics of single species, it is a far greater challenge to determine their effects on communities of different species. As a result, the more complex effects of extreme climate events on polar ecosystems are not well understood.

In the Arctic, one species prone to the rapidly changing conditions is its indigenous reindeer and caribou (Rangifer tarandus). With this in mind, the REINCLIM project, led by Norwegian University of Science and Technology (NTNU), is looking at the implications of global warming in an effort to enhance the tools and techniques for predicting the dynamics of reindeer populations. Regarded as a strong indicator of future global change, a greater understanding of climate variance in the Arctic could help predict the dynamics of wild reindeer populations beyond the local to national and international levels.

A SIMPLE SYSTEM
Leading the project is Dr Brage Bremset Hansen, a Researcher at NTNU’s Centre for Biodiversity Dynamics (CBD). Primarily investigating evolution and population and community dynamics, research at CBD is a highly interdisciplinary pursuit with strong emphasis on biostatistics, and REINCLIM is no exception. To achieve this level of cross-disciplinarity, the project has brought together a broad range of collaborators from Norway and the UK for its three-year duration including the James Hutton Institute, the Norwegian Polar Institute and the Norwegian Institute for Nature Research. Primarily funded through the Research Council of Norway (RCN)’s polar research programme, the extra financial and scientific support provided by CBD has proved critical to REINCLIM’s success.

Working at CBD since embarking on his academic career, Hansen’s studies focus on population, community and behavioural ecology and trophic interactions such as those between plants and herbivores. His investigations have now turned to Svalbard’s arctic tundra where reindeer represents a key component of a relatively simple food web. Without predators or other large herbivores to compete with, the factors dictating their fluctuation in numbers are limited to climate and the availability of space and vegetation. Combined with the pronounced effects of global warming on Svalbard, this relative lack of complexity makes the local reindeer populations an ideal model for testing ecological hypotheses and illustrating the effects of a changing climate.

However, while clearly defined weather fluctuations may benefit modelling efforts, they also bring their share of physical challenges to field studies. In order to develop a long-term time series of reindeer population dynamics, annual access to the numerous study populations is essential. Recently, contact with one of the reindeer subpopulations monitored by the Norwegian Polar Institute became impossible as an unexpected reduction in the fjord ice left the team unable to travel by snow mobile. Working in Svalbard is a logistical

Synchronised fluctuations in the Arctic ecosystem

Arctic researchers have long been aware of the effects of climate change. Now, a large cross-disciplinary team led by the Norwegian University of Science and Technology is conclusively demonstrating the broader ecological impacts of extreme climatic events.
challenge in itself, but current projections of climate change mean Hansen can expect more such events in future – a likelihood the project has had to embrace in order to avoid gaps in the time series: “Next winter we will be prepared to transport the snow mobiles on a boat,” states Hansen; a reminder of the challenges a warming climate poses to the entire planet.

CHALLENGING CONDITIONS

It has been suggested previously that Svalbard’s warmer and wetter winters may have a positive impact on the foraging conditions of the reindeer, with increased snowmelt exposing vegetation. The results from REINCLIM, however, would suggest that foraging has not been so straightforward. As the winters have become warmer there has been an increase in heavy rain-on-snow (ROS) events in the last few decades. Rather than exposing pastures, the warm spells and associated rain in winter lock vegetation under layers of ice, in particular, basal ice building up on the deeply frozen ground. In an area where heavy ROS occurs almost annually, and the reindeer population sizes have declined, Hansen and colleagues found that parts of the reindeer population go in search of refuge among the steep mountainous terrain where lichen resources act as a buffer against the icy conditions. Now, even this last resort for foraging is likely to be depleted.

Among the coastal populations, efforts to avoid starvation during winter have driven reindeer toward the sea-ice foot in search of washed up kelp and sea-weed. These last-ditch survival attempts represent a striking change in reindeer foraging habits, and one that may become common place with the increasing frequency of heavy ROS in these regions.

For other populations, relief can be found in the few degrees rise in temperature that the recent summers have brought, with some populations even showing strong positive trends. “The project has altered our understanding of how summer warming impacts aboveground plant biomass,” states Hansen. Rather than a gradual greening trend, it is now known from a study led by the University of Aberdeen that year to year weather variations cause huge fluctuations in green vascular plant biomass, sometimes as much as doubling it.

An examination of the long-term time series helps to contextualise these annual climatic fluctuations. Indeed, in a paper published in Science in 2013, Hansen and colleagues have uncovered exciting new evidence about the effects of winter and summer climate drivers revealed in the wider community dynamics and trophic interactions on Svalbard: “For the first time we have demonstrated that climate can drive whole animal communities into synchronous fluctuations”. As well as impacting the entire community of overwintering herbivores, these fluctuations in weather conditions, and especially ROS and icing events in winter, have an indirect effect on the arctic fox. Although a predator, this tundra scavenger relies on reindeer carrion as a valuable additional food source, the sporadic availability of which is reflected in the fox’s own population dynamics.

POLAR BELLWETHER

Rapidly shifting population patterns are a potent illustration of the broader ecological implications of extreme weather events such as heavy ROS. These events are predicted to occur with greater frequency in the circumpolar Arctic, and Hansen hopes to utilise Svalbard’s position as an early warning system of climate change impacts to demonstrate how a shifting climate can drive broad ecosystem dynamics.

The unique time-series data and mechanistic modelling approach employed in REINCLIM can clearly help improve predictions of future population changes, including potential local reindeer extinction in different climate scenarios. This knowledge is valuable to Svalbard’s reindeer management plans and a range of dissemination avenues are planned to maximise the group’s findings. At the project’s close in 2015, the team intends to deliver at least one discourse at local public meetings, communicating relevant findings. In addition, they aim to communicate directly with the Governor of Svalbard and Norwegian Polar Institute in order to produce customised reports on the key findings and possible management implications. Nevertheless, the importance of the REINCLIM investigations is broader than local management strategies. If Hansen is right, their reports could be in high demand as impacts become more acutely felt beyond Svalbard and extend southwards from the High North.

INTELLIGENCE

PREDICTING EFFECTS OF CLIMATE CHANGE ON SVALBARD REINDEER POPULATION DYNAMICS: A MECHANISTIC APPROACH

OBJECTIVE

To disentangle the mechanisms through which climate change influences our northernmost ungulate and, in turn, predict future population trends given different climate scenarios.

KEY COLLABORATORS

Norway:
- Åshild Ø Pedersen; Jack Kohler, Norwegian Polar Institute
- Audun Stien; Vebjørn Veiberg, Norwegian Institute for Nature Research
- Professor Steve Coulson, University Centre in Svalbard
- Professor Leif Egil Loe; Professor Erik Ropstad, Norwegian University of Life Sciences
- Rasmus Benestad; Ketil Isaksen; Dagrun V Schuler, Norwegian Meteorological Institute
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BRAGE BREMSET HANSEN received his PhD in Biodiversity from the Norwegian University of Science and Technology (NTNU), Trondheim, in 2008. The PhD focused on plant-herbivore interactions and how spatiotemporal variation in vegetation affects resource selection in Svalbard reindeer. He later worked as postdoc and researcher at the Centre for Biodiversity Dynamics.