

Nordic Reindeer Husbandry Conference 2025

Reindeer Husbandry in an unpredictable future

12-14 February 2025, Alta, Norway



RANGIFER REPORT

**Research, Management and Husbandry of Reindeer
and other Northern Ungulates**

Rangifer Report, No 25, 2025

Rangifer

Publisher: Swedish University of Agricultural Sciences
Department of Applied Animal Science and Welfare
P.O. Box 7024, 750 07 Uppsala
Sweden

Corporate identity number: SE 202100-2817

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As of volume 28 (2008), Rangifer is published as a web-based journal (ISSN 1890-6729) with free access on the Rangifer website: <http://rangiferjournal.com/>. A complete collection of all published issues of Rangifer, including Rangifer Special Issues and Rangifer Report, are available on the same website.

The publication of Rangifer is supported by funding from the Swedish Government. The standard issues of Rangifer contain peer-reviewed scientific articles in English. Rangifer Report has a more open format with a lower level of scientific review. Articles are published in Rangifer Report in Norwegian, Swedish or English (or in translation to multiple languages). For example, Rangifer Report might contain summaries of scientific meetings or popular science reports on research that is highly relevant to Rangifer's readers.

Cover photo: Ingebjørg Nymo

Program Nordic Reindeer Husbandry Conference

Where: Scandic Hotel Alta, Løkkeveien
61, 9509 Alta, Norway. Tel. +47 78482700
<https://www.scandichotels.no>

Date: 12.-14.02.2024

Format: Two lunch-to-lunch parts.

Part one is held in English only. Open to all.

Part two is directed at users (reindeer herders, administration, researchers). Open to all. With interpreters (Norwegian/Swedish, Finnish, North Sámi).

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Reindriftens utviklingsfond

Reindeer husbandry in an unpredictable future

Climate change, increasing land use pressures on the use of land, challenges and necessary adaptation are factors that lead to uncertainty for reindeer husbandry in the future.

In collaboration with NKJ (The Nordic Joint Committee for Agricultural and Food Research) and RUF (Reindriftens utviklingsfond), NIBIO (Norwegian Institute for Bioeconomy) invites to a reindeer husbandry conference at Scandic Hotel Alta, 12th – 14th February 2025. The main topics of the conference are climate change and challenges of current and future land use.

The conference will be divided into two parts: Part 1 (12th – 13th February) is mainly for researchers and is held in English but is also open to others. Part 2 (13th – 14th February) targets reindeer herders, administration/management and researchers, but others with an interest in reindeer husbandry can participate. Translation will be provided.

Reindrift i en uforutsigbar tid

Klimaendringer, økende press på bruken av arealene samt utfordringer med tilpasninger er flere faktorer som fører til usikkerhet for reindriften fremover.

I samarbeid med NKJ (The Nordic Joint Committee for Agricultural and Food Research) og RUF (Reindriftens utviklingsfond) inviterer NIBIO (Norsk institutt for bioøkonomi) til reindriftnkonferanse på Scandic Hotel Alta 12. – 14. februar 2025. Hovedtemaene på konferansen vil være klimaendringer og utfordringer knyttet til dagens og fremtidens arealbruk.

Konferansen vil bli todelt: Del 1 (12. – 13. februar) er i hovedsak for forskere og avholdes på engelsk, men er åpen også for andre. Del 2 (13. – 14. februar) har i hovedsak reindriftsutøvere, forvaltning og forskere som målgruppe, men også her kan andre som har interesse for reindrift delta.

Boazodoallu dán eahpediehttevaš áiggis

Dálkkádatrievdan, eanet ahte eanet sisabahkkemat mat váikkuhit areálageavaheapmái ja hástalusat heivehemiin leat dakkár áššit mat boazodollui das duohko ain dagahit eahpesihkarvuoda.

Norgga bioekonomalaš Instituhtta bovde ovttas NKJ:in (The Nordic Joint Committee for Agricultural and Food Research) ja RUF:in (Boazodoalu ovdánahttinforandain) boazodoallokonferánsii Scandic Hotellii Áltái guovvamánu 12.–14. beaivvi 2025. Konferánsa váldofáttat leat dálkkádatrievdamat ja dálá ja boahhteáiggi areálageavaheami hástalusat. Loga eambo dán birra dáppe prográmmas.

Konferánsa lea guovvtti oasis. Vuosttaš oasis (guovvamánu 12.–13. beaivvi) lea vuosttažettiin oavvilduvvon dutkiide ja lea eanjalasgillii, muhto dát lea rabas maid earáide. Nuppi oasis (guovvamánu 13.–14. beaivvi) ulbmiljoavku lea vuosttažettiin boazodoallit, hálddašeaddjit ja dutkit, muhto lea maid vejolaš earáide geain lea beroštupmi boazodollui searvat.

Rangifer Report, 25, 2025: 1-56
DOI [10.7557/2.45.1.8002](https://doi.org/10.7557/2.45.1.8002)

Program Nordic Reindeer Husbandry Conference

Start	End	Part 1, Wednesday, 12 th February 2025	Page nr
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14:45	15:00	Wallin Philippot: Poxviruses in semi-domesticated reindeer in Sweden	11
15:00	15:15	Malmström: Pestivirus demonstration and characterization from semi-domesticated Eurasian tundra reindeer (<i>Rangifer tarandus tarandus</i>) in Norway	12
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16:30	16:45	Byrne: <i>Setaria tundra</i> : a climate sensitive parasite in reindeer (<i>Rangifer tarandus tarandus</i>)	16
16:45	17:00	Våge: Is Chronic Wasting Disease (Rávžanvihki/oaivevuorri, CWD) a challenge for reindeer husbandry?	17
17:00	17:15	Holmen: Chronic wasting disease threatens Fennoscandian reindeer – How will breeding for CWD-resilience affect genetic variation and fitness	18
17:15	17:30	Itkonen: Post-mortem examinations and diagnoses of reindeer in Finland from years 2020-2024	19
17:30	17:45	Forsman: The effect of reindeer winter feeding diet and methods on the gut microbiota community	20
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Program Nordic Reindeer Husbandry Conference

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		Cumulative impact (Skarin, Jokinen & Wagner)	
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11:00	11:15	Cronvall: Advancing Ground Lichen Assessment: New Methods for Estimating Lichen Cover and Biomass.	29
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17:15	17:30	Kujala: A Herder's view on predators	
17:30	17:45	Risvoll: Combining local knowledge and wildlife cameras to enhance the knowledge base regarding large carnivores in the Salten region in Nordland, northern Norway	
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Program Nordic Reindeer Husbandry Conference

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09:00	09:15	Climate change adaptations in reindeer husbandry in Norway	
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Abstracts

Wednesday 12 February

Reindeer health & welfare I

First detection of a cervidpoxvirus in Europe – disease occurrence in Norwegian and Swedish semi-domesticated Eurasian tundra reindeer (*Rangifer tarandus tarandus*)

Ingebjørg H. Nymo^{1,2}, Cathrine Arnason Bøe³, Javier Sánchez Romano², Hans Lian², Renate Thorvaldsen², Faisal Suhel³, Mette Boye³, Øivind Øines³, Lars P. Folkow², Anna G. Henriksson¹, Fredrik Samuelsson², Tomas Jinnerot⁴, Jonas Johansson Wensman^{4,5}, Rebecca K. Davidson¹, Torill Mørk¹, Line Olsen¹, Morten Tryland^{6,2}, Ulrika Rockström⁷ & Bjørn Spilberg³

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Commencing in 2018, a novel disease involving periorbital lesions was reported in Swedish and Norwegian reindeer in multiple locations, both as individual cases and in larger outbreaks. Crusty lesions were seen on the genitals, nostrils, and ears, in combination with lethargy. At necropsy, in addition to these lesions, moderately swollen lymph nodes, liver, and spleen were seen. Histological examination of the eyelid lesions showed a marked chronic locally extensive necrotizing blepharitis, with marked subacute suppurative secondary infection. Shotgun sequencing of samples from outbreaks yielded a partial draft genome of a virus related to Deerpox virus W-848-83 (belonging to the species *Cervidpoxvirus muledeerpox*) in genus *Cervidpoxvirus*. An in-house qPCR targeting the cervidpoxvirus virion core protein gene was developed and *cervidpoxvirus* was detected across multiple organs, with the highest load in skin lesions. Viral transcripts were observed in the cytoplasm of epithelial cells in the eye lesions with RNAscope[®] *in situ* hybridization. *In vitro* infection in Madin-Darby bovine kidney (MDBK) epithelial cells demonstrated cytopathic effect. Transmission electron microscopy images revealed characteristic brick-shaped viral particles, consistent with the morphology of poxviruses, both within MDBK-cells and in skin lesions. We tentatively named the virus identified in reindeer as *Cervidpoxvirus reindeerpox* (CvRPV), following the binomial “genus-species” format approved by the International Committee on Taxonomy of Viruses (ICTV), but further characterization is needed to confirm whether this is a new species. The potential role of rodents in CvRPV disease dynamics, similar to their involvement in other poxvirus infections, requires further investigation. Rodent liver, kidney, spleen, and lung tissues is currently being screened for this virus (PCR) from rodents captured during a CvRPV outbreak in a Norwegian reindeer herd (results still pending). Cervidpoxviruses have previously only been detected in Capreolinae in North America. It is unknown whether the emergence of this disease in Norwegian and Swedish semi-domesticated reindeer is due to ecosystem changes, facilitating altered disease dynamics of an already persistent infection, or if the virus has been newly introduced.

Poxviruses in semi-domesticated reindeer in Sweden

Karin Wallin Philippot^{1,2}, Mikael Leijon³, Tomas Jinnerot³, Ingebjørg Helena Nymo^{4,5}, Ulrika Rockström⁶, Anna Omazic⁷ & Jonas Johansson Wensman^{3,8}

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Over the past 15 years, outbreaks of infectious diseases affecting the eyes and mouths of reindeer (*Rangifer tarandus tarandus*) have increased. These conditions severely impact animal welfare, causing pain, potentially blindness, starvation, and death. They also bring anxiety and economic losses to reindeer herders. In 2023, two poxviruses were detected in Sweden: cervidpoxvirus, identified for the first time outside North America, and red deerpox virus (RDPV), observed for the first time in a species other than red deer.

Both viruses cause similar clinical signs, such as skin lesions on eyelids and muzzles. In Fennoscandia, parapoxviruses like orf and pseudocowpox have previously caused outbreaks in reindeer. However, this is the first report of RDPV being associated with disease in reindeer.

In September 2023, five reindeer calves showing clinical signs were examined in Norrbotten, Sweden. One calf was euthanized for necropsy. Lesions were found on the muzzle, eyelids, and oral mucosa. Post-mortem samples confirmed parapoxvirus infection, with DNA sequencing showing 99.7% similarity to an RDPV strain from a red deer in Germany in 2013. Another calf in the group was PCR positive for cervidpoxvirus.

Preliminary data from 53 eye swabs collected from 31 herds showed cervidpoxvirus in almost 40% of herds and parapoxvirus in 16%. Despite its apparent spread, the pathogenesis and impact of cervidpoxvirus remain unclear.

The clinical signs reported in the case of RDPV were similar to those previously reported for lesions caused by other poxviruses, such as orf and cervidpoxvirus in reindeer. This highlights the difficulties of identifying the causative agent based solely on clinical observations. Emerging infectious diseases, such as poxviruses, are expected to increase due to intensified reindeer herding practices and climate change. This underscores the need for deeper insights into the causative agents and environmental factors to prevent future outbreaks.

Pestivirus demonstration and characterization from Semi-domesticated Eurasian tundra reindeer (*Rangifer tarandus tarandus*) in Norway

Ester Malmström¹, Shollie Falkenberg², Thomas Passler³, Kayla Buhler¹, Ingebjørg Nymo⁴, Javier Sanchez Romano⁵, Andrea Miller¹, Susan Kutz⁶ & Morten Tryland¹

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Studies have demonstrated a high seroprevalence of pestivirus in semi-domesticated Eurasian tundra reindeer (*Rangifer tarandus tarandus*) herds in Norway and Sweden, indicating that the virus is endemic in many of these herds, despite its eradication from domestic species in Scandinavia. Pestivirus is known to cause substantial economic losses in domestic livestock—manifesting as abortions, increased calf mortality, and reduced animal fitness. Pestivirus in free-ranging reindeer has never been conclusively demonstrated or characterized, which is why the impact of this pathogen on semi-domesticated reindeer populations remains unknown.

With the aims to demonstrate, isolate, and sequence the endemic pestivirus in Norwegian semi-domesticated reindeer, we examined 3,453 ear tissue samples from calves, 624 lymphoid tissue samples from adults and calves, and 151 fetal tissue samples from three geographically distinct herds in Norway. Using conventional PCR and agar gel electrophoresis, a 283-base pair sequence of the 5' untranslated amplicon region (5' UTR) of the pestivirus genome was amplified using a set of HCV90/HCV368 primers.

Our analyses resulted in the demonstration of pestivirus in 24 ear tissue samples, 47 lymphoid tissue samples, and 1 fetal tissue sample. Viral isolation and full genome sequencing was successful from one lymphoid tissue sample, which revealed a yet undocumented, divergent pestivirus species. Complete genome sequencing of this sample agreed with the 5' UTR amplicon sequencing, that the isolate most closely resembles the pronghorn antelope pestivirus rather than other well-known pestivirus isolates derived from domestic species and the Reindeer-1 pestivirus.

This study represents the first documentation of naturally occurring pestivirus in semi-domesticated reindeer. It also represents the first characterization of a novel pestivirus in reindeer through viral isolation and nucleotide sequencing. The presence of pestivirus in natural reindeer population is not a new phenomenon. With our findings, we have contributed to closing the knowledge gap regarding pestivirus in reindeer. The effect of pestivirus on reindeer reproduction, health & welfare and long-term economic losses for reindeer herders are yet to be investigated, as are the potential effects on the pestivirus eradication programs in Scandinavia.

Mitigating brainworm (*Elaphostrongylus rangiferi*) infections in a warming climate

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Elaphostrongylus rangiferi is ubiquitous in Norwegian reindeer (*Rangifer tarandus tarandus*) herds. This nematode parasite can damage the brain and spinal cord leading to disease and death in the reindeer final host. *Elaphostrongylus* has highly temperature-sensitive developmental stages in gastropod intermediate hosts and is a significant emerging climate sensitive infection. Concerns have been raised that it may threaten the future of sustainable reindeer herding. Record warm summers and autumns have resulted in disease outbreaks in herds in Trøndelag and Troms during the last two years. There are currently no diagnostic tests or treatments available. Prophylactic treatment can only be given whilst herds are gathered for calf marking during summer. Ivermectin has an estimated two weeks of anti-parasitic effect in reindeer. This is too short to mitigate for brainworm infection throughout the summer and autumn grazing season.

Individual infection prevalence and abundance varies between regions and herds, but the parasite has been found in all herds that have been tested. The disease progression and severity are dose-dependent, with many animals showing few to no clinical signs, provided the infection dose is low. Herders report early symptoms like emaciation despite normal food uptake, in addition to neurological signs. Accordingly, herders have reported that these animals had below average body condition even after the summer when maximum body condition is normally reached. We also found that reindeer with the highest brainworm faecal larval burdens had significantly poorer winter body condition than those with less infection. The parasite can therefore have a negative impact in herds even when no acute disease outbreaks, with neurological signs, are reported.

It is vital to improve reindeer health and welfare by developing mitigation strategies to combat this debilitating disease. Degree-day modelling of infection pressure based on parasite development times in gastropods is carried out annually to identify regions with particularly high infection risk. Webinars and meetings for herders from these areas have been arranged to discuss how seasonal grazing strategies (e.g. avoid forested areas with high gastropod densities) and anthelmintic treatment in early autumn can reduce infection pressure and disease occurrence. Furthermore, we tested, in experimental studies, two long-acting anthelmintic preparations which show the potential to provide effective protection from 40 (moxidectin) to 70 (eprinomectin) days. These promising drugs are to be trialed under natural infection conditions by giving a single subcutaneous dose during calf marking in the summer. The aim of this is to identify a prophylactic treatment that can decrease brainworm infection burden enough to prevent disease outbreaks.

Future research needs to focus on developing sensitive disease diagnostics and treatment strategies so that we can better evaluate the true impact of this parasite on herd sustainability and improve animal health and welfare.

Gastrointestinal parasite quantities in soil from reindeer feeding sites and evaluation of recovery efficiency in different soil types

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Due to diminishing pasture resources during recent decades, supplementary feeding of semi-domesticated reindeer has become more common in Sámi reindeer husbandry in Norway. Understanding the implications of different feeding practices for contamination of infectious organisms on the ground at feeding sites can improve our knowledge of disease dynamics in different management systems for semi-domesticated reindeer and provide a basis for adaptive measures to avoid increased infection pressure. High burden of parasites can have a wide range of detrimental health effects, from subtle ill-thrift with decreased weight gain, to acute and severe clinical conditions. We hypothesized that: (1) eggs and oocysts from parasites with direct life cycle can be detected in soil during the late summer season at sites where reindeer have been fed the previous winter and spring (2) parasite contamination levels are associated with animal density, with higher densities resulting in higher concentrations of parasite eggs and oocysts; and (3) soil type affects egg/oocyst recovery efficiency.

To test these hypotheses, we investigated the potential for environmental contamination from reindeer parasite eggs and oocysts in five feeding sites for semi-domesticated reindeer, located in Finnmark and Nordland, Northern Norway. The feeding regime differed from spreading out feed-stuff on the pasture for a short period of time, to feeding in a fenced area for several months every year. We collected soil samples from each site during the summer of 2023 and quantified eggs and oocysts using sedimentation and flotation techniques. Number of eggs and oocysts were plotted against animal density on the feeding site. To assess recovery efficiency, a controlled experiment is currently under way, using replicate samples of three distinct soil types with different levels of organic material, spiked with nematode eggs (*Nematodirella* sp. and *Nematodirus* sp.)

We were successful in identifying recognizable eggs/oocysts, specifically *Capillaria* sp. and strongylid type eggs and *Eimeria* sp. oocysts from feeding site samples. Preliminary investigations show a higher number of parasite eggs and oocysts in feeding sites with higher animal density. These findings represent baseline data, relevant for the sites or zones where the samples were obtained. However, initial findings from our validation experiment indicate that recovery efficiency of parasites eggs may vary between soil types. This should be considered when interpreting findings from the feeding sites, and further standardization of the method may be needed. Still, these preliminary results support our hypotheses and indicate that surveillance of soil contamination can be a useful tool in assessment of risk of parasitic exposure.

Reindeer health & welfare II

Vector-borne parasitic diseases emerged in Finnish reindeer; a review of Finnish studies of Filarioid nematodes

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The nematodes *Setaria tundra*, *Onchocerca* spp. and *Rumenfilaria andersoni* appear to have emerged in Fenno-Scandinavian reindeer during the latter half of the 20th century, associated with micro-filaremia, peritonitis, necrotic granulomas and tarsitis. Geographic shifts linked to climate warming and host colonization to reindeer from sources in white-tailed deer, roe deer and red deer have served as precursors and drivers of these parasites and associated diseases. Thousands of reindeer died in 1973 during emergence of *S. tundra* followed by recurrent outbreaks in 1989 among moose and in 2003–06 and 2014 among reindeer leading to condemnation of carcasses during reindeer slaughter. Concurrently, chronic tarsitis and necrotic granulomas in liver and muscles, caused by *Onchocerca* spp., were increasingly common in reindeer and moose as revealed during meat inspection. In 2004–06, previously unrecognized parasites were found in the lymphatic vessels of reindeer, and were identified, for the first time in Europe, as *Rumenfilaria andersoni* (Splendidofilariinae). In Finnish semi-domesticated reindeer, prevalence of *R. andersoni* was locally up to 95 %. In moose, the observed prevalence was 10 %, in wild forest reindeer 69 %, white-tailed deer 15 % and roe deer 3 %. The impact of *R. andersoni* to cervid health and meat quality is unknown but visible changes were seen around lymphatic vessels. Our current data, including genetic comparisons of North American and Finnish isolates of *R. andersoni*, suggest this filarioid became established in Finland recently, coincidental with introduction of white-tailed deer from North America in 1935. As *R. andersoni* is found in all the four cervid species in Finland through host colonization, it can be anticipated to spread more extensively in Eurasia. Mosquitoes transmit *S. tundra* and black flies *Onchocerca* spp., whereas the vector of *R. andersoni* is unknown. Incremental and accelerating climate warming and extreme or ephemeral events of elevated temperature appear to interact to directly influence the overall limits on northern distribution and the potential for population amplification leading to disease emergence on local to regional scales for this nematode assemblage. We demonstrated that high mean summer temperatures exceeding 14 °C drive the emergence of disease outbreaks due to *S. tundra*, where morbidity manifests in the following summer, if conditions remain warm. This hypothesis was further supported in autumn of 2014 following 2 consecutive exceptionally warm summers, leading to the emergence of the most recent outbreaks of *S. tundra* and *Onchocerca* in Finnish reindeer. Since then, there have been several outbreaks almost every year in Finland including the very northernmost part of Lapland. Although not zoonotic through meat consumption, Filarioids can cause significant morbidity, affecting the appearance, texture and quality of meat and organs, as well as impacting body condition, and in some cases, causing mortality. The consequent meat condemnation, and possible population level impacts (declines), have broader impacts on the food security for northern people who depend on reindeer for food and income.

***Setaria tundra*: a climate sensitive parasite in reindeer (*Rangifer tarandus tarandus*)**

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Reindeer are facing many challenges in the changing Arctic, some of which are directly and indirectly attributable to climate change. In particular, impact of climate change on temperature and precipitation can influence the development, survival, and feeding behaviours of mosquitoes. Higher summer temperatures also facilitate the development of *Setaria tundra* larvae in mosquitos. As a result, reindeer may be exposed to a higher infection pressure of mosquito-borne infections.

The filarioid nematode worm *S. tundra*, whose presence in Fennoscandia emerged in the 1960s, has been associated with outbreaks of peritonitis in Finland, Sweden and Norway during the early 1970s. Of most significant note was the outbreak in Finland during 1973, where tens of thousands of reindeer died in the northern herding area, many of which presented with severe peritonitis and presence of mature *Setaria* spp. worms in their abdomen, however a causal link between the parasite infection and reindeer death was not confirmed. Finland also encountered another significant outbreak spanning 2003-2006. Analysis of climate data and outbreaks showed correlations between outbreaks and years with abnormally warm summers in Finland (Laaksonen 2010).

Despite occurrence of these disease outbreaks in Finland, there are no official reports of *S. tundra* detection in Norway since approximately 1980. This is particularly surprising, due to increasingly favourable conditions for disease transmission, the observed presence of *S. tundra* infections in Sweden, and a rise in initial detections of *S. tundra* in mosquitoes and wild cervid populations across mainland Europe.

This project investigated the prevalence and abundance of *S. tundra* in Norwegian and Swedish reindeer herds, paying special attention to geographical, temporal and climatic variation. In both Norway and Sweden, blood samples for analysis were obtained from three distinct herds respectively involved in the WELFED and EQUIP Reindeer Projects (n=30 per Norwegian herd, n=150 per Swedish herd). This sampling is estimated to provide approximately 270 samples from Norway, and approximately 300 samples from Sweden.

S. tundra prevalence and abundance data was analysed using three laboratory diagnostic methods. Microfilariae were quantified using two microscopy-centric methods i.e. the Modified Knott's Assay, and by observing live microfilariae in the buffy coat in microhematocrit tubes. A PCR targeting the COX1 gene, followed by a sequencing/bioinformatics workflow was used to screen the blood samples.

Data obtained from analysis will be used to develop an epidemiological model to compare variation in *S. tundra* prevalence and abundance, with regard to year of sampling, geographical location, and climate variation. Ultimately, insights gained from this work could help to inform appropriate preventative or reactive strategies to reindeer disease management.

Is Chronic Wasting Disease (Rávžanvihki/oaivevuorri, CWD) a challenge for reindeer husbandry?

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Since 2016, CWD has been an important disease in Norwegian cervids. For wild reindeer on Hardangervidda and in Nordfjella, it has had major consequences for the populations, and the closest herds of reindeer husbandry has held its breath for the past 8 years. Combating CWD has required large resources, and by the end of 2024, the surveillance program has enrolled more than 185,000 cervids to look for this prion disease. About 1/3 of these are semi-domesticated reindeer.

Chronic Wasting Disease is always fatal and there is no available prophylaxis or treatment. The challenge of long-term infection from the environment makes it an almost impossible task to get rid of, once enzootic. The lecture will highlight the disease, give an update on research, and discuss management and relevance for reindeer husbandry.

Er skrantesjuka (Rávžanvihki/oaivevuorri, CWD) en utfordring for reindriften?

Skrantesjuka har siden 2016 vært en viktig sykdom hos norske hjortedyr. For villrein på Hardangervidda og i Nordfjella har den fått store konsekvenser for bestandene, og tamreinnæringa i områder tett på har holdt pusten de siste 8 årene. Bekjempelse av CWD har krevd store ressurser, og ved utgangen av 2024 har mer enn 185 000 hjortedyr vært undersøkt for denne prionsykdommen. Omtrent 1/3 av disse er tamrein.

Skrantesjuka har alltid dødelig utgang, lar seg ikke forebygge eller behandle. Utfordring med langvarig smitte fra miljøet gjør det til en nær umulig oppgave å skulle kvitte seg med sykdommen hvis den først har blitt etablert. Foredraget vil omtale sykdommen, gi en oppdatering om forskning, og diskutere forvaltning og relevans for reinnæringa.

Chronic wasting disease threatens Fennoscandian reindeer – how will breeding for CWD-resilience affect genetic variation and fitness?

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Chronic Wasting Disease (CWD) is an infectious prion disease affecting reindeer that is always fatal and extremely challenging to eradicate and control. The disease affects the brain, and there are currently no treatments or vaccines available to slow its progression in affected individuals. First described in the 1960s it has for many years been a concern restricted to North American cervid populations. However, in 2016, it was reported in wild reindeer in Southern Norway's Nordfjella region, representing the first instance in Europe.

In response to its detection, the Norwegian government implemented a plan to limit and, if possible, eradicate CWD. As part of this plan, >2400 wild reindeer in Nordfjella were culled, revealing 18 more infected individuals. Unfortunately, despite these efforts, a few years later, CWD was again confirmed in wild reindeer, this time in the nearby Hardangervidda region, first in 2020 and again in 2022. The wild reindeer populations inhabit areas adjacent to much larger populations of semi-domestic reindeer. To date, 21 CWD cases have been reported in wild reindeer in Norway, but no reports of CWD in semi-domestic reindeer herds, despite extensive surveillance. This is good news for the traditional reindeer herding industry but at the same time highlights that CWD has not been eradicated in Norway and continues to pose a significant threat to both wild and semi-domestic reindeer populations. Given the persistence of CWD agents in the environment, preventing further spread is critical.

Fortunately, certain known genetic variants in the prion protein gene (*PRNP*) reduces individual CWD susceptibility, creating an opportunity to enhance herd resilience through selective breeding. This project brings together five reindeer herding companies in Southern Norway with researchers from Norway and Italy. It aims to explore the potential of improving CWD resistance of semi-domesticated reindeer herds through selective breeding, without compromising genetic diversity and preserving production traits.

Using advanced DNA and RNA sequencing technologies, including Oxford Nanopore and Illumina platforms, the project will generate comprehensive multi-population genomic variation data including (i) an improved, annotated reference genome for reindeer, (ii) individual genome sequence data describing five semi-domesticated reindeer populations, and (iii) comprehensive genome-wide maps of genetic variation. These data will be used to develop models that assess the potential genetic loss resulting from *PRNP*-based breeding strategies. By evaluating the trade-off between disease resistance and genetic diversity, the project aims to provide valuable insights for sustainable breeding practices in response to CWD.

Post-mortem examinations and diagnoses of reindeer in Finland from years 2020 – 2024

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Post-mortem examinations of reindeer are scarce in Finland, as the transport distances are long. Oulu is the northernmost city in Finland where the Finnish Food Authority (FFA) performs post-mortem examinations of reindeer. Changes in logistics have made carcass transport to the FFA Oulu increasingly difficult. Collecting data on causes of death and the prevalence of infectious diseases in Finnish reindeer is valuable information for reindeer herders and veterinary authorities for disease surveillance as well as for promotion of reindeer health and welfare.

Post-mortem examinations of reindeer at the FFA Oulu include a necropsy and tissue samples for histology, parasitology, bacteriology, virology, and chronic wasting disease (CWD) sampling based on the condition of carcass, reindeer's age, anamnesis, and pathological findings. Since 2023 additional field necropsies have been conducted in PORAUS research project that aims to develop a remote digital necropsy (RDN) method for reindeer post-mortem examinations. Local veterinarians in reindeer herding areas have been trained to perform a field necropsy, fill in a form of findings, and collect tissue samples to be further studied at the FFA Oulu. The aim is to collect more data of Finnish reindeer pathology and diseases.

A total of 58 whole reindeer carcasses were examined at the FFA Oulu in years 2020-2024. The number of whole carcasses examined at the FFA Oulu has declined within the last five years almost linearly, with the highest sample number in 2020 (n=23) and the lowest in 2024 (n=2 by October 2024). Since the PORAUS project started in 2023, there have additionally been two field necropsies in 2023 and seven in 2024 (by October 2024) recorded by the FFA. Out of all reindeer carcasses examined either at the FFA Oulu or in field during 2020-2024 (n=67), the most common diagnoses were cachexia (n=24), peritonitis (n=15) and stomatitis (n=11). Each reindeer could be given several diagnoses.

In this study we found that post-mortem examinations of reindeer at the FFA Oulu have decreased during the most recent five years, causing a serious gap in knowledge of reindeer disease prevalence in Finland. The still ongoing PORAUS project of field necropsies has likely increased the total number of reindeer post-mortem examinations and disease results recorded by the FFA. The efforts of PORAUS project to implement RDN in Finland will hopefully ensure increasing information of reindeer diseases also in the future. More elaborate data of diseases and causes of death in Finnish reindeer in 2020-2024 will be presented and compared to other published research done in Nordic regions. Most common post-mortem findings of reindeer in Finland will be further discussed.

The effects of reindeer winter feeding diet and methods on the gut microbiota community

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Winter-feeding of reindeer - either in enclosures or in the wild - is a common adaptation strategy for unpredictable winter conditions induced by climate change. These feeding methods differ in the amount of natural forage the reindeer obtain on their own, which in turn can be expected to affect the structure of the bacterial community – the microbiota – living in the gastrointestinal tract (GIT) of the reindeer. For ruminants, healthy microbiota is vital as it produces up to 70% of the individual's energy needs and contributes to function of the immune system. In humans, the structure of the microbiome is known to affect overall well-being and health, but this has not been studied extensively in animals. We experimentally investigated the effects of winter-feeding diet and methods on the structure of the GIT microbiome in Kutuharju experimental reindeer farm in Inari, Finland. A total of 80 female reindeer were randomly assigned to two treatments: 1) enclosure feeding, where reindeer were kept in enclosures and with fed silage and concentrated feed and 2) pasture feeding, where reindeer roamed and grazed free on winter pastures and their diet was supplemented with concentrated feed and lichen. The experiment was conducted over two winters (2019-2022). Microbiome was estimated from faeces and fecal samples were collected three times each winter, and the bacterial fauna was analyzed using 16S amplicon sequencing. The feeding treatments had a strong effect on the structure of the GIT microbiome. In the pasture feeding treatment, microbiome diversity decreased significantly over the winter, while in the enclosure feeding, diversity remained stable, keeping the GIT microbiome in a “summer-like” state. The composition of microbiota also differed between treatments. During summer, the diversity of the GIT microbiome returned to similar level among experimental reindeer. Our results demonstrate that in devoid of grazing natural food on winter pastures, the microbiome of the reindeer GIT is missing its natural annual dynamics. While our results cannot suggest any direct health effects, they call for more research on winter feeding strategies and fodder composition and effects on the well-being of reindeer.

Climate change

Emerging new summers in the northern Fennoscandia

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The Arctic climate is changing fast. This means also significant changes in seasonal weather in northern land-areas, like reindeer management area of northern Fennoscandia. This work concentrates on changes experienced and expected during summer. Warming climate is bringing new kinds of summer conditions to northern Fennoscandia. Together with changing mean conditions, new and exceptional events are also experienced. This can mean more frequent, more severe, or longer hot periods, droughts, summer storms and forest fires – more frequent extreme summer events. This can also mean new conditions like tropical nights and risks of new insects, parasites and diseases. New summers are emerging, with new uncertainties.

Summer 2024 was an example of such conditions in many areas. This summer was exceptionally warm in almost all observational stations in Lapland, northern Finland. Record-breaking heat sums were observed in Lapland during the vegetation period of 2024. What was especially peculiar, was that there were practically no cool periods during the summer. For example, in Sodankylä, mid-Lapland, it is typical for hot summers that approximately one third of days are cooler than the long-term mean for that time of summer, and two thirds are warmer. During summer 2024 only 12 days cooler than the long-term mean for that time of summer were observed in Sodankylä – and 80 that were warmer. According to reindeer herders from Finland, warm weather and lack of rain impacted especially the northernmost part of the reindeer management area. Pastures suffered from drought and part of the vegetation withered already in early August. Also, there were no mushroom on pastures before early October. Drought, heat, and lack of mushrooms led to poor autumn condition of reindeer in these regions and negatively impacted calf growth.

In this work we combine analyses of long-term meteorological data to practitioner knowledge of reindeer herders in Finland, as revealed by annual management reports of herding districts and interview material. We also present projections related to summer conditions during following decades. These data, stories and other local experiences reveal coping measures during difficult summer conditions, and new adaptation needs. Finally, we discuss the knowledge gaps and monitoring needs, as well as development of summer adaptations in reindeer husbandry.

Sámi reindeer pastoralist system facing climate change: Effect of weather, pasture, insect harassment and maternal conditions on production with herders practicing individual marking

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Sami reindeer husbandry in its present form have been practiced during the last four-five hundred centuries throughout Sápmi. Over time the reindeer herding strategies have changed to adapt to changing environmental and climatic conditions as a way to stabilize or reinforce productivity. From having practiced mainly slaughter of grown-up bulls a transfer to calf slaughter started in the 1970-ties and is today a common practice to control the herd's composition and meat supply. To support this system, an individual marking program of reindeer was developed facilitating slaughter selection through the follow-up of female reproduction and calf's condition. In Ruvhten Sijte reindeer herding community, Sweden, reindeer herders initiated individual marking in 1980 and since 1986 they have performed selective breeding of their reindeer on calf body mass and individual reproductive success of the mother. Overall, herders in Ruvhten seem to have managed to sustain a viable production, however with climate change affecting forage quality in both summer and winter and competing land use diminishing their pastures, we may suspect an overall decrease in production. In this study our aim was to evaluate how environmental conditions, such as temperature, precipitation, insect harassment, and forage quality in summer may affect the reindeer herd productivity. We concentrated our analysis on the vegetation-growing season when reindeer accumulate body reserves for winter survival and breeding. We used information on female reindeer reproductive success and live calf body mass in summer and autumn, recorded by the herders in Ruvhten Sijte between 1986 and 2021. Records on temperature, wind speed, precipitation and cloud cover were retrieved from the Copernicus spatial program, from this we also estimated an insect harassment index. To estimate the effect of forage quality we used the maximum value of the Normalized Differentiated Vegetation Index (NDVI) estimated for each summer. We fitted two separate linear mixed-effects models, to assess the influence of insect harassment, mean temperature, maximum temperature, forage quality, and precipitation on calf daily summer growth and calf body mass in autumn. In addition, we incorporated the impact of the mother having a calf in the preceding year, and the mother's identity and year were included as random effects. Our analysis showed that the only environmental parameter that influenced calf body mass in autumn was the maximum temperature. None of the environmental drivers influenced the daily summer growth. The condition of the mother determined the body mass of the offspring but the effect on its capacity to gain energy and fat in summer is unclear. Our results suggest that the management strategies in Ruvhten Sijte are near-optimal yet inherently fragile. Further research on other reindeer herding community with varying management strategies is necessary to validate this assertion.

Assessing herd productivity based on weather conditions and decision-making processes is required for developing effective management strategies to address the challenges of climate change on the traditional Sami reindeer husbandry.

Extreme winter conditions may lead to a collapse of reindeer husbandry economy - results of a bioeconomic analysis

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Winter conditions affect reindeer population dynamics and the economic sustainability of reindeer husbandry. Difficult winter conditions reduce the body condition, survival, and calving success, of reindeer. Reindeer herders may use supplemental feeding to compensate for the reduced availability of natural winter energy resources. However, optimal feeding strategies and profitability of reindeer husbandry under extreme winter conditions have not been studied.

In this study, the effects of extremely difficult winter conditions on the reindeer husbandry system are investigated using a detailed economic-ecological optimization model. The model describes an age- and sex-structured reindeer population, and its winter food resources, including supplementary feed. This ecological model is combined with economic optimization and a description of the herding system with empirically estimated prices and costs. The model is validated and calibrated to describe the reindeer husbandry system in the northern part of Finnish Lapland. In this study, we extend the model to include the effects of extremely difficult winter conditions on the energy requirements and food resource use of the reindeer population. This is done by assuming that the average energy requirement of the reindeer increases by 18% and the average daily crater area decreases by 60% during extremely difficult winters compared to average winters. We solve the extended model numerically with various economic and ecological parameters.

Our results show that the optimality of supplementary feeding depends on these economic and ecological parameters as well as on the severity of winter conditions. Under the typical variation of winter conditions, the benefits of supplemental feeding remain low, especially when winter pasture resources are sufficient. However, during extremely difficult winters, supplemental feeding may be essential for economically sustainable reindeer husbandry. Our analysis suggests that without feeding, income from reindeer herding can fall by as much as 40% over the following decade after a single extremely difficult winter. The severity of the losses is highly dependent on the availability of supplemental feed or other additional energy resources for the reindeer.

Exceptionally difficult winter 2019-2020 - Factors affecting the extent of losses experienced in the reindeer herding in Finland

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The winter 2019–2020 was exceptionally difficult for reindeer and for the reindeer herding in all three Nordic countries. During this winter over 20 000 adult reindeer were estimated to be lost in the reindeer herding area of Finland. Also, the average calf percent in the following year dropped from 61% to 46%, and the number of slaughtered reindeer from 83 700 to 56 900 reindeer, respectively. In the following year the total size of the winter herd was also reduced by 12 700 reindeer. In addition, the costs of herding and feeding were estimated to be by 1.5 times higher than previously. We analyzed which factors affected the extent of losses experienced by reindeer herding co-operatives in Finland because of the winter 2019-2020. In the analyses we used data on the annual numbers and productivity of reindeer herds in the co-operatives from the Reindeer Herders' Association, the data on the reindeer losses from Finnish Food Authority, the weather and snow grid data from the Finnish Meteorological Institute and information from the large survey made to all co-operatives.

The analyses showed that the relative losses of reindeer during winter 2019-2020 were highest in the co-operatives where reindeer used to be graze mainly on natural pastures without notable feeding during winter. In these co-operatives, the calf and slaughter percentages as well as the total numbers of calves and slaughtered reindeer also collapsed the most in the following year. In contrast, the longer the reindeer were kept in the corral feeding during the winter 2019-2020, the smaller these losses were. The development of hard, icy, and thick bottom snow layer on the winter pastures at the beginning of the winter 2019-2020 increased the losses of reindeer and decreased the calf and slaughter percentages in the following year in the co-operatives. The higher the percent of reindeer reported to be in weak body condition at the beginning of the winter 2019-2020, the more reindeer were lost and the lower were the total numbers of calves and slaughtered reindeer in the following year. Also, the higher the percent of reindeer observed to suffer health problems and diseases during the winter, the lower was the following year calf percent. In addition, the lack of mushrooms observed in late summer and autumn of 2019 indicated a reduction in the number of calves in the following year.

The weather conditions in late autumn and early winter are crucial for the formation of difficult snow and pasture conditions for reindeer herding. Climate warming is changing these weather conditions to warmer, rainier, and more unstable, which increases the risk on the development of difficult snow and grazing conditions, and at the same time, formation of noxious mycotoxins on reindeer winter pastures (Kumpula et al. 2024). In turn, the body condition and physical status of reindeer during autumn and early winter, as well as the reindeer herding and feeding practices during winter, have significant influence on how well reindeer can cope with difficult winter conditions and maintain their body condition and productivity.

See also: Kumpula J, Rämö S, Holkeri L, Pekkarinen A.-J, Siitari J, Tuomenvirta H, Lehtonen I & Rasmus S 2024. Warm, rainy winter onset increases the risk of hard, icy snow layers and the occurrence of mycotoxins in reindeer winter pastures. *Regional Environmental Change* (2024) 24:160. <https://doi.org/10.1007/s10113-024-02321-5>

Tales that really matter: Tracing causalities of weather and climate impacts on pastoral landscapes through a storyline approach

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If research is to inform policy and practice on reindeer pastoralism, how should it examine the complex interactions between climate change and pastoral landscapes? In this presentation, we argue that the storyline approach can deliver more comprehensive and relevant analysis than the risk-based approaches that prevail in conventional climate research and policy.

We raise concerns about the practical relevance of conventional climate science – that is, risk-based approaches based on statistical analyses of climate data to predict how the likelihood and magnitude of (extreme) weather events are affected by climate change. These approaches may oversimplify complex interactions, because they primarily focus on (extreme) weather events and do not integrate complex interactions with place-based landscape dynamics. Furthermore, results from these approaches are often difficult to translate into practical recommendations.

As alternative, we present the storyline approach, an established method to complement conventional climate science. The storyline approach traces the impact of an event back to its causal factors—in our case, impacts on pastoral landscapes, and the causal factors of these impacts separated into the domain of weather and climate, and the domain of the biophysical environment.

This approach is suited to investigate how several factors interact in causing impactful events. We illustrate how this approach may produce more meaningful analysis on the multiple factors that cause impacts during (extreme) weather events – the timing, frequency and intensity of which are affected by climate change. Such causal factors can either be independent of each other or linked as compound events at different spatial and temporal scales.

We illustrate our storyline approach with two examples: the impacts of compound weather events on i) pasture availability during winter, and ii) on calf survival during spring. To develop these storylines, we depart from the ecological theory, quantitative data and proven experience on the plausible factors that lead to these impacts. We will interweave this quantitative analysis of the selected impacts and their causal relations, with workshops with reindeer herders to refine and ensure that the storylines are not only scientifically robust but also grounded in the lived experiences and knowledge of reindeer herders. Through this collaborative process, we aim to produce actionable knowledge that supports informed decision-making and practical strategies to adapt to the challenges posed by compound weather events.

Co-designing an observation system to monitor climate change impacts on Sámi Reindeer Herding husbandry

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The effects of climate change are increasingly felt by reindeer herders across all Sápmi. A major challenge in responding to changing conditions—such as shifts in the environment or extreme weather events—is the lack of environmental monitoring sites or programs that meet the specific needs of reindeer herders. This includes measurements of local weather at relevant spatial and temporal resolution. As a result, there is a risk that changes remain undetected or unquantified, making it difficult for herders and researchers to use data in environmental and social risk assessments. Observation systems and monitoring programs should therefore be co-designed by Indigenous knowledge holders and academic science by jointly articulating the needs and objectives and by agreeing upon protocols for how Indigenous knowledge and science will be combined to co-produce knowledge relevant for to climate adaptation.

Here, we present an Indigenous led co-production process to develop an online platform for reindeer herders to document the effects of climate change and unusual environmental events across Sápmi. The project CITE is a three-year project initiated by the Arctic Monitoring and Assessment Programme (AMAP) and the Saami Council. We discuss the aim of the project and our process of co-production to identify the relevant variables to be documented. We also present preliminary results from the one-year test phase of the online platform that has recently been terminated, and our vision for the way onwards with the CITE project to be accessible to the reindeer herding community.

Cumulative impact

How do impacts accumulate? Increasing impacts of industrial activity and infrastructure on reindeer living in a fast-paced changing Arctic

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Species, ecosystems, and ecological processes are increasingly subject to a multitude of land use changes derived from industrial activities, human infrastructure, and climate change. This is especially acute in the Arctic, where fast-paced transformations have been affecting the habitat of reindeer (*Rangifer tarandus* sp.). Far from being isolated, these landscape changes usually co-occur, leading to cumulative or synergistic impacts on the species. Impacts can accumulate in different dimensions, e.g. due to multiple features of the same type of stressor, presence of multiple stressors, continued exposure of individuals to disturbance through time, or as a consequence of bottom-up processes when impacts on the habitat and individuals amass to affect entire landscapes and populations. In this study, we disentangled and explored these different dimensions of impacts on the habitat quality, on the movement, and on the landscape connectivity of wild and semi-domesticated reindeer in Scandinavia. We used GPS data from multiple herds in Norway and Sweden to infer the selection for grazing areas and movement paths and to estimate landscape quality, permeability, and functionality, from the perspective of reindeer. First, we present methods on how to account for the different dimensions of cumulative impacts, in a workflow from data to habitat selection modelling, connectivity modeling, and visualization. Second, we present case studies by applying these methods to estimate habitat loss and fragmentation for multiple herds of wild and semi-domesticated reindeer in Norway and Sweden. Finally, we show how this framework can be used to estimate the human footprint on reindeer habitat and make predictions of the impact of past and future landscape changes, under scenarios with new developments or mitigation actions. The approach allows us not only to compare the effects of different types of disturbances on wild and semi-domesticated reindeer, but also to assess where and how disturbances result in cumulative impacts.

Assessing the cumulative impacts of wind energy projects on reindeer husbandry - towards comprehensive planning and agreement

Mikko Jokinen

Natural Resource Institute Finland

The reindeer husbandry area covers a third of Finland's territory, and the whole of northern Finland. The reindeer economy has a legal right to exploit the land owned by both the state and private individuals and companies. There are numerous other land uses in the reindeer husbandry area, the most important of which are forestry and tourism. However, the newest and fastest growing sector is wind energy production, which is part of the so-called green transition and considered as climate measure.

Wind energy production is a new industry whose effects on reindeer and reindeer husbandry are not sufficiently known. Reindeer economy is concerned about the potential negative impacts, which are seen as adding to previous adaptation effects. From the viewpoint of sustainable land-use planning it is problematic that either companies, herders or authorities do not know simultaneous and cumulative forestry and wind energy effects on reindeer herding.

We have studied the best and most sustainable ways to negotiate and agree on how to build wind farms while mitigating and avoiding negative impacts on reindeer herding. Both herders, wind energy companies and municipal land use officials stress that the most important thing is early and direct communication to build trust between the herders' cooperative and the wind energy company and to avoid conflict situations. A major problem is that there can be several wind energy projects in one cooperative at the same time, and nobody knows the cumulative and multiple effects on reindeer husbandry. Environmental planning and monitoring systems need to be improved.

In this paper, our research team proposes a more holistic and regional approach to land use planning that recognizes these simultaneous effects. Without such strategic planning, there is a risk that forests will be used in an ecologically and socially unsustainable way, increasing the risk of environmental conflicts. We think that land-use planning in reindeer husbandry area can be improved by studying the multiple effects on reindeer and understanding practices of reindeer husbandry. It is a scientific, social and political process.

Advancing Ground Lichen Assessment: New Methods for Estimating Lichen Cover and Biomass

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Ground lichen abundance and availability are strongly influenced by modern forestry, other land uses, and climate change, posing significant challenges for reindeer and Sami reindeer husbandry. Reliable methods for mapping and quantifying lichen are essential for monitoring changes over time and informing sustainable forest management, environmental assessments, and consultation processes.

We present a robust method for estimating ground lichen cover and biomass at a local scale. Our approach integrates drone-derived NDVI and tree height data into a sampling design that ensures a representative distribution of sample plots across the study area, improving estimates by reducing variance and potentially lowering overall sampling costs. Field data on lichen cover and height collected from these plots are used to produce statistically unbiased estimates of lichen cover and biomass. We reviewed the literature to compare equations relating lichen volume to biomass. Combining data from five studies, we fitted a linear regression on lichen volume ($\text{dm}^3 \text{m}^{-2}$) and biomass ($\text{kg dry weight m}^{-2}$) through the origin, yielding a slope of 0.0148, which we used for our biomass estimates. We also linked the biomass estimates to reindeer grazing by calculating the annual grazing days an area can sustain.

To evaluate how field methods for assessing lichen cover vary, we compared the presence-absence, point-intercept, and visual estimate methods in sample plots. Our findings highlight that different methods can produce significantly divergent results. We recommend the point-intercept method for its objectivity and consistency, which are important to ensure broad acceptance of results, particularly in land-use conflict scenarios. Building on this work, we are exploring an alternative approach, using image segmentation for estimating lichen cover, which has the potential to deliver accurate and consistent cover estimates efficiently. Additionally, we are developing a field app to make this method widely accessible and practical for broader applications.

Soil Carbon Storage of the Northern Fennoscandian tundra is not linked to decades of differential land use by reindeer husbandry

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Tundra ecosystems represent vast reservoirs of soil carbon storage. However, knowledge of what is impacting these reservoirs is still limited. In this study we make a region-wide assessment of the effect of *Rangifer* herbivory, alongside topography, bedrock and climate, on impacting soil carbon storage. We apply the unique system of management districts of reindeer husbandry to address to what extent decades of differential land use by *Rangifer* herbivory have affected the soil carbon storage.

We collected soil samples of the whole soil depth from a range of sites within a total of 20 coastal summer pasture districts. The districts span a 5-fold difference in animal density over the last six decades and cover many different vegetation types, topographic regions, temperature, and precipitation ranges. We measured the total soil carbon stored in the soil, separating between mineral and organic soil layers, and analysed the data using linear mixed modelling.

We found large variation in the amount of carbon stored, and as expected, our statistical modelling suggested the amount of organic soil to be a significant predictor of soil carbon storage. However, our modelling did not reveal any other clear predictors, neither from *Rangifer* herbivory, topography, bedrock or climate nor their interactions. The random effects indicate that there is some variability at the district level but little at the smaller landscape level.

Based on our results we conclude that more than half a century of different intensities of *Rangifer* herbivory alongside differences in topography, bedrock and climate are not predicting the regional variation in carbon stored in the Northern Fennoscandian tundra. We suggest that *Rangifer* herbivory can both promote and decrease carbon storage, balancing the effects at the regional level independent of animal density, and that the variation in carbon stored in this tundra ecosystem needs to be investigated at a finer scale.

Can't take the heat? Warmer temperature speeds up seasonal decline in plant nutrient concentrations in the tundra

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Herbivores encounter vegetation that vary in their concentrations of essential nutrients. We investigated whether climate and reindeer grazing affect plant nutrient and defense compound concentrations across plant functional groups and over a large spatial scale.

The concentrations of nitrogen (N), phosphorus (P), silicon (Si) and phenolics (Ph) were measured in plant samples collected in northern Norway, across a gradient in summer temperature and at varying reindeer grazing intensities.

Plant nutrients concentrations (N, P) decreased, while defense compounds (Si, Ph) accumulated over the summer. The seasonal decrease in nutrients was faster in warmer conditions. We suggest that this faster decline in forage quality towards senescence may impact herbivores like reindeer in the context of climate change. We found no evidence that reindeer grazing intensity affected plant chemical composition directly, however, grazing intensity may alter forage quality through effects on the plant species composition.

Land use conflicts

Cumulative impacts of mine and wind industry on reindeer and reindeer husbandry

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In a “green” transition from coal and coke to fossil-free steel production there is an increased demand for renewable energy sources. In Sweden, an expansion of land-based wind power is considered to have the greatest immediate potential to meet this increased energy demand. Wind power is rapidly growing as a form of energy production in Sweden, occupying large areas of highlands with favourable wind conditions. Reindeer husbandry, forestry and mining activities have coincided and attempted to “coexist” for more than 100 years, but with this new industrial development happening the problem for reindeer husbandry may increase exponentially. Understanding the impacts on reindeer behaviour and land use and on reindeer husbandry is essential to reach a fair permission process when new exploitations are planned. In peer reviewed research articles, research project reports, and as expert evaluators in court cases, we have documented and compiled information on how reindeer and reindeer husbandry has been and may be affected. We have worked with both qualitative and quantitative data. Our approach has been permeated by a process of coproduction of knowledge based on a combination of traditional knowledge acquired through the self-interpretation of real-life experience of the Sami reindeer herders, and a wide range of objective analyses of GPS data from reindeer. We have worked together with reindeer herders who were affected by the wind power and mining establishment, iteratively producing, adding and verifying new knowledge. In study areas with wind power developments, we have analysed GPS data from reindeer covering the period before the establishment of the wind power plants, during construction, and operation phases. This has given us the opportunity to create a multifaceted and complex understanding of how reindeer and reindeer husbandry are affected by both mining and wind power expansion in a landscape with ongoing industrial forestry. Reindeer herders’ knowledge have been essential to understand how reindeer husbandry is affected by such an expansion and has also been the basis for understanding and interpretation of reindeer GPS data. Our results indicate that reindeer and reindeer husbandry are negatively affected by wind power expansion and mining, and that the degree of impact and the way in which it affects varies with area and season. Both mines and wind power hindered reindeer from moving between different grazing areas. The opportunity for optimal use of the pastures were also often negatively affected over several kilometers. Wind power establishments on winter grazing lands coincide with grazing areas, located at higher elevations. These sites have become particularly important for reindeer husbandry due to climate change, when repeated freezing and thawing events in winter cause ice crust formation in the snow at lower elevations, hindering the reindeer from grazing. Expanding wind power to remedy climate change thus means that reindeer husbandry is affected in multiple ways, partly by climate change and partly by the loss of the type of grazing areas which are more greatly needed when the climate changes.

Winds of change in natural resource governance: Wind power and reindeer husbandry building new means for reconciliation in Northern Finland

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The aim of reconciliation is embedded in various planning and decision-making processes such as zoning and EIA. However, when examining extractivist land uses the objective of reconciliation becomes challenging and complex. From the perspective of the agenda of green transition, the northern sparsely populated areas such as the Reindeer Management Area (RMA) are seen potential for siting renewable energy production like wind power. While these areas may be sparsely populated, they are in no means “empty”: wind power projects land within the cumulative continuum where reindeer herders have had to adjust to various forms of land uses and are in some cases faced with critical questions on ensuring their livelihood's future. (e.g. Österlin & Raitio 2020; Hast 2021; Horstkotte et al. 2022.)

Due to the various land-use pressures there are a large number of reconciliation processes taking place, such as zoning on regional and municipal levels, EIA procedures, various environmental permitting procedures, and bilateral contract negotiations between herding co-operatives and private companies. The burden of participation, together with the experience of limited influence, lead to protracted conflicts and stall development in the area (e.g. Österlin & Raitio 2020; Hast 2021; Kløcker Larsen et al. 2022; Kumpula et al. 2022).

Gathering from the re-occurrence of these conflicts, it seems that the existing planning and permitting processes are not equipped to prevent or manage local conflicts. The processes of reconciliation remain largely a “black box”, where the factors leading to disputes on the one hand or mutually acceptable agreements on the other, are not evident. This is why studying more closely the practices of reconciliation and resourcification are needed (Hast 2021).

In our paper we look at an emerging collaborative forum for reconciliation between wind power and reindeer husbandry in Finland in which we authors have actively participated. Starting from 2019 the actors from wind power sector, reindeer husbandry, and public authorities have worked together to formulate good practices for the operation of wind power projects in the RMA including creative ways to assess, mitigate and compensate for the adverse effects of wind power (Anttonen et al. 2023). By 2024, the actors, supported by a professional neutral third party, have established a forum for an on-going collaboration where they identify and address common issues beyond singular projects.

In our paper we take a closer look at this collaborative arrangement and reflect on the emerging new practices. We follow the notion by Hast (2021) stating that the constant nature of reconciliation calls for change in the methods of collaboration especially at policy level in order to create practices and capacities that help the parties deal with occurring conflicts. We consider the collaborative forum as an example of such progress as it provides opportunities for building trust and dialogue on policy level and hence helps parties address the fundamental causes of the conflicts and develop new collaborative practice.

Proposal for a revised methodology for impact assessments in reindeer husbandry areas

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NIBIO Norwegian Institute of Bioeconomy Research, Department of Wildlife and rangelands, Division of Forest and Forest Resources

Through a project commissioned by the Ministry of Agriculture and Food, NIBIO has proposed a revised methodology for environmental impact assessments (EIAs) for land use interventions in the reindeer herding areas in Norway. The main goal of revising the methodology was to incorporate the traditional knowledge of the reindeer husbandry into the assessment process. NIBIO invited other research and professional environments to contribute to this work. Additionally, a reference group of experienced reindeer herders was established and actively contributed to the work of proposing a revised methodology.

Initially, we reviewed numerous completed environmental impact assessments and discovered that the reindeer husbandry was involved too late in the planning and assessment processes. Additionally, their traditional knowledge regarding the reindeers' use of the area and their behavior in relation to interventions and disturbances was not included in the descriptions and assessments within the EIAs. The reindeer husbandry did not have the opportunity to quality assure the descriptions and assessments in the EIAs. Furthermore, the industry was not given the opportunity to evaluate whether the proposed measures to reduce the impact of the interventions were realistic and effective.

In the proposal for the revised methodology, we suggest, among other things, that the reindeer herding industry should be actively involved (in accordance with international law; ILO Convention No. 169 and the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP)) in determining the area of influence (impact zone) around the planned intervention. This is to ensure that all rights holders from the reindeer husbandry are involved in the assessment process. We propose that it should be required that the traditional knowledge of the reindeer husbandry should be included in all phases of the assessment. Therefore, we suggest that a binding process plan should be developed, which describes how the reindeer husbandry will be ensured active involvement throughout the entire assessment process. This includes the description of land use, valuation, and assessment of how the planned intervention will affect the reindeer's land use. Additionally, the reindeer husbandry should be given the opportunity to quality assure these descriptions and assessments.

Furthermore, we propose that assessments should be made on how all previous and planned interventions contribute to the cumulative burden on the reindeer husbandry. If this burden is significant, it should be considered and included in the overall assessment of the impact on the reindeer husbandry of the planned intervention. An important part of the new methodology for environmental impact assessments is that we propose that in the valuation of the land planned for development, the descriptions of the land's overall function through the reindeer's annual grazing patterns provided by the reindeer herding industry should be emphasized. When assessing how the planned intervention affects the reindeer, the traditional knowledge of the reindeer herding industry should be given equal weight to research-based knowledge. We propose that health, environment, and safety for reindeer herders should be included as assessment criteria in the EIAs.

Supplementary feeding of reindeer - the role of experience-based knowledge and knowledge exchange

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Rapid and interacting change have significant implications for livelihoods and food security, and Sami reindeer herders in Norway are at a crossroads both economically and culturally. Some of these changes concern changing weather and pasture conditions caused by climate and environmental change. Others, driven by national management policies, human activity and developments, are poorly adjusted for the different and localized contexts. Herders have a long history of responding well to changing conditions. This is now at stake with the continued multiple pressures. Supplementary feeding has traditionally been a practice strictly to alleviate pasture crises. With the changing herding conditions, however, supplementary feeding has become increasingly needed as an emergency measure to buffer the lack of pastureland. Supplementary feeding changes the material foundation of reindeer husbandry and herders point to a number of factors related to economic losses, threats of losing rights to pastoral land and risk of losing traditional knowledge about pastures. Feeding changes the practical execution of reindeer husbandry as well as the relationship between herders, reindeer and the landscape. There is also an increased risk of diseases directly and indirectly related to feeding. Disease occurrence negatively affects both animal welfare, herder welfare and the economic output. This study shows the importance of traditional and experience-based knowledges for supplementary feeding practices. Flexibility in feeding practices can particularly be seen in herding districts that have had to long-term feed their herd, whereby constant re-learning and adjusting their practices to do what is best for the animals has been key.

Effects of winter-feeding on reindeer's future ability to utilize natural pastures

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Winter feeding of reindeer has become an increasingly common in reindeer husbandry in Sweden, Finland, and Norway when natural grazing resources are unavailable due to the loss of grazing grounds, disturbances, and icing events. The long-term effects on reindeer's ability to utilize natural pastures have not been investigated, but herders have raised concerns that fed reindeer, especially calves, do not utilize natural pastures as efficiently as other reindeer. In this project, we investigated the short- and long-term effects of winter feeding on reindeer habitat selection and future foraging behaviour. Interviews were conducted to collect experience-based knowledge on the effects of feeding among reindeer herders. An experimental study was conducted to test how winter feeding of calves during their first winter affects future habitat selection, foraging behaviour, and body weight. We found that there are several unintended effects of feeding that may compromise reindeer's ability to use the natural pastures efficiently. In the interviews, the effects identified by herders were related to physical traits or behaviour; the reported effects varied between herders, as did the perception of whether an effect was positive or negative. In the experimental study, we found that reindeer calves which were fed in enclosures during their first winter of life were less likely to select areas with higher lichen abundance when on natural pasture compared to reindeer that had spent their first winter on natural pasture. Knowledge of the effects of feeding on reindeer is important for herders when evaluating if, when and how to feed their reindeer.

What is the position of the Sami people in Finland's reindeer husbandry?

Juha Joona

University of Lapland, Finland

Unlike many other indigenous peoples, the Sámi in Finland do not have any specific rights related to the use of land and water areas. This also applies to reindeer husbandry. Reindeer herding is not restricted to the Sámi as an exclusive right, nor does the Finnish Reindeer Husbandry Act provide any special provisions for Sámi reindeer husbandry.

However, the Sámi have historically held a special status concerning reindeer husbandry. In most of Finland's current reindeer herding area, the right to practice reindeer husbandry, is based, according to legislative preparatory works, on the Sámi people's historical land use rights.

There has occasionally been debate in Finland on whether reindeer husbandry should, as in other Nordic countries, be an exclusive right of the Sámi. Recently, however, such discussions have been less prevalent. Nevertheless, the legal position of reindeer herders of Sámi origin differs from that of non-Sámi reindeer herders. This distinction has also influenced legislation. For example, in Sweden, where reindeer husbandry rights are almost exclusively reserved for the Sámi, reindeer husbandry is considered a land-use right protected under property law. The legal framework surrounding reindeer husbandry in Sweden is also more comprehensive than in Finland.

The issue primarily stems from the understanding of reindeer herding rights as a private legal right based on immemorial usage. While it is possible that individuals other than the Sámi may fulfill the criteria for immemorial usage, the long-standing land use by the Sámi has specifically been deemed to meet such criteria. This raises the question of whether Sámi reindeer husbandry should be more robustly protected legally compared to reindeer husbandry practiced by those who do not meet the requirements for immemorial usage.

Another perspective concerns the human rights of Sámi reindeer herders. Reindeer husbandry is part of the Sámi culture, which is protected not only by Finland's Constitution but also by several human rights treaties ratified by Finland. This issue has become particularly relevant due to the recent construction of numerous mines and wind farms in Finland's reindeer herding areas. In some regions, these development projects are located in areas critical to reindeer husbandry. If reindeer husbandry were explicitly understood as a Sámi livelihood—rather than merely an occupation—having a say in such projects would undoubtedly be easier. The Fosen wind farm project in Norway serves as a related example.

Wellbeing of young Sami reindeer herders

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Sami reindeer herders are facing challenges related to work that have further effect on their lives. This highlights an increased need for comprehensive understanding of mental health and wellbeing, and further developing new actions to support holistic well-being of reindeer herders, especially at early stage. It is essential to hear about their life and experiences, challenges and needs, keeping in mind the context of traditional lifeways and culture.

This project, based to meet these requirements, concentrates on understanding the experience of mental health and wellbeing of young Sami reindeer herders in Finland. Within three years, the mixed method study follows approach of community based participatory research and participants will be reindeer herders and their family members. Additionally, arts-based methods will be utilized to gain an understanding of reindeer herders' everyday lives and current challenges. The final decisions, especially on the arts-based methods (data collection and publishing the results) will be determined in consultation with the study's advisory committee. Study advisory committee will be established from the reindeer herders. This is important in supporting, but also ensuring participatory research process throughout the project. Also, it provides a real voice and an opportunity for Sami reindeer herders themselves to talk about their lives. Keeping all this in mind, it is important to work with local people together during this project. Results of this study can be applied for, not only increasing an understanding about well-being of Sami reindeer herding, but also providing information to develop new services.

Friday 14 February

Climate change & adaptations

How can we adapt to climate change and navigate in new conditions? Climate Challenges and Practical Solutions in Gran reindeer herding community

Marja-Kristin Skum & Anna-Marja Kaddik

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In 2022, Gran reindeer herding community completed a climate and vulnerability analysis, funded by the Swedish Sámi Parliament and conducted in collaboration with SMHI (Swedish Meteorological and Hydrological Institute) and the county administrative boards of Västerbotten and Norrbotten. The study, initiated by workshops with all members of the community, explored how changing grazing conditions and the impacts of climate change—such as warmer and more unpredictable seasons—affect reindeer herding, focusing on spring, summer, and autumn pastures.

The analysis was based on four aspects: how our reindeer herding is carried out today, how climate change has altered weather and grazing patterns, what adaptations are needed under future scenarios and land-use pressures, and how practical measures can be planned and implemented. Preliminary findings from a new analysis on winter pastures, to be completed in April 2025, will also be shared.

This presentation highlights how combining Sámi traditional knowledge with Western scientific methods provides actionable strategies for navigating climate uncertainty. We will also discuss collaborative projects with organizations like Rewilding Sweden to restore forest ecosystems degraded by industrial forestry, offering examples of ecological restoration.

The analysis serves as a vital resource for reindeer herders, researchers, and policymakers, offering practical guidance to address challenges and consequences and plan for a resilient future in reindeer herding.

Open topics

Lichen Indicator Maps (1980 and 2020): Enhancing Understanding of Reindeer Landscape Use and Supporting Restoration Planning

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We developed two ground lichen cover maps for Sweden's entire winter reindeer foraging area, representing conditions in 1980 and 2020. The 2020 map was created using Sentinel-2, LiDAR, and geomorphological data at a resolution of 10 m x 10 m, while the 1980 map utilized Landsat 5 and geomorphological data at a resolution of 30 m x 30 m. Swedish National Forest Inventory data served as training inputs for both models. To enhance usability, the continuous lichen cover predictions were categorized into four distinct cover classes (0–10%, 10–25%, 25–50%, >50%).

The 2020 map provides insights into how reindeer utilize the landscape under winter conditions today, identifying not only lichen-rich areas but also their connectivity. This information is critical for stakeholders to address land-use conflicts as land-use planning and evaluate habitat availability and quality.

By comparing the 2020 and 1980 maps, we can spatially visualize the loss of lichen-rich habitats over time. This comparison reveals patterns of persistence and decline, offering valuable lessons on forest management strategies that promote lichen retention. Moreover, areas with historically high lichen cover are identified as prime candidates for restoration efforts, as they may be more suitable for successful reestablishment of ground lichens.

The reliability of the 2020 lichen indicator map was validated using specialists – reindeer. GPS tracking data from reindeer demonstrate that the lichen indicator map strongly predicts reindeer movement during winter compared to other landscape features.

These maps serve as essential tools for understanding reindeer habitat use, mitigating land-use conflicts, and guiding strategic restoration planning.

The increase of crowberry undermines reindeer pasture quality and current management in the Norwegian tundra

Maria Tuomi, Tove Utsi & Kari Anne Bråthen et al.

UiT, The Arctic University of Norway

Ongoing Arctic greening can increase productivity and reindeer pasture quality in the tundra. However, greening may also entail proliferation of unpalatable species, with consequences for pastoral social-ecological systems. Here we show extensive greening across 20 reindeer districts in Norway between 2003 and 2020, which has reduced pasture diversity. The allelopathic, evergreen dwarf-shrub crowberry increased its biomass by 60%, with smaller increases of deciduous shrubs and no increase in forbs and graminoids, the most species rich growth forms. There was no evidence for higher reindeer densities promoting crowberry. The current management decision-making process aims at sustainable pasture management but does not explicitly account for pasture changes and reduced diversity. Large-scale shifts towards evergreening and increased allelopathy may thus undermine the resource base for this key Arctic herbivore and the pastoral social-ecological system. Management that is sensitive to changes in pasture diversity could avoid mismanagement of a social-ecological system in transition.

See also: Tuomi, M.W., Utsi, T.A., Yoccoz, N.G. et al. The increase of an allelopathic and unpalatable plant undermines reindeer pasture quality and current management in the Norwegian tundra. *Commun Earth Environ* 5, 414 (2024). <https://doi.org/10.1038/s43247-024-01451-2>

Reindeer as data: tracking movement and (un) greening the effects of wind power development

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This study explores the scientific assessments of impacts of industrial infrastructure on reindeer in Norway and in Sweden amidst land use conflicts by examining how the digital tracking and data therein have shaped animal and human relationships in different ways. It is part of an ongoing doctoral research in the social sciences where I ask: In data-saturated landscapes, how do tracking data become relevant to the study of the entanglements of animals and energy industry? What sensory worlds can these informational driven methods of impact assessments generate?

In both normative and critical literatures, networks for monitoring organism and ecosystems in natural sciences has become the main technical solution for the global environmental crisis, where action and decision-making is reassociated with data production and sharing, and vernacular ways of sensing and expressing environmental change remain underarticulated. Here I propose a more nuanced ethnographic account of the data practices and methods that have been deployed by two main research groups in Norway and Sweden in the past two decades. To the task, I combined document ethnography of impact reports, scientific papers and literature reviews published with the analysis of the materials from interviews and conversations sustained with scientists since 2019.

In the same period of recent expansion of green transition infrastructural projects, reindeer has become the most tracked terrestrial animal on the planet, with the largest number of digital position points ever produced on a deer. This study describes the shift from data collection through distinct techniques mainly by direct interaction with reindeer herds in the pastures towards the digital methods with the use of data from distributed sensors for investigating how the species inhabits Arctic environments. Tracking devices bring with them distinctions in how reindeer's response to human activities and infrastructure is observed and how the behavior data is interpreted. I argue that this shift towards an understanding of reindeer-space relations through remote sensing technologies changes what spatial-temporal scale is relevant and distributes who counts as sensing subjects. As researchers do less fieldwork, they became more dependent on data collection by those directly working with the herds. I highlight that the scientific definitions of reindeer sensitivity to infrastructure have been entangled with the back-and-forth travel of impact definitions between research institutions, wild hunting areas, and Sami districts, across borders.

Inspired by the contemporary scholarship on sensing technologies and datafication of nature in understood as practices, the study explores reindeer tracking as part of *sensory encounters*. In this study, sensory encounters materialized two divergent hypotheses: whereas the establishment of new energy production and reindeer activities can be made compatible, energy infrastructure can also be framed as one more negative impact that accumulates in the landscape.

The validity of economic viability as a description of reindeer herding

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Reindeer herding is facing multiple challenges. Climate change and growing land use are testing the resilience of reindeer herding. With the continuously changing local and global environment, expenses in reindeer herding have been increasing as prices are going up globally. Economic viability of reindeer herding is challenged. In Northern Finland, reindeer herding has for long struggled with high costs and low income. Income from reindeer herding rarely covers all the costs. The economic viability of reindeer herding is a current discussion topic in the Finnish Reindeer Herding Area. Herders need to consider if they can continue their livelihood as climate change has extended the feeding period, predators are changing the herd sizes and extractive industries are reducing pastures. Through a creation of an example reindeer farm from Northern Finland, the current economic situation is presented and analyzed with the help of viability factor, which has stayed under 1,0 for the past 20 years in Finland, meaning that the income has not covered the costs. The example farm presents the types of costs and income reindeer herders have and maps the percentages of those expenses and incomes. The economic numbers are telling one story of the viability of reindeer herding and showing the economic imbalance herders face. However, reindeer herding is still an alive livelihood striving through the economic challenges. With the help of livelihood approach the socio-cultural aspects of reindeer herding are added into the discussion of viability of reindeer herding. Reindeer herding as a traditional livelihood stretches beyond economic numbers, thus describing reindeer herding merely through economic lens can be lacking perspective. The viability of reindeer herding reaches further than economic limitations, as reindeer herding is a holistic livelihood.

Posters

Sustainability Perspectives on the Forestry and Reindeer husbandry conflict

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The reindeer husbandry area covers the northern half of Sweden and is simultaneously used for other practices, such as forestry. Modern forestry has since the 1950's severely affected reindeer pastures negatively due to intensified forest management, which has resulted in a decrease in lichen rich forests with over 70 %. Although forestry is obliged to take reindeer herding into consideration, lichen rich grounds keep decreasing with ca. 1 % per year, resulting in loss of winter forage for reindeer. The trend of declining lichen pastures must be reversed for reindeer husbandry to continue in a traditional way based on natural pastures. The loss of pasture leads to more supplementary feeding that is both costly and may affect health and welfare for reindeer as well as reindeer herders. The aim of this PhD-thesis is to investigate perspectives on the conflict between forestry and reindeer husbandry, focusing on sustainable practices.

The conflict between reindeer herding and forestry entails many interdisciplinary aspects. In a thematic review, we will investigate key concepts and themes regarding sustainability in the current scientific literature on the forestry and reindeer husbandry conflict. Emerging themes may include for example ecology, economy, social aspects, technology, reindeer welfare and judicial aspects. Furthermore, we will explore the concept of Visionary Goals (*Målbilder* in Swedish) in the context of forest management adaptations to reindeer herding. Visionary goals for nature consideration were developed due to the continued discrepancy between the forest agency and the forest companies regarding what it actually entailed to take nature, and culture values into consideration. In that regard, it is similar to the different views between forest companies and reindeer herding on what is sufficient consideration. Through interviews with reindeer herders and foresters, we will explore the potential of Visionary Goals for consideration to reindeer husbandry and reversal of the trend of declining lichen pastures.

In parallel research, including field experiments, we aim to develop thinning schemes that improve reindeer pastures in commercial forests. We also aim to investigate how reindeer behave in the landscape with regards to forest management practices, using time and motion studies, image analysis and GPS-data from reindeer. This will potentially reveal differences in time budget and foraging behaviour between different types of forest stands. Different types of stands create different snow conditions, which can be both favourable and unfavorable for reindeer grazing during different weather events. Further understanding of how reindeer and herders utilize different forest stands during different conditions can contribute to better knowledge for landscape level planning to ensure reindeer access to different kinds of pastures.

The objective for a poster during the conference is to share this PhD-project at its current early stage. We hope to encourage dialogue with regards to future forestry management to promote lichen rich pastures as well as developing our project with insights from reindeer herders and other scientists.

“There’s no future in ice”: Lichen, Reindeer, Olfaction and Environmental Change

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Olfaction is a vital and neglected sensory aspect of place-making and interspecies communication. Ephemeral and invisible, smell chemicals are exchanged at all scales, from the molecular to the atmospheric, flowing between microbes, fungi, plants, animals, soil, water and air. Odorants move through and between bodies and species, integral to life processes and multi-species place-making. However, olfactory orientations are increasingly redolent with the pungent stench of colonial and capitalist over-consumption, extraction and terra-firming. In the long dark winters across Sápmi, reindeer forage through the forests attracted by the smells of lichen buried under layers of snow. However, climate change causes rain and unpredictable snow melts, where melted snow freezes into ice. The volatile chemicals released by the lichen can’t diffuse through the ice and reindeer struggle to find their food. This seemingly small shift in olfactory relations between lichen, reindeer and frozen water has profound effects on multispecies migration, economies and cultures. This paper describes an artistic research project, “*There’s no future in ice*,” which explores how creative practices can help us better understand the olfactory relations of lichen, reindeer and ice, non-human experiences of ecological grief and loss, and the responsibilities of settler-colonial consumption.

Sami Perceptions of Ecological Changes - a project under construction

Nicolas Bureau

UMR METIS - Sorbonne University

This project, funded by Sorbonne University and carried out by the METIS research laboratory based in Paris, aims to analyze the effects of permafrost thaw on the spread of trace elements (including heavy metals) in the environment and their potential presence in the reindeer's organisms. The aim would be to assess the presence of these elements in the soils, vegetation (lichens, fungi, etc.), and reindeer, in order to analyze climate change in Arctic regions. Our wish is to facilitate the identification of ongoing and upcoming ecological changes and to report to reindeer herders on the consequences these changes could have on pastures and the health of their animals. To confirm the presence of trace elements, we first want to analyse reindeer hair, in which they might be visible. That's why we hope to hold talks with reindeer herders and scientists to develop a non-invasive sampling protocol that is easy to set up and not too time-consuming.

Furthermore, since our study combines biogeochemistry and anthropology, it seems pertinent to us to ask reindeer herders about their perceptions of ecological changes in their territories, in order to discuss with them their choices regarding transhumance routes, for example, and the necessity or not of providing dietary supplements to their animals. During this conference, we would be happy to present this project and discuss it with the scientific community, as well as with the Sami reindeer herders, in order to see what could be possible to achieve together. We would like to take advantage of this presentation to discuss future protocols that we wish to build together with the herders. Likewise, we would like to discuss the diffusion and use of the results we could obtain, so that they can serve the Sami reindeer herders.

Circular economy – additional income for reindeer herding?

Sanna-Mari Kynkäänniemi¹ & Niina Mattila²

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The number of slaughtered reindeer is decreasing due to predators in Finland. Slaughterhouses and reindeer herding districts are facing economic challenges. The meaning of this work is to study how side streams of the reindeer can increase the income from slaughtered reindeer. Here we present how linear model of side streams in reindeer slaughtering can be developed towards circular economy model. For example, collecting and selling the skins from reindeer legs brought more income to slaughterhouses in Salla and Kuusamo than selling the pelts of the reindeer in 2023. We are also developing a design tool for planning to collect side streams and testing the profitability of them. We suggest that developing the tool we need to consider environmental, economic and social values because collecting side streams brings additional work and challenges in changing the methods related to slaughtering. This work is part of the wider project, circular economy in practice in reindeer slaughtering, where we share information from side stream collection to reindeer slaughterhouses.

Animal Welfare at Reindeer Slaughter: Enhancing Training through Virtual Reality

Kirsi Muuttoranta, Karoliina Majuri, Mari Ronkainen, Juha-Matti Taikina-aho & Jarkko Piippo

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Reindeer meat is a premium quality product, produced in accordance with ethical principles. The ethical meat production process culminates in the consideration of animal welfare during reindeer slaughter. Key pre-slaughter factors affecting reindeer welfare and meat quality include transportation, handling, and stunning.

At reindeer slaughterhouses, workers are mostly reindeer herders themselves. During the hectic season, these slaughterhouses face challenges in maintaining adequate staffing levels. New recruits are needed yet require training. One part of the training is a certificate of competence to comply with animal welfare legislation.

In the poster we present implementation of a virtual reality (VR) training environment to facilitate sustainable learning for new recruits. The VR system comprises three components: 1) a VR environment with a headset and hand-held controllers, 2) a 3D model of the slaughterhouse, accessible via an internet browser, along with animations presenting the various phases of the work, and 3) an online material bank for slaughterhouse personnel.

The VR headset and controllers allow trainees to experience the slaughterhouse environment as if they were workers, enabling them to familiarize themselves with the setting and practice handling live animals. This approach prioritizes safety and animal welfare while providing immersive learning experience. Training in the VR environment makes it easier for new workers to transition to real slaughterhouse work, ensuring that animal welfare and meat quality are integral parts of their tasks.

The virtual slaughterhouse aims to attract young reindeer herders to the profession and offers a safe training platform before working with live animals. These elements collectively provide comprehensive learning experience, enhancing the training process for all workers. Feedback indicates that elementary training benefits from the VR environment, lowering the threshold for joining the slaughterhouse workforce in the reindeer herding district.

The virtual reindeer slaughterhouse was developed as part of a project funded by the European Social Fund through the Centre for Economic Development, Transport and the Environment. The learning environment has been used among young reindeer herders, as well as students in agriculture and veterinary science.

Using the Public Participation GIS system (PPGIS) to share information on the effects of climate change and land use on reindeer husbandry

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As part of the MountResilience project, we are developing the use of a Public Participation Geographic Information System (PPGIS) to collect and share local and practitioners' knowledge on the effects of climate change and land use on reindeer husbandry. PPGIS is an online tool that allows respondents to mark locations on a map and provide information about those locations.

In MountResilience we gather information from reindeer herders, tourism companies, locals, and visitors in Enontekiö and Utsjoki, the most mountainous municipalities in northernmost Finland. In the first phase (2024), we launched a PPGIS questionnaire to collect information on what types of changes respondents have observed in nature and on reindeer pastures. We also asked reindeer herders about their views on the impact of other land uses. In the second phase (2025-2026), the results of this PPGIS questionnaire will be used as background material when reindeer herders develop their climate change adaptation plans.

In the final phase (2026-2027), the aim is to integrate the use of PPGIS systems as a continuous practice in the municipalities of Enontekiö and Utsjoki. The goal is to use PPGIS systems to identify the most important and vulnerable areas where other land uses or climate change may threaten local reindeer husbandry. This would help municipalities in land-use planning and in supporting reindeer husbandry to cope with the effects of climate change.

More information about MountResilience: <https://mountresilience.eu/>

Microbial quality of hunted moose (*Alces alces*) and white-tailed deer (*Odocoileus virginianus*) carcasses in Finland

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In Finland hunting is a popular hobby and the quality of the game cervid carcasses had not been studied in Finland. Hunting and harvesting of the carcass have traditionally been taught in the family or co-hunters of the same hunting club. Hunting hygiene has been taught to some hunters over the years, but the knowledge range was thought to be wide. As for this also the carcass microbial quality range was thought to be wide. As the intestinal content and the skin are usual contamination sources in skinning and evisceration, we checked for zoonotic pathogens from the examined carcasses, assuming that zoonotic pathogens might be present.

In our study we examined 100 moose and 100 white-tailed deer carcasses by surface swabs from four parts of the carcass having one sample area of 25 cm² so total of 100 cm² per carcass. Surface contamination varied widely, and moose carcasses was more often contaminated than white-tailed deer carcasses. Mesophilic bacterial (MAB) counts in moose varied 1,4-8,4 log₁₀ cfu/ cm² (mean 4,2) and in white-tailed deer 1,4-8,1 log₁₀ cfu/ cm² (mean 4,5). Enterobacterial (EB) counts in moose varied 0,1-6,8 log₁₀ cfu/ cm² (mean 2,6) and in white-tailed deer 0,1-5,0 log₁₀ cfu/ cm² (mean 1,5). *E. coli* (EC) -bacterial counts in moose varied 0,1-2,3 log₁₀ cfu/ cm² (mean 1,2) and in white-tailed deer 0,1-3,3 log₁₀ cfu/ cm² (mean 0,7). Higher bacterial contamination was found in smallest hunting lodges with only one room. Gut hits were seen as high EB-counts of the carcasses. If the EU-legislation of microbial quality in carcasses would have been applied with MAB 25/100 moose and 34/100 deer would have been unacceptable. With EB-counts 47/100 moose and 23/100 deer would have been unacceptable.

We studied meat-borne pathogenic bacteria we looked for *Campylobacter* spp., *Salmonella* spp., stx-positive *E. coli* (STEC), *Yersinia enterocolitica* and *Listeria* spp. *Campylobacter* were found with PCR in 6,0 % of moose carcasses and 2 % of white-tailed deer carcasses. *Salmonella* was found with PCR in 4 % of moose carcasses. STEC was found in 16 % of moose and 12 % of white-tailed deer carcasses. *Yersinia enterocolitica* was found with PCR in 6,0 % of moose and 9,0 % of white-tailed deer carcasses. *Listeria monocytogenes* was found in 8,0 % of moose and 12,0 % of deer carcasses.

Our research suggest that hunting hygiene and training of the hunters is needed to raise the quality of hunted moose and white-tailed deer. The research suggests also that moose and white-tailed deer meat are potential sources of food-borne pathogens and should be taken into account when cooking.

See also: Food Microbiology 78 (2019) 82-88: Microbial contamination of moose (*Alces alces*) and white-tailed deer (*Odocoileus virginianus*) carcasses harvested by hunters. Mikaela Sauvala, Sauli Laaksonen, Riikka Laukkanen-Ninios, Katri Jalava, Roger Stephan, Maria Fredriksson-Ahoma.

Winter feeding of reindeer - effects on reindeer behaviour, herding practices and the environment

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Reindeer husbandry relies on access to natural pastures, but the effects of climate change, competing land use and predator presence increase the need to provide reindeer supplementary feeding. Herders must consider various factors before deciding to feed, balancing positive and negative effects. In Finland, winter feeding is common due to limited pastures, while in Sweden and Norway, it mainly occurs during harsh winters to prevent starvation and ensure animal welfare. In a series of preparatory workshops within each country and a main workshop in June 2022 with 26 reindeer herders, researchers and managers, we discussed effects of feeding on reindeer behaviour, herding practices and the environment. The work aimed at promoting knowledge exchange on winter feeding of reindeer to find solutions and mitigation actions to avoid negative effects of feeding on reindeer, reindeer herding and the environment. Many issues were discussed in relation to behaviour. For example, reindeer that have been fed previously adjust more easily to winter feed, making it easier to start feeding if winter conditions change. The choice between natural grazing and winter feeding poses difficulties, as fed reindeer alter their movement patterns and behaviour, making herding challenging. Previously fed reindeer may move towards feeding areas complicating herding operations, and when on natural pasture they seem to move around more and not stop for grazing. Snowmobiles, commonly used for feeding, create associations with food, making it hard for the herder to herd the reindeer. Several herders had concerns about decreased foraging efficiency and potential impacts on survival and predator vulnerability. The experience was also that type of feed influences reindeer behaviour with less activity among the reindeer if they were only given concentrated pelleted feed compared to silage. There was an agreement that feeding reindeer in the same area for extended periods negatively impacts vegetation, particularly in sensitive ecosystems like mountain tundra and dry forests with lichen heaths. In forests understory composition may be altered due to fertilization and trampling, intense grazing, may wear down vegetation, exposing bare soil. Notably, herders observe less impact on vegetation when reindeer are fed on peatland or grass heaths. Many herders emphasize the importance of continued pasture rotation, from areas where reindeer have dug for lichens to untouched snow, mimicking natural grazing patterns and minimizing ground wear. We concluded that reasons for feeding vary, and that feeding is becoming more common. If winter feeding is needed, the best for the reindeer's future grazing behaviour and a sustainable herding practice is to feed animals on natural pastures. However, in relation to the pasture and the environment it would be best to feed reindeer in enclosures. Thus, it is difficult to accomplish both needs and reindeer herders are often left to make a trade-off between the two.

EQUIP – Is reindeer husbandry equipped to handle the perfect storm?

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Reindeer husbandry is experiencing numerous novel environmental stressors with cumulative effects that are becoming increasingly difficult to manage. Climate change is severely affecting northern areas, with extreme and unpredictable weather. More extensive anthropogenic land use in reindeer grazing areas alters and diminishes these areas and habitats. These combined disturbances are causing a decrease in, and degradation of, the natural pastures used by reindeer. Additionally, successful predator conservation is increasingly forcing reindeer husbandry to coexist with large populations of predators. Reindeer herders report high losses (40-70%) of calves from July to November, which cannot be explained by predation alone and thus needs to be investigated further. The disturbances in reindeer grazing areas not only impact the reindeer, with poorer grazing, but can also result in changed disease transmission dynamics and disease susceptibility due to lowered body condition. This ultimately leads to herds being in worse condition and less resilient to cope with additional outside disturbances and stressors. The aim of the EQUIP-project is to investigate how elevated calf mortality is connected to different disturbances and environmental stressors. This is done through a collaboration with three reindeer herding communities in Sweden, which all report different challenges causing increased calf mortality; one of them with high calf mortality due to predators (30-50%); one with partly unknown causes of calf mortality (40-70%); and the last with low calf mortality (5-10%) but high proportions of parasite findings at slaughter (50%). The project commenced during calf marking in the summer of 2024, where 400 calves (150 in two of the herding communities and 100 in the third community) were sampled. The calves were weighed and blood samples, swabs from the eyes, nose and genitalia, as well as fecal samples were collected from each individual, for disease diagnostics including parasitology. Ear samples were also collected from approximately 50 of the calves in each herding community for genetic analyses. Additionally, each of the sampled calves in two of the three communities and 50 in the third were equipped with a GPS-tracker from calf marking to autumn slaughter enabling tracking of the calves' movement. The collars also had mortality alarm, making it possible to rapidly collect the carcasses for necropsy to investigate cause of death. Unfortunately, not all GPS-trackers worked properly throughout the first sampling period. Despite this, 17 dead calves were collected between July 9th until October 21st. All calves that survived from calf marking until the autumn were sampled again during autumn slaughter or winter gathering. The sampling and GPS marking will be repeated in 2025 with new calves. Ultimately, the hope is to identify causes of calf mortality and reductions of calf condition at slaughter. This knowledge will help seeking solutions to reduce calf mortality and mitigate other negative effects caused by new environmental stressors and disturbances of reindeer herding.

Drones in reindeer husbandry

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The introduction of unmanned aerial vehicles (UAV), or drones, to traditional reindeer herding has - literally - given indigenous Sámi herders a new perspective: the aerial one.

Areas of hard-to-reach reindeer rangelands can now be accessed through drone cameras, and drones can make finding, collecting and driving reindeer easier. Drones are light and mobile *ad hoc* tools. They fit into a backpack which can easily be transported into difficult terrain and can fast reach areas dangerous for people or helicopters. The aerial view of the drone enables significant savings in work time, physical strain, fossil fuels and costs.

Drone operations support herders in finding and collecting animals in challenging terrain, moving animals (away from predators, agriculture, avalanche terrain, traffic or between seasonal pastures), monitoring predators, monitoring reindeer behaviour and health, finding and documenting animal losses, checking fences and herding infrastructure, finding suitable pasture or safe migration routes. Experienced herders using drones also report a gentler approach to driving animals with a drone compared to a helicopter. They themselves can perform drone operations in combination with their traditional knowledge of reindeer behaviour. Many report they have observed reduced stress and strain for the animals compared to helicopter use. At least in parts, some of these costly helicopter operations may now be replaced by drone use. The potential reduction in CO₂ emissions based on decreased helicopter use is significant and could be measured in tens of tonnes in a best-case scenario. The potential for reduction depends on the type of helicopter and varies in time and space with helicopter type availability. Using drones instead of helicopters will further contribute to improved animal welfare and increased health and safety for the herders together with decreased costs due to less fossil fuel use and off-road-vehicle maintenance. Drones have been used in a field experiment to find above-ground cadavers and proved to be significantly more efficient than cadaver dogs both in success rate and time required. Soon drones will count reindeer with the help of AI in the visible and thermal spectrum.

Challenges to increased drone use in reindeer husbandry include legal obstacles to drone use beyond line of sight, investment costs and operator education. These may be met by pooling of investments, infrastructure and personnel by establishing drone companies overseeing many registered pilots from different locations and with a background in rangeland use.

A new reindeer herd and a new windfarm: a coincidence for adaptation through increased herding activity or crisis?

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The establishment of the Kvitfjell/Raudfjell wind farm in a reindeer winter, springwinter, spring (*dálvi*, *giddádálvi*, *gidda*) range in northern Norway, operational since 2020, has raised concerns about potential impacts on area use and herding. The wind farm was constructed between October 2017 and December 2020. Two years prior to construction, a herding family introduced their reindeer to this area, engaging in intensive herding activities to train the animals to navigate and utilize the best grazing sites. Moreover, the herder provides supplemental feeding during winter feed shortages, particularly under heavy snow conditions. The development of the wind farm is a concern to the herder, complicating winter herd management and availability of grazing resources.

To assess the effects of the wind farm on reindeer area use and grazing patterns, we analyze GPS data from 2015 to 2024 alongside herders' knowledge. The data cover the period prior to construction (~2 years), development phase (~3 years), and operational phase (4 years) of the windfarm. The study covers 4 seasons based on herders' information (early winter, late winter, spring and summer). We used Brownian bridge movement model (BBMM) to estimate yearly seasonal home ranges. We applied resource selection functions to identify reindeer habitat selection (use vs. availability), before, during and after the windfarm construction for each season.

Preliminary analysis indicates patterns of avoidance during late winter and spring in some years, suggesting possible aversion behaviors influenced by the wind farm. However, the intense herding practices introduced by the herder complicate our ability to isolate the wind farm's impact. Herding interventions may mitigate or obscure clear behavioral responses, as reindeer are actively guided through grazing sites, particularly during the earlier years.

While these early results provide some insight, definitive conclusions regarding the wind farm's impact on reindeer herding and the grazing resources remain as yet unclear, and further analysis is ongoing. This study aims to contribute to the understanding of renewable energy development in regions with social-ecological systems and inform best practices for balancing energy needs with the sustainability of traditional livelihoods.



