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CONFERENCE ABSTRACTS

The role of large herbivores for biodiversity in boreal forest ecosystems

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Background

Herbivores play an essential role in shaping plant productivity, community composition, and biodiversity through herbivory, trampling, and nutrient cycling (Côté *et al.* 2004, Persson *et al.* 2005, Tanentzap & Coomes 2012). In the boreal forests of Sweden, moose and reindeer influence and respond to forest management (Suominen & Olofsson 2000, Edenius *et al.* 2002, De Vriendt *et al.* 2023), but knowledge on their long-term effects on forest biodiversity over the full harvest cycle in managed forests is lacking. Most northern boreal forests are managed through rotational clear-cutting of Scots pine and Norway spruce monocultures, while old-growth forests, rich in biodiversity and important foraging grounds for reindeer, are becoming increasingly rare. While moose typically benefit from young stands (Esseen *et al.* 1997, Massé & Côté 2009, Edenius & Ericsson 2015), reindeer depend on lichens (Suominen & Olofsson 2000) for winter forage, typically found in older forests with high natural values. Only a small portion of Sweden's forested land consists of pristine forests, many of which predate the introduction of clear-cutting as a harvesting method (Ahlström *et al.* 2022) and were thus last significantly disturbed by fires. This discrepancy implies that herbivore-plant dynamics differ between managed and pristine forests, yet these interactions have not been compared directly. This research will help inform sustainable management and reach national and international goals for forest biodiversity and conservation.

To this end, this project will explore two key questions:

1. How does herbivore habitat use and grazing pressure change over time in managed (even-aged) versus pristine boreal forests?
2. How do herbivores affect forest regeneration and biodiversity over time in these contrasting forest types?

Methods

In this project, we use two forest chronosequences of managed and unmanaged boreal forests, spanning 1-109 years post-clearcutting and 4-375 years post-fire, to examine the effects of moose and semi-domesticated reindeer in shaping tree regeneration and biodiversity across forest types and ages.

Four hypotheses are tested: (1) herbivory is driven by forage availability—moose pressure peaks in young forests, reindeer in old lichen-rich stands; (2) moose limit tree regeneration more strongly than reindeer; (3) moose browsing is seasonal—broadleaves in summer, conifers in winter; (4) habitat use by moose and reindeer have distinct effects on biodiversity.

We measure herbivore impacts through browsing and droppings across all plots, combined with vegetation, soil, and structural data. This will be complemented by experimental treatments (herbivore exclosures, trampling simulations, planting, and seeding) where we assess how herbivory and trampling affect biodiversity and tree establishment. Together, these observations and experiments will explore how moose and reindeer influence regeneration, biodiversity, and ecosystem function across boreal forest succession.

Release of sucrose affect in situ nitrogen availability differently in fertilized boreal forest soil compared to non-fertilized soil

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Background

The carbon sink strength of boreal forest during the current and future global change is a subject of great uncertainty. Increased atmospheric carbon dioxide concentrations have the potential to lead to an increase in plant biomass production, which is however strongly dependent on soil nitrogen availability. Through exudation of energy-rich carbon compounds, plant roots are considered to have an important influence on soil microbial activity and consequently on soil nitrogen cycling. But through the multitude of mechanisms in which root exudation can affect soil nitrogen cycling there are still uncertainties regarding the effect on nitrogen availability for plants. For instance, by providing usually carbon limited microbes with an easily available carbon source in form of root exudates, plant roots can stimulate microbial decomposition of soil organic matter, and by that increase availability of nitrogen in the rhizosphere. Alternatively, the stimulation of microbial growth could lead to greater competition and immobilization of the available nitrogen compound in microbial biomass resulting in overall decreased availability of soil nitrogen. However, microbial biomass can in turn become a critical soil nitrogen source via viral predation, protozoa grazing, or microbial death and starvation e.g. when the carbon fluxes from the root have seized.

Methods

A useful tool to study the relationship between root exudation and soil nitrogen availability at a high spatial resolution at the root tip scale, is microdialysis. This tool allows for the simulation of root exudation, through the targeted release of a compound of choice, while simultaneously sampling resulting effects on nitrogen availability and presence of extracellular enzymes. In a previous study we found that simulated root exudation in form of sucrose release led to a significant decrease in inorganic nitrogen fluxes in organic forest soils. However, no statements about the underlying mechanisms and how sucrose release affected organic nitrogen could be made during this study. Additionally, as soil fertilization affect soil microbial communities and therefor the effect of root exudation on soil nitrogen availability might also be affected. To investigate the effect of fertilization on the relationship between root exudation and soil nitrogen availability and to learn more about the underlying mechanisms of the observed nitrogen fluxes, we set up a similar microdialysis study, with an additional focus on extracellular enzyme activity and amplicon sequencing of the microbial community in soil and on the microdialysis probe. In microcosms, containing long-term fertilized and unfertilized boreal forest soil, we mimicked growth of a root tip through and passed the point of observation, by releasing sucrose during 7 days, followed by a 7-day period of carbon starvation.

Main results

Sucrose release led to a reduction of ammonium fluxes in non-fertilized soil, while not being affected in fertilized soil. Contrary to this, nitrate fluxes were reduced upon sucrose release in fertilized soil whereas nitrate was undetectable in non-fertilized soil. Amino acid fluxes increased during both sucrose release and starvation in non-fertilized soil, which coincided with increased oxidative enzyme activity, whereas hydrolytic enzyme activity was unaffected.

Conclusion

These results confirmed varying responses to root exudation caused by fertilization.

The separate roles of vascular plants and Sphagnum mosses in regulating the boreal peatland carbon cycle

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Background

Northern peatlands are an important sink for carbon. Peatland carbon uptake and release are influenced by abiotic and biotic factors (eg. vegetation composition, plant phenology). Plant functional types (PFTs) exhibit differing phenological patterns and responses to environmental factors, leading to seasonal shifts in their respective contributions to peatland net ecosystem CO2 exchange. Further, the presence of vascular plants may regulate methane (CH4) emissions by introducing a plant-mediated transport pathway and increased substrate supply for CH4 production. However, detailed knowledge on the separate responses of PFT-specific production and respiration of CO2 and CH4 to abiotic and biotic factors on daily to sub-seasonal scales are currently missing.

Methods

In this study, we analysed high-resolution CO2 and CH4 flux data collected from an automated chamber system installed across experimental vegetation removal plots (separating vascular plants and Sphagnum mosses) over three growing seasons at the oligotrophic minerogenic mire Degerö Stormyr. Further, bi-weekly soil solution samples from multiple depths were analysed for organic acids and sugars in order to estimate seasonal variation of substrates supporting methane production.

Results

We found that Sphagnum mosses contributed 49-55% of the growing season ecosystem gross primary production (GPP), with temporal variation between the key phenophases (green-up: 54%, peak 44-48% and senescence 47-57%). Key drivers for seasonal variations in daily Sphagnum moss and vascular plant GPP were photosynthetically active radiation and plant phenology. However, the relative importance of the environmental controls varied among the key phenophases. Vascular plants contributed 78-93% of the growing season autotrophic respiration (RA) and 38-40% of ecosystem respiration. Regression analysis revealed a higher daytime temperature sensitivity of moss RA compared to vascular plants during peak season and senescence. We observed significantly higher CH4 emissions with the presence of vascular plants and an increased sugar concentration in late summer, which suggest higher rates of plant-mediated CH4 transport and increased substrate supply for methanogenesis via root exudation during senescence.

Conclusion

These findings call for a better understanding of how vascular plants and Sphagnum mosses contribute to regulating CO2 and CH4 fluxes under varying environmental conditions to improve predictions for future northern peatland carbon cycle-climate feedbacks.

Challenges in creating “Målbilder” to guide forestry’s consideration of reindeer husbandry

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Background

In northern Sweden, forest owners and reindeer husbandry - practiced by the indigenous Sámi people - both have a constitutional right to use the same land. The profitability and survival of traditional mobile pastoral systems, like reindeer herding, depend on high-quality grazing grounds. However, the lichen-rich sites for winter grazing have decreased substantially since the modernisation of forestry in the middle of the 1900s. In addition to modern forestry, changes in climate and winter foraging conditions also affect grazing grounds and their availability. Hence, there is an urgent need to sustain these resources. Different forms of consultations (*samråd)* between industrial forest owners and reindeer herding communities have been practiced since the 1920s in an attempt to mitigate the negative impacts of forestry on reindeer husbandry. The Swedish Forest Agency (SFA) now aims to establish general guidelines for forest operations on reindeer grazing grounds. Such guidelines (*målbilder*) have already been agreed upon between the Swedish Forest Agency and the forestry industry with regard to increasing biodiversity and limiting damage on soil and water quality during final felling.

Methods

In this study, we explore the process of defining and reaching agreement on guidelines for forestry operations on reindeer winter grazing grounds, focusing on aspects of legitimacy and power imbalances. The process was initiated already in 2016 but halted in 2017 by the reindeer husbandry representatives. We define three actors in the process: Reindeer herders, Industrial forestry representatives and Governmental official. Semi-structured interviews are carried out with representatives from every actor group. To achieve the goal of Målbilder that can be implemented in practice, both the process and the outcome must be perceived as legitimate by all actors. By analysing documentation from meetings, workshops, and interviews, we delineate the mechanisms that facilitate or hinder the process and its outcomes. We use a framework of three dimensions of legitimacy. - Procedural, source-based, and substantive legitimacy. The same framework has previously been used to evaluate the guidelines for final felling. Legitimacy is also dependant on a deliberative process where power imbalances are addressed and evened out. To analyse statements concerning power, we also incorporate a framework addressing instrumental, structural and discursive power.

Beyond mosses: expanding the view of nitrogen fixation in boreal ecosystems

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Background:

Nitrogen is a critical nutrient that regulates forest productivity and carbon sequestration in boreal forests and thus plays an important role in ecosystem recovery after disturbance. Boreal forests frequently experience wildfires as a primary natural disturbance, often resulting in significant losses of both carbon and nitrogen (Mack et al., 2021). Post-fire ecosystem recovery largely depends on new nitrogen inputs derived from nitrogen deposition and biological nitrogen fixation (BNF). Nitrogen deposition rates are relatively low in most boreal forests, and for more than two decades, research on BNF in boreal ecosystems has focused primarily on moss-diazotroph associations, assuming that these symbioses provide the major source of nitrogen input (Hupperts et al., 2021). However, recent studies (Heumann et al., 2025; Hupperts et al., 2025) have begun to suggest that there may be overlooked nitrogen-fixing niches, particularly in association with deciduous forest, that may contribute substantially to ecosystem nitrogen inputs. Therefore, the contribution of different ecological niches to biological nitrogen fixation process across stand development remains poorly understood.

Method:

To quantify the contribution of different ecological niches to BNF, we will measure nitrogen fixation rates across multiple niches using the ^{15}N incorporation method. The stable isotope approach will provide direct evidence of nitrogen fixation and will allow us to compare the rates of BNF among different ecological niches. In addition, we will use quantitative PCR (qPCR) to estimate *nifH* gene abundance and reverse transcription qPCR (RT-qPCR) will measure *nifH* transcriptional activity of diazotroph communities. Sampling will be conducted across stands representing different times since fire disturbances, including early, mid and late successional stages, as well as across both deciduous and evergreen dominated stands.

Expected outcomes:

We hypothesize that nitrogen fixation rates will depend on the time since disturbance, with deciduous-associated niches exhibiting higher fixation rates than evergreen-associated niches. We further expect that *nifH* gene abundance will vary among ecological niches and across successional stages, with a positive relationship between *nifH* gene abundance and measured nitrogen fixation rates. The strength of this relationship is likely to differ across niches. These findings are expected to reveal overlooked niches that contribute significantly to nitrogen cycling in boreal forests.

Cold acclimation – a tug of war between transcriptional activation and repression

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Keywords: cold response, transcriptional regulation, non-coding RNA, *Arabidopsis thaliana*

ABSTRACT

Climate change is driving increasingly extreme weather conditions and rapid temperature fluctuations. As sessile organisms, plants must rely on intricate regulatory mechanisms to cope with environmental stress. One key pathway involved in cold stress adaptation is the CBF-dependent signalling pathway, where C-repeat/dehydration-responsive element binding factors (*CBF*s) serve as central regulators. Two of the *CBF* genes, *CBF1* and *CBF3*, sit next to each other in the Arabidopsis genome and both genes are tightly controlled to ensure an optimal response to stress.

One regulatory mechanism involves the antisense long non-coding RNA *SVALKA* (*SVK*), which downregulates *CBF1*. *SVK* is activated a few hours after cold exposure, leading to RNA Polymerase II stalling and the premature release of immature *CBF1* mRNA.

Beyond *SVK*, we have identified another long non-coding RNA, *SVALNA* (*SVN*), as a negative regulator of *CBF3*. The positional conservation between *SVK-CBF1* and *SVN-CBF3* suggest a common mechanism. Understanding how *SVN* and *SVK* function together or independently to fine-tune the *CBF* response will provide deeper insights into the complexity of cold stress regulation.

While *SVK* and *SVN* act as repressors of *CBF*s, we are also exploring novel activators of *CBF* transcription, particularly ARGONAUTE 1 (AGO1). AGO1 is a highly conserved protein known for binding small non-coding RNAs (sRNAs) of 21–24 nucleotides, traditionally associated with post-transcriptional gene silencing in the cytosol via RNA interference. However, recent evidence suggests that AGO1 also functions in the nucleus, binding chromatin. After cold exposure, we observed increased AGO1 binding at the *CBF* genomic region, along with an AGO1-bound sRNA cluster in the *SVK* regulatory region, suggesting a coordinated regulation of AGO1 and non-coding transcription on *CBF1* and *CBF3*.

Understanding how AGO1, *SVK*, and *SVN* coordinate cold stress responses could provide valuable insights into plant resilience and inform strategies to enhance stress tolerance across diverse plant species.

Forest growth and environmental impact of nutrient recycling trough bio-nutrient fertilization

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ABSTRACT

This study examines potential long-term growth effects and environmental consequences of applying residues from biogas production (Bio-nutrient) as fertilizer in boreal forests. Bio-nutrient is dried, heated, and hygenised (class A level, Swedish EPA) organic sewage sludge digestate, which is pelletized or granulated. It has a dry matter content >90 %, nitrogen content >3 %, and the same limits for levels of heavy metals and synthetic organic substances as for usage on agricultural land.

The field trials in this study are located in northern Sweden, in eastern part of Norrbotten. The study consists of 22 stands with a total area of 863 ha, that span 19 -78 years old, mostly dominated by pine (Pinus sylvestris) and spruce (Picea abies), but a mixture of birch (Betula spp.) in some cases. Fertilization experiments were conducted over several years between 2006 and 2010. The experimental design includes largescale fertilization with Bio-nutrient, mineral fertilizer (Skog CAN) and control areas. Bio-nutrient used in these field trials had a nitrogen content between 4.1 -4.2 %. The total amount of nitrogen dispersed using Skog CAN where 300kg/ha and for bio-nutrient varied between 348-694kg N/ha between the different stands. Measurements include tree stem growth, nutrient analysis in needles, chemical composition of humus layer and groundwater.

Five years post fertilization, we found that diameter growth increased, increasing volume growth from about four to six m^3sk/ha/year, following both bio-nutrient and Skog-CAN fertilization, compared to unfertilized plots. Furthermore, needle nutrient analysis showed enhanced nitrogen and phosphorus uptake in fertilized plots. Groundwater showed no significant increase in heavy metal concentrations and soil chemistry analyses indicated minimal changes in pH and organic matter content following fertilization.

Future research will assess the long-term effects 15-20 years after fertilization.