Project information

Keywords

forest mortality, insect outbreaks, resilience, ecosystem dynamics

Project title

What comes after the new pest? Ecosystem transitions following insect pest outbreaks induced by climate change in the European high North (After-the-Pest)

Year

2018

Project leader

Jane Uhd Jepsen

Geographical localization of the research project in decimal degrees (max 5 per project, ex. 70,662°N and 23,707°E)

The Varanger fiord area including Tana and Polmak. Example coordinate Tana Bru 70.1994, 28.1852

Participants

Project participants:

From NINA: Audun Stien (audun.stien@uit.no) and Erling Solberg (erling.solberg@nina.no).

From UiT: Stian N. Anfinsen (stian.normann.anfinsen@uit.no), Jørgen Agersborg (PhD student), Rolf A. Ims (rolf.ims@uit.no), Nigel Yoccoz (nigel.yoccoz@uit.no), Ole Petter Vindstad (postdoc, ole.p.vindstad@uit.no) and Malin Ek (PhD student).

Flagship

Terrestrial

Funding Source

Research Council of Norway, Fram Centre, UIT, NINA

Summary of Results

2018 was the last year of the NFR funded project After-the-pest. The final report of the project was delivered NFR Sept 2018. In the following we hence summarize the results of the project as a whole.

Moth outbreaks of unprecedented extent have affected 1 mill ha of boreal birch forest in northern Fennoscandia, and is arguably the most abrupt, and large-scale terrestrial ecosystem disturbance attributed to recent climate change in Europe. Our research has targeted how the ecosystem in the most disturbed region may transform into new ecosystem states under continued climate warming, recurrent pest outbreaks, the action of wild and domestic herbivores and forest management. Such new ecosystem states may imply loss of biodiversity and changed functions within the ecosystem, that involves feedback to the climate system and provisional ecosystem services. With a combination of large-scale comparative and small-scale experimental studies, we have targeted the following topics: 1) Regional ecosystem state transitions following moth outbreaks, 2) The importance of large herbivores as drivers and maintainers of state changes, 3) Salvage logging as a management action, and 4) Ecosystem cascades.

We have shown that the intensified outbreaks that occurred during the 2000's have exceeded the resilience of the birch forest and caused large scale mortality, locally above 90% of stems. We have identified a strongly non-linear relationship (a threshold) between defoliation intensity and stem mortality, indicating that this ecosystem is prone to abrupt transitions from a forested to a non-forested state. Low recovery on a regional scale, likely both due to herbivory from mammalian grazers/browsers and a positive feedback between the density of surviving stems and sapling establishment, suggests that this transition will be long-term, or even permanent, in many areas.

The role of mammalian herbivores has been further quantified by means of experimental exclosures. We have shown particularly 1) that a higher proportion of trees die during the outbreak in areas which are subject to summer grazing by reindeer, and 2) that summer grazing impairs the establishment of new forest. Four years after the outbreak (2012) the proportion of surviving stems was <2% and ~5% in summer and winter grazed areas respectively. Six years later (2018), this was unchanged in summer grazed areas but had increased to ~40% in winter grazed areas. This shows that the two grazing regimes are on two completely different trajectories, one towards recovery, and one towards a non-forested state.

Forest management can potentially direct these trajectories. In collaboration with forest management authorities, we have tested how salvage logging of dead and damaged trees shortly after an outbreak, can increase forest recovery. On a short term, logging is a promising action, with approx. 4 times more basal shoots being produced in logged stands relative to unlogged controls. The long-term benefits, however, will depend both on the intrinsic state of the forest, mainly site conditions, and on the local browsing pressure from large herbivores. As a management action, salvage logging should thus not be applied indiscriminately, but carefully targeted towards those stands and areas where it is most likely to be successful.

Moth outbreaks, and the short- and long-term state changes following, are likely to influence other parts of the birch forest ecosystem, including biodiversity values such as bird and insect communities, game species such as moose, ptarmigan and hare, and associated small predators, for instance the red fox. These cascading effects are poorly known, and often difficult to quantify. We have targeted this with a diverse array of methods, incl. field surveys (snow tracking, acoustic surveys), camera trapping, and insect flight interception traps. We

have shown that bird communities so far seem robust towards the changes, and that communities of dead wood associated insects, although species rich, respond numerically less than might have been expected to the drastic increase of dead wood available in the system. The suggests that these insects may not play a strong functional role in the decomposition of the dead wood, at least at the present state of succession. Further, we have shown that small herbivores in the system, in particular ptarmigan, are responding to forest damage through lower presence in heavily damaged areas, and that this cascade also to the generalist predator red fox.

The long-term state changes and implications of continued warming and recurrent moth outbreaks cannot be targeted in a short-term project, and this project has benefitted from both research infrastructure and time series established by us during previous NFR-projects. Despite this we are still in an early phase of understanding the mechanisms behind, and the implications of intensified moth outbreaks for the future of the birch forest. We therefore aim at extending the present research and partnership with managers into the long-term through the adaptive monitoring system COAT (www.coat.no).

Master and PhD-students involved in the project

Malin Ek (PhD student)

Jørgen Agersborg (PhD student)

For the Management

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Published Results/Planned Publications

PAPERS AND REPORTS

Sandén, H., Mayer, M., Stark, S., Sandén, T., Nilsson, L.O., Jepsen, J.U., Wäli, P.R., & Rewald, B. Moth outbreaks reduce decomposition in subarctic forest soils. Submitted *Ecology*.

Vindstad, O.P.L., Jepsen, J.U., Ek, M., Pepi, A. & Ims, R.A. Can novel pest outbreaks drive ecosystem transitions in northern-boreal birch forest? *J. Ecology accepted.*

Metcalfe, D.B., Cherif, M., Jepsen, J.U., Vindstad, O.P.L., Kristensen, J.Å., & Belsing, U. (2018). Ecological stoichiometry and nutrient partitioning in two insect herbivores responsible for large-scale forest disturbance in the Fennoscandian subarctic. *Ecological Entomology in press.*

Vindstad, O.P.L., Jepsen, J.U., Yoccoz, N.G., Bjørnstad, O.N., Mesquita, M.S. & Ims, R.A. Signatures of spatial synchrony in sub-arctic geometrid moths reflect dispersal in multiple lifecycle stages. *J. Anim. Ecol. In revision*

Timmermann, Volkmar; Andreassen, Kjell; Brurberg, May Bente; Clarke, Nicholas; Herrero, Maria-Luz; Jepsen, Jane Uhd; Solheim, Halvor; Strømeng, Gunn; Talgø, Venche; Vindstad, Ole Petter Laksforsmo; Wollebæk, Gro; Økland, Bjørn; Aas, Wenche. 2018. Skogens helsetilstand i Norge. Resultater fra skogskadeovervåkingen i 2017. Ås: NIBIO 2018 (ISBN 978-82-17-02156-8) ;Volum 4.86 s. NIBIO Rapport(102)

CONFERENCE CONTRIBUTIONS

Ahonen, Saija H.; Saravesi, Karita; Wäli, Piippa R.; Ruotsalainen, Anna Liisa; Aikio, Sami; Suominen, Otso; Jepsen, Jane Uhd; Markkola, Annamari. 2018. Soil microbial communities in subarctic mountain birch forests in two reindeer grazing regimes recovering from severe moth herbivory. Ecology of Soil Microorganisms 2018; 2018-06-17 - 2018-06-21 POSTER

Jepsen, J.U.; Vindstad, O.P.L; Ims, R.A. 2018. Small engineers with a large impact: Critical transitions in ecotone forest driven by pest outbreaks. Oikos 2018; 2018-02-19 - 2018-02-22. POSTER

Laparie, Mathieu; Vindstad, Ole Petter L.; Ims, Rolf Anker; Jepsen, Jane Uhd. 2018. Inter-individual heterogenity in melanism in a cyclic geometrid pest expanding through Fennoscandia: exploring thermal melanism. 5th AgreenSkills Annual Meeting; 2018-06-11 - 2018-06-14 POSTER

Vindstad, Ole Petter Laksforsmo; Klinghardt, Moritz; Ek, Malin; Jepsen, Jane Uhd; Ims, Rolf Anker. 2018. Salvage logging of mountain birch after geometrid outbreaks: ecological context determines management outcomes. Oikos 2018; 2018-02-19 - 2018-02-22 POSTER

Jepsen, J.U. Vindstad, O.P.L. & Ims, R.A. 2018. Lauvmakk og lauvmakkutbrudd. Konferansen Natur i endring. Alta, Okt 2018. TALK

Jepsen, J.U. Vindstad, O.P.L. & Ims, R.A. 2018. Effekter av lauvmakkutbrudd. Konferansen Natur i endring. Alta, Okt 2018. TALK

Jepsen, J.U. 2018. Ecosystem transitions following a geographic range expansion of a forest pest in northern-boreal birch forest. Joint Annual Meeting Entomological Societies of America, Canada and British Columbia (Entomology 2018), Vancouver, Nov. TALK

Communicated Results

Radio/TV: NRK P1, NRK Ut i Naturen (‘Spis og bli spist’), NRK Nordnytt

Local newspapers: ca 6 cases in 2018

Fram Forum 2018

Interdisciplinary Cooperation

With support from the Fram Center we have since 2016 developed an interdisciplinary collaboration with remote sensing specialists at UiT Physics (machine learning group). This has resulted in a joint PhD student, initiated Sept 2017 via the project COAT Tools. This student is trained in physics and remote sensing and in the use of radar data in particular. He has participated in field work in East Finnmark and will over the next few years collaborate with After-the-pest and COAT personnel on developing new methods for detecting vegetation structural changes based on radar (SAR).

Budget in accordance to results

Costs in 2018 have been in accordance to budget. With the funding from the Fram Centre we have throughout the project been able to strengthen two collaborations in particular. 1) the interdisciplinary collaboration with remote sensing and machine learning experts to develop SAR based mapping of vegetation structure, and 2) the collaboration with ungulate ecologists on ungulate habitat use of moth damaged forests based on GPS tagged individuals and camera traps.

Could results from the project be subject for any commercial utilization

No

Conclusions

The aims of the project was fulfilled and funding from the Fram Centre has contributed significantly to this.