

Storflaket long-term permafrost thaw experiment

Background: The Arctic has long acted as the freezer of our planet. Due to the low temperatures, organic remains of dead organisms such as plants have been protected from microbial breakdown for hundreds to thousands of years. This process has slowly built-up large stocks of material rich in organic-C in permafrost soils and thereby withdrawn the greenhouse gas CO₂ from the atmosphere and helped our global climate to cool. However, ongoing global climate change causes greater warming in the Arctic than elsewhere on Earth. One of the consequences is a rapid thawing of these permafrost soils. This would expose the organic material to breakdown by microbes, potentially causing a huge release of greenhouse gasses (CO₂, methane) into the atmosphere, but also a release of nitrogen-compounds in the deep soil. Because the growth of arctic plants is strongly limited by the availability of nitrogen, this might boost their growth and production, and thus possibly their CO₂ uptake. One of the major questions in arctic ecosystem science at the moment is therefore whether this warming and thawing will cause a net release of greenhouse gasses into the atmosphere, or if increased biomass production of the vegetation will outweigh the increased greenhouse gas release and thus cause a negative net feedback to climate warming.

The field experiment: The Storflaket long-term permafrost thaw experiment is an experimental facility to study the long-term ecological, biogeochemical and physical changes in a palsa mire that may happen when permafrost thaws due to ongoing and future climate change. Storflaket palsa mire is situated immediately south of the main road between Abisko and Stoflaket, approx. 5km from Abisko, and therefore extremely accessible year-round. The Storflaket long-term permafrost thaw experiment was started in 2005 (Johansson et al. 2013). Six snow fences (1m high, 10m long) are put up each autumn (September) and stay in place until the start of the growing season (June) to increase snow thickness on their lee-side during the winter months (Fig. 1). As a consequence, winter soil temperatures remain higher than in the control plots and the annual thaw of the upper soil layer during the summer (the ‘active layer’) goes faster and deeper, leading to thaw of the upper permafrost underneath (Johansson et al. 2013). Six plots (10x10m) have been established on the west sides of the fences, as well



Figure 1. Snow fences reduce the wind speed, thus creating a wind lee where snow can accumulate to greater depths than on the surrounding, snow-poor Storflaket palsa mire. Snow provides good insulation during the winter months, leading to higher soil temperatures and faster soil thaw during the summer. As a consequence, the top of the permafrost thaws deeper every year, exposing more soil to potential biological activity.

as six control plots of the same dimensions in between the snow fence plots, but far enough away to not be affected by the snow fence effects. Active Layer Thickness (ALT) has been measured each year in September at 50 points in each plot. Soil temperature is continuously measured and logged in one point in each plot. Since 2025, the Climate Impacts Research Centre (CIRC) of Umeå University has taken over the coordination and maintenance of the experiment.

Previous data and results: The increased snow accumulation quickly led to soil subsidence,

increases in soil moisture and formation of small ponds, and strong shifts in species composition of the vegetation (Johansson et al. 2013; Fig. 2). Additional studies in the past two decades have (for example) found that the rooting depth of cotton grass (*Eriophorum vaginatum*) has increased due to the deeper summer thaw (Blume-Werry et al. 2019). Other studies have focussed on soil microbial community (Monteux et al. 2018; Doherty et al. 2020), greenhouse gas fluxes (Bösiö et al. 2014), and peat carbon balance (Olid et al. 2020).



Figure 2. Storflaket long-term permafrost thaw experiment in the summer clearly shows the increase in cotton grass (*Eriophorum vaginatum*) in the wet patches on the west side of the snow fences (not present during the summer).

Possibilities for BSc- and MSc-Thesis projects: In the above experiment, there are possibilities to perform thesis projects at BSc- and MSc-level, with a lot of freedom to adapt the project and research question to your own interests and the required length and timing of your thesis project. Projects include fieldwork to collect data, with shorter or longer stays at the Abisko Scientific Research Station. Because of the good accessibility of the site, fieldwork can be done any time of the year, depending on the research question. Research can focus on above- or belowground aspects of the vegetation, or on plant or microbial processes in the soil. Some *examples* of research questions:

- What is the effect of two decades of permafrost thaw on vegetation composition?
- What is the effect of two decades of permafrost thaw on above- and belowground vegetation biomass?
- What is the effect of deeper snow and permafrost thaw on vegetation phenology*?
- How do mosses respond to deeper snow and permafrost thaw?
- What is the effect of deeper snow and permafrost thaw on frost resistance of plant leaves?
- What is the effect of two decades of permafrost thaw on CO₂-fluxes?
- ... (feel welcome to come with your own idea and we can see if it's doable!)

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(Some) Publications from the The Storflaket long-term permafrost thaw experiment:

- The **short film** 'Changes in alpine and forest ecosystems' (Knut och Alice Wallenberg Foundation; <https://youtu.be/tSunbpDtFkk>) features our research at Storflaket and explains the background (scroll to 1:30-5:00 min)
- Scientific papers: **Blume-Werry** G et al *NewPhytol*2019_223_1328-1339; **Bösiö** J et al *ClimaticChange*2014_127_321-334; **Doherty** SJ et al *FrontMicrobio*2020_11_596589; **Johansson** M et al *EnvResLett*2013_8_doi1010881748; **Monteux** S et al *ISMEJournal*2018_12_2129-2141; **Olid** C et al *GCB*2020_26_5886-5898

* Phenology is the timing of events in the annual cycle of organisms, for example the timing of bud break, flowering, leaf senescence.