

# Effects of multi-level N addition on SOM chemical composition in boreal forests

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## Introduction

Boreal forests store a large amount of C in soils as soil organic matter (SOM). N enrichment suppresses decomposition and further enhances C accumulation there. Despite the significant contribution of the boreal forests to global C cycling, the mechanisms underlying suppressed decomposition and the extent to which soils respond to different levels of N addition remain poorly understood. To address this uncertainty, consideration into chemical composition in SOM is warranted as this could potentially indicate which compounds are more reactive to altered N conditions than others.

**Aim:** We investigate which forms of soil organic matter (SOM) are responsible for the accumulation of SOM under ranging N addition regimes in boreal forests to elucidate the mechanisms by which SOM decomposition is suppressed.

**Reference:** Bonner et al. *Soil Biology and Biochemistry* 137 (2019). **Acknowledgement:** This project was funded by Knut and Alice Wallenberg Foundation (#2015.0047); The Kempe Foundations.

## Methods

This study was conducted in long-term N addition experiments established in boreal forests in northern Sweden. There were four sites, of which two were dominated by Scots pine and the others by Norway spruce. They annually received  $\text{NO}_3\text{NH}_4$  fertiliser, covering a range of N addition regimes with addition rates and period varying between 3–70  $\text{kg N ha}^{-1} \text{ year}^{-1}$  and 15–30 years, respectively (Fig 1). Organic soils were collected from the fragmented litter and humus layers, holistically analysed for chemical composition using  $^{13}\text{C}$ -solid state nuclear magnetic resonance spectroscopy ( $^{13}\text{C}$ -NMR) and pyrolysis GC/MS.

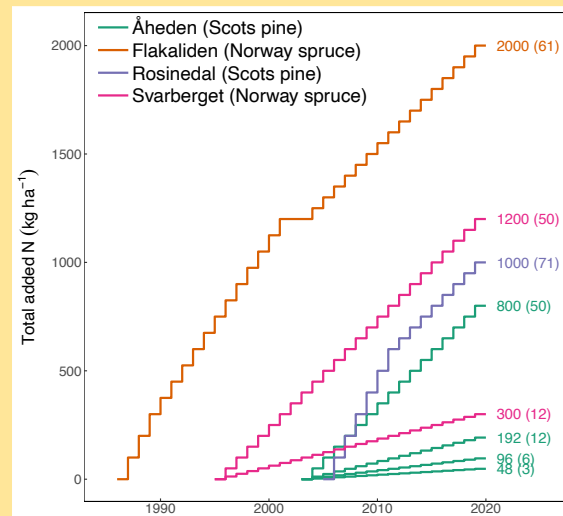


Fig 1. History of N addition. The total amount of added N is shown by each line ( $\text{kg N ha}^{-1}$ ) alongside addition rates within parentheses ( $\text{kg N ha}^{-1} \text{ year}^{-1}$ )

## Results

Redundancy analysis (RDA) was performed to assess the effects of N-addition on chemical composition of SOM (Fig 2). Two distinct metrics (NMR and pyrolysis) confirmed a consistent shift in chemical composition of SOM, demonstrating that N-addition increased lignin-derivatives (methoxy, aromatic, *O*-aromatic C) at the expense of carbohydrate-derivatives (*O*-alkyl, Di-*O*-alkyl C). The compositional shift was especially apparent at N-addition rates higher than 12  $\text{kg N ha}^{-1} \text{ year}^{-1}$  across the study sites. The results from Åheden showed that the magnitude of N-addition effects was not proportional to N-addition rates.

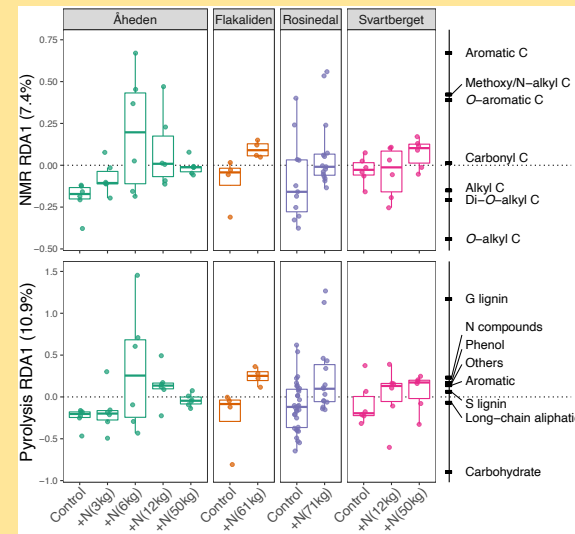


Fig 2. The RDA scores for NMR (top) and pyrolysis products (bottom), comparing chemical composition between control and fertilised treatments.

## Discussion

The N-induced shift in chemical composition of SOM was mainly driven by altered balance of lignin- and carbohydrate-derived compounds. Increased lignin:carbohydrate ratios at N enrichment were in line with suppressed lignolytic enzyme activity (white-rot) relative to non-enzymatic lignin oxidation (brown-rot) under the added N treatment at Flakaliden, Rosinedal (Bonner *et al.* 2019) as well as Svarberget. This was also observed at Åheden but only in the plots receiving 50  $\text{kg N ha}^{-1} \text{ year}^{-1}$ .

**Conclusion:** Regardless of N addition regimes and vegetation, N enrichment seems to influence the balance of saprotrophic decomposition, leading to altered SOM chemical composition. However, the effect size does not proportionally correspond to the total amount, rates or duration of N addition, especially at addition rates between 3–12  $\text{kg N ha}^{-1} \text{ year}^{-1}$ .

