



INSTITUTIONEN FÖR GEOVETENSKAPER

# **The Nitrogen Cycle in Soil**

## **– Climate Impact and Methodological Challenges in Natural Ecosystems**

**Anna-Karin Björnsne**

Institutionen för geovetenskaper  
Naturvetenskapliga fakulteten

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## Abstract

Nitrogen (N) is a fundamental element for life, and limiting in many terrestrial ecosystems. In non-N-fertilized ecosystems, the N inputs can be low, and the nutrient availability for plants is determined by the internal cycling of N. The N availability might alter with different factors, such as climate change, forest management practices, and tree species. Soil N cycling is investigated using stable isotopes, where the activity in the soil can be monitored over time. The overall aim of this thesis is to increase the understanding of the N cycle in natural and semi-natural ecosystems and the environmental factors important for nutrient cycling.

The results show that all sites investigated in this thesis had higher  $\text{NH}_4^+$  turnover than  $\text{NO}_3^-$  turnover. The mineralization rates were highest in the site with the lowest C:N ratio, and the lowest mineralization rates and the highest C:N ratio in the spruce forests, which demonstrate the importance of organic matter quality on gross N transformation rates. The N cycle responses to combined climate treatments were generally lower than responses to single climate treatments. For some processes, we observed opposing responses for  $\text{eCO}_2$  as single and main treatment compared to the plots receiving the full treatment. This points to the importance of conducting multifactor climate change experiments, as many feedback controls are yet unknown. Gross nitrification was lowered with fertilization in a northern boreal forest, which is an interesting result in the light of the very low nitrous oxide ( $\text{N}_2\text{O}$ ) emissions from the investigated site, despite heavy annual fertilization of 50–70  $\text{kg ha}^{-1}$ . Moreover, the results from an experiment with soil of common origin and land history showed generally higher gross mineralization, immobilization and nitrification rates in a beech stand compared to a spruce stand. The beech stand had also higher initial concentration of nitrate ( $\text{NO}_3^-$ ) which indicates a more  $\text{NO}_3^-$  based N cycling. Finally, numerical modeling together with  $^{15}\text{N}$  tracing is an improvement for simultaneously determining free amino acid (FAA) mineralization, peptide depolymerization and gross N mineralization rates, compared to analytical solutions.

This thesis confirms that N cycling in natural ecosystems is governed by the properties of the soil, vegetation and climate, but also that the experimental set-up strongly affects the outcome of the experiment. In turn, this affects the potential of doing reliable experiments, especially in ecosystems where the external inputs of N are very low. The thesis also highlights some methodological challenges that lie in the future of N cycling research.

## Keywords

Nitrogen cycle,  $^{15}\text{N}$  tracing experiments, gross N transformation rates, climate change, climate treatments, mineralization, nitrification, forest fertilization, nitrous oxide emissions, boreal forest soil, tree species, soil organic matter, C:N ratio