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Nitrogen limitation of a soil-vegetation system in arctic polygonal tundra in East Siberia may turn into phosphorus limitation

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Plant growth in arctic tundra is known to be commonly limited by nitrogen. Changes in plant species composition under higher temperatures (e.g. shrub encroachment) are expected and already observed. By influencing soil hydrology regime, albedo and snow holding capacity, vegetation dynamics cause different climate feedbacks and change the conditions for soil microbial activity. Changes in plant species composition may also enhance the carbon storage potential of arctic ecosystems. Thus, it is crucial to understand state and dynamics of nutrient limitation under climate variability.

We investigated different compartments of the trophic web in the polygonal tundra: Soils and vegetation biomass were studied and analyzed for their contents of carbon, nitrogen, phosphorus and potassium. Also content of carbon, nitrogen and phosphorus in the microbial biomass were analyzed. The study site was located in the Indigirka lowlands in north-eastern Siberia, Russia. Samples were taken during one expedition in July and August 2011. One single ice-wedge polygon was investigated in a highly detailed grid. We used a stoichiometric approach based on the N/P ratios in the different analyzed fractions of the soils to analyze limitation relations in our system. By these integrated analyzes we were able to get a detailed overview on the relationships within the trophic web of the arctic polygonal tundra.

In contrast to large amounts of total nitrogen but little amounts of available inorganic nitrogen, an excess in inorganic plant-available phosphorus and potassium in the soils was observed. Most of the mineralized inorganic nitrogen appears to be instantly consumed by plants and/or microorganisms whereas mineralized inorganic phosphorus can accumulate to some extent. However, the elemental composition of the microbial biomass suggest that nitrogen mineralization and fixation, as key processes for plant nutrition, may be limited at present by phosphorus. Higher temperatures in the arctic tundra probably will lead to increased nitrogen mineralization and thus enhanced supply of available inorganic nitrogen. As there is currently an excess in inorganic plant-available phosphorus increased primary production and changes in the plant-species composition might follow. But as the pool of potentially mineralizable phosphorus is limited, in the long-term strict phosphorus limitation is possible.