Submitted Abstract

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Abstract

Treelines are striking vegetation boundaries. In unmanaged regions, treeline position is mainly attributed to low temperatures limiting growth processes. Treeline shifts due to climate change are observed to lag behind climate warming, which is primarily related to species interaction. Belowground processes remain largely understudied, but as nutrient mineralization from soil organic matter is highly temperature sensitive, the resulting changes in nutrient availability may also affect plant growth and species competition and thus, treeline dynamics. In our study, we explored how nitrogen and phosphorus availability and cycling in the soil changed across forest-tundra ecotones and how this is linked to plant traits and treeline productivity. In three Russian mountain ranges (South and Polar Urals, Khibiny mountains on Kola Penninsula), we sampled and analyzed plants and entire soil profiles along elevation gradients across treeline reaching from the closed forest to the tundra.

In all three regions, indices for nutrient availability (foliage nutrient concentration, natural 15N abundance, soil extractable N and P concentrations) showed pronounced increases from tundra to the forest. Mineralization experiments indicate that the improved N and P availability in the forest is related to a greater release of N and P from litter layers and soils in the forest than in the tundra, very likely due to tighter C-to-nutrient ratios in decomposing organic matter. We suggest that this pattern in nutrient cycling stabilizes existing vegetation patterns: while the slow nutrient cycle and the low nutrient availability in the tundra contributes to the restricted tree establishment, the several fold higher nutrient supply in the forested soil possibly contributes to the abrupt growth enhancement below treeline once the thermal limitation for tree growth is relieved. These results indicate that belowground processes play an improtant but underexplored role in treeline dynamics.