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Climate change-driven treeline advances in the Urals alter soil microbial communities

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Climatic warming may affect microbial communities and their functions either directly through increased temperatures or indirectly by changes in vegetation. Treelines are temperature-limited vegetation boundaries from tundra to forests. In unmanaged regions of the Ural mountains, there is evidence that the forest–tundra ecotone has shifted upward in response to climate warming during the 20th century. Little is known about the effects of the treeline advances on the microbial structure and function and hence they feedbacks on the belowground carbon and nitrogen cycling

In our study, we aimed to estimate how ongoing upward shifts of the treeline ecotone might affect soil biodiversity and its function and hence soil carbon (C) and nitrogen (N) dynamics in the Southern and Polar Ural mountains. Along altitudinal gradients reaching from the tundra to forests, we determined the soil microbial community composition (using Phospholipid Fatty Acids method) and quantified the activity of several extracellular enzymes involved in the C and nutrient cycling. In addition, we measured C pools in biomass and soils and quantified C and N mineralization.

The results for the top soils, both in South Urals and in the Polar Ural, indicate a close link between climate change driven vegetation changes and soil microbial communities. The observed changes in microbial structure are induced through the resulting more favorable conditions than due to a shift in litter quality. The activities of chitinase were significantly higher under trees than under herbaceous plants, while activities of cellulase and protease declined with altitude from the tundra to the closed forest. In contrast to enzymatic activities, soil carbon stocks did not change significantly with altitude very likely as a result of a balancing out of increased C inputs from vegetation by an enhanced C output through mineralization with forest expansion. The accelerated organic matter turnover in the forest than in the tundra leads to higher contents of mineral N and net nitrification rates. In turn, the increasing N availability may stimulate plant growth and hence, induce a positive feedback between treeline advances and soil nitrogen cycling through soil microbial communities.