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Experimental soil warming at the treeline shifts fungal communities species

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In terrestrial ecosystems, fungi play a major role in decomposition processes, plant nutrient uptake and nutrient cycling. In high elevation ecosystems in Alpine and Arctic regions, the fungal community may be particularly sensitive to climate warming due to the removal of temperature limitation in the plant and soil system, faster nutrient cycling and changes in plant carbon allocation to maintain roots systems and sustain the rhizosphere. In our study, we estimated the effects of 9 years CO_2 enrichment and three years of experimental soil warming on the community structure of fungal microorganisms in an alpine treeline ecosystem.

In the Swiss Alps, we worked on a total of 40 plots, with c. 40-year-old Larix decidua and Pinus mugo ssp. uncinata trees (20 plots for each tree species). Half of the plots with each tree species were randomly assigned to an elevated CO_2 treatment (ambient concentration +200 ppm), whereas the remaining plots received no supplementary CO_2. Five individual plots for each combination of CO_2 concentration and tree species were heated by an average of 4°C during the growing season with heating cables at the soil surface.

At the treeline, the fungal diversity analyzed by high-throughput 454-sequencing of genetic markers, was generally low as compared to low altitude systems and mycorrhizal species made a particularly small contribution to the total fungal DNA. Soil warming led to a shift in the structure and composition of the fungal microbial community, with an increase of litter degraders and ectomycorrhizal fungi. We further observed changes in the productivity of specific fungal fruiting bodies (i.e. more Lactarius rufus sporocarps and less Hygrophorus lucorum sporocarps) during the course of the experiment, that were consistent with the 454-sequencing data. The warming effect was more pronounced in the Larix plots. These shifts were accompanied by an increased soil CO_2 efflux (+40%), evidence of increased N availability and a substantial reduction in fine root biomass (-40%) in warmed soils. In comparison, CO_2 enrichment had a weaker effect on the composition of the fungal community. Collectively, our results show that soil warming alters fungal communities both directly, by higher temperature, and indirectly, by an improved nitrogen availability associated with an enhanced SOM cycling. These changes may have a vital effect on several ecosystem processes and, in particular, may alter the rate at which soil organic matter is formed and decomposed.