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Changes in fungal community composition in response to experimental soil warming at the alpine treeline

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Increased CO_2 emissions and global warming may alter the composition of fungal communities through the reduction of low temperature limitation in the plant-soil system, faster nitrogen cycling and changes in the carbon allocation of host plants to the rhizosphere. Shifts in fungal community composition due to global changes are likely to affect the routes of carbon and nitrogen flows in the plant-soil system and alter the rates at which organic matter is decomposed. The main aim of our study was to estimate the effects of multiple years of free air CO_2 enrichment (ambient concentration +200 ppm) and soil warming (+ 4°C) on the fungal community structure and composition. At an alpine treeline in Switzerland featuring two key high-elevation tree species, Larix decidua and Pinus uncinata, fungal communities within different organic horizons were analysed by high-throughput 454-pyrosequencing of ITS2 amplicons. In addition, we assessed the ectomycorrhizal community composition on root tips and monitored changes in sporocarp productivity of fungal species during the course of the experiment.

Three years of experimental warming at the alpine treeline altered the composition of the fungal community in the organic horizons, whereas nine years of CO_2 enrichment had only weak effects. Tree species influenced the composition of the fungal community and the magnitude of the responses of fungal functional groups to soil warming differed between plots with Larix and those with Pinus. The abundance of ectomycorrhizal fungi was positively correlated with nitrogen availability, and ectomycorrhizal taxa specialized for conditions of high nitrogen availability proliferated with warming, corresponding to considerable increases in extractable inorganic nitrogen in warmed soils. Changes in productivity of specific fungal fruiting bodies in response to soil warming (e.g. more Lactarius rufus sporocarps and less Hygrophorus speciousus sporocarps) were consistent with the 454-sequencing data and the colonization of ectomycorrhizal root tips. Several fungal taxa known to be involved in needle degradation responded positively to the warming treatment by increasing in their relative abundance.

These findings provide novel insights into the spatial distribution of functional groups of fungi both vertically in the soil and between different rhizospheres of trees. Moreover, they indicate that traits related to nitrogen utilization are important in determining responses of ectomycorrhizal fungi to warming in cold regions, such as high-elevation ecosystems, with low N availability. Shifts in the overall fungal community composition in response to higher temperatures may alter fungal-driven processes with potential feedbacks on ecosystem nitrogen cycling and carbon storage at the alpine treeline.