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Long term effects of fire on the carbon balance in boreal forests

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Fire is the primary process which organizes the physical and biological attributes of the boreal biome and influences energy flows and biogeochemical cycles, particularly the carbon and nitrogen cycle.

We established a forest fire chronosequence in the northern boreal forest in Lapland (Värriö Strict Nature Reserve), Finland (67°46' N, 29°35' E) that spans 160 years. Soil organic matter and its turnover were measured in and ex situ, as well as biomass of trees. The fungal biomass was assessed using soil ergosterol contents.

The results indicate that fires slow down the turnover of soil organic matter for a period of at least 50 years. The turnover rate in recently burnt sites was only half of the turnover of the old forest site. Decreases in the turnover where still substantial 50 years after fire. The slow recovery of fungal biomass after fires seems to be the cause of the decrease since sites with a higher concentration of fungal biomass in the soils had shorter soil organic matter turnover rates. Increases in stand foliar biomass were less important for the turnover of soil organic matter.

We tried to explore the potential importance of our finding using a simple data driven simulation model that estimates soil carbon dynamic from litter input and the measured soil carbon turnover times. The results indicate the initial post-fire slowdown of soil carbon turnover is an important component of the boreal carbon cycle. Using our fire intervals the simulated soil carbon stocks with a lower post-fire soil organic matter turnover were up to 15 % larger than simulations assuming a constant carbon turnover rate. Our sensitivity analysis indicates that the effects will be larger in areas with frequent fires. We do not know which environmental factors cause the delay in the turnover time and the effects of fires on post fire soil organic matter turnover could be considerably smaller or larger. Altogether our results fit well to published results from laboratory studies and show that post-fire depression of microbial activities are important on the ecosystem and landscape level. Since fire frequencies in boreal forests will increase in many areas as the result of climate change, it will be important to better understand the effects of fire on the soil carbon turnover and to incorporate it into carbon cycle models.