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Long term implications of fire to soil C content and soil CO_2 efflux in northern 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 (C) cycle. Especially the soil organic matter pool in boreal forests is an important C storage with a long C turnover time, but fire frequencies that are expected to increase with changing climate, can change that.

We compared the initial recovery of C pools and CO_2 efflux following fire disturbance in Scots pine (Pinus sylvesteris) stands in the northern boreal forests, of eastern Lapland, Värriö Strict Nature Reserve, Finland (67°46' N, 29°35' E). The sites are situated north of the Arctic Circle, near to the northern timberline at an average of 300 m altitude. We have established 8 sample areas (with two replicate plots in each) in a chronosequence of 4 age classes (2 to 152 years since the last fire). The chronosequence consisted of four types of areas: (i) fire 2 years ago old areas, (ii) fire 42 years ago, (iii) fire around 60 years ago, (iv) fire 152years ago.

The total C contents in the first 10 cm of the topsoil were highest on old areas (fire 150 years ago) and lowest on new areas (fire 2-40 years ago). The total C pool at the old site was 2411 g m-2. The area where the fire was 2 years ago had the lowest total C pools, 1474 g m-2 respectively. The lowest C pools were measured from area where the fire was 60 years ago, and from B horizon. The highest C pools were measured on old areas from top soil horizons (consisting of decomposing litter). When we compared the total C pools, the newly burned areas (areas where the fire was 2 – 40 years ago) formed one group (had similar values of total C) and old areas (areas where the fire was 60-150 years ago) formed another group with similar values. These results are also correlating to the soil respiration measurements. Soil CO_2 efflux was lowest straight after the fire (0.042 mg CO_2 m-2 s-1) and it reached a stable level of around 0.140 mg CO_2 m-2 s-1 60 years after the fire. The CO_2 effluxes were lowest on newly burned area through the entire growing season.

Our results show that forest fire has a substantial effect on the C content in the top soil layer, but not in the humus layer and in mineral soil layers. Soil respiration showed similar chronological response to the time since the forest fire indicating that substantial proportion of the respiration was originating from the very top of the soil. Other studies have also found that fire can reduce the C amount available for soil CO_2 efflux.