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Forest fires and their effect on soil carbon turnover – comparison of permafrost and non-permafrost areas from Canada

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Boreal forests, which cover 15% of the Earth's land area, are a crucial part of the climate system as they contain approximately 60% of the carbon (C) bound in global forest biomes and approximately 12–13% of the organic C stocks in the world's soils. The presence of permafrost (about 24% of the land in the Northern Hemisphere) makes these high latitude ecosystems especially vulnerable to changing climate

The soil organic matter (SOM) pool in boreal forests is a particularly important C storage, with a long turnover time ranging from several decades to millennia. Even small changes in the turnover of soil C stocks there may reverse the terrestrial carbon sink into a source with consequent increase in the atmospheric CO_2 concentrations.

Fire is one of the most important natural disturbances in the boreal forest, strongly influencing boreal forest structure and function. Thus it is important to study the response of arctic forest soils to rising temperature and increased fire frequency and the present and future role of arctic forests in the global C cycle.

In this study, we characterise the post-fire C dynamics (CO_2 efflux, soil C content, soil C turnover times) along a fire chronosequences in northern boreal forests of north-western Canada. Our study areas were located along the Klondike Highway (non-permafrost areas) and Dempster Highway (permafrost areas), in Northwest Territories and Yukon, Canada.

In the summer of 2015, four different study areas (each with a different time since the last stand replacing forest fire), were established both in permafrost areas and non-permafrost areas. The fire chronosequence in permafrost areas consisted areas with last forest fire in years 2012, 1990 and 1969, and fourth area was a control which had no fire for at least 100 years. The fire chronosequence in non-permafrost areas consisted areas with last forest fire in years 2013, 1969 and 1950, and a control area (no fire for at least 100) years. The dates of the fires were determined from the Yukon and Northwest Territories fire maps.

At each fire chronosequence we established three 150 meter-long-lines with three sample plots along each line at 50 meter intervals. The lines were spaced by at least a few hundred meters from each other. We thus had nine sample plots per age class.

The total C contents in the first 30 cm of the topsoil were lowest in newly burned areas and in general total soil C content was higher in areas with permafrost. Same trends were observed when soil CO_2 effluxes were analyzed. The values were significantly lower in in newly burned areas and when permafrost and non-permafrost areas were compared the areas with permafrost were shoving about 1.5x higher values than non-permafrost areas. Thus, all in all soil C turnover time had no significant difference when permafrost and non-permafrost areas were compared.