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Below-ground carbon input in black spruce stands with different fire history in interior Alaska

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Permafrost forests account for more than 20% of forested area in boreal biome. Those permafrost forests have a key role in carbon dynamics of terrestrial ecosystems due to their huge carbon stock in permafrost (frozen soil). However, recent reports suggested that permafrost ecosystems would be vulnerable to climate change (e.g. rising temperature) and disturbances such as forest fire, which may result in increased carbon release including greenhouse gasses such as CO_2.

In interior Alaska, permafrost is present at poorly drained north-facing slope or bottom lands, where black spruce stands have been established. Forest fire is a process needed for regeneration of the black spruce stands, which is considered to occur every 100-200 years. However, recent reports suggested that fire frequency in the permafrost regions was likely to increase in the past decades and effects of the fire would vary with varied fire intensity. Thus, it would be needed to clarify effects of different fire history or different fire intensity on black spruce stands for better understanding of carbon dynamics in permafrost forest ecosystems.

In this study, we examined below-ground carbon input in three black spruce stands, which experienced fire in 2004, 1999 and around 1920 (intact 90-year black spruce stand). The fire in 2004 and 1920 was stand replacing fire, whereas fire intensity in 1999 was low and the fire burned the stand only partially. As a result, above-ground biomass in 2004- and 1999-fire stands were 8% and 38% of that in 1920-fire stand (ca. 2.6 kg m^{-2}). We established study plots in those three stands in the summer of 2009. In each plot, production rates of litterfall, fine roots and forest floor mosses were estimated, which are major components of below-ground carbon inputs in the black spruce stands on permafrost.

In the 2004-, 1999- and 1920-fire plots, estimated production rates of litterfall were 20.5, 21.8 and 30.3 g m^{-2} y^{-1}, respectively; those of fine roots were 48.0, 47.0 and 64.5 g m^{-2} y^{-1}, respectively; those of forest floor mosses were 46.4, 33.3 and 37.7 g m^{-2} y^{-1}, respectively. Assuming that carbon concentrations in these components are 50% (0.5 g g^{-1}), below-ground carbon input was estimated to be 57.5, 51.0 and 66.5 g C m^{-2} y^{-1} in the 2004-, 1999- and 1920-fire plots, respectively. These results suggested that the amounts of below-ground carbon input could recover to the level before fire during the 5-10 years after the forest fires, although decreases in above-ground biomass was still evident even after the low-intensity fire (1999-fire plot). The quick recovery of below-ground carbon input is likely to be attributed to increased contribution of understory vascular plants on production of litterfall and fine roots, and to changes in species composition for production of forest floor mosses after the forest fires.

Keywords: permafrost, forest fire, litterfall, fine roots, forest floor mosses