

Effects of fire on fine root biomass in a black spruce forest:
A preliminary study at the Poker Flat Research Range.

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ABSTRACT: Fine root is a key component in nutrient cycling of forested ecosystems. In this study, fine root biomass (< 2 mm in diameter) were examined at a severely burned black spruce forest at the Poker Flat Research Range in August 2005, one year after severe wildfire in summer 2004. An unburned black spruce forest close to the burned site was also investigated as a control. Estimated fine root biomass, including live and dead fine roots, in surface moss + organic layer to the soil depth of 20 cm was ~1010 and ~1040 g m⁻² in burned and unburned sites, respectively, 70% of which was concentrated to surface moss + organic layers in both sites. However, because of technical difficulties, we could not separate roots from root-organic matter complexes in part and they were 360 and 900 g m⁻² in burned and unburned sites, respectively. Thickness of the surface moss + organic layer was smaller in the burned site (~22 cm) than in the unburned site (~38 cm), which resulted in larger fine root density at the surface layer in burned site (~4.4 kg m⁻³) than in unburned site (~2.4 kg m⁻³). Roughly estimated living proportion of fine roots was 1% and 65% in the burned and unburned plots, respectively. Although there are technical problems to be solved, the results of this study suggested that wildfire in 2004 substantially affected ground surface condition (decline in moss + organic layer) and killed most of fine roots at the severely burned black spruce forest, but the effects on total fine root biomass might not be remarkable.

1. INTRODUCTION

Boreal forest is believed to play an important role in carbon dynamics in terrestrial ecosystems. One of the reasons is that the amount of soil carbon contained in boreal forests was estimated to be twice as large as that of temperate and tropical forests combined, even though boreal forests cover only half the land area of the other two forest types. However, it is expected that boreal forests may shift to a net source of carbon from a net sink in the near future, due to events such as deforestation activities and fire disturbance (Kasischke 2000). Black spruce (*Picea mariana*) is a dominant tree species on poorly drained north facing slopes, which is usually underlain with permafrost. Black spruce forests are widespread in interior Alaska and they cover more than 40% of the Fairbanks area (Viereck et al. 1983). Although black spruce forests are known to have low aboveground productivity, some papers suggested that belowground processes are much more dynamic than expected. In particular, a recent paper by Ruess et al. (2003) showed an importance of fine root dynamics: fine root production and respiration in black spruce forests accounted for 56% of total stand production and 56% of soil CO₂ efflux, respectively (Ruess et al. 2003). Fire is a dominant disturbance in boreal forests and affects carbon and nutrient cycling in those forests significantly. However, there is only limited information on fire effects on fine root biomass and its dynamics, which would be a key factor in carbon and nutrient dynamics in black spruce forests. Therefore, in this study, we examined fine root biomass in a black spruce forest that was severely burned by wildfire that occurred in summer 2004.

2. FIELD SURVEY METHODS AND OBJECTIVES

The objective of this study was to elucidate effects of the wild fire in summer 2004 on fine root biomass in a black spruce (*Picea mariana*) forest. In August 2005, a field survey was conducted at a black spruce forest at the Poker Flat Research Range (65° 07' N, 147° 28' W) of the University of Alaska, Fairbanks, which was severely burned by wildfire in summer 2004. An unburned black spruce forest close to the burned forest was also investigated as a control. Samples, including surface moss + organic (MO) layer and mineral soils to the depth of 20 cm, were taken at 6 sampling

places in each site using a knife and/or a soil corer (4.8 cm in inner diameter) (Split tube sampler, Eijkelkamp, Netherland). Distances between the sampling places were approximately 3.5 m. The samples were divided into MO layer and 0–10 and 10–20 cm mineral soil layers and were kept at cool temperature or in a freezer (-20 °C) until processed. Then the samples were washed with tap water on a 0.5-mm mesh sieve and fine roots (< 2 mm in diameter) were picked up using tweezers. The fine roots were further classified into live and dead roots with criteria: live roots were firm and resilient. The fine root samples were dried at 70 °C for more than 48 hours and were weighed using an electric balance.

3. RESULT

In the burned site, surface moss + organic (MO) layer was severely burned by the wildfire in summer 2004 and there was no permafrost (to 160 cm deep mineral soil, Matsuura 2005) at sampling places in this site. In contrast, in the unburned site, some of the sampling places were frozen at bottom of the MO layer and mineral soils. Therefore we were not able to reach the soil depth of 20 cm for 4 of 6 soil core samplings in the unburned site.

Fine root biomass, including live and dead roots was ~1010 and ~1040 g m⁻² in MO layer to the soil depth of 20 cm in burned and unburned sites, respectively (Fig 1). Most of the roots (~99%) appeared to be dead in the burned site, whereas 65% of the fine roots in the unburned site were classified as living roots (Fig 1). Fine roots were concentrated to surface MO layer in both burned and unburned sites. The fine root biomass in the MO layer was ~850 and ~950 g m⁻² in the burned and unburned sites, respectively, which was ~70% of the total fine root biomass in surface to 20 cm deep mineral soil (Fig 2). Fine root density in the MO layer was larger in the burned site than in the unburned site due probably to reduced thickness of the MO layer in the burned site. If we assume that carbon contents in the fine roots were ~50%, fine roots in the MO layers would contain ~425 and ~475 g C m⁻² in burned and unburned sites, respectively. These values corresponded to ~20% and ~10% of organic carbon in the MO layers of burned (2.2 kg C m⁻²) and unburned sites (4.4 kg C m⁻²), respectively (Matsuura unpublished).

Because of technical difficulties, we were not able to separate roots, in part, from root-organic matter complexes (RO in Fig 1). In addition, fine roots of < 0.5 mm in diameter was partly lost through 0.5-mm mesh sieve during the root separation process. Therefore, the fine root biomass might be underestimated in this study.

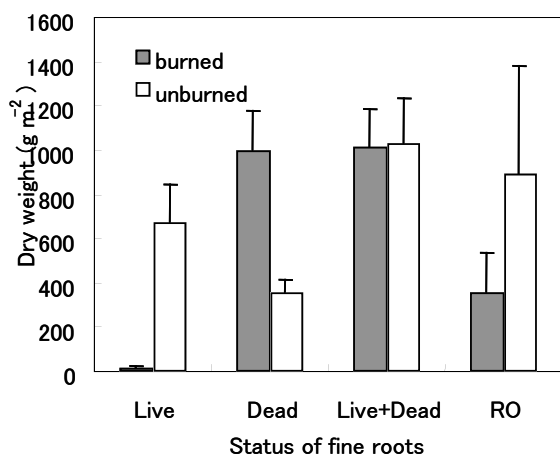


Fig 1: Live and dead fine root biomass in surface MO layer to 20 cm deep mineral soil (d < 2 mm)

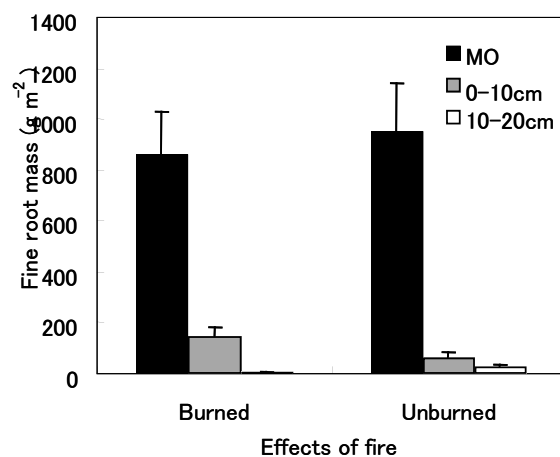


Fig 2: Vertical distribution of fine root biomass (d < 2 mm)

4. CONCLUSION

In conclusion, this study suggested that wildfire in summer 2004 burned surface moss + organic (MO) layer of a black spruce forest severely and reduced their thickness. It is also suggested that the disturbance killed most of fine roots in the burned site, although the effects on the total fine root biomass might not be remarkable.

Further research would be needed especially to evaluate effects of fire on very fine roots ($d < 0.5$ mm) that were partly lost in this study. Increase in depth of active soil layer after fire may change patterns of vertical distribution of fine roots in the future. It would be fruitful to elucidate fine root production and/or decomposition rates using ingrowth cores, root-litter bags or minirhizotron techniques related to status of the MO layers and depth of active soil layers for our better understanding of fire effects on carbon and nutrient dynamics in black spruce forests.

5. REFERENCE

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