Impact of fire disturbance on soil thermal and carbon dynamics in Alaskan Tundra and Boreal forest ecosystems

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Introduction

In Alaska, fire disturbance is a major component influencing carbon, water and energy balance in both tundra and boreal forest ecosystems. Fire-caused changes in soil environment further affect both above- and below-ground carbon cycles depending on burn severities. Understanding effects of fire disturbance on soil thermal change requires implicit modeling work on the post-fire soil thawing and freezing processes. In this study, we study the fire impact on soil thermal change and the post-fire biomass, carbon and nutrients recovery during the early successions.

Methodology

We model soil temperature profiles along a fire severity gradient and compare the fire impact on soil thermal dynamics in continuous permafrost (Anaktuvuk River 2007 fire in North Slope), discontinuous permafrost (Erickson Creek fire at Hess Creek) and non-permafrost zone (Delta Junction fire, interior Alaska). 1. The thawing depth is not significantly governed by burn severity. 2. The post-fire permafrost is more unstable in boreal forest than in tundra site. 3. Compared with non-permafrost, the soil thermal dynamics in permafrost is more vulnerable to fire disturbance in boreal forest ecosystem. 4. Soil thermal condition in Arctic tundra is more resilient than that in boreal forest ecosystem.

Results

1. Plant productivity during the early succesions is negatively related to burn severity.
2. In the first growing season after fire, the severe site is a carbon source while the moderate shift already from a C source to a C sink. After 5 years, the carbon exchange could recover to pre-fire level in term of magnitude.
3. Biomass amount in the severe burned sites recovers to 50% of pre-fire level in 2011, 4 years after the fire.

Discussion & Summary

In the moderate and control sites, carbon reaccumulation is always most limited by nitrogen availability. In the severe burn site, nitrogen is the most limiting element during the early successions, however phosphorus becomes the most limiting elements during the following several years. For the long term, carbon sequestration is most limited by nitrogen. Biomass recovery is most determined by below-ground biomass in the most acidic tundares along North Slope and the time needed to completely recover depends on burn severities. Compared with biomass which may totally recovery within 20 years, soil C, N, P stocks need much longer time to recover to pre-fire level.

Bibliography

Rastetter et al., Ecological Applications, in press.