

Carbon loss from forest floor/top soil by wildfire:  
- A case study of 2004 fires at Poker Flat Research Range -

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## ABSTRACT

Carbon loss after one year of 2004 wildfire was estimated in Poker Flat Research Range (PFRR). By comparing organic C storage at burned site with those of unburned sites, C loss from forest floor/top soil was estimated at three different forest types. Three profiles were surveyed at *Picea mariana* (black spruce) stands, of which two profiles were located on the burned forest. Heavily burned site showed remarkable permafrost table subsidence below 160cm of mineral soil horizon; on the other hand, permafrost table existed at the depth of 33 cm below mineral soil at the unburned black spruce stand. Forest floor thickness of unburned black spruce stand was 20 to 30 cm. Decline of forest floor thicknesses after wild fire in *Betula papyrifera* var. *humilis* (Alaskan paper birch) stands was distinct with slightly scorched top soil, whereas there was not so much decline of forest floor thickness in *Populus tremuloides* (quaking aspen) stands. Organic C loss from forest floor was estimated as follows; 2.0 – 2.2 kg C m<sup>-2</sup> in black spruce stands, 2.6 kg C m<sup>-2</sup> in Alaskan paper birch stands, 0.2 kg C m<sup>-2</sup> in quaking aspen stands. C loss from top soil (30 cm storage) was not so clear in birch and aspen stands. Further studies on dead root organs and CWD contribution to C storage and loss are needed.

## 1. INTRODUCTION

Wildfire is one of major disturbances in northern forest ecosystems. Wildfire disturbances release large amount of carbon dioxide during burning process, and also change the site from sink to source for carbon (Kasischke & Stocks 2000). Soil properties such as nutrient storage and other chemical constituents are also affected by burning severity and fire frequencies (Dyrness & Van Cleve 1989; Certini 2005; Smithwick et al. 2005). The year 2004, there were many wildfire occurrences in Interior Alaska and Yukon Territories. Those fire occurrences and total burnt area in Interior Alaska was the worst record in the past five decades (Prof. Fukuda, personal communication). Effects of this fire are great concerns for regional environment, especially for carbon sink / source balance.

Permafrost type in Interior Alaska is discontinuous, so that permafrost melting event and postfire regeneration/succession process may vary site to site. Based on general scientific information on post fire regeneration in Alaskan forests (Van Cleve et al. 1986), long-term monitoring research after wildfire is attempted with integrated interdisciplinary fields (Chapin et al. 2006).

The large wildfire occurred in 2004 may be an important event which provides us an opportunity to recognize ecosystem processes and functions. This paper reports preliminary results of 2004 wildfire effects on carbon storage decline at Poker Flat Research Range.

## 2. STUDY SITE AND METHODS

I selected soil survey area in Poker Flat Research Range (65°07' N—147°28' W) burned in 2004 summer. Soil profile survey and soil sampling were conducted in August 2005. Seven profiles were surveyed; three in *Picea mariana* (black spruce), two in mixed *Betula papyrifera* var. *humilis* (Alaskan paper birch / black spruce), and two in *Populus tremuloides* (quaking aspen) stands. Those seven profiles were located on NNW to WNW facing slope. For *Picea* stands, profile description and soil sampling were conducted in heavily burned stand (PF-1), no fire damages stand (PF-2), and moderately burned stand (PF-3). For *Betula* and *Populus* stands, pair of no fire damages and burned stand was surveyed; no fire damages *Betula* (PF-5), burned *Betula* (PF-6), no fire damages *Populus*

(PF-4), and burned *Populus* (PF-7). Forest floor condition and litter accumulation depth, regeneration species, and depth of permafrost table were recorded. Other features of soil profile were described according to FAO/ISRIC system (FAO 1990). Soil organic C and total N storage were analyzed by dry combustion method (NF-22F, SUMIGRAPH).

### 3. RESULTS AND DISCUSSION

Permafrost existed under *Picea* stands, except for heavily burned stand (PF-1). The shallowest depth of permafrost was 33cm below mineral soil surface at no fire damage *Picea* stand (PF-2). Surface organic layer with moss and lichen accumulated with 20 to 26cm thickness. Moderately burned *Picea* stand (PF-3) had permafrost table at deeper position (67 cm). Heavily burned stand (PF-1) had no permafrost table until 160cm depth from surface soil. Permafrost table might subside more than 1.3 m in one year after fire disturbance. There was no permafrost tables under the both burned and no fire damages stands of *Betula* and *Populus* within 1.1 m depth. Permafrost table might not be formed under these deciduous tree stands where more heat energy was supplied than in north facing black spruce stands.

Regeneration process in *Picea* stands started with patches of *Chamaenerion angustifolium* (fireweed), *Calamagrostis* spp., and *Polygonum* spp. Survived shrubs, such as *Ledum decumbens* and *Vaccinium uliginosum*, flushed new foliage. Another dense vegetation patch of *Equisetum* spp. and *Marchantia polymorpha* developed at mesic site in burned area of *Picea* stands.

Thickness of forest floor in *Betula* stands decreased much; 12 cm in no damage stand (PF-5) to 2cm in burned stand (PF-6). *Populus* stands showed less decrease of organic layer; 7-10 cm in no damage stand (PF-4) and 4-7 cm in burnt stand (PF-7). Vigorous regeneration observed in both deciduous dominant stands (PF-5 and PF-7). Seedling germination and vegetative sprout observed in burned *Betula* stand. Vegetative sprout regeneration from survived root system was dominant in burned *Populus* stand.

Organic carbon storage in each stands was estimated (Fig. 1). Decline of carbon storage after wildfire was estimated, assuming that C storage in unburned stands in 2005 were same regime of C storage as burned stands before 2004 wildfire. Compare with unburned black spruce stand, 2.0 to 2.2 kg C m<sup>-2</sup> was lost, which derived from surface moss + lichen layer and 1/3 of O horizon. Mixed Alaskan paper birch/black spruce stand showed large C storage decline in forest floor. Nearly 80 % of O horizon, 2.6 kg C m<sup>-2</sup> was lost. On the other hand, there was only 10 % of forest floor C storage decline (0.2 kg C m<sup>-2</sup>) in quaking aspen stand.

Although top mineral horizon of soil profile in burned stands showed lighter soil color (10YR 5/3), comparing with topsoil color in no damage stands (10YR 3/3), there were no clear C storage decline in top 30 cm mineral soil. The C/N ratio of top 30 cm slightly decreased in black spruce and mixed Alaskan paper birch/black spruce stands.

### 4. CONCLUSION

Wildfire disturbance in 2004 caused much C loss from forest floor (0.2 – 2.6 kg C m<sup>-2</sup>). Heterogeneity of fire severity and litter flammability affected mosaic pattern in disturbed area. Mineral soil C storage showed no clear decline, however top 30 cm mineral soil C/N ratio slightly decreased at burned black spruce and Alaskan paper birch/black spruce stands. This estimation excluded coarse woody debris (CWD) contribution to C storage after fire. Further research on C storage is needed.

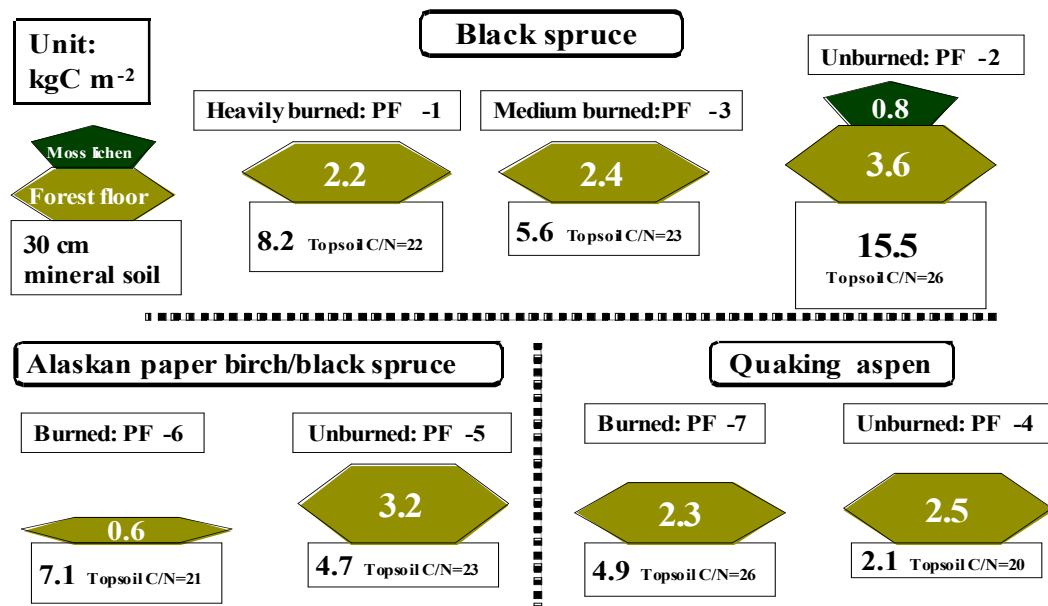


Fig. 1. Estimated organic C storage of seven stands at PFRR. Shapes of polygons indicate C storage in each component as shown at upper left part of the figure.

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