Understanding Soil Carbon Loss and Charcoal Conversion in Northern Peatland Wildfires

SURF Application
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Introduction
Northern peatlands and wetland ecosystems serve as an important stronghold for terrestrial carbon. These ecosystems currently contain as much as half of the world’s soil carbon, depending on how deeply one measures the soil (Tarnocai et al., 2009). In the circumboreal region of Canada and the northern Great Lakes states, these ecosystems are experiencing rapid rates of change, owing to climate warming and increased variation in precipitation (Tarnocai, 2009). As a consequence of drying, the extent of wildfire in northern forests has been increasing (Kasischke and Turetsky, 2006), and is now encroaching into peatland and wetland ecosystems that have previously been thought resistant to burning (Turetsky et al., 2006). For example, in the relatively dry summer of 2007 in northern Michigan (Luce County) 19,200 acres primarily consisting of wetlands, peat bogs, and circumboreal coniferous forest were burned. This fire, called the Sleeper Lake Fire, was one of the largest wildfires in Michigan history (Figure 1).

Objective
Our objective is to quantify the amount of carbon loss from the ecosystem during the 2007 Sleeper Lake Fire and to generate a biometric equation to calculate the conversion rate of the organic layer into residual surface charcoal (char material, or biochar). We will collect post-burn organic layer depths (and char depths) from a representative sampling of the site and use allometric relationships to extrapolate pre-fire organic layer depths to address the following hypotheses:

1) Char conversion rates in this late season fire will be related to pre-fire organic layer depths, as this factor likely influenced the burning conditions.
2) Soil carbon losses (therefore overall carbon emissions) from this temperate peatland complex following the wildfire will be greater than those measured in other upland boreal forest systems, owing to the presence of a greater quantity of pre-burn carbon.

Motivation
The motivation to conduct this study lies in two fields; first, there is a considerable lack of carbon cycle data in peatland ecosystems, which represent a considerable carbon reservoir in the Northern Hemisphere. To our knowledge, this is the first study focusing on Lake States-area wildfire carbon consumption and char conversion rates. Findings from this study may offer considerable insight into this unexplored facet of fire science, and will be of great interest in collaborations between managers in the Lake States and Canadian Forest Services. Second, wildfires have long been considered a vital part of ecosystems’ carbon and nutrient cycles, particularly in coniferous forests where the majority of the nutrients are not in the mineral soil itself but in the thin organic top layer and the standing timber (Gough et al., 2007). We will be adapting an allometric equation for organic layer depth determination, and another for char conversion rate, using Picea mariana in this ecosystem from existing biometrics used for this purpose in a different study (Figure 2; Kasischke et al., 2008). We will also adapt these...
relations to a more widespread tree species (*Larix laricina*), opening the door to future studies in a wider variety of ecosystems and a possible metric correlating *Picea*- and *Larix*-dominated systems.

**Methods**

**Post-fire Soil carbon**—Following reconnaissance of the Sleeper Fire site, road accessible parcels (Figure 1) will be coarsely parsed into six physiographic categories, depending on dominance of *Picea*, *Larix*, or *Picea* + *Larix* genera on upland or lowland landscape positions. Emergent wetland or hardwood systems will not be included in this study. Within each of the six categories, six plots will be established following previous studies (Kane et al., 2007; Kasischke et al., 2008). At each plot we will run a 40 m baseline transect in a homogeneous patch of burned forest. This will be bisected by three 30 m transects, one located at the center, and two located at random distances in each direction from the center. Points will be sampled every 5 m along each 30 m transect (7 per transect) and an additional 4 points will be located along the baseline (at 5, 15, 25, and 35 m), for a total of 25 points per site, along which the depth of different organic layers will be measured. Soil samples by horizon from each point at two plots from each category (12 plots total) will be obtained and taken back to the Soils Lab. at MTU for percent organic matter determination using a muffle furnace.

**Pre-fire Soil carbon**—Along each transect previously described, the nearest tree (either *Picea* or *Larix*) will be measured. These conifers produce adventitious roots as they grow, to keep pace with the developing moss. Therefore, the adventitious root depth height above the mineral soil can provide a good metric for determining pre-fire organic layer depths, even in the post-burn environment (Figure 2). Char conversion rates will be determined as the amount of soil carbon consumed divided by the amount of char carbon left on the soil surface after burning.

**Timeline**—Field work at the Sleeper Lake site will begin May 7, and will continue in four field campaigns thereafter. Laboratory analysis (soil drying and elemental analysis) will be performed between field campaigns, and into the fall if necessary. Manuscript preparation will follow, into the fall semester.

**Ensuring success**—Dr. Evan Kane (MTU, USFS) will evaluate weekly reports on progress, and will facilitate research at the burn site. Dr. Rodney Chimner and Jim Bess (MTU, SFRES) are both working on restoring a portion of the vegetation at the Sleeper Lake fire site, and are amenable to collaboration on this project. Resources for soil sampling and processing will be provided through the Soils lab at MTU. Gas and transportation support is available through collaboration with Dr. Kane, who will also be working in the Seney area this summer.

**Plans for Future Work**

Following the completion of this project, I plan to continue my work with Terra Preta at MTU, studying the unique characteristics of biochar as a soil amendment and the burn conditions which are necessary to generate a useable final product. After completing my Bachelor’s of Science degree from Michigan Tech, I will continue my work with biochar’s role in ecosystems. For the next couple of years at least, I have been graciously extended the privilege of partnering with USDA researchers insofar as use of their facilities and resources in my final goal of trying to find a correlation between synthetic production of post-burn conditions in clearcut logging programs—via biochar soil amendment—and forest longevity.

![Figure 2: Allometric relationship for determining pre-fire organic layer depth in the post burn environment using Picea root depths (Kasischke et al., 2008). This same relationship will be evaluated for Larix trees in the Sleeper Lake peatland complex.](image-url)


