GC33A-0934

The Effect of Fire Intensity on Soil Respiration in Siberia Boreal Forest

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1.Introduction

Russian boreal forests have an annual wildfire activity averaging 10 to 20 million ha, which has increased in recent years. Increases in burn areas of varying fire severity will have an unknown effect on carbon in including release by soil respiration and uptake by tree growth as a result of mortality from fires and regeneration initiated by fire. Fire can change the rate of soil respiration by reducing soil moisture and organic matter, increasing surface temperature, and reducing soil microbial populations to varying degrees. In this study we measured soil respiration on multiple plots at each of three Scots pine forest sites that were burned under a variety of weather and fuel conditions. We measured postfire soil respiration periodically over three to eight years, to assess the effects of variation in fire behavior on soil respiration rates, and how the soil respiration changed over time as the sites recovered. This study is part of the Russian FIREBEAR (Fire Effects in the Boreal Eurasia Region) Project, which quantifies the impacts of fire severity on ecosystem processes, emissions, and the carbon cycle. .

2. Method

The soil respiration measurement system consists of a 1 liter PVC chamber that is placed on to the soil surface. Soil CO_2 flux from the chamber is drawn through tubing with a pump-flow controller module to a model LI-800 CO_2 analyzer. Soil temperature and chamber pressure are measured. Measurements were made annually at the sites in June and July from 2003 through 2010. Soil respiration of the burn plots was measured at the same time on adjacent (unburned) control plots at each site.

3. Experimental Design

Experimental fire plots at Yartsevo and Khrebtova were approximately 200 m 200 m (4 ha), and smaller at Govorkova (2.3 and 3.1 ha). The plots were burned under a range of fuel moisture conditions to observe effects on fire behavior, fire severity, fuel consumption, emissions, vegetation, and other factors. A reference grid point system was established on each plot for various measurements and sampling.The fires were conducted in June and July of 2000–2003, during the main fire season for this region. A sample of 8 to 12 grid points per plot was selected for soil respiration measurements. Three measurements were made at at separate locations near each sample pointfor a total of 24 to 36 measurement points per plot, and averaged to produce an integrated value. The sampling design was used for adjacent unburned control plots.

4. Sites

The Yartsevo field site is located on the central Yenisey River, and the Govorkova and Khrebtova sites are located north and south of the Angara River, in central Siberia. The plots are in a Scots pine (*Pinus sylvestris)*/lichen (*Cladonia* sp.)/feather moss (*Pleurozeum schreberi*) forest type. The soils are sandy alluvial-ferrous podzols supported by small-grained sand. There is no underlying permafrost at these sites.

5. Results

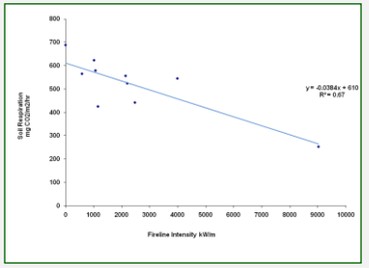

Figure 1. The fire s on the plots at the Yartsevo site were in a range of fireline intensities. A strong trend between fireline intensity and soil respiration rate as measured in 2008 is evident (r^2 = .67), six to eight years after burning.

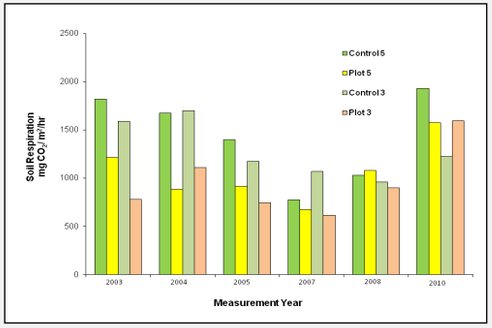

Figure 2. At the Khrebtova site, soil respiration was reduced by approximately 50 percent for the two medium intensity burn plots vs. controls for the first three years, and subsequently began to recover. By 2008 the burn plots and the unburned controls had the statistically same soil respiration rates.

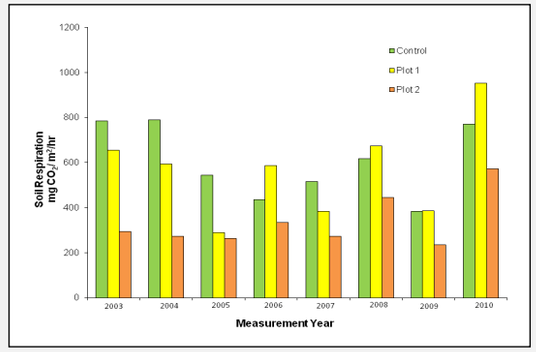

Figure 3. Soil respiration has been measured at the Govokorvo site annually since it was burned in 2002. Soil respiration has recovered on the lower intensity Plot 1. The soil respiration rate on Plot 2 for 2010 was approximately two thirds the rate of plot 1 and the control plot.

Fire	Year Burned	Fireline Intensity (kW/m)	C Release T /ha (Fire)	Carbon Release T /ha /yr			
				2003	2005	2007	2010
Control	Control	0	-	9.2	7.2	6.0	9.0
Plot 1 - control	2002	3196	7.6	7.7 -1.5	3.4 -3.8	4.8 -1.2	11.2 2.2
Plot 2 - control	2002	4876	11.0	3.4 -5.8	3.1 -4.1	3.3 -2.7	6.6 -2.4

Table 1. Estimated annual carbon release from soil respiration at the Govorkovo site with published seasonal data from Kurganova (2006) for Russian podzolic forest soils. The reduction in annual carbon release from soil respiration vs. the control is equal to or greater than the amount of carbon released by the fires on plot 2, the higher intensity fire, after four years. After seven years on plot 1, the lower intensity fire plot, soil respiration had recovered to a similar rate as the control plot.

6. Summary

Soil respiration has been measured annually at three Scots pine sites in central Siberia where experimental fire plots were established and burned from 2000 to 2003. On low intensity fire plots, soil respiration was initially reduced by as much as 50 percent but now is similar to unburned controls. For medium intensity plots, the soil respiration rate was initially reduced by more than 50 percent and has subsequently increased, but is less then that of the control plots. The estimated summed annual reduction in carbon release from soil respiration due to burning on the medium fire intensity plot equals the carbon release from the fire after four years.

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