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MICROMETEOROLOGICAL CHANGES TO THE BOREAL FOREST FOLLOWING WILDFIRES: AIRBORNE MEASUREMENTS DURING BOREAS

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1. INTRODUCTION

Fire is the main stand-renewing agent in the Canadian boreal forest, typically burning about 1% of the forest area annually (Weber and Stocks 1998). As a major disturbance, fire is implicated to control much of the net carbon balance of the forest on time scales of decades (Kasischke et al. 1995, Kurz and Apps 1999). In addition, the large area burned has local effects on the meteorology and climate of affected sites, largely caused by changes in the vegetation. Despite some micrometeorological measurements at specific sites (e.g., Rouse 1976), there are few measurements of the effect of forest fires at the landscape scale.

During the BOREAS experiment (Sellers et al. 1997), meteorological measurements were made over the Canadian boreal forest at a variety of scales. Part of this experiment included airborne measurements of energy and mass fluxes over many different surfaces. Here we present meteorological measurements that have been tied to the burning history of the landscape. Additional details are presented by Amiro et al. (1999).

2. METHODS

The flux and meteorological data were collected during mid-day flights in the summers of 1994 and 1996 along a 500-km transect from near Prince Albert, Saskatchewan (53.98N, 104.79W) to near Thompson, Manitoba (55.89N, 98.00W). The fluxes were measured at a height of about 30 to 40 m using the eddy covariance technique (MacPherson 1996, MacPherson and Bastion 1997). Sensible heat flux (H), latent heat flux (LE), CO_2 flux, surface radiometric temperature and net radiation were analyzed from the dataset. Also, a "greenness" index was measured as the ratio of near-infrared (730 nm) to red (660 nm) radiation.

The position of the aircraft during the flights was geo-referenced and plotted on a map of fires that occurred in the 1980 to 1996 period. Two-km flight segments were used to characterise the landscape below the aircraft and these were related to age of burn, presence of a lake, or control site (not burned since 1980). In addition, some older sites with a known fire history, which were about 15 and 30 years old respectively, were measured at the BOREAS northern study area.

3. RESULTS AND DISCUSSION

The transect intersected two fires from 1989 (15 segments) and three fires from 1995 (26 segments). About 160 control segments were included. Radiometric surface temperatures were significantly warmer by 2 to 6°C at the 1989 and 1995 burns compared to controls ($P<0.05$, Mann-Whitney test), although the 1989 and 1995 burns were not different from each other. H increased and LE decreased in the newly-burned areas for about the first decade (Fig. 1), and then the pattern was reversed for about the next two decades. The Bowen Ratio (ratio of H to LE) clearly shows this cross-over (Fig. 1). This pattern shows decreased evapotranspiration from the more recently burned forest because there is less vegetation. Hence, more energy is dissipated as sensible heat. Net radiation was largely unaffected by the age of burn (Fig. 1), likely because the warmer soil temperatures emit more thermal infrared radiation that partially compensates for the reduced albedo at the most freshly burned sites. Figure 1 also shows that the greenness index returns to background levels at about 30 years as vegetation develops.

The CO_2 flux decreased to about 25% of background control measurements in the year following a fire (Fig.

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1). This flux steadily increased with time since fire but did not reach the control levels until about 30 years following a fire.

Our measurements are for day-time only, and for a few days during the growing season. Hence, we cannot calculate net carbon balances for these sites. Also, night-time respiration plays an important role in the carbon balance and we have no measurement of this. However, our measurements are consistent with some of the models that estimate a decrease in net ecosystem carbon flux for periods of years to decades following a fire (e.g., Kasischke et al. 1995, Kurz and Apps 1999).

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Figure 1: Effects of fire on net radiation, greenness index, sensible heat flux (H), latent heat flux (LE), Bowen ratio (H/LE) and CO_2 flux. The points are the mean data for a given flight, expressed as the burned to control (older stand) ratio. The error bars represent ± 1 S.E. among flights (n = 1, 4, 6 or 11).