Exploring the sensitivity of soil carbon dynamics to climate change, fire disturbance and permafrost thaw in a black spruce ecosystem

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Supplemental Materials

Field measurements of soil temperature and soil moisture

For the Unburned Mature stand, temperature probes were installed at depths of two, five, 16, 24, 51, and 200 cm. For the 2003 Burn, temperature probes were installed at depths of 3, 8, 13, 81, and 205 cm. For the 1967 stand, temperature probes were installed at depths of three, six, 11, 20, and 74 cm.

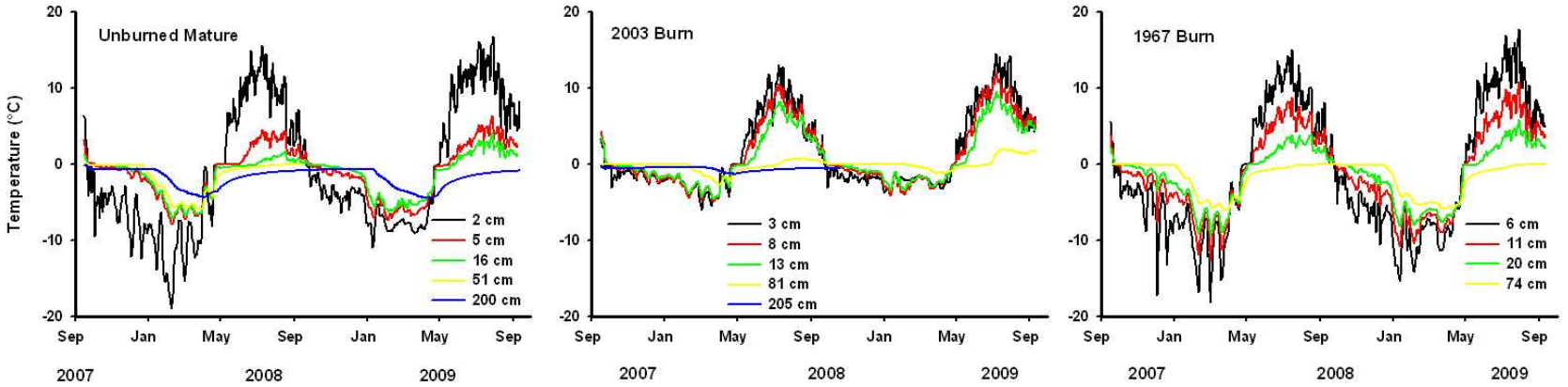
At the Unburned Mature stand, soil moisture was monitored in the live/dead moss horizon (3 cm), fibric horizon (7 cm), and mesic/humic horizon (22 cm). At the 2003 Burn, soil moisture was monitored in the fibric horizon (6 cm), and mesic/humic horizon (10 cm), and mineral A horizon (18 cm). At the 1967 Burn, soil moisture was only monitored in the mesic/humic horizon (16 cm). Soil moisture probes were calibrated following the methods of O'Donnell et al. (2009a).

Soil thermal dynamics, soil moisture dynamics, and snow depth across fire-thaw chronosequence

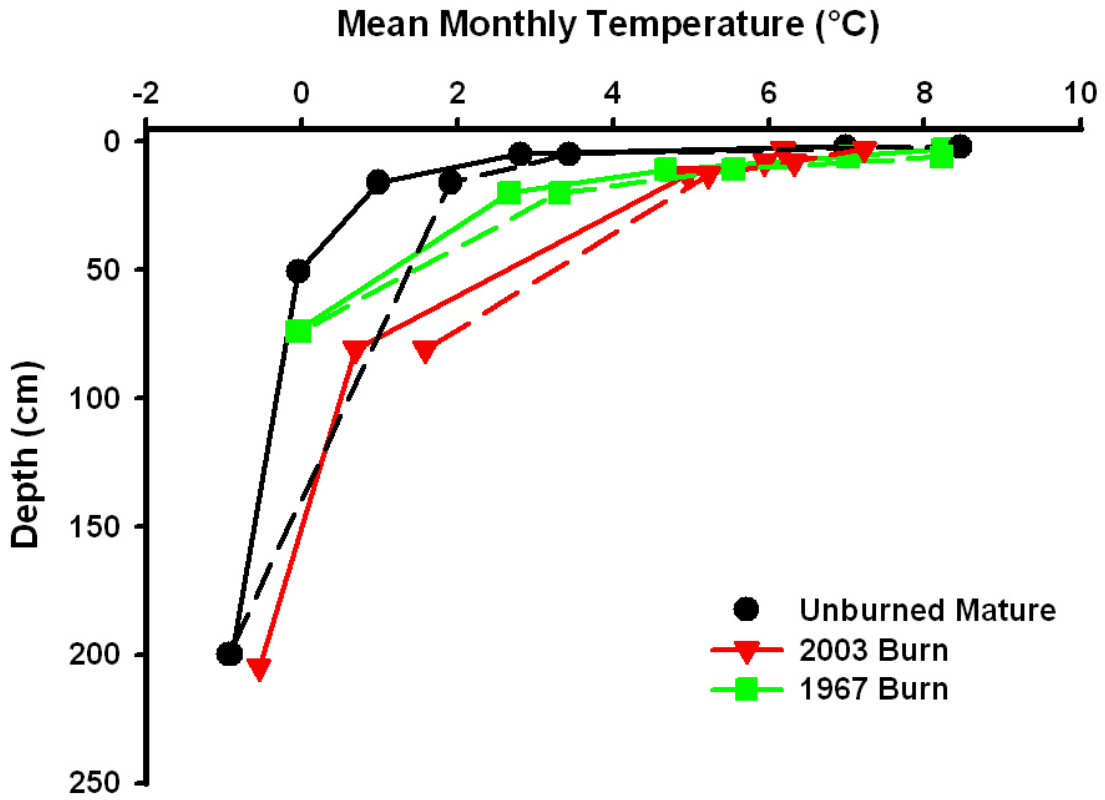
Soil temperature patterns varied seasonally across study sites along the fire chronosequence (Supplemental Figure 1a-c). For example, mean winter (December, January, February) temperatures at the ground surface were substantially colder in the Unburned Mature stand (2008 = -9.04 °C; 2009 = -7.74 °C) than in the 2003 Burn (2008 = -2.35 °C; 2009 = -2.18 °C; Figure 2). Mean monthly temperature (MMT) at the ground surface in August, when thaw depth reaches an annual maximum, was similar across sites, averaging 6.99, 8.23 and 6.18 °C at the Unburned Mature, 1967 Burn, and 2003 Burn, respectively. However, MMT in August at depth was cooler in the Unburned Mature stand than in the 2003 Burn and 1967 Burn (Supplemental Figure 2).

In general, the 2003 Burn was considerably wetter than the Unburned Mature stand throughout the organic horizon. At the 2003 Burn, VWC during summer averaged 61.7 ± 13.2 %, 55.5 ± 13.7 %, and 29.7 ± 10.2 % in the fibric, mesic/humic, and A horizons, respectively, whereas at the Unburned Mature stand, volumetric water content (VWC) during summer (May – August) averaged 7.8 ± 4.7 %, 17.2 ± 7.0 %, and 30.1 ± 13.4 % in the live/dead moss, fibric, and mesic/humic horizons, respectively (Supplemental Figure 3). Using these VWC values, we then calculated average thermal conductivity values for each organic soil horizon (Table 2). The higher VWC values in the 2003 Burn resulted in considerably higher thermal conductivity values (0.353 – 0.364 W m^{-1} K^{-1}) than in the Unburned Mature stand (0.070 – 0.211 W m^{-1} K^{-1}). Using the GIPL model, we observed good agreement between measured and modeled ALD (Supplemental Figure 4) at sites across the Hess Creek fire chronosequence.

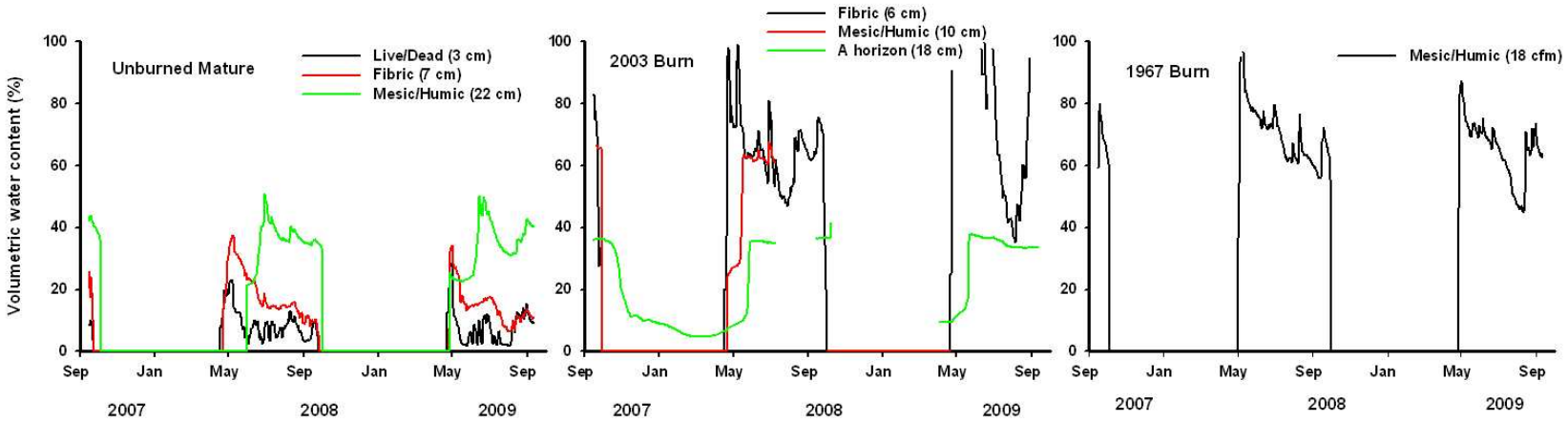
Supplemental Figures



Supplemental Figure 1.



Supplemental Figure 2.



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65 **Supplemental Figure 3.**

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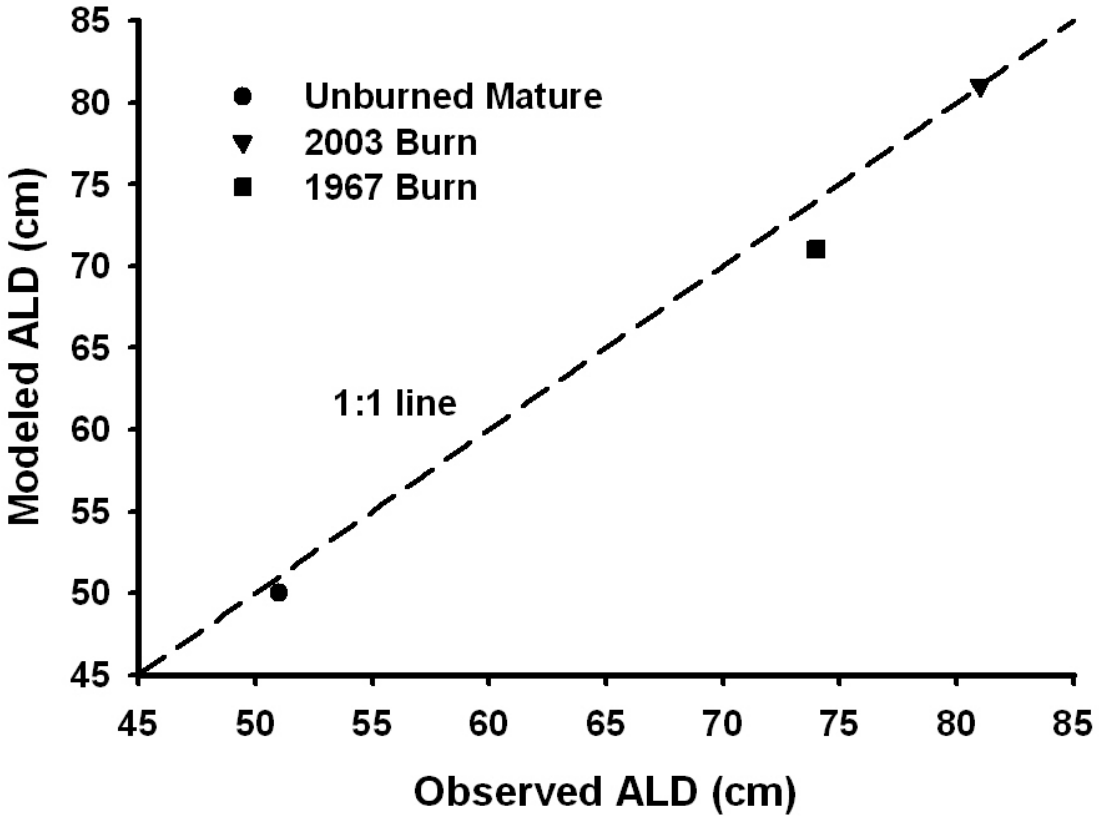

Supplemental Figure 4.

Supplemental Figure Legends

Supplemental Figure 1. Seasonal and interannual variation in soil temperature (°C) at Unburned Mature stand, 2003 Burn, and 1967 Burn.

Supplemental Figure 2. Mean monthly temperature profile for August 2008 (solid lines) and 2009 (dashed lines) at three study sites across the fire chronosequence.

Supplemental Figure 3. Mean daily volumetric water content from September 2007 to September 2009 at three stand ages across fire chronosequence at Hess Creek.

Supplemental Figure 4. Comparison of modeled ALD (from GIPL model) and observed ALD measured in late-August 2008.