Geophysical Research Abstracts, Vol. 7, 05893, 2005
SRef-ID: 1607-7962/gra/EGU05-A-05893

Boreal Landscapes: Wildfire and permafrost effects on ground fuel, combustion, and soil climate

J. Harden (1), M. Turetsky (2), K. Manies (1), J. Carrasco (3), J. Neff (3), L. Pruett (1), I. Meyers-Smith (4), H. Veldhuis (5), K. Yoshikawa (4)

(1) U.S. Geological Survey, Menlo Park, California, USA (2) Michigan State University, East Lansing, Mich USA (3) University Colorado, Boulder, CO, USA (4) University of Alaska, Fairbanks, AK, USA (5) Agriculture Canada, Winnepeg, Manitoba, Canada (jharden@usgs.gov/ Fax 650-3294920 Phone: 650-3294949)

Spatial and temporal variations in boreal forest wildfires are influenced by a legacy of soil organic matter and permafrost that is unprecedented for other fire-prone regions. Understanding these legacy effects is paramount to forecasting hydrological, chemical and biological responses to the rapidly changing climate. Fire history and soil climate in Alaska and Canada have dictated the spatial distribution of soil organic matter, which includes shallow soil layers that accumulate as ground fuels between burns, as well as deeper organic soils that accumulate for centuries to millennia.

Permafrost occurs discontinuously beneath the boreal forest and impedes moisture at its upper boundary: fuel storage is higher in permafrost sites as compared to well drained uplands, owing mainly to the presence of deep, wet organic layers that resist most wildfires. Therefore, shallow permafrost impacts patterns of combustion. For example, during a wildfire of moderate severity a well drained, non-permafrost sites lost 54% of available ground fuels, whereas poorly drained permafrost sites lost only 18% of ground fuels. As a result, organic matter storage is generally greater in permafrost landscapes both before and after the wildfire as compared to well- drained landscapes, which are permafrost-free. These patterns of fuel storage and combustion manifest important effects on the soil thermal regime: Near-surface temperatures decline significantly with increasing thickness of the organic layers, by approximately 0.5 deg C for every 1cm of organic soil. Colder temperatures result in slower rates of decomposition, supplying a positive feedback to organic matter accumulation. Moreover, burning invokes a recalcitrance to the organic matter in the form of black carbon.

In lowlands, patterns of fuel storage and burning are dictated by the depth of the water table. Potential fuels persist in the form of peat, a legacy of high water tables and/or frozen conditions. Above the water table, fuels are subject to fire and rapid decomposition. In drought years, water tables decline and render more fuels available for combustion. In a 20-yr spatial analysis of fire occurrence, upland areas were found to dominate fire emissions during wet years and the lowland areas dominate combustion products during average and drought years. In a model for western Canada, climatic variations that invoke drought and wet conditions result in $>$100-Fold variations in carbon emissions.

Modeling and forcasting climate and carbon cycling should consider disturbance on these landscapes, which are most strongly influenced by (1) soil moisture and water-table, (2) thickness of the organic layers before and after disturbance, and (3) changes in radiation (albedo, shading, snow interception) after disturbance. Active layer, water table, and subsurface drainage are clearly pivotal to recovery of permafrost and vegetation, yet their spatial patterns in relation to fire and climate are likely changing through our decades of study.