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# *Wildfire in the Subarctic Boreal Forests, Ecosystem Impacts and Response to a Warming Climate (Extended Abstract)*

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Frostfire is a highly technical project, attempting to develop or in some aspects further refine our knowledge and modeling capability of fire effects, ecosystem impact, and vegetation recovery. Although extensive fire research has been conducted in more temperate regions, relatively little has been executed in the boreal forests and almost none in areas of discontinuous permafrost. The goal of this project is to determine the impacts and interrelated effects of fire on ecosystem processes in a small research watershed called Caribou-Poker Creeks Research Watershed near Fairbanks, Alaska. This is a very broad-based project, which includes scientific studies related to fire science, nutrient dynamics, permafrost response, vegetation response and recovery, climatic influence and feedbacks, and hydrology (Hinzman, 2000). Intensive pre-burn surveys quantified fuel status of the soil organic layer and forest canopy throughout the experimental watershed. We also collected pre-burn data on climatic processes, vegetation distribution, streamflow quantities and chemistry, and permafrost and active layer temperatures. The above-mentioned data sets are currently being augmented and additional data is being collected on microclimate controls, soil nutrient status, groundwater/surface water partitioning in streams, and other important aspects.

Forest fires in the boreal forest project an immediate effect upon the surface energy and water budget by drastically altering the surface albedo, roughness, infiltration rates, and moisture absorption capacity in organic soils. Although the forest fire creates a sudden and drastic change to the land-cover, it is only the beginning of a long process of recovery and perhaps a shift to a different successional pathway. In permafrost regions, these effects become part of a process of long-term (20-50 years) cumulative impacts. Burn intensity may largely determine immediate impacts and long-term disturbance trajectories. As transpiration decreases or ceases, soil moisture increases markedly, remaining quite wet throughout the year. Because the insulating quality of the organic layer is removed during fires, permafrost begins to thaw near the surface and warm to greater depths. Within a few years, it may thaw to the point where it can no longer completely refreeze every winter, creating a permanently thawed layer in the soil called a talik. After formation of a talik, soils can drain internally throughout the year. At this point, soils may become quite dry. The local ecological community must continuously adapt to the changing soil thermal and moisture regimes. The wet soils found over shallow permafrost favor black spruce forests. After a fire creates a deeper permafrost table (thicker active layer) the invading tree species tend to be birch or alder. The hydrologic and thermal regime of the soil is the primary factor controlling these vegetation trajectories and the subsequent changes in surface mass and energy fluxes. Understanding these shifts in vegetative communities and quantifying the recent past and future changes in regional energy balance can only be accomplished through complementary analyses of field research data, numerical simulations and remotely sensed data. These are essential steps to a useful and valid regional analysis.

The goals of the hydrologic component of this project is two-fold: (1) to determine how forest fire intensity and time since recovery affect the surface energy and water balances primarily through changes in the permafrost regime using site-specific field studies; and (2) to develop models and approaches to extrapolate the site-specific measurements over broader spatial and temporal scales. Surface moisture and surface temperature are the main driving variables in local terrestrial and atmospheric linkages. Surface temperature is the linchpin in energy fluxes as it links atmospheric thermal gradients, driving convective heat transfer, with the sub-surface thermal gradients, driving conductive heat transfer. Soil moisture exerts a strong influence upon energy fluxes through controls on evaporative heat flux, phase change in thawing of permafrost and indirect effects on thermal conductivity. In order to project ecosystem response to a changing climate and the resultant feedbacks, it is critical to quantify the dynamic interactions of soil moisture and temperature with meteorology as a function of fire intensity and recovery. This study is attempting to unravel the complicated hydrologic and thermal dynamics that follow a fire to elucidate how these changing land surface processes may impact local and regional climate.

Three wildfire burn areas and one experimental prescribed burn area located in or near the Caribou Poker Creeks Research Watershed (CPCRW), located 48 km north of Fairbanks Alaska, were selected for study. The wildfires occurred in 1920, 1990, 1996 and the prescribed fire, called Frostfire, took place in 1999. The hypotheses being tested are 1) the short-term effects of wildfire (proportional to fire severity — measured as the relative amount of organic layer consumed by the fire) will increase both ground temperature and soil moisture content and 2) the long term impact will be to cause deeper thaw of the permafrost and drier soils. Both of these changes to the soil system will cause changes to the surface energy balance that will feedback to impact climatic processes. At the study areas, ground temperature and soil moisture profiles were created between the burned area and the adjacent non-burned area. Between the burned and non-burned areas, measurements of surface temperature, surface soil moisture content, organic layer thickness, active layer depth, ground temperature and soil moisture content at the organic layer/mineral soil interface were made every three meters and soil and climatic monitoring has been initiated. Complete meteorological stations are operated in the 1999 burn area and in a near by control area to detect changes in the surface energy balance.

Examination of the distribution of permafrost and temperatures of the permafrost within Caribou-Poker Creeks Research Watershed has shown that the discontinuous permafrost is even more sporadic than one would expect from thermal analyses. It appears that forest fires earlier in this century (probably those from 1920s) initiated a disturbance to the surface and caused substantial permafrost degradation in isolated occurrences. This has significant implications on the long-term impact of forest fires. If, under the existing climate, the surface disturbance caused by fire initiate wide-spread degradation of permafrost, then substantial changes to the

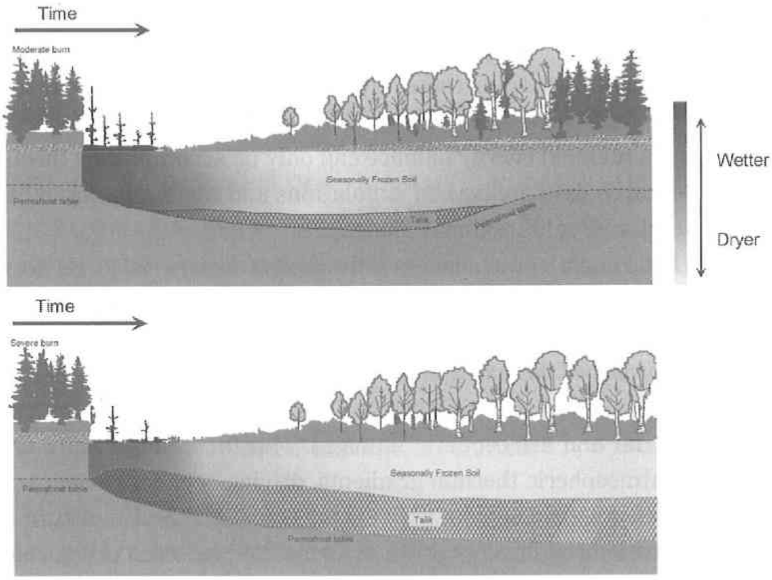


Fig. 1. Hypothesized impacts of fire following a moderate (top) and severe (bottom) fires in the boreal forest.

boreal forest ecosystems will certainly follow (Figure 1). Permafrost maintains the very wet soils near the surface sustaining the environment for hydrophilic species common in the boreal forest. Permafrost degradation may initiate drying of surface soils and a cascade of ecosystem changes. Additional research needs to verify if permafrost will continue to degrade after disturbance in this area, or if it will recover in time.

## References

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