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Modeling boreal fire and forest dynamics

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The circumpolar boreal forest covers about 1.4 billion ha, representing 1/3 of global forest land. Approximately 2/3 of the boreal forest is located in Eurasia and the remainder in North America. Wildland fires annually burn an estimated 12-20 M ha across the entire boreal region, having a major influence on forest structure and composition. However, fire weather, fire behaviour, and fire ecology differ greatly between the boreal forests in eastern and western hemispheres, which have significant impact on tree survival, post-fire regeneration and forest succession. Every year, wildland fires in Canada and Alaska burn an average of 2-3 M ha, primarily by stand-replacing, high intensity crown fires. By comparison, Russian fires burn about 10-15 M ha annually, primarily by low to moderate intensity surface fires that cause minimal tree mortality. Fire weather conditions in the most fire prone regions of Russia are generally more severe than in similar regions of North America. Finally, the species composition of eastern and western boreal forests is also very different. Russian forests are dominated by larch (30%) and pine (28%) with lower components of spruce (14%) and poplar/birch hardwoods (18%) By contrast, Canadian forests are comprised mainly of spruce (35%), pine (22%), poplar/birch (16%), and fir (9%). All of these factors contribute to the variability in vegetation dynamics occurring within the circumpolar boreal region.

This modeling study examines the interactions of fire weather, forest composition, fire behaviour, and fire ecology on forest vegetation dynamics within the boreal region. Similar active fire zones in western Canada and eastern Siberia were used as study sites. Historical weather data were collected for both locations and used to calculate fire weather data, which were used as primary driving variables for the Boreal Fire Effects model (BORFIRE). Fire behaviour was calculated in BORFIRE using data for major tree species at both study sites. Tree mortality, post-fire regeneration, and stand successional trajectories were also calculated using BORFIRE based on plant vital attributes and fire ecology traits for individual species. The results are summarized to compare the influence of fire weather and forest vegetation (fuels) on the typical range of fire behaviour, and the impact on subsequent post-fire vegetation dynamics at both study sites. Key fire behaviour and fire ecology criteria that are critical to modeling post-fire stand composition and successional trends are discussed.