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Adapting fire management to future fire regimes: impacts on boreal forest composition and carbon balance in Canadian National Parks

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The effects of future fire regimes altered by climate change, and fire management in adaptation to climate change were studied in the boreal forest region of western Canada. Present (1975-90) and future (2080-2100) fire regimes were simulated for several National Parks using data from the Canadian (CGCM1) and Hadley (HadCM3) Global Climate Models (GCM) in separate simulation scenarios. The long-term effects of the different fire regimes on forests were simulated using a stand-level, boreal fire effects model (BORFIRE). Changes in forest composition and biomass storage due to future altered fire regimes were determined by comparing current and future simulation results. This was used to assess the ecological impact of altered fire regimes on boreal forests, and the future role of these forests as carbon sinks or sources. Additional future simulations were run using adapted fire management strategies, including increased fire suppression and the use of prescribed fire to meet fire cycle objectives. Future forest composition, carbon storage and emissions under current and adapted fire management strategies were also compared to determine the impact of various future fire management options.

Both of the GCM's showed more severe burning conditions under future fire regimes. This includes fires with higher intensity, greater depth of burn, greater total fuel consumption and shorter fire cycles (or higher rates of annual area burned). The Canadian GCM indicated burning conditions more severe than the Hadley GCM. Shorter fire cycles of future fire regimes generally favoured aspen, birch, and jack pine because it provided more frequent regeneration opportunity for these pioneer species. Black spruce was only minimally influenced by future fire regimes, although white spruce declined sharply. Maintaining representation of pure and mixed white spruce ecosystems in natural areas will be a concern under future fire regimes. Active fire suppression is required in these areas. In other areas where recent fire suppression history has been very successful, prescribed fire will be an important fire management activity to maintain current forest, shrubland, and grassland ecosystems. The model simulations showed that total fire exclusion would effectively lead to the loss of jack pine, and cause a sharp decline in aspen and birch stands.

Increased future fire activity caused a general decrease in total carbon storage, but this impact was moderated by two other related impacts. Shorter fire cycles created a younger age-class distribution, which was represented by more fast-growing, high density stands with high detrital output. The second factor was a general forest composition shift towards faster growing species. Increased fire suppression caused an increase in long-term total biomass storage, but prescribed burning could also have a similar impact if controlled fires were used to replace wildfires and conducted during periods of reduced fire behaviour.