Nature's archives of global climate change

BC Ministry of Forests, Lands, and Natural Resource Operations.

Forest fires with smoke plumes, illustrating how charcoal can be transported to lake depositional environments.

Global climate change has the potential to affect plant community dynamics and ecosystem processes worldwide. Changes in climate are now affecting ecosystem configurations in disparate regions around the globe, resulting in new species groupings, canopy structures, and ecosystem functions. Consequently, plant community dynamics, species interactions, and processes are being transformed, including wildfire. Scientists anticipate that vegetation response to climate forcing will alter fire regimes, which describe the pattern of fire frequency, size, intensity, severity, type, and seasonality in an ecosystem. Climate-driven changes to the fire regime will further modulate forest response to climate change, resulting in a potential feedback linking climate, vegetation, and fire. Given that Canada has a vast forest cover of ecologic and economic importance, it is in the public interest to understand the drivers and dynamics of fire disturbance. Such knowledge is especially paramount given the potential consequences of climate change.

Fire is a complex combustion process that rapidly oxidizes fuel, releasing energy in the form of heat as well as greenhouse gases. These gases directly connect fire disturbance to climate. Post-fire dynamics are also important because additional CO_2 is released at a slow rate as dead organic matter decomposes. Carbon dioxide is also sequestered as the site regenerates. Critically, the combustion reaction is rarely complete during a forest fire—incomplete combustion results in the production of a variety of products, including charcoal. Through various transport mechanisms, charcoal fragments enter nearby lake basins where they accumulate. Subsequent fires deliver additional charcoal to the basins over time, forming a long-term record of disturbance history that is preserved in the lake sediment.

In addition to charcoal, pollen grains and plant macrofossils are also well preserved in lake sediment deposits. These records not only document how forest composition and structure change through time, but can also be used to reconstruct climate history. Using these various proxies, it is possible to assess the interaction between climate, fuel, and fire disturbance, providing a long-term perspective that has relevance in both ecological theory and management.

Given that recent land management practices and fire suppression initiatives have dramatically altered the natural fire regime in parts of Canada and in other regions of the world, long-term records help place the modern fire regime in better perspective. Scientists, forest managers, policymakers, and other officials can use these records to establish baseline conditions, generate analogues, assess ecosystem sensitivity and resilience, identify key processes, and examine rates and magnitudes of change. Furthermore, the records can also be used to calibrate and validate models that are being used to generate ecosystem forecasts for a variety of future scenarios.

"Fortunately, we can use a variety of sampling approaches to recover nature's incredible archives, and in so doing, we open a portal into the past with a view towards the future," says **Kendrick Brown** (Kendrick.Brown@nrcan.gc.ca), a research scientist with the Canadian Forest Service.

For example, in a recent collaborative investigation, vegetation and fire disturbance histories were examined for the southern boreal forest of Scandinavia. Lake cores were collected from two sites near the boreal–temperate forest ecotone. During the early Holocene (ca. 10 000–8000 years ago), pine- and birch-dominated forest typified the region, and both sites exhibited comparable patterns of fire disturbance. However, in the warmer-than-present mid-Holocene (ca. 8000–4000 years ago), temperate forest expanded northward, as evidenced by an increase in thermophilous (warmth-requiring) pollen at the more southern site. At the same time as this change in vegetation occurred, there was a

decrease in fire disturbance. Given their proximity to each other, the sites would have experienced a comparable change in climate. This suggests that the change in fire disturbance at the southern site was in response to the climate-induced change in vegetation.

It is possible that increased summer leafing shaded the understorey, facilitating a relatively moist microclimate that reduced fire disturbance. Other potential factors that may have contributed to the decline in fire disturbance include changes in the moisture content of the foliage, alteration of the fuel structure, and a reduction in volatiles (pitch, wax, resin) available for combustion. A similar decrease in fire disturbance could recur in the southern boreal zone in the future, as vegetation responds to climate forcing. For example, in Canada, the southern boreal fire regime will change in response to a climate-induced expansion of either eastern temperate forest or western aspen parkland.

During the late-Holocene interval (ca. 4000 years ago to present day) climate has cooled and become wetter, and spruce has expanded regionally in Scandinavia, marking the establishment of the modern boreal forest. Notably, both Scandinavian sites experienced an increase in fire disturbance even though climate was deteriorating; another result that highlights the important role of forest composition in regulating the fire regime.

Several similar projects are currently being initiated at the CFS to investigate the various factors that influence the Canadian fire regime and to examine how the fire regime may change in the future. Records of fire disturbance are being collected from fire-prone regions, particularly in the boreal forest, across both lightning strike and precipitation gradients. In addition, charcoal records from the boreal–prairie ecotone are being analyzed to assess the role of fire disturbance at this dynamic vegetation boundary, particularly during times of climate change. *–K.B.*

Kendrick Brown, CFS

Extracting a core in a fire prone region of central British Columbia (left) yielded a 7-m long sediment core that contained laminated sections (right). The core likely spans several millennia, and will be used to examine the various factors that affect fire disturbance through time, including changes in vegetation and climate.

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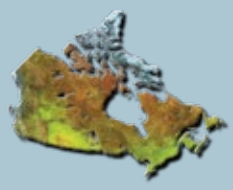

Information Forestry

Science and Technology Research at the Canadian Forest Service • Pacific Forestry Centre

August 2011
ISSN 1701-6649

Canada