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Tracking the Spread and Intensity of Crown Fires

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While high-intensity, crowning forest fires account for a very large proportion of the annual area burned by wildfires in Canada and in many other regions, a complete understanding of crown fire phenomena has been a long-standing research need for the wildland fire management and research communities.

The Canadian Forest Service (CFS) has been an international leader in conducting experimental crown fires in coniferous forest fuel types, and in formulating empirical models and systems for quantitatively predicting crown fire initiation and spread. These models and systems are currently in operational use by Canadian fire management agencies and others.

After four decades of crown fire research, much remains to be explored and developed. The CFS, in cooperation with the Northwest Territories' (NWT) Department of Resources, Wildlife and Economic Development, and with significant participation by the U.S. Forest Service (USFS), initiated a new research thrust in the mid-1990s.

The ICFME study area. Plots averaged 150 x 150 metres in size.

The International Crown Fire Modelling Experiment (ICFME) represents a major field activity of the International Boreal Forest Research Association's Fire Working Group and the International Geosphere-Biosphere Programme's project on global atmospheric chemistry associated with biomass burning. ICFME is one of three recent burning experiments conducted to investigate the behavior, ecological impacts and atmospheric chemical effects of high-intensity crown fires in northern circumpolar boreal forests. The others took place in central Siberia in July 1993, and interior Alaska in July 1999.

ICFME's principal focus was the testing and calibration of a new, physically based model for predicting the rate of spread and intensity of crown fires. The model was developed by Dr. Frank Albini of Montana State University, a theoretical wildland fire modeller, and supported by both the CFS and USFS.

Research methodology

In June 1994, an ideal outdoor laboratory for conducting early-summer experimental crown fires was located approximately 50 kilometres (~30 miles) northeast of the town of Fort Providence, NWT. The forest is a dense, 70-year-old jack pine stand, averaging 13 metres in height with an equally dense black spruce understorey—a perfect fuel complex for generating crown fires. The bulk of the plot establishment, fireguard construction

High-intensity flame front associated with an ICFME experimental crown fire soon after ignition.

and pre-burn sampling of ground, surface and crown fuel characteristics was undertaken during the summers of 1995 and 1996.

The "burning window" for the ICFME project was a three-week period from mid-June to early July, before the Northwest Territories lightning fire season. In preparation for burning, a fully automated fire weather station was set-up on site each season. Daily observations from this station were used to calculate the Canadian Forest Fire Weather Index System components (editor's note: see *Initial Attack* ...Spring 1996, page 6). This information, coupled with the formulated burning prescription, the daily fire weather forecasts issued by a CFS meteorologist, and the results from small-scale test fires, were the principal considerations in deciding which plot (if any) should be burned on a given day.

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To quantify the characteristics associated with the complex and dynamic nature of crown fires, a network of ground-, tower-, and aircraft-based instrumentation was deployed at various locations in, around and above each burning plot. This included a vast array of thermocouples and continuous video. This instrumentation permitted the measurement, monitoring and recording of many parameters, including: thermal radiation, vertical temperature profiles in and above the advancing flame front, fire spread pattern, spotting distances and densities, flame front residence times, flame size and geometry, fuel moisture and consumption, trace gases and aerosol emissions from smoke, and entrainment winds.

Accomplishments to date

Plot burning began on Canada's national day, July 1, 1997 and concluded June 28, 2000. In total, 18 experimental crown fires were conducted in the study area. Attempts were made to burn a single remaining plot in June 2001, but to no avail. This constitutes the world's most thoroughly documented set of experimental crown fires.

Each ICFME plot was ignited as a 'line of fire' using a truck-mounted "terra-torch" pressurized flame-thrower. The fire behavior characteristics were typical for active crown fires in the boreal forest, advancing at 1-5 kilometres per hour, consuming significant quantities of fuel and, in turn, releasing vast amounts of thermal energy. The resulting flame fronts were commonly two to three times the tree height. Despite the small size of the burned areas, well-defined convection columns were established, although temporarily, and prolific short-range downwind spotting was commonly observed for distances up to 300 metres.

ICFME enabled researchers and managers to test and examine models, theories, operational guidelines and equipment.

Installation of thermocouples and continuous video cameras.

The control, mop-up and patrol of all experimental fires was the responsibility of the territorial fire management staff and their contract fire suppression crews, who experienced no problems containing and extinguishing the fires.

Future lessons

While ICFME's initial objective was physical modelling of crown fire behavior, it also permitted examination of other aspects and implications of crown fires, including linkages to fire effects, firefighter safety, and the wildland-urban interface. ICFME enabled researchers and managers to test and examine models, theories, operational guidelines and equipment. The variety of concurrent objectives brought to ICFME by the diverse group of participants illustrates that multidisciplinary undertakings of this magnitude can accommodate both applied as well as fundamental studies, including client-driven and long-term research and development activities.

International endeavors such as ICFME, which involve extensive cross-disciplinary collaboration, are expected to be the model for future wildland fire research, as organizations share resources and effort to make progress.

However, large-scale projects such as ICFME require extensive planning, commitment, collaboration and trust among participating agencies. The working atmosphere must enable participants to work in an unfettered manner. ICFME's success in this regard can be attributed to: thoughtful planning based on similar experimental burns, enlightened fire management, good working relationships between and among the local community, operational personnel and researchers, and the support of senior management. Patience and perseverance are also essential for participants.

Briefing the ICFME team prior to ignition.

Further information

ICFME has provided valuable new data sets and insights into the characteristics of crown fires. Researchers and managers developing strategies to protect communities from wildfire and ensure the safety of wildland firefighters need these resources. The knowledge and experience acquired during ICFME will be critical to developing the next generation of fire behavior models, and we can expect Improvements in the science of fire behavior prediction.

The photographic documentation acquired through ICFME is proving valuable in fire management training and public education. ICFME has been the subject of three film and television documentaries produced in Austria, England and Holland. The USFS Technology Development Center in Missoula, Montana, released a short video presentation on ICFME in early 1998.

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While some preliminary findings and studies carried out during ICFME have already been published, more detailed results will begin to appear within the next two years. Readers can visit the ICFME web site for a comprehensive listing of information resources, including photo coverage of all the ICFME fires. For the latest updates see: http://www.nofc.cfs.nrcan.gc.ca/fire/frn/nwt/.

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