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2.1 THE INTERNATIONAL CROWN FIRE MODELLING EXPERIMENT: AN OVERVIEW AND PROGRESS REPORT

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Wildland fire research scientists in Canada and the United States have been working for many years on the development of fire danger rating and fire behavior prediction systems, which are now in widespread use across North America and overseas. These systems are used daily by fire management agencies in these countries, forming the basis for decision support systems pertaining to fire control and fire use activities. Although much progress has been made to date, much more remains to be accomplished, including the formulation of a physical-based model of wildland fire behavior that can encompass the full range of the types and intensities of free-burning fires encountered in nature for any combination of fuel, weather and topography.

Despite the fact that high-intensity crown fires currently account for an overwhelming proportion of the annual area burned in Canada, a full understanding and the subsequent ability to model the initiation, propagation and spread of crowning forest fires remains an elusive goal for fire research scientists in this country and throughout the world. The Canadian approach to the prediction of crown fire phenomena has been largely empirical in nature. An extensive experiment burning program carried out in several major fuel types, involving both gentle surface to high-intensity crown fires, coupled with observations obtained from monitoring selected wildfires, created a large data base that is the foundation for the system of quantitatively predicting fire behavior used in Canada today. Conversely, the development of systems for rating fire danger and predicting fire behavior in the United States has been based largely on a semi-theoretical, laboratory-based fire spread model, which has proven limited in the prediction of crown fire behavior. Canadian fire researchers have come to realize that it would be virtually impossible to carry out a series of experimental fires over a range of burning conditions in all the important fuel types found in Canada for a number reasons (e.g., time, expense, logistics, shortage of personnel).

Within this context, Canadian Forest Service (CFS) fire researchers began cooperating with Frank A. Albini of Montana State University, a leading fire modeller, on the extension of a somewhat limited crown fire spread model developed and tested in the mid-80s. This process, initiated in 1993, was to involve a large amount of theoretical model development, coupled with specific experimental fires carried out in a field setting for testing and validation purposes. This initiative has also come to be supported by the USDA Forest Service.

After three years of planning and preparation, the first phase of the International Crown Fire Modelling Experiment (ICFME) in Canada's Northwest Territories was successfully carried out between June 19 and July 12, 1997. Designed primarily to develop knowledge and data essential to predicting the physical behavior and impacts of high-intensity crown fires, the ICFME brought together a diverse group of wildland fire scientists and fire managers from various parts of Canada and the United States in a cooperative research undertaking.

The ICFME study area, located about 40 km northeast of the town of Fort Providence, NWT (61.6 deg N latitude, 117.2 deg W longitude), was selected in June 1994 following a reconnaissance of potential candidate sites by the CFS and Northwest Territories Department of Resources, Wildlife and Economic Development (DRWED). The fuel complex consists of a 65-year-old jack pine stand with the overstory canopy averaging 12 m in

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height and 4100 stems/ha with a dense understory (4600 stems/ha) of black spruce, and seemed ideal for supporting high-intensity crown fires in normal summer weather. The study area is surrounded by shrub-dominated meadows that were burnt off in May 1995 with a view to begin securing the area from the possibility of "escapes" or excursions from the planned experimental fires.

Ten experimental burning plots were surveyed in the summer of 1995. Eight of the plots are 150 x 150 m in size; the other two are smaller (75 x 75 m and 100 x 100 m). Plot orientation has been purposely varied to account for some variation in wind directions during the "burning window", which was selected on the basis of day length, local knowledge and an analysis of historical fire danger records.

Preburn sampling of the ground, surface and crown fuel characteristics (load, depth and bulk density) was undertaken during the summers of 1995 and 1996. Construction of 50-m wide fire-guards around each of the plots in order to facilitate access and fire control considerations was begun in 1995 and completed in the fall of 1996. Three additional plots were established adjacent to the primary plots to examine various aspects of fuel management.

Two ICFME planning meetings were held in Calgary, Alberta, during December 1995 and again in January 1997 in order to bring together the participating fire researchers from Canada and the United States together with DRWED staff and native community leaders from Fort Providence. These meetings resulted in the development of logistical and research plans that were acceptable to all parties.

After a wet spring in the Fort Providence area, fire researchers began arriving on June 19 in preparation for three weeks of experimental burning in 1997. A total of 45 research staff from outside of the NWT participated, for varying lengths of time, in the first field phase of the ICFME. This included a group of 20 from Canada (principally members of the CFS fire management network at Edmonton, Alberta, Sault Ste. Marie, Ontario and Victoria, British Columbia, as well as representatives from York University, University of Alberta, and the Alberta Land & Forest Service), a group of 23 from the United States (principally members of the USDA Forest Service from Missoula, Montana, as well as representatives from the National Center for Atmospheric Research (NCAR), National Aeronautics and Space Administration (NASA), Duke University, the USDI Bureau of Land Management's Alaska Fire Service, the USDA Forest Service's National Forest System, and Storm King Mountain Technologies), and two grassland fire scientists from South Africa.

Over the next three weeks, a gradual drying trend produced some ideal burning conditions at the ICFME site. The weather experienced during this three-week period was unusual in several respects. Typically, in the upper atmosphere (500 mb) the experimental site is on the east side of a upper ridge that extends along the west coast of Nortn America. However, this year the 500 mb level was dominated by two well-developed upper lows, one over the Gulf of Alaska and the other over the Arctic Islands, which resulted in a broad trough over the Southern Mackenzie District. At the surface, a trough usually extends along the Mackenzie River valley at this time of year. During the 1997 burning window, surface pressure highs and ridges were common over the Mackenzie District. Rainfall was very light through this three-week period. Rainfall totals (24-h) exceeded 0.5 mm on June 26/97 (5.3 mm) and again on July 11/12 (10.1 mm). A cold front was responsible for the rain on June 26 while an upper disturbance (cold low) brought rain to the site on July 11/12. In a typical summer airmass showers/thunderstorms triggered by daytime heating are common. Winds were light during most of the period, with wind speeds over 20 km/h observed on only three days.

Forecasts were prepared twice daily at 0800 and 1300 MDT (see Appendix) and posted on the ICFME web page. The 0800 forecast predicted the weather for the current day including hourly predictions of temperature, relative humidity, probability of precipitation, wind speed and direction as well the sky condition. The 1300 issue was the forecast for days 2 to 4 and included maximum temperature, minimum relative humidity, probability of precipitation and predominate wind speed and direction. For both forecasts a synoptic discussion of the key features in the upper air and surface was included. The forecasts were prepared by a CFS meteorologist in Edmonton using information obtained from a variety of internet sites. Surface analysis, upper air charts, skew-T thermodynamic diagrams (tephigram) from nearby upper air stations (Fort Smith, Norman Wells and Fort Nelson), satellite images (GOES and NOAA, visible, infrared, enhanced and animations (loops)), and hourly surface observations were all available on the internet in a timely fashion. Also, available on the internet were output from a wide variety of numerical weather models (ECMWF, MRF and CMC products) as well as fore-casts prepared by the Canadian Atmospheric Environment Service.

No radar data was used as there is no radar operating in this region. Next year a portable radiosonde will be used on potential burning days to provide a detailed vertical structure of the atmosphere over the fire site. Updated forecasts and consultations were provided as required on potential burning days via communication through a satellite phone link right at the ICFME site

After a few small test fires, the first full-scale crown fire was ignited on July 1 -- Canada Day! This was followed by two additional successful high-intensity crown fires on July 4 and July 9. A number of other potential burning days had to be cancelled due to largely unfavourable wind directions. The 1997 burning window effectively ended with rains beginning on July 10. Postburn fuel sampling and clean up was completed by July 12.

The experimental plots were ignited as a "line source" using a truck-mounted pressurized flame thrower (terra torch). Permanent DRWED staff and fire crews on contract to DRWED provided all the necessary logistical support for conducting the experimental fires, including the establishment of a temporary base camp near the study area.

A large amount of ground, tower and helicopter-based instrumentation was employed on each of the three experimental crown fires in order to document numerous fire characteristics in the most detailed manner possible. All of the instrumentation worked extremely well, permitting smoke measurements of smoke chemistry, flame geometry, radiant flux, gas temperatures and fire spread using visible and infrared cameras, radiometers and an array of thermocouples. The experimental fires also permitted the testing of personal protective equipment (PPE) used by wildland firefighters including fire shelters and standards for building safety in forest areas and minimum firebreak widths.

The three experimental crown fires carried out at the ICFME site in 1997 were the most complex, intensively monitored experimental fires of their kind conducted in the Northern Hemisphere to date. Fire researchers are currently analyzing the data gathered and will be meeting in early 1998 to jointly discuss the preliminary results. All participating parties plan to return to the NWT in June-July 1998 in order to complete the burning of the remaining ICFME unburned plots.

The ICFME is providing a unique opportunity to bring together wildland fire scientists and fire managers from around the world to study fire behavior in an integrated, interdisciplinary field experiment that should result in a greater understanding of crown fire dynamics that will translate into improved forest fire management decision making in the future. Such an experiment could not have been designed and carried out without the vision, cooperation, and support of many agencies and individuals, including DRWED staff in Fort Smith, Hay River and Fort Providence, the Evergreen Forestry fire crews based in Fort Providence, and especially the community of Fort Providence.

For further details on the ICFME, including photo-graphic images of the three 1997 experimental crown fires, refer to: http://www/nofc.forestry.ca/fire/fmn/nwt/

APPENDIX: Sample Forecasts for ICFME

Forecast Issued at 0815 MDT 04 July 1997
Forecast for Friday 04 July 1997

Synoptic Discussion

At the surface.....High pressure area over the Beaufort with a ridge extending to Great Slave Lake. Mostly sunny skies and light winds accompany the ridge.

At 500 mb....Upper high over southern Alaska with ridge eastward to extreme western sections of the southern Mackenzie. Upper low along the Arctic coast with a trough southeastward to northern Saskatchewan. Moderate northwest flow over the southern Mackenzie.

Time MDT	Sky	RH (%)	Temp. (°C)	Wind Direction/ Speed (Km/h)
1300	Sunny	30	20	Light + variable
1400	Sunny	28	21	L+V
1500	A few clouds	25	22	L+V
1600	A few clouds	25	22	L+V
1700	A few clouds	25	22	L+V
1800	A few clouds	28	21	L+V
1900	Sunny	28	21	L+V
2000	Sunny	30	20	L+V

Comments and Confidence

Winds....light northeast this morning becoming light and variable by noon. Best guess as to direction would be NE this morning becoming E or SE this afternoon. Wind-speed will be light but variable as well with winds up to 15 km/h on occasion. One model- the Canadian Spectral Model has a high pressure cell developing just south (100 km) of the fire site this afternoon. If this happens then outflow from the high could push the direction to a more southerly direction.

Probability of prec..... 0%
Steering Flow (500 mb).... Moderate northwest.

End

Day 2-4 forecast issued at 1415 MDT Friday 04 July 1997

Synoptic Discussion/Remarks

Upper air features... Upper high and ridge in Alaska moves west. Ridge over Alberta - southern Mackenzie weakens and moves southeast. This results in a broad trough extending from a low over the Arctic Islands to a low in the Gulf of Alaska.

At the surface....High pressure area moving into Saskatchewan with a ridge extending to Great Slave Lake on Saturday. Low pressure area developing over the extreme southwest corner of the Mackenzie. Saturday...increasing cloud with a chance of an afternoon shower. Sunday and Monday....Mainly cloudy with a chance of an afternoon shower.

Saturday..	40% pop	Temp 23C Min RH 40% Winds SE 20 km/h
Sunday....	40% pop	Temp 23C Min RH 40% Winds E 15 km/h
Monday...	40% pop	Temp 23C Min RH 40% Winds E 15-20 km/h

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