APPLICATION OF FIRE DANGER RATING TO THE WILDLAND/URBAN FIRE PROBLEM:

A CASE STUDY OF THE NISBET PROVINCIAL FOREST, SASKATCHEWAN

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ABSTRACT: Fire potential is quantified in terms of fire intensity, rate of fire spread, and fire growth for a wildland/urban interface area in central Saskatchewan based on historical weather records and the Canadian Forest Fire Danger Rating System (CFFDRS). Conditions conducive to fast spreading (>22 m/min), high intensity (>4000 kW/m) fires with rapid growth (>55 ha in one hour) occur on a regular basis during the fire season. The CFFDRS can indirectly be used to communicate this wildland/urban fire problem to the public.

INTRODUCTION

The problem of fire in the wildland/urban interface has become increasingly more apparent through the many recent workshops, symposiums and conferences dealing with this topic, as well as through home and life-threatening occurrences. Quantification of this fire problem through research and technology transfer has been described as part of the solution (Gale and Cortner 1987; Laughlin and Page 1987). Although the exact role that the research community will play has not been specifically identified, there undoubtedly are opportunities for application of current available research through the technology transfer process.

Research into fire danger rating and fire behavior has a long history (Brown and Davis 1973) and products from this research can be used to quantify the wildland fire aspects of the wildland/urban fire problem. This includes rate of fire spread, area burned, fireline intensity, spotting, and crowning potential. These forest fire management terms follow those defined by Merrill and Alexander (1987). For those concerned about protecting people and homes from wildfire, important information would include fire intensity, rate of fire spread and area burned. This paper deals solely with quantifying fire potential in these terms. This type of fire behavior information can be used to develop a means of communicating the wildland/urban fire problem to the general public. Using the wildland/urban area of the Nisbet Provincial Forest as an example, fire potential (measured in terms of rate of fire spread, fire intensity and area burned) was quantified using the Canadian Forest Fire Danger Rating System (CFFDRS) (Canadian Forestry Service, 1987).

THE WILDLAND/URBAN FIRE PROBLEM

The Nisbet Provincial Forest is located in central Saskatchewan, just north of Prince Albert (fig. 1). Mean daily temperatures in this area during January and July are -21.5°C (-6.7°F) and 17.4°C (63.3°F). The mean first snow-free and snow-cover dates are April 22 and October 30. Mean annual precipitation is 40.1 cm (15.8 in.), including 125.0 cm (49.2 in.) of snowfall. The critical area of the Forest (fig. 2) is 26 366 ha (65 153 ac) and has a residential population of over 1 500 either within, or directly adjacent to, its boundaries (Saskatchewan Parks and Renewable Resources 1984). Commercial, institutional and industrial values are also prevalent in the Forest.

Figure 1--Geographical location of the Nisbet Provincial Forest (arrow).

Paper presented at the Symposium and Workshop on Protecting People and Homes from Wildfire in the Interior West, Missoula, MT, October 6-8, 1987.

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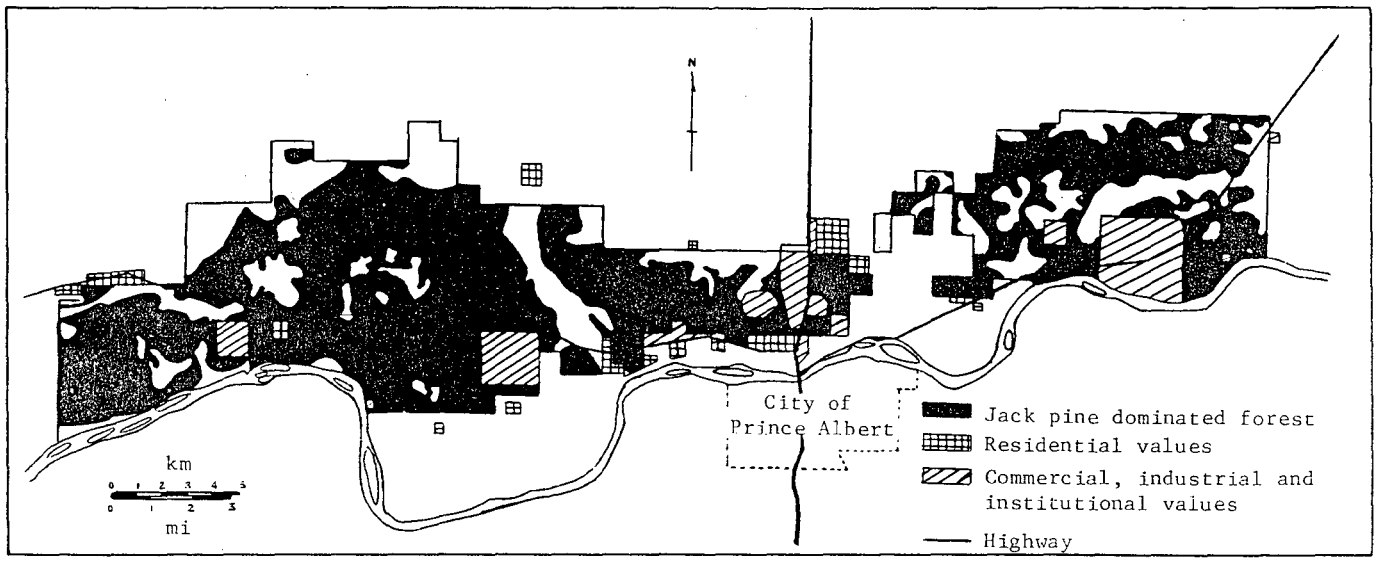

Figure 2--Critical areas within the Nisbet Provincial Forest (after Saskatchewan Parks and Renewable Resources 1984).

The Nisbet Forest is a high-use recreational area, primarily because of the proximity to the City of Prince Albert. Ninety-nine percent of all fires are man-caused, usually the result of abandoned campfires. In 1987, 95 fires required suppression action in the Forest.

Although the Nisbet Forest is located in the mixedwood section of the southern boreal ecoregion (Kabzems and others 1986), jack pine (Pinus banksiana Lamb.) dominates the generally moisture deficient sandy soils of the area. Much of the Forest is heavily infected with dwarf mistletoe (Arceuthobium americanum Nutt. ex Engelm.). The understory is typically reindeer moss (Cladonia sp.), bearberry (Arctostaphylos uva-ursi (L.) Spreng.), dry ground cranberry (Vaccinium vitis-idaea L. var. minus Lodd.), and feather moss (Pleurozium schreberi (BSG.) Mitt.). The topography varies from gently undulating to strongly rolling.

The combination of significant values-at-risk, extensive recreational use with resulting high fire incidence, and the presence of a hazardous fuel type on droughty sites creates a potentially serious fire problem in this wildland/urban interface area.

ANALYZING THE HISTORICAL FIRE POTENTIAL

The only additional element needed to create a dangerous wildfire situation in the Nisbet Forest is the appropriate fire weather. The Canadian Forest Fire Weather Index (FWI) System (Canadian Forestry Service 1984; Van Wagner 1987) is a sub-system of the CFFDRS, and uses consecutive daily noon weather observations to gauge the relative fire potential in a standard fuel type on level terrain. Harrington and others (1983) calculated the component values of the FWI System using meteorological data supplied by the Atmospheric Environment Service of Environment Canada for the period 1953-80. Summaries for the 28 years of FWI System values for the Prince Albert airport meteorological station (Harrington and others 1983) were then applied to the Canadian Forest Fire Behavior Prediction (FBP) System (Alexander and others 1984), another sub-system of the CFFDRS, to quantify frontal fire intensity (Alexander 1982) and rate of fire spread potential on a historical basis.

The fire intensity levels shown in figure 3 follow those designated on the intensity class chart presented in Alexander and De Groot (1988) with low as Class 1, moderate as Class 2, etc. The units of measure are kilowatts per metre (kW/m); the english equivalent is Btu's per second per foot (Btu/(s.ft) [1 kW/m = .29 Btu/(s.ft)]. The intensity class levels for the chart were based primarily on fire suppression capabilities as determined by the expected fire behavior. The rate of fire spread levels used in figure 4 follow

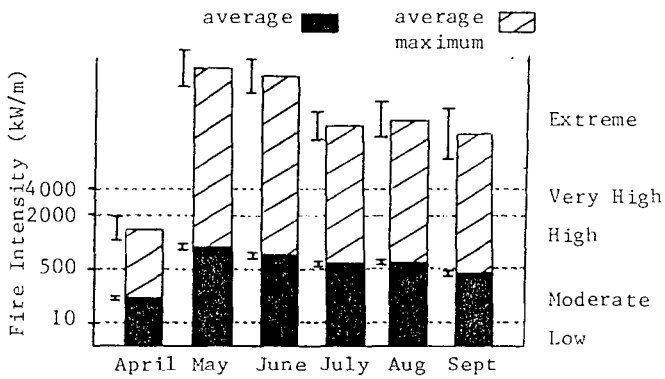

Figure 3--Historical frontal fire intensity potential in the Nisbet Provincial Forest based on level terrain, a mature jack pine fuel type, and fire weather data for 1953-80 (±1 standard error indicated by error bars on the left).

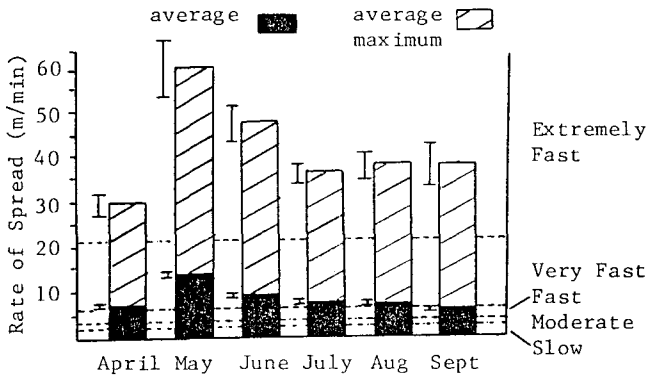

Figure 4--Historical rate of fire spread potential in the Nisbet Provincial Forest based on level terrain, an immature jack pine fuel type, and fire weather data for 1953-80 (±1 standard error indicated by error bars on the left).

those of the province of British Columbia (British Columbia Ministry of Forests 1983), with the exception of 22 m/min (72 ft/min) being used to separate Very Fast from Extremely Fast. For both figures 3 and 4, the average bar reflects a 28-year average of every day in that month; the average maximum bar reflects a 28-year average of only the single most severe burning day in that month.

THE NISBET WILDFIRE SCENARIO

In order to quantify potential area burned, several assumptions had to be made in the construction of the wildfire scenario.

Good ground access and fire detection capabilities in the Forest make it reasonable to assume that initial attack forces should be at the fire site no later than one hour after it starts. This state of readiness would certainly hold true on severe burning days, provided that a multiple-fire situation did not occur. For the purposes of the present exercise, each fire was allowed to burn freely for a one-hour period.

To get a reasonably accurate estimate of the probable area that would be burned over, a worst-case situation was created. Each one-hour fire growth projection was started during the peak burning period in mid-afternoon on the most severe fire weather day in each month of the normal fire season.

Two problems which needed to be addressed in the development of this scenario were in establishing the location and number of fire starts. Knowing fire locations would allow accurate selection of the fuel type and slope. As well, the area burned could be mapped overtop of values-at-risk using a simple elliptical fire growth pattern (Alexander 1985) as in the FBP System (Lawson and others 1985; De Groot and Alexander 1986). However, to simplify this scenario it was decided that selecting fire locations would not be done. Immature jack pine on level terrain was used for all fires since it is the most hazardous and predominant fuel type in this area.

Creating multiple-fire situations would also overcomplicate the scenario. It was decided that one fire per month occurring on the most severe fire weather day in each month would be sufficient to indicate the potential for area burned.
For the period 1978-82, noon weather observations from the Prince Albert weather station were used to calculate the FWI System component values (Van Wagner and Picket 1985). The simple elliptical fire growth model incorporated in the FBP System was then used to calculate area burned (McAlpine 1987). Table 1 summarizes the results of the one-hour free-burning fire growth simulations.

DISCUSSION

The historical fire potential of the Nisbet Forest indicates that it is an area of high fire danger. Historically, the average fireline intensity (from May to September, 1953-80) is classed as 'High' (fig. 3). Fires in this category are often surface fires of moderate vigor requiring heavy ground equipment and air support for control (Alexander and De Groot 1988). Also, at least one day of each month during the same period was classed as an 'Extreme' fire intensity day (fig. 3). Fires starting under such conditions become active crown fires and often exhibit 'blowup' or 'conflagration' type behavior which cannot be controlled. It should be noted that figure 3 was based on the mature jack pine fuel type because similar information is not yet available for immature jack pine. However, it is expected that immature pine would exhibit greater frontal fire intensities under similar conditions.

Figure 4 shows that the average forward rate of fire spread during the fire season (by month for April to September) is Very Fast (6-22 m/min; 20-72 ft/min). As well, at least one day of each month during the same period was classed as a day of Extremely Fast (>22 m/min.; >72 ft./min.) forward spread rates.

The results in table 1 show that there is potential for serious fires in the Nisbet Forest. Severe burning conditions are reflected in the components of the FWI System. Using the Initial Spread Index (ISI) to calculate probable area burned, it is apparent that most summer months have conditions which are conducive to a fire becoming 100-200 ha (250-500 ac) in size within an hour of ignition. Realistically, most of the simulated fires in table 1 would be uncontrollable if allowed to attain the one-hour size. The possibility of multiple fires should also be considered. Any fires that might still be burning during a period of critical weather could further complicate control problems. This could translate to over-extended suppression resources and a longer free-burning period for new fires. The point to realize is that this wildfire scenario is still a fairly conservative estimate of potential fire growth.

Table 1--Noon weather observations and potential area burned in the Nisbet Provincial Forest associated with the most severe fire weather day of each month during the 5-year period 1978-82. Fire size calculations are based on a single ignition burning uncontrolled for a one-hour period at midafternoon in an immature jack pine fuel type on level terrain

Date			Temperature		Relative	Wind Speed		Selected FWI System Components[1]			Area Burned	
M	D	Y	°C	(°F)	Humidity (%)	km/h	(mph)	FFMC	ISI	FWI	hectares	(acres)
5	14	78	20	68	26	26	16	91.5	19.6	25.9	141	348
6	3		24	75	36	28	17	90.2	18.2	31.2	105	260
7	25		25	77	34	33	20	90.8	25.3	47.8	162	400
8	7		22	72	41	46	29	89.3	39.3	49.5	198	489
5	27	79	26	79	31	30	19	91.8	25.1	31.0	186	460
6	18		23	73	35	30	19	90.5	20.8	25.5	128	316
7	20		31	88	40	19	12	90.8	12.5	18.4	75	185
8	1		25	77	38	33	20	90.1	22.8	37.8	133	329
5	20	80	24	75	22	37	23	93.4	45.1	88.4	356	880
6	12		20	68	42	35	22	90.4	26.5	50.4	160	395
7	27		23	73	21	19	12	92.5	15.9	32.9	136	336
8	22		17	63	45	37	23	87.7	19.8	34.2	82	203
5	15	81	5	41	41	41	26	89.0	29.5	47.6	147	363
6	26		27	81	32	33	20	91.8	29.1	56.4	212	524
7	9		22	72	32	28	17	88.3	13.8	30.1	55	136
8	28		28	82	37	26	16	91.0	18.3	38.1	121	299
5	25	82	26	79	29	35	22	92.2	34.3	43.2	253	625
6	30		21	70	37	31	19	91.4	25.0	50.1	174	430
7	1		23	73	60	31	19	88.1	15.6	37.7	63	156
8	7		19	66	55	41	26	85.7	18.3	20.3	57	141

[1]FFMC, Fine Fuel Moisture Code; a numerical rating of the moisture content of litter and other cured fine fuels. ISI, Initial Spread Index; a numerical rating of the expected rate of fire spread (combines FFMC and wind). FWI, Fire Weather Index; a numerical rating of fire intensity (combines ISI and a fuel availability index) that is used as a general index of fire danger.

CONCLUDING REMARKS

In the Nisbet wildland/urban interface area which has 1 500 permanent residents and a heavy recreational demand, a rapidly-spreading, high-intensity fire could be disastrous. An analysis of historical fire potential and the previous wildfire scenario demonstrated that these types of forest fires are distinctly possible.

Often a crisis is required for the general public to appreciate the seriousness of a situation. Perhaps the threat of catastrophic fire in the wildland/urban setting can be better communicated to landowners and recreationists by using fire danger rating to quantify potential fire damage and impacts.

REFERENCES

Alexander, M. E. 1982. Calculating and interpreting forest fire intensities. Canadian Journal of Botany. 60: 347-359.

Alexander, M. E. 1985. Estimating the length-to-breadth ration of elliptical forest fire patterns. In: Proceedings, Eighth Conference on Fire and Forest Meteorology; 1985 April 29-May 1; Detroit, MI. SAF Publ. 85-04. Bethesda, MD: Society of American Foresters: 287-304.

Alexander, M. E.; De Groot, W. J. [In press]. Fire behavior in jack pine stands as related to the Canadian Forest Fire Weather Index (FWI) System. Edmonton, Alberta: Government Canada, Canadian Forestry Service, Northern Forestry Centre. Poster (with text).

Alexander, M. E.; Lawson, B. D.; Stocks, B. J.; Van Wagner, C. E. 1984. User guide to the Canadian Forest Fire Behavior Prediction System: rate of spread relationships. Interim edition. Environment Canada, Canadian Forestry Service, Fire Danger Group. 73 p. + Supplements [First Printing July 1984; Revision and Second Printing September 1984].

British Columbia Ministry of Forests. 1983. Fire weather indices-decision aids for forest operations in British Columbia. Forest Protection Handbook No. 12. British Columbia Ministry of Forests, Protection Branch.

Brown, A. A.; Davis K. P. 1973. Forest fire: control and use. 2d ed. New York: McGraw-Hill. 686 p.

Canadian Forestry Service. 1984. Tables for the Canadian Forest Fire Weather Index System . 4th ed. For. Tech. Rep. 25. Ottowa, Ont. Environment Canada, Canadian Forestry Service. 48 p.

Canadian Forestry Service. 1987. Canadian Forest Fire Danger Rating System--User's Guide. Three-ring binder (unnumbered publication). Canadian Forestry Service Fire Danger Group.

De Groot, W. J.; Alexander, M. E. 1986. Wildfire behavior on the Canadian Shield: a case study of the 1980 Chachukew fire, east-central Saskatchewan. In: Alexander, M. E., comp. and ed. Proceedings, Third Central Region Fire Weather Committee Scientific and Technical Seminar; 1986 April 3, Winnipeg, Man. Study No. NOR-5-05 (NOR-5-191) File Report No. 16. Edmonton, Alberta: Government Canada, Canadian Forestry Service, Northern Forest Research Centre.

Gale, Robert D.; Cortner, Hanna J. editors. 1987. People and fire at the wildland/urban interface--a sourcebook. In: Proceedings, wildland/urban fire interface workshop for social scientists; 1987 April 6-8; Asheville, NC. Washington, DC: U.S. Department of Agriculture, Forest Service. 71 p.

Harrington, J. B.; Flannigan, M. D. Van Wagner, C. E. 1983. A study of the relation of components of the Fire Weather Index to monthly provincial area burned by wildfire in Canada 1953-80. Inf. Rep. PI-X-25. Chalk River, Ont. Environment Canada, Canadian Forestry Service, Petawawa National Forestry Institute. 65 p.

Kabzems, A.; Kosowan, A. L. Harris, W. C. 1986. Mixedwood section in an ecological perspective, Saskatchewan. 2d ed. Tech. Bull, No. 8. Prince Albert, Saskatchewan: Saskatchewan Parks and Renewable Resources, Forestry Division, 122 p.

Laughlin, Jerry; Page, Cynthia, editors. 1987. Wildfire strikes home! Report of the national wildland/urban fire protection conference sponsored by U.S. Forest Service, National Fire Protection Association, and U.S. Fire Administration. Publ. NFPA No. SPP-86. Quincy, MA: National Fire Protection Association. 90 p.

Lawson, B. D.; Stocks, B. J.; Alexander, M. E.; Van Wagner, C. E. 1985. A system for predicting fire behavior in Canadian forests. In: Proceedings, Eighth Conference on Fire and Forest Meteorology; 1985 April 29-May 2; Detroit, MI. SAF Publication 85-04. Bethesda, MD: Society of American Foresters: 6-16.

McAlpine, R. S. 1987. Two BASIC programs for fire danger and fire behavior computations. For. Mgmt. Note 43. Edmonton, Alberta, Government Canada, Canadian Forestry Service, Northern Forestry Centre. 3 p.

Merrill, D. F.; Alexander, M. E., editors. 1987. Glossary of forest fire management terms. 4th ed. Publ. NRCC No. 26516. Ottowa, Ont. Natural Resources Council Canada, Canada Committee for Forest Fire Management.

Saskatchewan Parks and Renewable Resources. 1984. Wildfire action plan for the Nisbet Provincial Forest. Unpublished report on file at: Saskatchewan Parks, Recreation and Culture Prince Albert, Saskatchewan.

Van Wagner, C. E. 1987. Development and structure of the Canadian Forest Fire Weather Index System. For. Tech. Rep. 35. Ottowa, Ont: Government Canada, Canadian Forestry Service. 37 p.

Van Wagner, C. E.; Pickett, T. L. 1985. Equations and FORTRAN program for the Canadian Forest Fire Weather Index System. For. Tech. Rep. 33. Ottowa, Ont: Government Canada, Canadian Forestry Service. 18 p.

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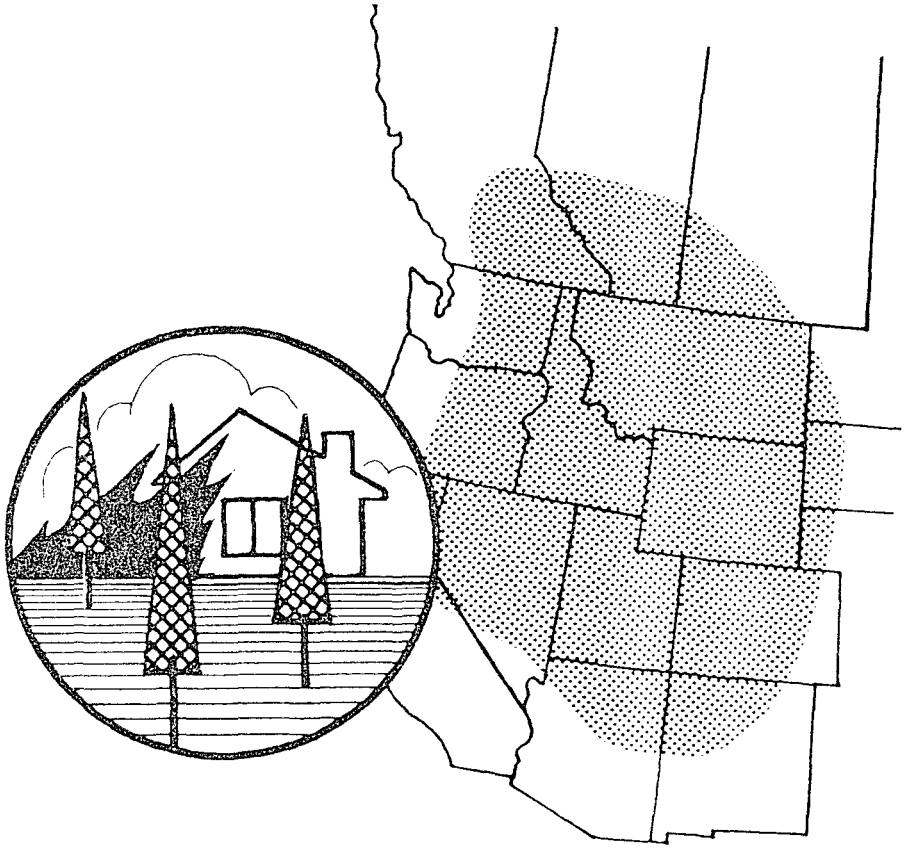
Research Station**

General Technical
Report-251

September 1988

Protecting People and Homes From Wildfire in the Interior West:

Proceedings of the Symposium and Workshop



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U.S. Department of Agriculture
Missoula, Montana

Symposium and Workshop Sponsors:

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