A STUDY OF THE RELATION OF COMPONENTS OF THE FIRE WEATHER INDEX TO MONTHLY PROVINCIAL AREA BURNED BY WILDFIRE IN CANADA 1953-80

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Abstract

The relationship between the monthly area burned by wildfire from May to August in nine Canadian 'provinces'*, and the flammability of the forest as measured by the components of the Fire Weather Index, was investigated. In western Canada, with the exception of the Yukon and Northwest Territories, explained variance averaged 33%. In the 'Territories' and eastern Canada explained variance averaged 12%. The best predictors of area burned were the monthly means and extreme maximum values of the Duff Moisture Code and the Daily Severity Rating.

Résumé

On a étudié le rapport entre la superficie ravagée chaque mois par les incendies forestiers de mai à août dans neuf "provinces"* canadiennes et l'inflammabilité de la forêt telle que mesurée par les divers paramètres de l'indice Forêt-Météo. Dans l'Ouest du Canada, exception faite du Yukon et des Territoires du Nord-Ouest, la variance expliquée s'élève en moyenne à 33 %, tandis que dans les "territoires" et l'est du Canada, elle est de 12 %. Les meilleures prévisions de la superficie incendiée sont fournies par les moyennes mensuelles et les valeurs maximales extrêmes de l'indice de l'humus et de l'estimation journalière de la gravité.

PREFACE

The Canadian Forest Fire Weather Index (FWI), described by Van Wagner (1974), was designed to provide an objective assessment of the susceptibility of Canadian forests to fire. The system has a theoretical structure supported empirically by the observation of a large number of test fires. General experience during the past decade shows that the system does well in portraying day-to-day flammability of most Canadian forests and fuel complexes (Stocks 1971, 1974, Turner 1973, B.C. Forest Service 1975, Kiil et al. 1977, Harvey and Janz 1983[1]). In this report the FWI and its components are tested for the degree to which they can explain the variance in monthly provincial area burned by wildfire.

Area burned, the most conspicuous feature of fire statistics, is affected by many factors including the number of simultaneous fires, fire control policies and priorities, variations in fire accessibility, fire control organizational efficiency, the nature and extent of the

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*The 'provinces' include British Columbia, the Yukon and Northwest Territories combined ('Territories'), Alberta, Saskatchewan, Manitoba, western Ontario (west of Lake Nipigon), eastern Ontario, Quebec and the combined Atlantic Provinces.

*Sont considérés ici comme des "provinces" la Colombie-Britannique, les Territoires du Yukon et du Nord-Ouest réunis ("territoires"), l'Alberta, la Saskatchewan, le Manitoba, l'ouest de l'Ontario (ouest du lac Nipigon), l'est de l'Ontario, le Québec et les provinces de l'Atlantique réunies.

[1] Harvey, D.A.; Janz, B. 1983. A comparison of fire weather severity in northern Alberta during the 1980 and 1981 fire seasons. Alberta For. Serv., unpubl. mss.

fuel, topography, variation of daily burning period with season and latitude, and the weather. One would anticipate that the last of these, as expressed by the components of the FWI, would explain a significant fraction of variance in area burned. However, as mentioned in an earlier report (Harrington 1982), these components could never perfectly express the fire-weather relationship because a fraction of the explained variance would be lost by aggregation of burned area data by month and province, and due to limitations on the number and locations of weather stations.

The purpose of this report is to determine the degree to which broad-scale weather patterns, as reflected in the monthly means and extremes of the FWI, explain variations in monthly provincial area burned. Normal statistical procedures are modified to maintain, as nearly as possible, simple relationships between the explanatory variables and area burned. The clarity gained is considered by the authors to compensate for the small reduction in explained variance.

Of four broad categories of variables affecting area burned, namely; weather, fuel, ignition agents, and fire control agencies, this report deals with only a part of the 'weather' category. The first section of this report deals with various components of the FWI system, their statistics on a monthly provincial basis, and their degree of interdependence. The second part describes the correlation between these components and monthly provincial area burned.

PART I

A statistical analysis of components of the Fire Weather Index

Data

Monthly area burned data for nine provinces over 28 years from 1953-80 have been described in detail (Harrington 1982). Noon meteorological data for the same period were abstracted from tapes of the Atmospheric Environment Service. It was hoped to find five long-term weather stations in forested parts of each province. This proved to be impossible.

A list of the number of stations in each province for which data were available is given in Table 1. A few stations,

Table 1. Number of weather stations in each provincial area used in this study*

British Columbia	5
Yukon and Northwest Territories	5
Alberta	4
Saskatchewan	4
Manitoba	5
Western Ontario (W of Lake Nipigon)	5
Eastern Ontario	5
Quebec	3
Atlantic Provinces	5
Total	41

*The names of the stations may be found in Table 16.

such as Winnipeg, are not located in forested areas. Others were not operating for the full period and, therefore, their data were combined with data from nearby stations to form a complete record, for example, Kimberley and Cranbrook. Short gaps in the data up to five days were filled by averaging the data on either side of the gap for a period equal to the number of days of missing data. Missing data for each day in longer gaps were replaced by average values for that day over the full 28-year period. Observations at three stations were taken at 3-h intervals and, in these cases, data closest to noon were selected. A listing of missing and combined observations is given in Appendix A. Missing data amounted to less than one percent of the total. The completed data set was used to compute the FWI and the Daily Severity Rating (DSR).

Structure of the Fire Weather Index

A block diagram of the structure of the FWI is shown in Fig. 1. Three moisture codes represent the moisture content of fine fuels, loosely compacted duff, and compact organic soil respectively. Two intermediate indices show rate of fire spread and total available fuel and the FWI represents the intensity of the spreading fire. A seventh index, the Daily Severity Rating (DSR) is an exponential function of the FWI designed to explain

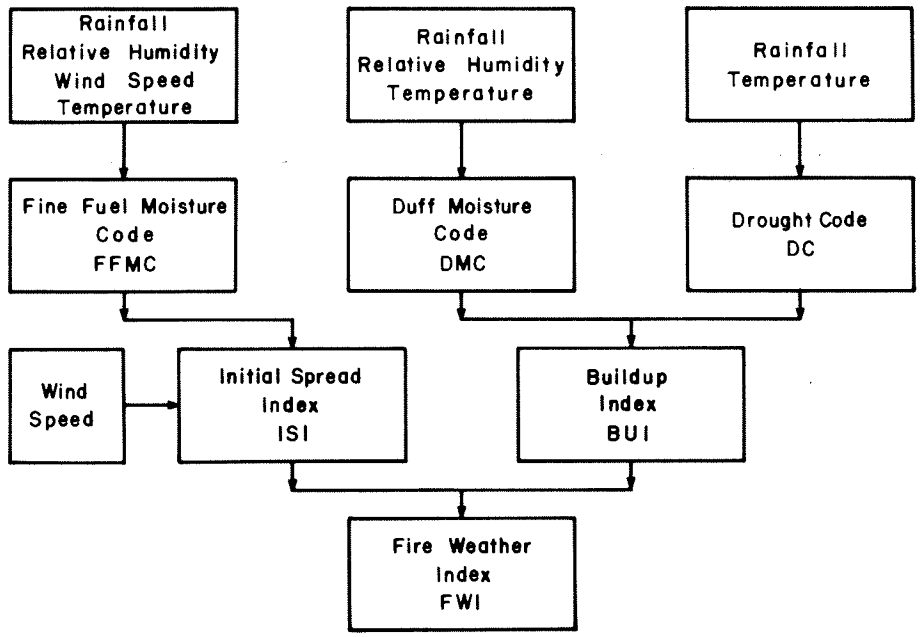


Figure 1. The structure of the Fire Weather Index (Van Wagner 1974).

the exponential increase of area burned with fire size and the effort needed to control fire in its early stages. It provides an integrated measure of fire danger over any desired period such as a month or season. All components were computed according to the equations listed by Van Wagner and Pickett (1975). Mean monthly values and maxima within each month for each of the moisture codes and fire indices were used as potential indicators of area burned by wildfire. The monthly extreme values were thought to be useful indicators of drought periods shorter than a month. In the case of rapidly changing variables such as the Fine Fuel Moisture Code (FFMC) or Initial Spread Index (ISI) the maxima would indicate extreme conditions leading to fire initiation and rapid spread over a short period such as a day. However, for slowly changing variables such as the Duff Moisture Code (DMC) or DSR the maxima would indicate longer periods of drought, but less than a month in duration, during which fire might become established over a large area.

Fine Fuel Moisture Code (FFMC)

A statistical analysis of the FFMC was carried out by Simard and Valenzuela (1972) using ten years of data from 364 weather stations across Canada. They showed that the FFMC has a strongly negatively skewed distribution. The potential range of FFMC values is zero to 101 but 70 percent of the observed values lie above 65, the point at which the probability of fire ignition begins to increase exponentially. "These observations suggest that a majority of days in the fire season have conditions suitable for fires to start" (Simard and Valenzuela 1972).

The present study, in which only mean monthly values and monthly extremes are examined, supports those observations. The mean monthly FFMC values were surprisingly uniform across the country with averages of provincial values ranging from 69 to 77 (Table 2). Values for individual stations are shown in the Appendix, Table B1. These show a similar uniformity within each province.

Table 2. **Provincial monthly mean FFMC**

	April	May	June	July	Aug.	Sept.	Average
British Columbia	78.3	78.4	77.3	79.2	78.1	72.7	77.3
Yukon - N.W.T.	77.1	79.9	80.0	77.6	75.6	71.0	76.9
Alberta	75.7	76.2	73.0	73.6	71.7	69.4	73.3
Saskatchewan	76.3	80.2	77.7	78.0	77.3	74.5	77.3
Manitoba	72.5	76.0	76.2	77.9	76.9	72.0	75.3
W. Ontario	68.6	71.7	72.5	75.0	72.7	65.9	71.1
E. Ontario	69.7	73.0	74.7	76.8	74.4	67.5	72.7
Quebec	68.8	72.7	73.7	74.0	72.5	66.8	71.4
Atlantic Provinces	63.0	67.3	70.2	72.5	70.9	68.6	68.8
Average	72.2	75.0	75.0	76.1	74.5	69.8	73.8

Table 3. **Range in the provincial monthly mean FFMC**

	April	May	June	July	Aug.	Sept.	Average
British Columbia	24.2	19.8	24.4	22.8	25.2	28.8	24.2
Yukon - N.W.T.	24.0	18.0	18.2	19.2	22.6	25.0	21.2
Alberta	34.0	23.3	23.3	20.0	31.2	28.5	26.7
Saskatchewan	38.8	22.0	22.0	16.8	26.0	26.5	25.4
Manitoba	37.2	25.0	23.6	16.0	21.8	24.2	24.6
W. Ontario	38.6	25.8	20.8	17.8	20.8	24.6	24.7
E. Ontario	33.6	22.6	21.2	19.2	21.6	26.4	24.1
Quebec	27.0	32.3	21.0	16.0	24.0	20.7	23.5
Atlantic Provinces	36.0	27.2	31.0	23.2	26.8	21.6	27.3
Average	32.6	24.0	22.8	19.0	24.4	25.1	24.7

Table 4. Provincial average monthly extreme FFMC

	April	May	June	July	Aug.	Sept.	Average
British Columbia	88.6	91.1	91.1	91.5	91.2	89.1	90.4
Yukon - N.W.T.	86.1	91.0	91.7	91.0	89.4	86.7	89.3
Alberta	89.3	92.2	91.2	90.0	88.6	88.3	89.9
Saskatchewan	88.9	92.8	92.1	90.7	90.3	89.2	90.7
Manitoba	87.7	91.8	91.3	90.3	89.9	88.6	89.9
W. Ontario	87.4	91.0	90.8	89.9	88.7	86.6	89.1
E. Ontario	88.4	91.6	91.0	90.3	89.4	87.3	89.7
Quebec	87.8	90.7	90.7	89.8	88.5	87.0	89.1
Atlantic Provinces	85.6	89.6	90.3	89.8	89.0	87.4	88.6
Average	87.8	91.3	91.1	90.4	89.4	87.8	89.6

Table 5. Provincial monthly mean DMC

	April	May	June	July	Aug.	Sept.	Average
British Columbia	18.7	33.1	37.7	41.8	52.2	33.5	36.2
Yukon - N.W.T.	9.9	26.7	44.9	40.8	31.9	18.4	28.8
Alberta	16.1	28.4	25.8	20.1	17.5	14.3	20.4
Saskatchewan	14.4	33.9	36.0	27.4	26.6	25.4	27.3
Manitoba	10.8	22.7	28.9	26.0	24.1	17.3	21.6
W. Ontario	7.8	16.3	18.7	19.2	16.0	9.3	14.6
E. Ontario	8.5	17.6	22.2	22.5	18.2	9.9	16.5
Quebec	7.1	16.5	19.1	17.3	13.8	8.0	13.6
Atlantic Provinces	4.1	9.9	15.6	17.2	14.1	9.8	11.8
Average	10.8	22.8	27.7	25.8	23.8	16.2	21.2

Table 6. Range in the provincial monthly mean DMC

	April	May	June	July	Aug.	Sept.	Average
British Columbia	33.6	67.4	69.6	77.2	107.0	116.0	78.5
Yukon - N.W.T.	22.4	44.8	82.4	90.6	80.4	52.0	62.1
Alberta	45.0	60.5	54.5	60.3	46.8	53.3	53.4
Saskatchewan	39.3	88.3	83.5	69.0	62.5	86.0	71.4
Manitoba	37.4	85.0	81.8	65.2	61.6	54.0	64.2
W. Ontario	22.6	54.8	36.6	37.6	31.4	38.6	36.9
E. Ontario	27.0	35.8	38.0	43.6	41.0	25.2	35.1
Quebec	15.7	37.7	34.3	23.7	28.0	15.0	25.7
Atlantic Provinces	9.2	21.2	30.6	36.8	33.4	23.8	25.8
Average	28.0	55.0	56.8	56.0	54.7	51.5	50.3

Stations as different as Victoria and Williams Lake in British Columbia record a difference of only about eight percent. A slight trend toward higher values in the months from May to August and a slight decreasing trend from west to east are apparent. It should be noted that the relationship between the FFMC and flammability is highly non-linear such that small variations in FFMC at the high end of the scale represent important variations in flammability. The average FFMC for all 41 stations and all six months is 73.8, virtually identical to the value of 74 found by Simard and Valenzuela (1972). The range in mean monthly FFMC value is similarly uniform (Table 3).

Monthly averages of extreme values of the FFMC (FFMCX) are given by province in Table 4. The uniformity of the monthly maxima of the FFMC across Canada and from month to month during the fire season is clearly evident. This pattern is further demonstrated by the narrow range of extremes over the 28-year period.

Duff Moisture Code (DMC)

The Duff Moisture Code has a virtually unlimited range and a strongly positively skewed distribution (Simard and Valenzuela 1972). This implies that, given suitable fuels, a majority of days will have a potential for moderate fire behavior and a small percentage of days for extreme fire behavior.

Monthly averages of the DMC exhibit a considerable variation from one province to another (Table 5) and from one station to another (Table C1). There is a more or less steady decline in the value of the DMC from west to east, with values in British Columbia exceeding those in the Atlantic Provinces by a factor of three. The highest single monthly average DMC was 233 at Williams Lake, B.C.; the lowest was zero, occurring at several locations.

The range in provincial average DMC values is shown in Table 6. The months of maximum average DMC correspond roughly to the months having the largest area burned; namely, August in British Columbia, July in the Territories, and May in Alberta (Harrington 1982). In the remaining provinces, where the peak of the fire season occurs in June, or, in the case of Manitoba in May and June, the correspondence is only fair.

Extreme values of the DMC, DMCX, may be used to infer an extensive period of drought because, with a 12-day time lag, the DMC is a moderately conservative quantity. From the curves given by Simard and Valenzuela (1972) it is apparent that values of the DMC past the

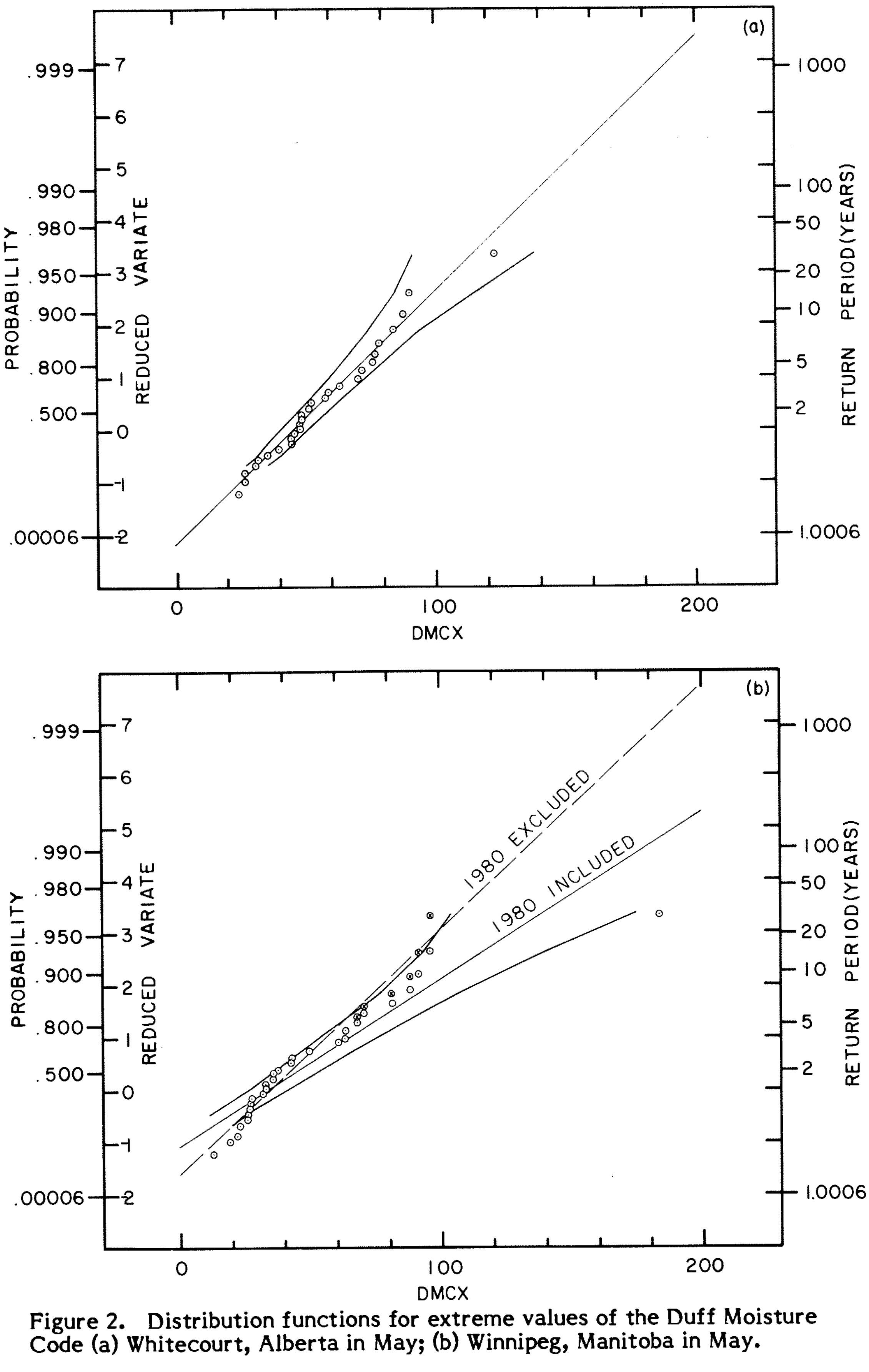


Figure 2. Distribution functions for extreme values of the Duff Moisture Code (a) Whitecourt, Alberta in May; (b) Winnipeg, Manitoba in May.

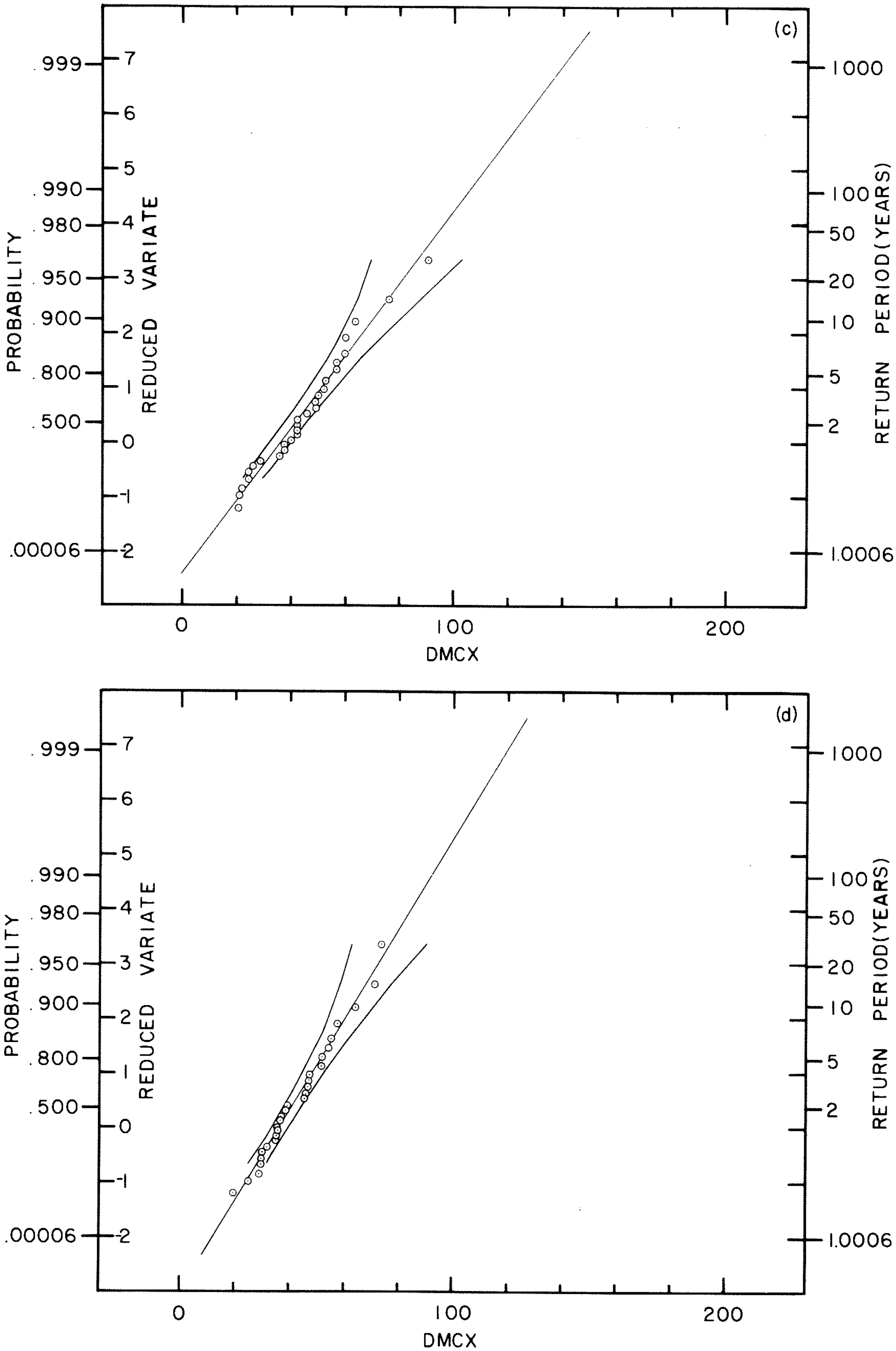


Figure 2, cont. (c) Timmins, Ontario in June; (d) Fredericton, New Brunswick in June. The 68% confidence limits are shown.

modal value follow an exponential decline. Based on this observation the extreme values of the DMC in each month should conform to the double exponential distribution (Gumbel 1958). The extreme values of the DMC do, for the most part, lie within the 68% confidence limits computed for the double exponential distribution as illustrated in Fig. 2. The known distribution permits computation of return periods of extreme DMC values beyond the interval over which the data were obtained. At Whitecourt, Alta., for example, the largest value of the May DMC to be expected in 100 years is 140. Extreme probability graphs for Winnipeg, Man. in May, Timmins, Ont. in June and Fredericton, N.B. in June are also shown in Fig. 2. The agreement with theory is good, falling within the 68% confidence limits, except for the extreme DMC at Winnipeg in May of 1980.

The analysis indicates that such a large value should occur no more frequently than once in 100 years or longer. If this one value is removed from the analysis an entirely different curve results. When 1980 is excluded, the return period of a value as high as that observed in 1980 would be 1024 years. The probability of experiencing the 1000-year drought in only 28 years of records is about one chance in 40. Yet, with 40 independent observing stations there would be a significant possibility that the 1000-year record would be reached at one of them. In the case discussed here, however, the 40 stations are not totally independent and therefore the chance of observing a 1000-year record is greatly reduced.

Drought Code (DC)

The Drought Code, with a lag time of 52 days (Van Wagner 1974), responds slowly to environmental changes. In the spring, its initial value depends upon the intensity of previous fall rains and winter snows. Generally speaking the early spring value will be close to zero, rising as the season progresses to values which, in some instances, exceed 800 in early fall. The frequency distribution (Simard and Valenzuela 1972) shows a mode of approximately 0.4% at a DC value of 25 with an almost linear decline to about 0.05% at a DC value of 400, followed by an exponential decline to near zero at values in excess of 800. Monthly averages of the Drought Code (Table 7 and Appendix, Table D1) show an accelerating increase in late spring and a slower increase in the summer, reaching a plateau by August and September. The Drought Code generally declines from west to east with values on the east coast less than half those on the west coast. This is largely the result of low summer rainfall in British Columbia and generally low rainfall in the Territories and western provinces.

The range in mean DC values is large (Table 8), reflecting a considerable variation in summer rainfall from year to year. As might be expected the range is greatest in the prairie provinces where the summer rainfall is most variable. As will be seen later, despite its broad range, the DC is not effective in predicting monthly area burned by wildfire except in British Columbia. It should be related, however, to the deep penetration of fire into muskeg and peat and the resultant difficulty of extinguishing hot spots.

Both the means and the ranges of extreme values of the DC are large, as might be expected. The same increasing trend in the mean from east to west and spring to fall is evident (Appendix, Table D2). The largest DC value recorded during the 28 years of observation was 956 at Williams Lake, B.C.

Initial Spread Index (ISI)

The Initial Spread Index is the product of an exponential function of the wind speed and a negative exponential function of the FFMC. The frequency distribution of the ISI is strongly positively skewed, a somewhat mirror image of the FFMC amplified by the effect of wind speed (Simard and Valenzuela 1972). Mean ISI values are generally small and relatively invariant in time and location (Table 9 and Appendix, Table E1). A combination of drying weather and stronger winds in May creates a small maximum which then trails off to about three fifths of the May

Table 7. Provincial monthly mean DC

	April	May	June	July	Aug.	Sept.	Average
British Columbia	51.3	120.0	227.7	338.5	452.9	481.9	278.7
Yukon - N.W.T.	36.9	100.2	221.0	334.3	413.3	434.6	256.7
Alberta	41.9	95.0	164.8	204.2	238.7	251.7	166.1
Saskatchewan	41.3	105.8	195.6	259.8	317.8	350.5	211.8
Manitoba	31.8	79.3	156.8	225.2	287.7	285.7	177.8
W. Ontario	24.7	63.9	120.3	178.7	220.1	201.5	134.9
E. Ontario	24.1	63.7	134.6	199.3	241.5	212.5	146.0
Quebec	23.9	66.0	125.9	173.8	195.9	168.1	125.6
Atlantic Provinces	14.5	45.2	101.3	171.0	203.9	183.6	119.9
Average	32.3	82.1	160.9	231.7	285.8	285.6	179.7

Table 8. Range in monthly mean DC

	April	May	June	July	Aug.	Sept.	Average
British Columbia	58.6	114.2	184.4	316.2	401.6	465.2	256.7
Yukon - N.W.T.	45.6	85.8	179.8	292.2	357.0	413.0	228.9
Alberta	67.0	127.0	223.3	350.0	411.8	497.5	279.4
Saskatchewan	62.0	134.0	227.8	347.8	403.8	565.5	290.2
Manitoba	65.4	152.8	234.0	327.6	389.8	436.6	267.7
W. Ontario	53.0	137.8	215.8	258.4	350.2	417.4	238.8
E. Ontario	59.4	107.0	187.0	280.8	307.6	356.4	216.4
Quebec	50.0	116.3	208.7	269.0	318.7	297.3	210.0
Atlantic Provinces	36.0	84.4	163.8	265.4	331.6	357.8	206.5
Average	55.2	117.7	202.7	300.8	363.6	423.0	243.8

Table 9. Provincial average monthly mean ISI

	April	May	June	July	Aug.	Sept.	Average
British Columbia	4.4	4.9	4.7	5.4	5.2	3.4	4.7
Yukon - N.W.T.	4.1	6.0	6.1	5.1	4.3	3.0	4.8
Alberta	4.6	5.8	4.0	3.5	3.0	2.9	4.0
Saskatchewan	5.9	9.3	7.1	5.8	5.7	5.4	6.5
Manitoba	5.6	7.8	6.6	5.8	5.4	5.1	6.1
W. Ontario	3.7	4.9	4.5	4.2	3.6	2.7	3.9
E. Ontario	3.7	5.2	5.0	4.7	4.0	2.7	4.2
Quebec	3.0	4.8	4.5	3.7	3.2	2.3	3.6
Atlantic Provinces	2.6	4.0	4.5	4.4	3.9	3.4	3.8
Average	4.2	5.9	5.2	4.7	4.3	3.4	4.6

Table 10. Range of extreme values of the ISI

	April	May	June	July	Aug.	Sept.	Average
British Columbia	19.9	30.8	31.5	35.0	44.0	39.8	33.5
Yukon - N.W.T.	21.6	36.0	33.3	29.3	27.8	26.5	29.1
Alberta	32.9	51.0	29.2	20.4	19.6	23.9	29.5
Saskatchewan	40.0	80.4	67.6	54.7	48.8	84.7	62.7
Manitoba	107.4	93.9	55.6	43.3	56.4	85.4	73.7
W. Ontario	37.4	68.2	45.7	31.0	38.4	33.3	42.3
E. Ontario	32.3	35.5	31.2	26.8	24.1	21.0	28.5
Quebec	31.4	53.5	34.9	15.7	18.5	23.2	29.5
Atlantic Provinces	21.4	44.3	35.6	26.7	28.8	31.1	31.3
Average	38.3	54.8	40.5	31.4	34.0	41.0	40.0

value by September. There is also a small peak in the annual average in Saskatchewan and Manitoba which exceeds the country-wide average value by about 40 percent. The range is similarly small with the largest values occurring in drier climates such as the interior of British Columbia, central Saskatchewan, and southern Manitoba.

Extreme ISI values are wide ranging (Table 10 and Appendix, Table E2). The greatest range in extreme values occurs in Saskatchewan and Manitoba, corresponding to high winds and low relative humidities in those provinces. The highest seasonal values occur in May, but the greatest extremes occur in April and September. At Winnipeg in April, 1980 the ISI reached a value of 197.6. The spring and fall extremes result from higher winds during these seasons of the year.

Buildup Index (BUI)

The Buildup Index is a harmonic mean of the DMC and the DC, with the latter adjusted downward to make the two codes have equal weight. Its frequency distribution is similar to the DMC except that the curve is flatter and shifted to higher values (Simard and Valenzuela 1972). Because the BUI is similar to the DMC it will not be discussed further here. Tables F1 and F2 in the Appendix present statistics on the mean and extreme values of the BUI.

Fire Weather Index (FWI)

The Fire Weather Index is a nonlinear, basically empirical combination of the ISI and BUI (Van Wagner 1974). The frequency distribution as shown by Simard and Valenzuela (1972)* has a maximum frequency at a value of zero, an average value of eight, an approximately exponential decline toward higher values, and an extreme maximum in the vicinity of 200. To facilitate use of the FWI, a class system is specifically tailored for use in each province. For the sake of comparison the classification established for Petawawa, Ont. (Van Wagner 1974) has been applied to data from across Canada (Table 11). One outstanding feature of the data in Table 11 is the uniformity of frequencies in the low and moderate classes. The major differences between the class frequencies are in the very low, high, and extreme categories. In Alberta and the extreme eastern provinces there is an excess of very low values and a

*Simard and Valenzuela's 1972 data are not fully compatible with the present FWI, especially at high values, because the FWI equation was changed in 1976.

Table 11. Percentage occurrences of FWI values April 1 to September 30 within fire danger class intervals selected for Petawawa, Ontario

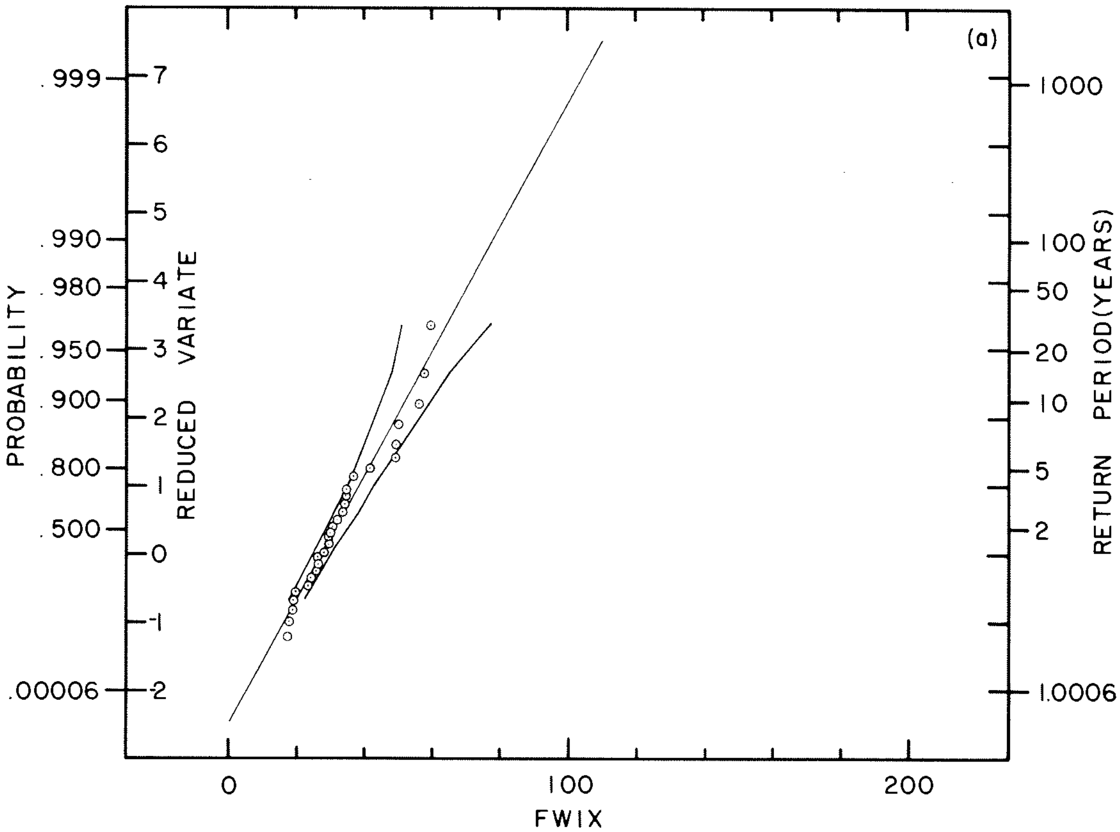
FWI Limits Danger Class	0-1 Very Low	2-5 Low	6-12 Moderate	13-24 High	> 24 Extreme
Petawawa, Ontario	29	20	25	20	6
British Columbia	25	18	23	22	12
Yukon - N.W.T.	26	20	22	21	11
Alberta	36	20	23	16	5
Saskatchewan	23	18	22	22	15
Manitoba	28	20	22	19	11
Ontario	38	22	22	14	4
Quebec	43	22	21	11	3
Atlantic Provinces	45	20	20	12	3

Table 12. **Monthly mean FWI values**

	April	May	June	July	Aug.	Sept.	Average
British Columbia	6.6	10.2	11.6	14.4	15.2	9.1	11.2
Yukon - N.W.T.	4.7	10.8	15.1	13.6	10.9	6.3	10.2
Alberta	6.5	10.6	8.4	6.9	6.0	5.2	7.3
Saskatchewan	7.6	16.1	15.0	12.1	12.4	11.3	12.4
Manitoba	6.2	11.6	12.5	11.7	11.3	9.0	10.4
W. Ontario	3.7	7.2	7.8	8.0	6.7	3.8	6.2
E. Ontario	3.9	7.7	9.3	9.5	7.6	4.2	7.0
Quebec	2.9	7.2	7.9	6.7	5.6	3.2	5.6
Atlantic Provinces	2.2	4.7	6.9	7.7	6.7	4.8	5.5
Average	4.9	9.6	10.5	10.1	9.2	6.3	8.4

Table 13. **Monthly mean extreme FWI values**

	April	May	June	July	Aug.	Sept.	Average
British Columbia	17.0	29.8	33.3	38.1	40.3	29.3	31.3
Yukon - N.W.T.	11.9	29.4	38.4	36.3	31.1	20.9	28.0
Alberta	17.7	34.0	29.1	23.3	19.5	19.8	23.9
Saskatchewan	20.9	49.4	47.0	36.5	37.0	36.8	37.9
Manitoba	20.0	42.1	41.0	36.6	34.6	33.8	34.7
W. Ontario	12.2	27.2	28.0	26.8	23.1	16.1	22.2
E. Ontario	13.6	28.6	29.9	27.8	23.5	16.8	23.4
Quebec	11.5	26.6	28.2	21.9	18.2	14.2	20.1
Atlantic Provinces	8.4	20.5	26.6	27.0	23.3	19.2	20.8
Average	14.8	32.0	33.5	30.5	27.8	23.0	26.9



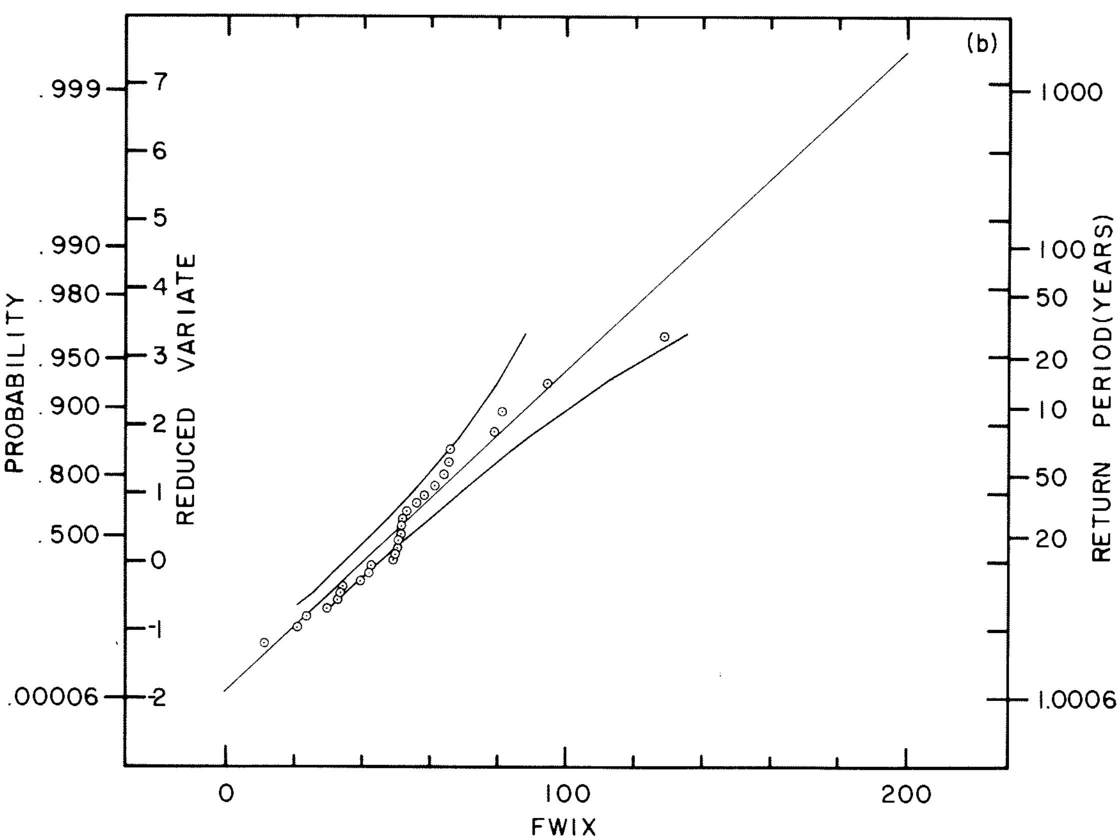
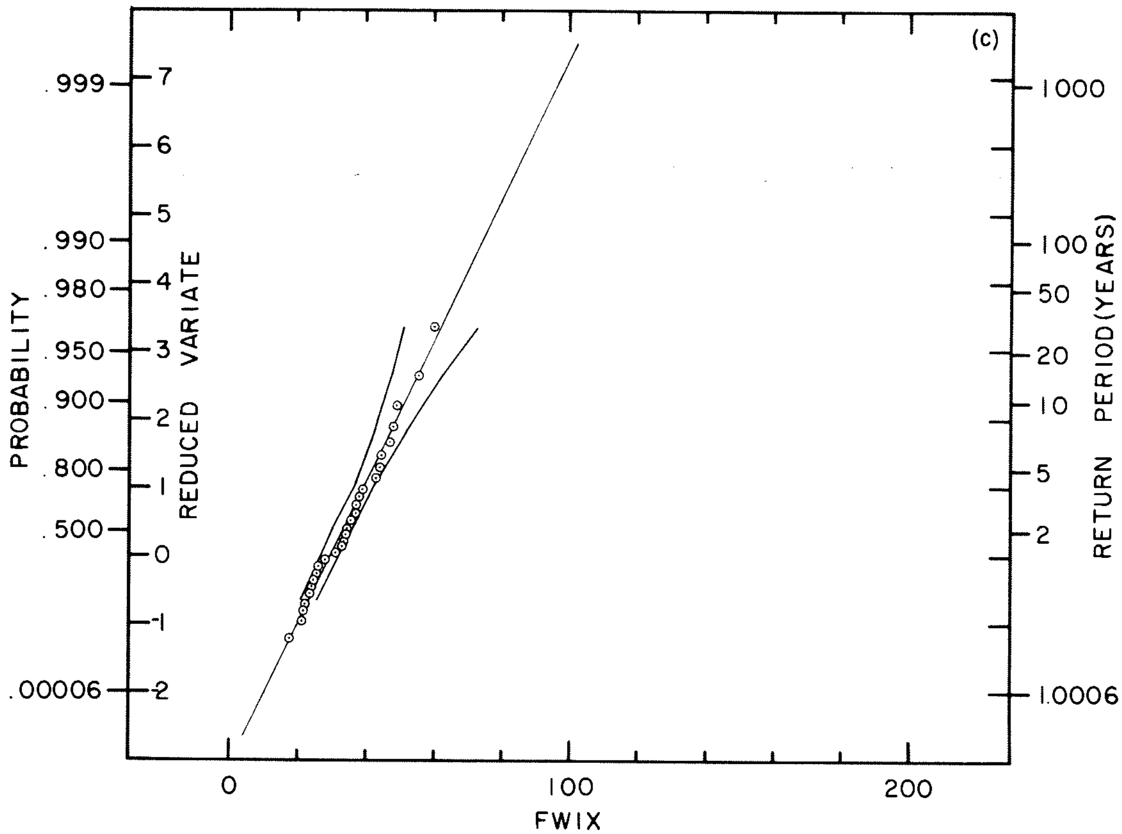


Figure 3. Distribution functions for extreme values of the Fire Weather Index at (a) Whitecourt, Alberta in May; (b) Winnipeg, Manitoba in May.



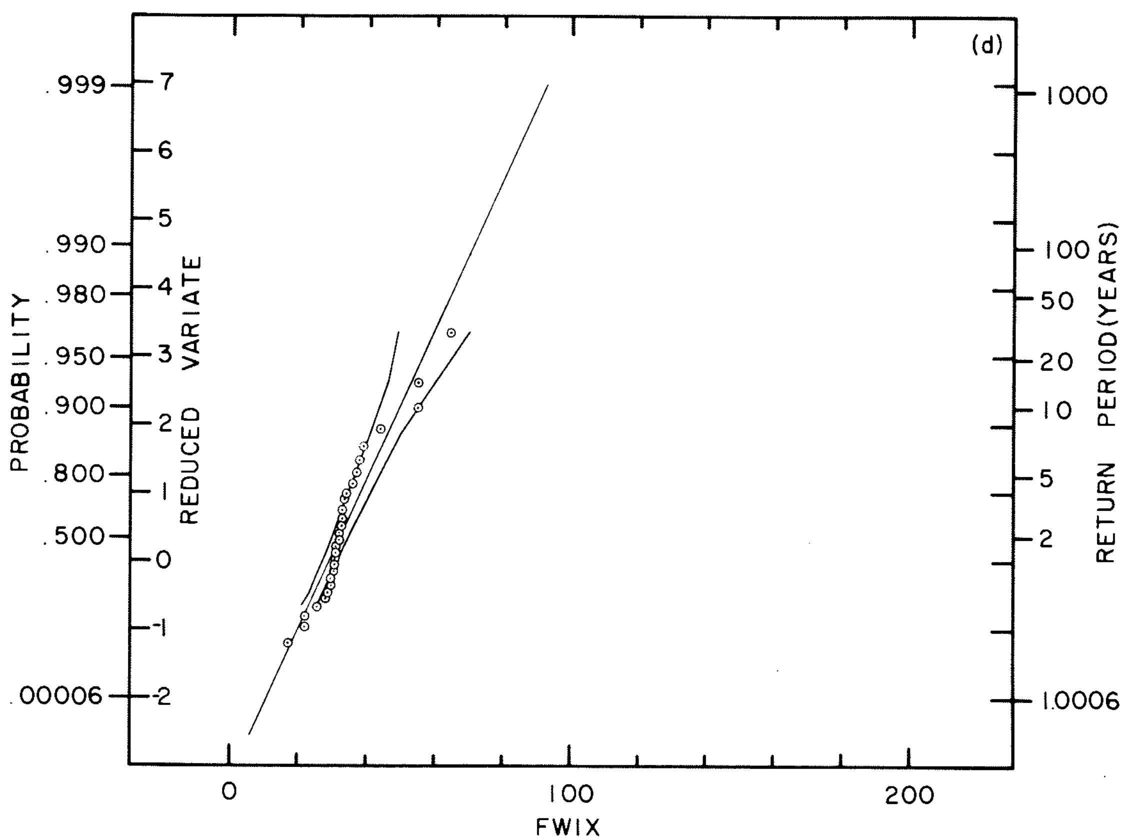


Figure 3, cont. (c) Timmins, Ontario in June; (d) Fredericton, New Brunswick in June. The 68% confidence limits are shown.

scarcity of high and extreme values.

Monthly mean FWI values are shown in Table 12 and Appendix, Table G1. The average of monthly mean values of the FWI in the western provinces was roughly twice what it was from Ontario eastward in the period from 1953 to 1980, Alberta excepted. Seasonally, the highest values appear more or less in those months when the area burned by wildfire is greatest.

The means of the extreme values of the FWI are given in Table G2 in the Appendix. Provincial averages of the mean of these extreme values for each month are given in Table 13. From May to August inclusive, the average extreme monthly FWI exceeds the extreme danger level established for Petawawa west of Ontario and exceeds the high danger level from Ontario eastward. From this it is evident that, by itself, the occurrence of an extreme FWI value is not a sure indication of a severe fire year.

It was seen in Figure 2 that the distribution of extreme DMC values closely followed Gumbel's double exponential distribution, thereby permitting the estimation of return periods greater than the 28 years for which data were available. For illustrative purposes the distribution functions of extremes of the FWI at the same four representative locations are shown in Figure 3. The fit to the Gumbel curve is not as good, with many values exceeding the 68% confidence limits. Despite these drawbacks the curves, at least, provide a crude estimate of the expected extremes in FWI values.

Daily Severity Rating (DSR)

The Daily Severity Rating is a simple exponential function of the FWI intended to increase the weight of higher values in order to accommodate the exponential increase in area burned with fire diameter (Williams 1959). The equation developed by Van Wagner (1970)

$$DSR = 0.0272\ FWI^{1.77}$$

is averaged over a month to produce the Monthly Severity Rating (MSR), or over a season to produce the Seasonal Severity Rating (SSR). The effect of the transformation is to compress the entire range of FWI values between zero and 24 into a DSR range from zero to 7.5. At FWI values greater than 24 the gap between the FWI and DSR gradually closes. They are equal at 108 and beyond 108 the DSR becomes progressively larger than the FWI.

MSR values are generally low (Table 14 and Appendix, Table H1). The flat peak in June and July and higher values in the west than in the east

Table 14. Monthly mean Severity Ratings

	April	May	June	July	Aug.	Sept.	Average
British Columbia	1.2	2.6	3.4	4.9	5.7	2.7	3.4
Yukon - N.W.T.	0.8	2.8	4.8	4.3	3.1	1.3	2.9
Alberta	1.4	3.0	2.2	1.5	1.2	1.0	1.7
Saskatchewan	1.8	5.8	5.3	3.6	3.9	3.8	4.0
Manitoba	1.7	4.1	4.2	3.4	3.4	2.9	3.3
W. Ontario	0.6	1.8	1.9	1.8	1.4	0.7	1.4
E. Ontario	0.7	1.9	2.4	2.4	1.6	0.7	1.6
Quebec	0.4	1.7	1.8	1.3	1.0	0.5	1.1
Atlantic Provinces	0.3	0.9	1.6	1.8	1.5	0.9	1.2
Average	1.0	2.7	3.1	2.8	2.5	1.6	2.3

correspond to similar distributions in the FWI. The distorted scale of the DSR makes the ratio of extreme to mean values (Appendix, Table H2) greater than they are for the FWI but, otherwise, the two sets of values are similar. The exponential stretching of the DSR scale destroys the fit of extreme values to Gumbel's double exponential distribution. The loss of predictability is not a serious problem because return periods of extreme DSR values can be calculated from return periods of extreme FWI values obtained from extrapolation of the double exponential distribution. Extreme values of the DMC and FWI to be expected in 10 years and 100 years are shown for all 41 stations in Tables I1 through I4. These can be used to reconstruct the extreme probability curve* and, thereby, to find the return period for any value of the DMC or FWI.

* The extreme probability curve is reconstructed as follows: Using linear graph paper, scale the abscissa for the range of DMC or FWI extreme values likely to be observed in 1000 years. Scale the left hand ordinate linearly from −3 to +7. This scale is called the reduced variate y. From the equation

$$P(y) = \exp(-\exp(-y))$$

find the value of y corresponding to a 100 year and 10 year return period, that is, P(y) = .99 and P(y) = .90 respectively. Plot the 100 year and 10 year return period values and draw a straight line through these points. To find the return period for any other value of the DMC or FWI simply find y from the graph, compute P(y) from the equation given above and the return period from the inverse of 1-P(y).

PART II

Variance in monthly provincial area burned by wildfire explained by components of the Fire Weather Index

Introduction

A detailed knowledge of the social, political, physical, and environmental influences on area burned by wildfire could lead, potentially, to better fire control. No single variable could be expected to explain a large fraction of the variance in area burned. Components of the FWI have previously been shown to relate well to fire occurrence, rates of spread, fire intensity, and ultimate fire size (Turner 1973, B.C. Min. of Forests 1975). The goal is to determine the extent to which components of the FWI explain variance in the monthly provincial area burned.

The variables tested as predictors of monthly provincial area burned by wildfire were monthly averages and monthly extremes of the three moisture codes FFMC, DMC, and DC, the two intermediate indices ISI and BUI, and the FWI and DSR.

Several of these variables are highly correlated and, therefore, not well suited to multiple correlation analysis. For example, Table 15 is a correlation matrix of these variables for The Pas, Man., in the center of the country. Although the correlation matrix varies from station to station, certain relationships seen in Table 15 are common to all stations. Some correlations are so high that information in one of the variables is largely redundant. For example, the correlation between the means and extreme values of the DMC and DC, the correlation between the MSR and FWI, and that between the

Table 15. Correlation matrix between area burned and component of the FWI for The Pas, Manitoba, 1953-1980

	AREAB	FFMC	DMC	DC	ISI	BUI	FWI
AREAB*	1.00						
FFMC	.33	1.00					
DMC	.37	.74	1.00				
DC	-.01	.28	.35	1.00			
ISI	.43	.71	.62	-.02	1.00		
BUI	.29	.72	.95†	.58	.51	1.00	
FWI	.41	.83†	.91†	.32	.85†	.87†	1.00
MSR	.42	.73	.88†	.27	.87†	.82†	.97†
FFMCX††	.44	.41	.46	-.19	.66	.33	.57
DMCX	.43	.70	.94†	.24	.65	.86†	.88†
DCX	.02	.34	.41	.99†	.03	.64	.38
ISIX	.28	.25	.17	-.13	.71	.10	.43
BUIX	.33	.69	.91†	.56	.51	.94†	.85†
FWIX	.33	.52	.56	.16	.80	.52	.74
DSRX	.31	.47	.53	.13	.78	.48	.70
	MSR	**FFMCX**	**DMCX**	**DCX**	**ISIX**	**BUIX**	**FWIX**
MSR	1.00						
FFMCX	.60	1.00					
DMCX	.85†	.58	1.00				
DCX	.32	-.14	.31	1.00			
ISIX	.52	.51	.21	-.12	1.00		
BUIX	.79†	.41	.92†	.62	.10	1.00	
FWIX	.80†	.63	.59	.20	.85†	.54	1.00
DSRX	.79†	.60	.55	.16	.86†	.48	.98†

*AREAB is the monthly area burned by wildfire in the province in question.

† Correlations between these variables are high at most stations.

†† The X following the variable name signifies the maximum value.

BUI and DMC are high enough to make one of each pair redundant. As might be expected, the FWI is well correlated with all of its components except the DC. The three moisture codes are only moderately correlated; each one generally explaining less than 50 percent of the variance in each of the others.

Method of analysis
Three methods of analysis were tried; principal component analysis, multiple linear regression (using all variables simultaneously), and step-wise multiple linear regression.

Principal component analysis is a method of linearly combining variables to produce a reduced set of independent variables which explain a maximum fraction of the variance in the predictand. Its advantages lie in the reduction in the number of variables, in the independence of the new variables, and in the possible discovery of new important relationships between the variables. Its disadvantage, which made it unsuitable for this study, lay in the lack of any known physical relationship between the new variables and fire behavior.

Multiple linear regression, in which all variables are entered simultaneously, combines the variables so as to explain a maximum fraction of the variance in the predictand at any given level of confidence. If prediction of area burned had been the only goal of this study, multiple linear regression would have been the method of choice. It was unsuitable here because, with highly correlated variables, the resulting coefficient of each variable was unstable and had no clear physical significance. For example, a positive coefficient for one variable was, in many cases, balanced by a negative coefficient for another highly correlated variable.

The method of analysis finally selected was forward step-wise multiple linear regression. It had the advantage of selecting one variable at a time, permitting the combination of a traditional statistical method with a subjective manipulation of the variables based on a foreknowledge of their relationship to fire behavior. In particular, highly correlated variables tended to appear in the regression equation with balancing positive and negative coefficients. The removal of those with negative coefficients preserved a clearer relationship between the variable and area burned while losing little in explained variance. The analysis was performed in two ways, by individual weather station and by pooled stations in each province.

Individual stations
The correlation between monthly area burned and components of the FWI at selected stations in each province are shown in Table 16. These correlations are provided for comparative purposes only. The lack of normality in both area burned and fire index data precludes the inclusion of general significance levels. It is immediately apparent that no component of the FWI in any province explains more than 42 percent of the variance in area burned. At a few stations such as Charlo, N.S. or Maniwaki, Que. there is no significant correlation between any component of the FWI and area burned. It should be emphasized that these relatively low correlations are not necessarily a reflection on the accuracy or usefulness of the fire indices for other purposes.

To illustrate the general nature of relationships between components of the FWI and area burned, the mean monthly DMC is shown plotted against relative area burned for Kenora, Ont. (Fig. 4). Although the correlation coefficient in this case is higher than average (0.63) the general characterization of the relationship is similar to most of the data. One typical characteristic is the broad range of DMC values occurring for relative area burned data which are below average (less than 1.00), a second is the apparent threshold in DMC values located near the average mean monthly DMC, above which the relative area burned may exceed its average value. Another is the unpredictability of area burned in western Ontario, based on the mean DMC measured at Kenora. Finally, in all of the graphs, of which Figure 4 is only one sample, the best fit to the data appeared to be a straight line. Considering the fact that

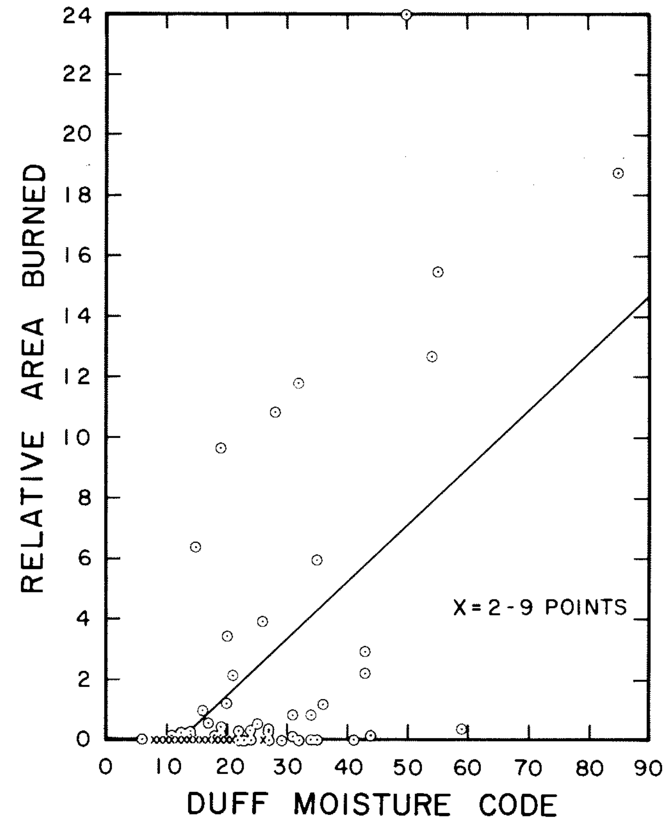


Figure 4. Relative area burned versus mean monthly DMC at Kenora, Ontario, 1953-80. The least squares regression of area burned on DMC is shown.

Table 16. Correlations* between monthly area burned and monthly averages of components of the FWI, May - August 1953-80

	British Columbia						
	FFMC	DMC	DC	ISI	BUI	FWI	DSR
Kimberley-Cranbrook							
Mean	0.25	0.50	0.31	0.34	0.46	0.39	0.43
Extreme	0.31	0.48	0.32	0.21	0.46	0.29	0.30
Fort Nelson							
Mean	0.21	0.34	0.39	0.23	0.42	0.37	0.38
Extreme	0.15	0.33	0.38	0.26	0.41	0.32	0.34
Smithers							
Mean	0.23	0.49	0.28	0.29	0.51	0.44	0.47
Extreme	0.17	0.48	0.31	0.15	0.51	0.34	0.36
Victoria							
Mean	0.24	0.36	0.20	0.24	0.34	0.34	0.35
Extreme	0.18	0.33	0.21	0.06	0.31	0.24	0.24
Williams Lake							
Mean	0.16	0.33	0.23	0.17	0.32	0.24	0.25
Extreme	0.15	0.32	0.24	0.04	0.32	0.11	0.12

Table 16. (cont'd)

Yukon and Northwest Territories

	FFMC	DMC	DC	ISI	BUI	FWI	DSR
Fort Simpson							
Mean	.21	.30	.26	.37	.36	.42	.46
Extreme	.27	.31	.27	.28	.37	.43	.42
Fort Smith							
Mean	.22	.24	.24	.10	.32	.25	.20
Extreme	.30	.20	.25	.04	.28	.21	.19
Yellowknife							
Mean	.33	.37	.20	.33	.36	.40	.39
Extreme	.36	.40	.23	.10	.39	.31	.29
Dawson-Burwash							
Mean	-.03	.12	.19	.15	.16	.23	.31
Extreme	-.08	.13	.19	.30	.17	.31	.37
Whitehorse							
Mean	-.09	.09	.12	-.13	.11	-.02	.04
Extreme	.00	.12	.13	-.04	.14	.05	.09

*Correlations greater than |0.24| and |0.19| would be significant at the 1% and 5% levels respectively if the data were normally distributed.

Alberta

	FFMC	DMC	DC	ISI	BUI	FWI	DSR
Fort McMurray							
Mean	.18	.37	-.14	.39	.27	.38	.45
Extreme	.32	.38	-.11	.44	.31	.41	.44
Rocky Mtn. House							
Mean	.19	.43	-.06	.52	.29	.46	.61
Extreme	.35	.44	-.04	.62	.32	.58	.67
Wagner-Slave Lake							
Mean	.17	.30	-.11	.34	.19	.32	.36
Extreme	.42	.32	-.10	.36	.21	.37	.38
Whitecourt							
Mean	.21	.29	-.07	.36	.20	.33	.37
Extreme	.29	.29	-.07	.28	.21	.31	.34

Saskatchewan

	FFMC	DMC	DC	ISI	BUI	FWI	DSR
Cold Lake							
Mean	.12	.44	.09	.12	.42	.28	.26
Extreme	.34	.47	.10	.08	.44	.25	.23
Prince Albert							
Mean	.15	.42	-.01	.18	.33	.29	.33
Extreme	.42	.47	.01	.01	.38	.26	.27
North Battleford							
Mean	.07	.30	-.06	.13	.22	.21	.24
Extreme	.36	.43	-.05	.04	.32	.22	.20
Hudson Bay							
Mean	.15	.42	.01	.28	.34	.37	.42
Extreme	.36	.43	.04	.08	.34	.26	.28

Table 16. (cont'd)

Manitoba

	FFMC	DMC	DC	ISI	BUI	FWI	DSR
Gimli-Bisset							
Mean	.30	.48	.11	.40	.40	.51	.56
Extreme	.44	.53	.13	.26	.47	.44	.45
Dauphin							
Mean	.33	.54	.09	.41	.45	.47	.52
Extreme	.37	.56	.11	.25	.48	.40	.41
The Pas							
Mean	.33	.37	-.01	.43	.29	.41	.42
Extreme	.44	.43	.02	.28	.33	.33	.31
Wabowden-Thompson							
Mean	.33	.49	.06	.38	.42	.45	.46
Extreme	.35	.44	.08	.34	.38	.42	.44
Winnipeg							
Mean	.33	.58	.15	.55	.50	.55	.61
Extreme	.42	.65	.19	.35	.58	.53	.57

Western Ontario

	FFMC	DMC	DC	ISI	BUI	FWI	DSR
Armstrong							
Mean	.31	.49	.07	.29	.42	.44	.44
Extreme	.26	.48	.12	.05	.41	.23	.19
Kenora							
Mean	.39	.63	.14	.51	.53	.60	.65
Extreme	.41	.61	.16	.39	.53	.53	.55
Lansdowne House							
Mean	.18	.38	-.04	.25	.27	.27	.27
Extreme	.26	.35	-.01	.16	.22	.26	.25
Sioux Lookout							
Mean	.19	.37	.01	.30	.29	.34	.38
Extreme	.35	.39	.05	.08	.33	.25	.23
Thunder Bay							
Mean	.17	.26	-.04	.15	.18	.23	.23
Extreme	.21	.30	-.02	.05	.21	.19	.16

Table 16. (cont'd)

	Eastern Ontario						
	FFMC	DMC	DC	ISI	BUI	FWI	DSR
Earlton							
Mean	.14	.27	-.08	.22	.16	.20	.24
Extreme	.38	.31	-.08	.16	.19	.24	.24
Kapuskasing							
Mean	.26	.36	.05	.37	.31	.39	.43
Extreme	.33	.43	.07	.21	.38	.35	.36
Muskoka							
Mean	.09	.21	-.04	.23	.15	.21	.23
Extreme	.11	.26	-.04	.15	.17	.26	.25
Killaloe-Petawawa							
Mean	.08	.10	-.11	.13	.03	.09	.09
Extreme	.26	.14	-.14	.07	.04	.05	.02
Timmins							
Mean	.17	.24	-.03	.20	.18	.20	.18
Extreme	.38	.31	-.02	.16	.21	.23	.21

	Quebec						
	FFMC	DMC	DC	ISI	BUI	FWI	DSR
Maniwaki							
Mean	.13	.11	.02	.06	.10	.10	.11
Extreme	.12	.08	.02	.02	.06	.04	.04
Bagotville-Roberval							
Mean	.21	.42	.12	.18	.40	.32	.28
Extreme	.26	.33	.17	.04	.32	.21	.21
Val d'Or.							
Mean	.22	.35	.17	.27	.34	.34	.34
Extreme	.28	.30	.16	.29	.29	.33	.35

Table 16. (cont'd)

	Atlantic Provinces						
	FFMC	DMC	DC	ISI	BUI	FWI	DSR
Campbellton-Charlo							
Mean	.04	.10	.01	.04	.08	.06	.04
Extreme	.13	.15	.00	.00	.10	.06	.04
Fredericton							
Mean	.07	.11	.06	.19	.10	.17	.17
Extreme	.09	.08	.06	.21	.07	.22	.23
Gander							
Mean	.24	.36	.24	.29	.35	.36	.39
Extreme	.32	.36	.25	.08	.33	.23	.23
Goose Bay							
Mean	.24	.27	.15	.26	.24	.27	.30
Extreme	.11	.28	.18	.06	.28	.19	.20
Copperlake-Truro							
Mean	.20	.18	.13	.11	.18	.19	.19
Extreme	.15	.15	.14	.06	.15	.17	.19

these correlations were for monthly averages at single locations and that no other factors such as ignition sources were considered, correlations such as that at Kenora could be considered surprisingly high.

Results of the step-wise regression analysis are given in Table 17. The program used a minimum acceptable F value of 4.0 to enter, corresponding to a confidence level of about 5 percent, a maximum acceptable F value of 3.9 to remove and a minimum acceptable tolerance of 0.01. The relatively high F level to enter was chosen to prevent selection of variables having high correlations by chance. This conservative procedure was required because the residuals were unlikely to be normally distributed with constant variance and, consequently, the F values might not closely follow an F distribution.

All variables with negative partial correlation coefficients were removed. Of the 41 stations across Canada, three showed no significant relationship between the 14 predictors and area burned by wildfire, 30 showed a single significant variable, and 8 showed two significant variables. The highly correlated DMC, BUI, and MSR and their extreme values accounted for 84 percent of the significant first choices. The only other significant first choice was the FFMCX and at one station the FFMC. Regression equations in Table 17 are given solely to illustrate the relationships between variables and not for predictive purposes.

Pooled stations

The best correlations between area burned and components of the FWI were obtained when the components were computed from weather data averaged over all of the weather stations in the province. This surprising result is likely due to weather conditions at any one station over 28 years, particularly summer rainfall, being unrepresentative.

The explained variance and the variables selected by the step-wise regression program are given in Table 18. The sharp contrast in explained variance between areas east and west of Lake Nipigon is

Table 17. Regression equations and explained variance for the relative area burned by wildfire - by weather station

1953-1980

British Columbia

Fort Nelson								
Area	=	02.162	+	0.050	BUI	+	0.0065	DC
Standard Error	=			.018			.0031	
Variance Explained	=	0.20						
Kimberley - Cranbrook								
Area	=	-1.151	+	0.049	DMC			
Standard Error	=			0.008				
Variance Explained	=	0.25						
Smithers								
Area	=	-1.886	+	0.062	BUI			
Standard Error	=			0.010				
Variance Explained	=	0.26						
Victoria								
Area	=	-0.782	+	0.050	DMC			
Standard Error	=			0.012				
Variance Explained	=	0.13						
Williams Lake								
Area	=	-0.547	+	0.031	DMC			
Standard Error	=			0.008				
Variance Explained	=	0.11						

Yukon - Northwest Territories

Fort Simpson								
Area	=	-0.150	+	0.576	MSR			
Standard Error	=			0.107				
Variance Explained	=	0.21						
Fort Smith								
Area	=	-23.898	+	0.022	BUI	+	0.262	FFMCX
Standard Error	=			0.009			0.120	
Variance Explained	=	0.14						
Yellowknife								
Area	=	-28.704	+	0.020	DMCX	+	0.317	FFMCX
Standard Error	=			0.006			0.135	
Variance Explained	=	.20						

Table 17. (cont'd)

Dawson-Burwash								
Area	=	0.321	+	0.097	DSRX			
Standard Error	=			0.023				
Variance Explained	=	.14						
Whitehorse								
Area	=							
Standard Error	=							
Variance Explained	=	None						
			Alberta					
Fort McMurray								
Area	=	-1.998	+	0.496	MSR	+	0.113	ISIX
Standard Error	=			0.209			0.051	
Variance Explained	=	.24						
Rocky Mountain House								
Area	=	-1.522	+	0.291	DSRX			
Standard Error	=			0.031				
Variance Explained	=	.45						
Wagner-Slave Lake								
Area	=	-61.608	+	0.709	FFMCX			
Standard Error	=			0.146				
Variance Explained	=	.18						
Whitecourt								
Area	=	-0.203	+	0.710	MSR			
Standard Error	=			0.171				
Variance Explained	=	.13						
			Saskatchewan					
Cold Lake								
Area	=	-1.127	+	0.046	DMCX			
Standard Error	=			0.008				
Variance Explained	=	.22						
Hudson Bay								
Area	=	-1.476	+	0.055	DMCX			
Standard Error	=			0.011				
Variance Explained	=	.19						
North Battleford								
Area	=	-1.484	+	0.044	DMCX			
Standard Error	=			0.009				
Variance Explained	=	.18						
Prince Albert								
Area	=	-1.151	+	0.040	DMCX			
Standard Error	=			0.007				
Variance Explained	=	.22						

Table 17. (cont'd)

Manitoba

Gimli-Bisset								
Area	=	-1.286	+	0.370	MSR	+	0.030	DMCX
Standard Error	=			0.116			0.013	
Variance Explained	=	.34						
Dauphin								
Area	=	-1.594	+	0.050	DMCX			
Standard Error	=			0.007				
Variance Explained	=	.31						
The Pas								
Area	=	-40.811	+	0.447	FFMCX	+	0.044	DMCX
Standard Error	=			0.162			0.016	
Variance Explained	=	.24						
Wabowden-Thompson								
Area	=	-2.596	+	0.119	DMC	+	0.084	ISIX
Standard Error	=			0.024			0.034	
Variance Explained	=	.28						
Winnipeg								
Area	=	-2.195	+	0.038	DMCX	+	0.157	ISI
Standard Error	=			0.007			0.076	
Variance Explained	=	.44						

W. Ontario

Armstrong					
Area	=	-1.827	+	0.199	DMC
Standard Error	=			0.034	
Variance Explained	=	.24			
Kenora					
Area	=	-1.401	+	1.117	MSR
Standard Error	=			0.123	
Variance Explained	=	.43			
Lansdowne House					
Area	=	-1.392	+	0.195	DMC
Standard Error	=			0.046	
Variance Explained	=	.14			
Sioux Lookout					
Area	=	-2.024	+	0.084	DMCX
Standard Error	=			0.019	
Variance Explained	=	.15			
Thunder Bay					
Area	=	-1.646	+	0.080	DMCX
Standard Error	=			0.024	
Variance Explained	=	.09			

Table 17. (cont'd)

		E. Ontario			
Earlton					
Area	=	-55.928	+	0.632	FFMCX
Standard Error	=			0.146	
Variance Explained	=	.15			
Kapuskasing					
Area	=	-0.402	+	1.031	MSR
Standard Error	=			0.205	
Variance Explained	=	.19			
Muskoka					
Area	=	-0.598	+	0.046	DMCX
Standard Error	=			0.016	
Variance Explained	=	.07			
Killaloe-Petawawa					
Area	=	-40.039	+	0.455	FFMCX
Standard Error	=			0.159	
Variance Explained	=	.07			
Timmins					
Area	=	-46.564	+	0.525	FFMCX
Standard Error	=			0.123	
Variance Explained	=	.14			

		Quebec			
Maniwaki					
Area	=				
Standard Error	=				
Variance Explained	=	None			
Bagotville-Roberval					
Area	=	-1.224	+	0.175	DMC
Standard Error	=			0.037	
Variance Explained	=	.17			
Val d'Or					
Area	=	-0.486	+	0.111	DMC
Standard Error	=			0.029	
Variance Explained	=	.12			

Table 17. (cont'd)

Atlantic Provinces

Campbellton-Charlo					
Area	=				
Standard Error	=				
Variance Explained	=	None			
Fredericton					
Area	=	-0.079	+	0.112	DSRX
Standard Error	=			0.046	
Variance Explained	=	.05			
Gander					
Area	=	-0.340	+	0.973	MSR
Standard Error	=			0.220	
Variance Explained	=	.15			
Goose Bay					
Area	=	-0.0075	+	0.942	MSR
Standard Error	=			0.288	
Variance Explained	=	.09			
Copperlake-Truro					
Area	=	-7.243	+	0.121	FFMC
Standard Error	=			0.058	
Variance Explained	=	.04			

Table 18. Variables selected by step-wise regression and variance of area burned by wildfire explained by combined weather stations

Province	Variance Explained	Variables Selected*
British Columbia	0.35	DMCA
Yukon and Northwest Territories	0.15	BUIA
Alberta	0.35	MSRA
Saskatchewan	0.22	DMCXA
Manitoba	0.38	DMCXA
Western Ontario	0.36	DMCXA
Eastern Ontario	0.12	DMCXA
Quebec	0.12	BUIA
Atlantic Provinces	0.10	DMCXA

*The suffix A has been added when province-wide averages are used.

notable. The abrupt change is particularly interesting in light of an earlier report in which Harrington (1982) found that the correlation in area burned between the two parts of Ontario was very high. One reason for this change is that a high pressure ridge usually remains over eastern British Columbia and the Yukon during summer, creating a generally northwesterly flow from the prairies to the Great Lakes. East of the Great Lakes the upper flow is usually westerly, causing weather systems to move more rapidly and long periods of drought to be less common. Another possible explanation lies in the coincidence of bad fire years with extreme drought in the western provinces during the late 1970s.

The lack of significant correlations in data from the combined Yukon and Northwest Territories is likely due to the very different climatic regimes in these areas. Mean upper level weather maps reveal a high pressure ridge line running almost along the eastern Yukon border, creating quite different flow patterns over the two territories. It is seen to have been a mistake to have combined their area burned data.

CONCLUSIONS

The mean and extreme values of components of the FWI measured at individual stations explained as much as 42% and as little as none of the variance in monthly provincial area burned by wildfire. The best predictors based on individual stations were the DMC, the DSR, and their extreme values. The extreme value of the DMC is particularly useful because its distribution function fits the double exponential distribution closely and, therefore, the return period of extreme values can be determined.

The explained variance was generally higher when meteorological data within each province were pooled than it was when data from each weather station were treated individually.

The relation between fire indices and area burned is strongest west of Lake Nipigon where the explained variance averages 33%, and weakest east of Lake Nipigon where the explained variance averages 12%. This effect is possibly due to weather patterns which produce extreme variations in burning conditions in the west and more constant burning conditions in the east.

The area burned by wildfire is such a complex function of social, political, and environmental variables that no one variable can be expected to explain a large fraction of the variance. Despite this limitation, interest has remained high in how well the FWI system matches the area burned.

It is unfortunate that published data on area burned do not exist on a temporal scale shorter than a month or a spatial scale smaller than a province. Only with a finer aggregation would rapid response variables such as the FFMC or the ISI be expected to show high correlations with area burned. Despite these drawbacks a respectable fraction of the variance in area burned west of Lake Nipigon has been explained by the DMC, the DSR and their extremes. The DC is interesting in that its non-significant but negative correlation with area burned in most provinces (excepting British Columbia) almost certainly results from its gradual increase during the fire season, whereas most large fires occur in spring when the DC values are low.

It is possible that additional weather variables or combinations of variables will explain more of the variance than are explained by components of the FWI. This will be the subject of a third paper in this series.

REFERENCES

British Columbia Forest Service. 1975. Fire weather indices, decision aids for forest operations in British Columbia. Protection Branch, Victoria, B.C. 57 p.

Donnelly, R.E.; Harrington, J.B. 1978. Forest fire history maps of Ontario. Can. Dep. Environ., Can. For. Serv., Forest Fire Res. Inst., Misc. Rep. FF-Y-G, Ottawa. 8 p.

Gumbel, E.J. 1958. Statistics of

extremes. Columbia Univ. Press. 375 p.

Harrington, J.B. 1982. A statistical study of area burned by wildfire in Canada 1953-1980. Environ. Can., Can. For. Serv., Petawawa Natl. For. Inst. Inf. Rep. PI-X-16. 32 p.

Kiil, A.D.; Miyagawa, R.S.; Quintilio, D. 1977. Calibration and performance of the Canadian Fire Weather Index in Alberta. Environ. Can., Can. For. Serv., Northern For. Res. Centre, Inf. Rep. NOR-X-173. 45 p.

Simard, A.J.; Valenzuela, J. 1972. A climatological summary of the Canadian Forest Fire Weather Index. Can. Dep. Environ., Can. For. Serv., Forest Fire Res. Inst., Inf. Rep. FF-X-34, Ottawa. 425 p.

Stocks, B.J. 1971. Fire severity index distribution in Ontario, 1963 to 1968. Can. Dep. Environ., Can. For. Serv., Great Lakes Forest Res. Centre, Inf. Rep. O-X-151. 18 p.

Stocks, B.J. 1974. Wildfires and the Fire Weather Index in Ontario. Can. Dep. Environ., Can. For. Serv., Great Lakes Forest Res. Centre, Inf. Rep. O-X-213. 17 p.

Turner, J.A. 1973. A fire load index for British Columbia. Can. Dep. Environ., Can. For. Serv., Pacific Forest Res. Centre, Inf. Rep. BC-X-80. 15 p.

Van Wagner, C.E. 1970. Conversion of Williams Severity Rating for use with the Fire Weather Index. Can. Dep. Fisheries and For., Petawawa Forest Expt. Stn., Inf. Rep. PS-X-21. 5 p.

Van Wagner, C.E. 1974. Structure of the Canadian Forest Fire Weather Index. Can. Dep. Environ., Can. For. Serv., Publication No. 1333, Ottawa. 44 p.

Van Wagner, C.E.; Pickett, T.L. 1975. Equations and Fortran IV program for the 1976 metric version of the Forest Fire Weather Index. Can. Dep. Environ., Can. For. Serv., Petawawa Forest Expt. Stn., Int. Rep. PS-X-58. 19 p.

Williams, D.E. 1959. Fire season severity rating. Can. Dep. Northern Aff. and Nat. Res., Forest Res. Div., Tech. Note 73, Ottawa. 13 p.

APPENDIX A

Details for Each Station by Region

British Columbia

Victoria	
Smithers	
Fort Nelson	
Williams Lake	
Kimberley-Cranbrook	1953-69 from Kimberley 1970-80 from Cranbrook

Yukon - N.W.T.

Whitehorse	
Fort Smith	
Yellowknife	
Fort Smith	
Dawson-Burwash	1953-66 from Dawson 1967-80 from Burwash

Alberta

Rocky Mountain House	
Fort McMurray	
Wagner-Slave Lake	1953-71 from Wagner 1972-80 from Slave Lake
Whitecourt	

Saskatchewan

Cold Lake	
North Battleford	
Prince Albert	
Hudson Bay	

Manitoba

Winnipeg	
Gimli-Bisset	1953-68 from Gimli 1969-80 from Bisset
The Pas	
Dauphin	
Wabowden-Thompson	1953-70 from Wabowden 1971-80 from Thompson

Western Ontario

Lansdowne House	
Kenora	
Sioux Lookout	
Armstrong	
Thunder Bay	

Eastern Ontario	
Earlton	
Kapuskasing	
Timmins	
Killaloe-Petawawa	1953-72 from Killaloe 1973-80 from Petawawa
Muskoka	
Quebec	
Maniwaki	
Bagotville-Roberval	1953-56 from Bagotville 1958-80 from Roberval
Val d'Or	
Atlantic Provinces	
Campbellton-Charlo	1953-66 from Campbellton 1957-80 from Charlo
Gander	
Goose Bay	
Fredericton	
Copperlake-Truro	1953-60 from Copperlake 1961-80 from Truro

APPENDIX B

Table B1. Mean monthly FFMC

	April	May	June	July	Aug.	Sept.
B.C.						
Victoria	72.8	75.2	76.3	79.9	78.0	73.2
Smithers	80.1	78.1	75.5	74.8	73.4	65.8
Fort Nelson	78.8	78.4	75.1	74.2	74.1	68.4
Kimberley-Cranbrook	79.8	79.8	79.0	81.4	80.9	76.9
Williams Lake	79.9	80.5	80.4	85.9	84.1	79.4
B.C. Avg.	78.3	78.4	77.3	79.2	78.1	72.7
Yukon-NWT						
Whitehorse	82.6	83.9	82.1	79.3	76.8	73.7
Fort Smith	77.4	79.7	80.4	78.8	77.7	69.5
Yellowknife	75.3	79.0	82.8	80.9	77.4	72.0
Fort Simpson	74.6	78.3	77.8	77.6	75.3	69.6
Dawson-Burwash	75.4	78.8	76.8	71.5	70.9	70.3
Yukon-NWT Avg.	77.1	79.9	80.0	77.6	75.6	71.0
Alberta						
Rocky Mountain House	71.5	73.0	71.1	73.8	72.8	70.7
Fort McMurray	78.4	79.8	75.8	75.3	73.4	67.1
Slave Lake-Wagner	75.9	75.2	71.5	72.3	71.5	69.4
Whitecourt	77.0	76.9	73.5	72.9	69.2	70.5
Alberta Avg.	75.7	76.2	73.0	73.6	71.7	69.4
Saskatchewan						
Cold Lake	78.3	80.5	77.9	76.3	74.7	74.0
N. Battleford	76.8	81.4	78.7	78.8	79.5	77.7
Prince Albert	76.8	80.8	77.8	79.5	78.6	75.3
Hudson Bay	73.4	78.0	76.4	77.2	76.2	70.8
Saskatchewan Avg.	76.3	80.2	77.7	78.0	77.3	74.5
Manitoba						
Winnipeg	72.7	77.0	78.3	80.4	79.9	76.5
Bisset-Gimli	71.4	75.0	75.4	78.0	76.1	72.5
The Pas	71.4	76.3	75.3	76.9	75.9	70.0
Dauphin	73.0	77.3	77.5	79.5	78.8	74.6
Thompson-Wabowden	73.8	74.6	74.6	74.8	73.7	66.3
Manitoba Avg.	72.5	76.0	76.2	77.9	76.9	72.0
Western Ontario						
Landsdowne House	66.8	68.5	71.2	72.1	70.1	63.0
Kenora	70.4	73.9	73.9	77.1	75.9	70.0
Sioux Lookout	68.5	72.9	73.0	75.7	73.3	65.5
Armstrong	66.3	70.6	71.3	73.5	70.4	62.6
Thunder Bay	71.0	72.8	73.0	76.4	74.0	68.3
Western Ontario Avg.	68.6	71.7	72.5	75.0	72.7	65.9

Table B1. (cont'd)

	April	May	June	July	Aug.	Sept.
Eastern Ontario						
Earlton	69.3	74.5	74.4	76.9	74.3	67.3
Kapuskasing	67.1	69.5	72.4	74.1	72.0	63.3
Timmins	70.0	71.6	74.2	76.2	72.8	64.9
Killaloe-Petawawa	72.4	76.2	77.0	79.0	77.4	72.7
Muskoka	69.8	73.4	75.5	77.8	75.4	69.5
Eastern Ontario Avg.	69.7	73.0	74.7	76.8	74.4	67.5
Quebec						
Maniwaki	70.8	75.9	74.6	76.8	74.3	69.4
Bagotville-Roberval	69.2	71.2	73.9	71.7	71.8	67.4
Val d'Or	66.4	71.1	72.5	73.5	71.3	63.5
Quebec Avg.	68.8	72.7	73.7	74.0	72.5	66.8
Atlantic Provinces						
Campbellton-Charlo	63.4	67.1	70.4	71.2	69.3	67.0
Gander	54.2	62.5	68.0	73.6	69.2	67.5
Goose Bay	64.1	67.5	68.6	70.5	69.4	66.3
Fredericton	69.2	72.3	74.3	75.7	75.5	71.6
Truro-Copperlake	64.1	67.0	69.7	71.5	71.1	70.8
Atlantic Provinces Avg.	63.0	67.3	70.2	72.5	70.9	68.6

APPENDIX B

Table B2. Mean monthly extreme FFMC

	April	May	June	July	Aug.	Sept.
B.C.						
Victoria	85.2	88.0	87.8	89.0	89.2	88.9
Smithers	89.0	91.1	90.5	90.0	89.5	86.1
Fort Nelson	89.8	92.4	92.2	91.4	90.5	88.5
Kimberley-Cranbrook	89.7	92.3	92.4	93.1	93.1	90.7
Williams Lake	89.5	91.9	92.6	93.9	93.5	91.2
B.C. Avg.	88.6	91.1	91.1	91.5	91.2	89.1
Yukon-NWT						
Whitehorse	88.6	92.2	92.5	91.6	90.9	88.0
Fort Smith	87.1	92.1	92.5	91.9	90.1	87.3
Yellowknike	82.7	89.8	91.5	91.4	89.3	85.9
Fort Simpson	86.0	90.6	91.6	90.9	89.1	86.6
Dawson-Burwash	86.0	90.4	90.4	89.0	87.4	85.8
Yukon-NWT Avg.	86.1	91.0	91.7	91.0	89.4	86.7
Alberta						
Rocky Mountain House	89.9	92.3	91.5	90.9	90.1	90.2
Fort McMurray	89.9	93.2	92.3	90.9	89.4	88.4
Slave Lake-Wagner	87.7	90.6	88.9	88.2	86.9	86.4
Whitecourt	89.8	92.8	91.9	89.9	87.9	88.2
Alberta Avg.	89.3	92.2	91.2	90.0	88.6	88.3
Saskatchewan						
Cold Lake	89.8	93.3	92.4	90.6	89.5	89.2
N. Battleford	88.8	93.0	92.3	91.2	91.5	90.0
Prince Albert	88.7	92.7	92.4	90.6	90.7	89.4
Hudson Bay	88.2	92.4	91.4	90.2	89.6	88.3
Saskatchewan Avg.	88.9	92.8	92.1	90.7	90.3	89.2
Manitoba						
Winnipeg	88.7	92.7	92.0	90.5	90.9	90.2
Bisset-Gimli	88.1	91.7	90.9	89.7	89.7	88.6
The Pas	86.0	90.7	90.6	89.7	88.9	87.4
Dauphin	88.4	92.7	91.5	90.4	90.6	90.1
Thompson-Wabowden	87.2	91.3	91.6	91.1	89.4	86.5
Manitoba Avg.	87.7	91.8	91.3	90.3	89.9	88.6
Western Ontario						
Landsdowne House	84.9	88.9	90.0	88.7	87.8	85.0
Kenora	88.4	91.7	91.2	90.3	89.4	87.5
Sioux Lookout	88.4	92.2	91.8	90.6	89.0	87.4
Armstrong	86.5	90.4	90.8	89.9	88.5	86.4
Thunder Bay	88.8	91.6	90.3	89.9	89.0	86.6
Western Ontario Avg.	87.4	91.0	90.8	89.9	88.7	86.6

Table B2. (cont'd)

	April	May	June	July	Aug.	Sept.
Eastern Ontario						
Earlton	87.1	91.6	90.7	90.1	89.4	87.4
Kapuskasing	87.3	91.3	91.1	89.8	88.9	86.5
Timmins	88.1	91.8	92.0	91.0	89.6	87.4
Killaloe-Petawawa	90.3	91.9	90.8	90.6	89.7	87.8
Muskoka	89.2	91.3	90.5	90.0	89.2	87.6
Eastern Ontario Avg.	88.4	91.6	91.0	90.3	89.4	87.3
Quebec						
Maniwaki	89.9	91.4	90.6	89.9	89.0	87.4
Bagotville-Roberval	87.0	90.4	90.5	89.2	88.2	87.1
Val d'Or	86.6	90.4	91.0	90.2	88.3	86.6
Quebec Avg.	87.8	90.7	90.7	89.8	88.5	87.0
Atlantic Provinces						
Campbellton-Charlo	85.8	89.7	89.8	88.8	88.3	86.8
Gander	82.5	88.0	89.9	89.9	88.3	87.1
Goose Bay	84.4	89.7	91.2	91.2	90.0	87.8
Fredericton	89.0	91.7	91.6	90.8	89.9	88.6
Truro-Copperlake	86.3	89.0	89.0	88.4	88.4	86.9
Atlantic Provinces Avg.	85.6	89.6	90.3	89.8	89.0	87.4

APPENDIX C

Table C1. Mean monthly DMC

	April	May	June	July	Aug.	Sept.
B.C.						
Victoria	12.0	24.5	33.3	43.8	54.9	29.5
Smithers	19.8	33.8	40.1	33.5	33.5	15.8
Fort Nelson	18.8	34.2	31.6	24.7	25.9	17.8
Kimberley-Cranbrook	21.3	37.0	42.9	45.6	64.4	47.7
Williams Lake	21.7	36.2	40.6	61.5	82.2	56.5
B.C. Avg.	18.7	33.1	37.7	41.8	52.2	33.5
Yukon-NWT						
Whitehorse	14.5	39.5	60.8	47.3	38.9	20.7
Fort Smith	10.8	28.7	46.0	41.5	32.0	15.4
Yellowknife	5.6	15.8	46.0	54.4	40.6	22.1
Fort Simpson	9.6	26.0	37.3	37.1	28.8	20.1
Dawson-Burwash	8.8	23.3	34.3	23.8	19.1	13.8
Yukon-NWT Avg.	9.9	26.7	44.9	40.8	31.9	18.4
Alberta						
Rocky Mountain House	15.3	22.9	22.6	19.3	20.6	18.1
Fort McMurray	18.2	37.0	33.6	25.8	17.9	12.8
Slave Lake-Wagner	13.1	23.0	20.4	15.8	14.9	11.5
Whitecourt	17.7	30.6	26.4	19.4	16.4	14.7
Alberta Avg.	16.1	28.4	25.8	20.1	17.5	14.3
Saskatchewan						
Cold Lake	16.7	34.8	35.0	22.8	17.6	17.0
N. Battleford	14.3	35.8	40.7	30.0	34.0	35.9
Prince Albert	14.3	35.7	37.4	31.9	30.2	27.7
Hudson Bay	12.3	29.2	31.0	24.7	24.5	20.8
Saskatchewan Avg.	14.4	33.9	36.0	27.4	26.6	25.4
Manitoba						
Winnipeg	12.3	24.8	33.0	30.5	28.6	22.0
Bisset-Gimli	10.8	22.5	25.9	24.5	21.2	15.6
The Pas	7.8	21.6	26.8	22.8	23.1	13.9
Dauphin	13.6	26.8	32.8	31.3	29.2	24.8
Thompson-Wabowden	9.3	18.0	25.8	20.9	18.3	10.2
Manitoba Avg.	10.8	22.7	28.9	26.0	24.1	17.3
Western Ontario						
Landsdowne House	5.5	10.1	16.4	15.6	12.1	7.9
Kenora	10.3	20.3	20.6	22.0	19.5	12.3
Sioux Lookout	9.1	18.6	20.5	20.8	17.1	8.4
Armstrong	6.0	15.0	18.0	16.1	12.9	7.1
Thunder Bay	8.3	17.4	17.8	21.6	18.5	11.0
Western Ontario Avg.	7.8	16.3	18.7	19.2	16.0	9.3

Table C1. (cont'd)

	April	May	June	July	Aug.	Sept.
Eastern Ontario						
Earlton	6.8	17.4	21.1	21.6	17.3	9.1
Kapuskasing	5.9	14.1	18.7	17.1	14.2	7.1
Timmins	8.3	16.3	22.1	21.6	15.5	7.0
Killaloe-Petawawa	12.3	23.4	26.5	27.5	24.8	16.1
Muskoka	9.4	16.9	22.4	24.7	19.1	10.4
Eastern Ontario Avg.	8.5	17.6	22.2	22.5	18.2	9.9
Quebec						
Maniwaki	9.4	20.6	21.3	21.2	18.0	10.3
Bagotville-Roberval	6.3	13.8	17.5	13.5	11.6	7.3
Val d'Or	5.7	15.0	18.4	17.1	11.9	6.3
Quebec Avg.	7.1	16.5	19.1	17.3	13.8	8.0
Atlantic Provinces						
Campbellton-Charlo	4.1	10.4	15.1	15.8	11.4	8.5
Gander	1.9	6.9	13.9	18.1	14.4	8.4
Goose Bay	2.1	7.4	13.5	14.3	11.0	7.5
Fredericton	7.4	14.8	20.6	21.6	18.7	13.0
Truro-Gopperlake	4.8	10.0	15.1	16.4	15.0	11.5
Atlantic Provinces Avg.	4.1	9.9	15.6	17.2	14.1	9.8

APPENDIX C

Table C2. Mean monthly extreme DMC

	April	May	June	July	Aug.	Sept.
B.C.						
Victoria	19.5	41.2	54.3	67.5	86.9	52.0
Smithers	29.5	57.0	68.8	59.4	60.2	32.2
Fort Nelson	28.5	58.6	58.1	50.4	46.2	32.3
Kimberley-Cranbrook	31.0	62.6	76.7	81.1	104.5	75.8
Williams Lake	31.3	62.2	70.2	100.6	127.1	85.3
B.C. Avg.	28.0	56.3	65.6	71.8	85.0	55.5
Yukon-NWT						
Whitehorse	21.6	63.6	96.1	76.1	64.0	34.9
Fort Smith	17.6	52.0	73.5	75.1	55.0	29.9
Yellowknife	8.0	33.3	72.1	82.7	66.5	36.4
Fort Simpson	14.7	46.8	64.5	66.4	48.7	35.9
Dawson-Burwash	14.1	40.4	54.6	43.3	37.5	23.0
Yukon-NWT Avg.	15.2	47.2	72.2	68.7	54.3	32.0
Alberta						
Rocky Mountain House	25.5	46.9	49.7	37.8	38.6	33.8
Fort McMurray	28.1	64.0	62.9	46.8	34.4	25.9
Slave Lake-Wagner	20.5	42.4	39.1	31.4	29.3	21.5
Whitecourt	27.8	56.2	55.5	38.1	30.5	26.1
Alberta Avg.	25.5	52.4	51.8	38.5	33.2	26.8
Saskatchewan						
Cold Lake	26.1	61.9	65.1	45.9	34.7	30.4
N. Battleford	23.6	64.7	72.4	56.1	56.3	53.9
Prince Albert	23.4	64.6	68.4	54.9	51.5	45.1
Hudson Bay	20.4	54.0	56.0	43.1	45.7	36.4
Saskatchewan Avg.	23.4	61.3	65.5	50.0	47.0	41.5
Manitoba						
Winnipeg	21.5	50.6	61.4	57.7	51.8	40.9
Bisset-Gimli	19.1	44.9	52.3	45.8	38.8	27.6
The Pas	13.5	41.3	48.0	39.8	39.6	27.9
Dauphin	23.1	54.0	64.8	55.5	52.6	43.1
Thompson-Wabowden	15.2	35.8	49.2	42.4	34.5	19.8
Manitoba Avg.	18.5	45.3	55.1	48.2	43.5	31.9
Western Ontario						
Landsdowne House	9.8	22.4	32.8	33.8	24.5	16.2
Kenora	18.6	40.5	43.3	42.3	36.6	22.4
Sioux Lookout	16.6	38.6	42.9	41.4	32.6	18.2
Armstrong	11.7	30.8	38.1	34.7	24.9	16.7
Thunder Bay	15.3	35.7	35.8	39.2	35.0	21.0
Western Ontario Avg.	14.4	33.6	38.6	38.3	30.7	18.9

Table C2. (cont'd)

	April	May	June	July	Aug.	Sept.
Eastern Ontario						
Earlton	12.3	37.0	40.2	43.1	30.8	22.8
Kapuskasing	12.2	31.5	38.9	34.4	27.0	17.4
Timmins	15.0	36.7	44.4	41.9	30.4	18.4
Killaloe-Petawawa	20.4	46.2	48.3	49.7	44.2	30.7
Muskoka	17.9	37.2	42.5	45.5	35.9	22.5
Eastern Ontario Avg.	15.6	37.7	42.9	42.9	33.7	22.4
Quebec						
Maniwaki	18.2	41.5	42.7	41.0	34.6	23.2
Bagotville-Roberval	12.6	28.9	34.6	28.7	22.4	17.3
Val d'Or	11.3	33.5	38.5	35.9	24.3	16.4
Quebec Avg.	14.0	34.6	38.6	35.2	27.1	19.0
Atlantic Provinces						
Campbellton-Charlo	8.4	23.0	31.5	32.0	24.1	18.5
Gander	5.0	18.1	29.7	33.4	29.6	17.8
Goose Bay	5.2	17.7	30.4	29.8	24.0	15.8
Fredericton	14.5	31.8	43.3	43.6	36.2	26.8
Truro-Copperlake	9.7	22.4	30.2	30.2	30.3	23.7
Atlantic Provinces Avg.	8.6	22.6	33.0	33.8	28.8	20.5

APPENDIX D

Table D1. Mean monthly DC

	April	May	June	July	Aug.	Sept.
B.C.						
Victoria	48.3	124.5	252.9	402.1	548.6	567.3
Smithers	53.4	120.0	235.5	346.1	437.2	437.6
Fort Nelson	47.3	109.0	187.9	235.1	296.4	313.9
Kimberley-Cranbrook	52.2	122.2	235.1	341.6	462.0	521.8
Williams Lake	55.1	124.1	227.1	367.7	520.5	569.0
B.C. Avg.	51.3	120.0	227.7	338.5	452.9	481.9
Yukon-NWT						
Whitehorse	44.9	119.3	252.8	377.8	471.8	497.2
Fort Smith	35.1	98.9	213.2	312.9	395.2	404.9
Yellowknife	31.3	86.2	215.8	365.9	453.0	457.6
Fort Simpson	36.9	98.9	214.1	325.9	394.1	418.0
Dawson-Burwash	36.3	97.6	208.9	289.0	352.5	395.5
Yukon-NWT Avg.	36.9	100.2	221.0	334.3	413.3	434.6
Alberta						
Rocky Mountain House	39.4	80.9	131.9	167.1	216.1	249.6
Fort McMurray	44.8	113.3	202.2	265.9	285.5	266.5
Slave Lake-Wagner	41.2	93.6	163.3	204.2	255.6	264.6
Whitecourt	42.1	92.0	161.9	179.7	197.6	226.1
Alberta Avg.	41.9	95.0	164.8	204.2	238.7	251.7
Saskatchewan						
Cold Lake	45.7	109.8	196.4	248.0	261.1	280.5
N. Battleford	41.4	109.6	216.0	283.7	361.8	426.5
Prince Albert	42.1	108.3	191.9	265.8	348.6	386.2
Hudson Bay	35.9	95.6	178.0	241.5	299.7	308.9
Saskatchewan Avg.	41.3	105.8	195.6	259.8	317.8	350.5
Manitoba						
Winnipeg	32.1	74.0	146.2	211.8	282.6	286.1
Bisset-Gimli	30.0	76.1	145.6	216.1	259.9	246.7
The Pas	28.0	83.0	177.8	247.7	323.5	318.4
Dauphin	36.3	85.2	155.8	231.8	301.4	321.2
Thompson-Wabowden	32.4	78.3	158.4	218.7	271.0	256.2
Manitoba Avg.	31.8	79.3	156.8	225.2	287.7	285.7
Western Ontario						
Landsdowne House	21.9	55.2	119.3	171.6	208.8	196.4
Kenora	28.6	73.6	134.4	180.9	225.1	215.3
Sioux Lookout	27.2	67.7	117.9	175.5	219.1	189.6
Armstrong	20.8	59.1	108.1	164.5	193.4	173.5
Thunder Bay	24.8	64.0	121.6	201.0	254.2	232.6
Western Ontario Avg.	24.7	63.9	120.3	178.7	220.1	201.5

Table D1. (cont'd)

	April	May	June	July	Aug.	Sept.
Eastern Ontario						
Earlton	24.0	67.9	134.2	199.9	240.6	204.9
Kapuskasing	21.0	53.2	116.2	166.6	196.6	163.6
Timmins	23.0	59.5	120.4	170.1	214.6	177.5
Killaloe-Petawawa	29.3	81.5	172.0	254.2	306.9	307.5
Muskoka	23.0	56.4	130.3	205.9	248.6	208.8
Eastern Ontario Avg.	24.1	63.7	134.6	199.3	241.5	212.5
Quebec						
Maniwaki	26.1	71.5	138.2	196.8	228.9	198.4
Bagotville-Roberval	22.1	59.9	116.5	155.4	178.4	160.9
Val d'Or	23.5	66.6	123.0	169.1	180.5	145.1
Quebec Avg.	23.9	66.0	125.9	173.8	195.9	168.1
Atlantic Provinces						
Campbellton-Charlo	15.7	47.1	98.6	166.2	194.4	165.3
Gander	10.0	37.9	94.6	183.4	236.4	209.9
Goose Bay	12.8	42.2	88.1	133.2	150.5	133.7
Fredericton	19.0	52.9	116.5	187.2	222.2	208.3
Truro-Copperlake	15.0	44.1	108.6	185.2	216.0	200.6
Atlantic Provinces Avg.	14.5	45.2	101.3	171.0	203.9	183.6

APPENDIX D

Table D2. Mean monthly extreme DC

	April	May	June	July	Aug.	Sept.
B.C.						
Victoria	68.6	185.4	326.4	496.3	622.9	637.0
Smithers	71.3	176.0	296.6	420.2	502.6	492.5
Fort Nelson	64.0	163.2	252.3	303.4	365.0	360.2
Kimberley-Cranbrook	69.4	179.5	298.4	423.7	534.8	573.8
Williams Lake	72.9	182.2	296.9	466.6	595.7	626.4
B.C. Avg.	69.2	177.3	294.1	422.0	524.2	538.0
Yukon-NWT						
Whitehorse	59.2	178.7	322.3	449.7	532.6	544.9
Fort Smith	48.6	155.7	282.8	388.7	461.6	451.1
Yellowknife	40.4	139.9	296.7	443.6	531.6	499.9
Fort Simpson	50.1	154.4	286.0	398.2	468.1	468.2
Dawson-Burwash	48.9	149.0	270.9	347.7	415.1	428.9
Yukon-NWT Avg.	49.4	155.5	291.7	405.6	481.8	478.6
Alberta						
Rocky Mountain House	55.9	132.5	191.2	233.1	287.5	294.8
Fort McMurray	61.7	170.6	261.2	327.4	357.6	321.0
Slave Lake-Wagner	56.8	141.3	218.6	266.0	320.2	323.3
Whitecourt	59.0	145.4	220.6	249.7	259.2	269.3
Alberta Avg.	58.4	147.5	222.9	269.0	306.1	302.1
Saskatchewan						
Cold Lake	62.5	166.3	255.8	306.7	328.7	333.9
N. Battleford	58.7	171.0	285.4	348.1	434.2	475.6
Prince Albert	60.6	171.7	257.8	335.8	418.6	443.2
Hudson Bay	51.7	153.7	243.0	314.1	371.2	367.9
Saskatchewan Avg.	58.4	165.7	260.5	326.2	388.2	405.2
Manitoba						
Winnipeg	48.6	125.0	213.6	289.8	359.7	342.4
Bisset-Gimli	47.0	124.7	209.1	285.6	332.3	311.5
The Pas	41.8	135.6	244.0	313.0	388.6	378.5
Dauphin	54.2	140.7	226.5	308.4	379.8	392.4
Thompson-Wabowden	46.3	123.5	217.5	282.7	330.4	308.5
Manitoba Avg.	47.6	129.9	222.1	295.9	358.2	346.7
Western Ontario						
Landsdowne House	34.2	92.9	172.9	235.5	269.2	244.1
Kenora	45.5	119.4	188.7	249.8	295.7	264.5
Sioux Lookout	42.1	111.9	172.3	236.9	274.8	241.9
Armstrong	33.9	101.2	161.0	220.4	242.8	216.9
Thunder Bay	39.3	108.2	179.4	267.9	316.1	290.9
Western Ontario Avg.	39.0	106.7	174.9	242.1	279.7	251.7

Table D2. (cont'd)

	April	May	June	July	Aug.	Sept.
Eastern Ontario						
Earlton	36.5	118.0	189.7	264.1	301.4	285.0
Kapuskasing	34.3	97.3	168.8	229.5	253.5	212.6
Timmins	37.6	106.7	177.3	229.2	267.9	231.0
Killaloe-Petawawa	44.9	133.8	233.7	322.7	381.0	360.9
Muskoka	37.2	99.3	192.8	273.7	316.5	272.8
Eastern Ontario Avg.	38.1	111.0	192.5	263.8	304.1	272.5
Quebec						
Maniwaki	40.9	117.9	196.0	259.9	295.7	260.1
Bagotville-Roberval	36.1	99.6	172.1	213.2	239.9	221.2
Val d'Or	36.3	114.3	175.3	228.6	239.7	204.8
Quebec Avg.	37.8	110.6	181.1	233.9	258.4	228.7
Atlantic Provinces						
Campbellton-Charlo	26.6	85.3	155.7	222.2	253.8	225.6
Gander	20.0	79.5	147.1	247.3	295.1	263.3
Goose Bay	21.8	76.8	133.1	192.1	203.0	180.9
Fredericton	32.6	94.3	181.0	254.1	284.3	272.9
Truro-Copperlake	27.9	86.1	169.0	247.5	290.1	263.1
Atlantic Provinces Avg.	25.8	84.4	157.2	232.6	265.3	241.2

APPENDIX E

Table E1. Mean monthly ISI

	April	May	June	July	Aug.	Sept.
B.C.						
Victoria	2.5	3.1	3.4	4.4	3.9	2.9
Smithers	4.1	4.1	3.4	3.1	2.8	1.8
Fort Nelson	4.8	5.1	4.5	3.7	3.7	2.6
Kimberley-Cranbrook	5.1	5.9	5.7	6.9	6.6	4.4
Williams Lake	5.3	6.1	6.7	9.0	8.8	5.4
B.C. Avg.	4.4	4.9	4.7	5.4	5.2	3.4
Yukon-NWT						
Whitehorse	5.7	7.9	7.3	5.6	5.1	3.9
Fort Smith	4.6	6.5	6.6	5.6	4.6	2.8
Yellowknife	3.2	5.4	7.8	7.1	5.3	3.2
Fort Simpson	3.0	4.5	4.3	4.2	3.3	2.2
Dawson-Burwash	3.9	5.6	4.7	3.0	3.1	3.1
Yukon-NWT Avg.	4.1	6.0	6.1	5.1	4.3	3.0
Alberta						
Rocky Mountain House	4.0	4.9	3.8	3.1	3.0	2.9
Fort McMurray	5.1	6.6	4.7	3.9	3.4	2.7
Slave Lake-Wagner	4.5	5.2	3.3	3.4	2.9	3.1
Whitecourt	4.9	6.3	4.2	3.5	2.7	2.7
Alberta Avg.	4.6	5.8	4.0	3.5	3.0	2.9
Saskatchewan						
Cold Lake	6.2	9.9	7.2	5.5	4.7	5.3
N. Battleford	6.4	10.3	7.9	5.9	7.2	6.4
Prince Albert	6.5	10.1	7.8	6.8	6.6	5.9
Hudson Bay	4.4	6.7	5.5	4.8	4.3	3.9
Saskatchewan Avg.	5.9	9.3	7.1	5.8	5.7	5.4
Manitoba						
Winnipeg	7.8	10.2	8.5	7.2	7.3	7.3
Bisset-Gimli	5.0	7.3	5.9	5.5	4.9	4.8
The Pas	3.8	6.0	5.4	5.2	4.5	4.1
Dauphin	7.4	10.8	8.5	7.1	7.0	7.0
Thompson-Wabowden	3.8	4.6	4.6	4.2	3.5	2.4
Manitoba Avg.	5.6	7.8	6.6	5.8	5.4	5.1
Western Ontario						
Landsdowne House	2.3	3.2	3.6	3.1	3.1	2.3
Kenora	4.6	5.8	5.0	5.1	4.4	3.5
Sioux Lookout	3.7	5.1	4.8	4.5	3.6	2.4
Armstrong	2.8	4.3	4.4	3.6	3.1	2.1
Thunder Bay	4.9	6.2	4.5	4.9	3.9	3.0
Western Ontario Avg.	3.7	4.9	4.5	4.2	3.6	2.7

Table E1. (cont'd)

	April	May	June	July	Aug.	Sept.
Eastern Ontario						
Earlton	3.5	5.8	5.1	5.0	4.2	2.9
Kapuskasing	3.1	4.7	5.1	4.1	3.6	2.4
Timmins	3.7	5.0	5.8	5.3	4.0	2.6
Killaloe-Petawawa	4.5	5.6	5.0	5.0	4.4	3.1
Muskoka	3.9	4.8	4.2	4.3	3.6	2.7
Eastern Ontario Avg.	3.7	5.2	5.0	4.7	4.0	2.7
Quebec						
Maniwaki	3.5	5.1	4.0	3.7	3.3	2.2
Bagotville-Roberval	3.0	4.7	5.0	3.5	3.3	2.8
Val d'Or	2.6	4.6	4.4	3.8	3.0	2.0
Quebec Avg.	3.0	4.8	4.5	3.7	3.2	2.3
Atlantic Provinces						
Campbellton-Charlo	2.3	3.5	3.8	3.6	3.2	2.7
Gander	1.7	3.8	4.9	5.1	4.0	3.9
Goose Bay	2.3	3.5	4.5	4.5	4.0	3.5
Fredericton	4.1	5.7	5.7	5.3	4.7	3.7
Truro-Copperlake	2.8	3.5	3.4	3.3	3.5	3.1
Atlantic Provinces Avg.	2.6	4.0	4.5	4.4	3.9	3.4

APPENDIX E

Table E2. Mean monthly extreme ISI

	April	May	June	July	Aug.	Sept.
B.C.						
Victoria	6.8	9.5	8.8	9.6	9.9	8.3
Smithers	11.3	14.9	11.8	9.0	9.0	7.5
Fort Nelson	13.4	17.6	15.8	13.9	14.6	13.7
Kimberley-Cranbrook	13.4	22.2	21.0	24.1	23.3	20.1
Williams Lake	16.9	21.1	28.2	33.1	33.4	21.9
B.C. Avg.	12.4	17.1	17.1	17.9	18.0	14.3
Yukon-NWT						
Whitehorse	13.0	22.8	23.8	18.2	18.7	13.8
Fort Smith	11.7	22.7	21.7	19.1	15.1	10.4
Yellowknife	7.4	18.2	21.2	20.7	16.3	10.6
Fort Simpson	8.3	13.6	13.3	13.7	11.0	8.2
Dawson-Burwash	11.4	17.8	18.5	11.2	11.8	12.4
Yukon-NWT Avg.	10.4	19.0	19.7	16.6	14.6	11.1
Alberta						
Rocky Mountain House	13.5	22.6	16.3	12.2	10.1	10.9
Fort McMurray	13.9	24.8	16.4	14.4	11.4	11.6
Slave Lake-Wagner	14.5	23.3	13.9	13.5	10.3	14.0
Whitecourt	13.5	22.0	16.2	11.8	9.6	12.5
Alberta Avg.	13.9	23.2	15.7	13.0	10.4	12.3
Saskatchewan						
Cold Lake	20.4	42.5	30.2	23.3	18.9	24.0
N. Battleford	19.5	43.1	31.7	22.5	30.0	26.0
Prince Albert	18.7	39.5	31.1	23.0	24.2	23.9
Hudson Bay	14.0	27.4	22.0	16.6	15.5	18.2
Saskatchewan Avg.	18.2	38.1	28.8	21.4	22.2	23.0
Manitoba						
Winnipeg	35.3	47.9	33.9	25.1	25.6	34.1
Bisset-Gimli	23.8	39.3	26.3	23.0	21.7	22.8
The Pas	11.3	24.4	21.0	21.3	16.0	23.5
Dauphin	27.5	56.7	40.7	29.2	32.8	34.4
Thompson-Wabowden	11.0	16.4	18.6	16.3	12.3	9.8
Manitoba	21.8	36.9	28.1	23.0	21.7	24.9
Western Ontario	7.5	15.2	17.0	13.3	14.6	11.4
Kenora	14.4	22.3	19.7	17.4	15.1	12.8
Sioux Lookout	11.4	24.7	18.2	16.0	13.2	10.1
Armstrong	9.0	17.0	19.5	14.5	12.3	9.8
Thunder Bay	20.4	34.7	20.4	20.2	16.3	14.6
Western Ontario Avg.	12.5	22.8	19.0	16.3	14.3	11.7

Table E2. (cont'd)

	April	May	June	July	Aug.	Sept.
Eastern Ontario						
Earlton	13.1	24.5	20.9	16.6	14.8	12.0
Kapuskasing	11.1	22.9	20.5	15.7	13.2	11.3
Timmins	13.5	22.6	23.4	17.8	14.6	11.3
Killaloe-Petawawa	14.7	23.5	16.8	17.3	14.3	11.7
Muskoka	12.7	16.8	13.5	11.3	10.3	8.7
Eastern Ontario Avg.	13.0	22.1	19.0	15.7	13.4	11.0
Quebec						
Maniwaki	12.3	19.7	15.4	11.0	9.8	8.0
Bagotville-Roberval	11.6	23.2	23.1	14.2	12.2	13.1
Val d'Or	9.7	19.0	18.1	12.6	10.8	8.4
Quebec Avg.	11.2	20.6	18.9	12.6	10.9	9.8
Atlantic Provinces						
Campbellton-Charlo	8.4	15.3	15.4	14.1	13.1	12.6
Gander	7.3	20.7	22.6	21.9	16.0	20.6
Goose Bay	8.5	17.9	24.4	23.1	19.6	17.2
Fredericton	15.4	23.9	23.6	17.5	15.0	12.6
Truro-Copperlake	9.5	14.9	13.6	11.8	12.6	10.8
Atlantic Provinces Avg.	9.8	18.5	19.9	17.7	15.3	14.8

APPENDIX F

Table F1. Mean monthly BUI

	April	May	June	July	Aug.	Sept.
B.C.						
Victoria	15.4	31.3	48.3	66.5	84.4	50.2
Smithers	22.3	38.7	53.1	51.4	53.5	28.0
Fort Nelson	20.9	38.0	42.4	37.5	40.9	29.3
Kimberley-Cranbrook	23.7	41.7	56.0	65.4	89.8	72.8
Williams Lake	24.3	41.1	52.6	84.1	111.7	83.4
B.C. Avg.	21.3	38.2	50.5	61.0	76.1	52.7
Yukon-NWT						
Whitehorse	16.8	42.6	72.7	68.7	61.6	36.7
Fort Smith	12.8	32.8	57.0	59.1	51.2	27.0
Yellowknife	7.8	21.0	58.6	75.4	63.2	37.6
Fort Simpson	11.9	30.4	49.5	55.5	47.0	34.3
Dawson-Burwash	11.4	28.3	46.3	37.0	32.1	24.4
Yukon-NWT Avg.	12.1	31.0	56.8	59.1	51.0	32.0
Alberta						
Rocky Mountain House	17.2	26.3	29.5	28.5	31.5	29.0
Fort McMurray	20.2	40.7	44.9	39.8	30.1	21.7
Slave Lake-Wagner	15.5	27.4	29.3	25.0	24.9	20.1
Whitecourt	19.4	33.4	35.3	28.7	25.6	24.4
Alberta Avg.	18.1	32.0	34.8	30.5	28.0	23.8
Saskatchewan						
Cold Lake	18.9	38.6	45.8	35.2	28.7	28.3
N. Battleford	16.7	39.1	51.9	45.3	52.7	56.2
Prince Albert	16.6	39.2	47.1	46.4	48.3	44.7
Hudson Bay	14.1	32.6	41.0	38.0	39.5	33.4
Saskatchewan Avg.	16.6	37.4	46.5	41.2	42.3	40.7
Manitoba						
Winnipeg	13.9	27.2	40.2	42.4	44.1	35.4
Bisset-Gimli	12.6	25.5	33.9	36.3	34.0	25.6
The Pas	9.4	25.6	37.3	35.6	37.7	23.8
Dauphin	15.6	29.9	40.7	44.7	45.1	39.5
Thompson-Wabowden	11.4	22.1	34.9	32.4	30.3	17.9
Manitoba Avg.	12.6	26.1	37.4	38.3	38.2	28.4
Western Ontario						
Landsdowne House	6.8	13.3	23.4	24.2	20.3	13.6
Kenora	11.8	23.4	28.1	32.4	30.5	19.9
Sioux Lookout	10.6	21.4	27.0	30.5	27.2	14.2
Armstrong	7.0	17.6	24.1	24.7	21.3	12.0
Thunder Bay	9.7	20.1	24.9	32.5	30.3	18.6
Western Ontario Avg.	9.2	19.2	25.5	28.9	25.9	15.7

Table F1. (cont'd)

	April	May	June	July	Aug.	Sept.
Eastern Ontario						
Earlton	8.1	20.5	29.0	32.4	28.2	15.7
Kapuskasing	7.2	16.3	25.0	26.0	23.0	12.1
Timmins	9.3	18.6	28.8	31.3	25.1	12.3
Killaloe-Petawawa	13.6	26.6	36.9	42.0	39.9	28.1
Muskoka	10.4	19.1	30.0	36.3	30.5	17.8
Eastern Ontario Avg.	9.7	20.2	29.9	33.6	29.3	17.2
Quebec						
Maniwaki	10.7	23.5	28.9	32.0	28.8	17.5
Bagotville-Roberval	7.8	17.1	24.2	21.3	19.3	12.8
Val d'Or	7.1	18.1	25.4	25.9	19.4	10.8
Quebec Avg.	8.5	19.6	26.2	26.4	22.5	13.7
Atlantic Provinces						
Campbellton-Charlo	5.1	12.7	20.7	24.3	19.2	14.4
Gander	2.6	9.0	19.3	28.1	23.9	14.8
Goose Bay	3.0	9.7	18.6	21.4	17.8	12.4
Fredericton	8.4	17.1	27.3	32.0	29.6	21.8
Truro-Copperlake	5.6	12.4	21.3	25.8	24.6	19.2
Atlantic Provinces Avg.	4.9	12.2	21.4	26.3	23.0	16.5

APPENDIX F

Table F2. Mean monthly extreme BUI

	April	May	June	July	Aug.	Sept.
B.C.						
Victoria	22.4	50.3	73.0	98.4	125.6	84.0
Smithers	30.1	60.6	81.1	84.4	89.1	53.1
Fort Nelson	28.9	61.0	69.5	69.2	67.8	50.8
Kimberley-Cranbrook	31.5	65.7	89.6	105.9	134.8	108.8
Williams Lake	31.8	66.3	83.1	127.4	159.3	120.0
B.C. Avg.	28.9	60.8	79.3	97.1	115.3	83.3
Yukon-NWT						
Whitehorse	22.7	66.7	104.7	101.0	95.1	59.1
Fort Smith	18.7	56.1	85.1	95.8	82.3	49.7
Yellowknife	10.1	40.7	86.9	106.7	98.5	59.3
Fort Simpson	16.5	51.8	78.3	90.3	75.3	58.4
Dawson-Burwash	16.0	46.4	68.6	63.1	59.0	39.3
Yukon-NWT Avg.	16.8	52.3	84.7	91.4	82.0	53.2
Alberta						
Rocky Mountain House	25.9	50.1	57.9	51.0	55.6	50.6
Fort McMurray	28.5	66.7	74.8	66.2	54.2	41.5
Slave Lake-Wagner	21.9	47.0	51.1	46.2	45.9	36.0
Whitecourt	28.0	58.2	64.8	52.6	46.3	41.0
Alberta Avg.	26.1	55.5	62.2	54.0	50.3	42.3
Saskatchewan						
Cold Lake	26.9	64.9	75.7	62.7	53.3	48.2
N. Battleford	24.5	67.1	83.5	76.6	82.3	80.6
Prince Albert	24.6	67.4	78.1	74.5	77.1	69.3
Hudson Bay	21.2	57.4	67.3	62.5	68.2	56.0
Saskatchewan Avg.	24.3	64.2	76.2	69.1	70.2	63.5
Manitoba						
Winnipeg	22.1	52.0	67.8	72.6	74.5	60.7
Bisset-Gimli	19.9	47.0	61.8	62.4	58.4	43.8
The Pas	14.8	46.2	61.5	58.1	61.2	45.6
Dauphin	23.9	56.8	72.4	72.5	76.0	64.7
Thompson-Wabowden	16.6	40.2	59.4	59.4	53.1	33.2
Manitoba Avg.	19.5	48.4	64.6	65.0	64.6	49.6
Western Ontario						
Landsdowne House	11.1	26.1	42.5	47.7	38.5	26.6
Kenora	19.1	42.6	52.1	57.1	53.3	34.8
Sioux Lookout	17.3	40.8	49.7	55.7	47.7	29.3
Armstrong	12.4	33.7	45.3	47.2	38.6	26.8
Thunder Bay	15.9	38.6	45.4	55.0	53.4	34.1
Western Ontario Avg.	15.2	36.4	47.0	52.5	46.3	30.3

Table F2. (cont'd)

	April	May	June	July	Aug.	Sept.
Eastern Ontario						
Earlton	13.2	40.5	49.7	59.4	47.0	37.3
Kapuskasing	13.0	34.3	46.3	47.2	41.1	28.2
Timmins	15.6	38.7	51.8	54.7	45.9	29.8
Killaloe-Petawawa	20.6	47.6	61.5	69.0	67.0	49.3
Muskoka	18.1	38.8	51.7	61.7	54.0	36.0
Eastern Ontario Avg.	16.1	40.0	52.2	58.4	51.0	36.1
Quebec						
Maniwaki	18.4	44.0	51.8	56.4	51.9	37.0
Bagotville-Roberval	13.5	32.6	42.9	40.9	35.0	28.2
Val d'Or	12.2	37.1	47.3	49.5	36.9	26.3
Quebec Avg.	14.7	37.9	47.3	48.9	41.3	30.5
Atlantic Provinces						
Campbellton-Charlo	9.2	26.5	39.5	45.1	37.9	29.7
Gander	5.8	22.2	37.9	47.9	46.3	29.7
Goose Bay	6.2	21.6	37.2	41.1	35.8	24.7
Fredericton	14.7	33.7	51.7	57.1	53.7	42.1
Truro-Copperlake	10.3	26.0	40.0	44.1	47.0	37.3
Atlantic Provinces Avg.	9.2	26.0	41.3	47.1	44.1	32.7

APPENDIX G

Table G1. Mean monthly FWI

	April	May	June	July	Aug.	Sept.
B.C.						
Victoria	3.3	6.5	9.0	13.4	13.9	8.0
Smithers	6.5	9.0	9.3	8.8	8.2	3.6
Fort Nelson	7.1	10.6	10.1	8.4	8.8	5.0
Kimberley-Cranbrook	8.0	12.4	14.2	17.7	19.2	13.0
Williams Lake	8.3	12.6	15.3	23.9	26.0	15.7
B.C. Avg.	6.6	10.2	11.6	14.4	15.2	9.1
Yukon-NWT						
Whitehorse	7.4	15.7	19.3	15.4	13.8	8.4
Fort Smith	5.5	11.9	16.1	14.7	11.6	5.2
Yellowknife	2.7	8.2	18.5	19.4	14.3	7.2
Fort Simpson	3.3	8.6	10.8	11.5	8.7	5.3
Dawson-Burwash	4.4	9.5	10.8	7.0	6.1	5.4
Yukon-NWT Avg.	4.7	10.8	15.1	13.6	10.9	6.3
Alberta						
Rocky Mountain House	5.6	8.4	7.4	6.3	6.5	6.0
Fort McMurray	7.5	13.4	10.9	8.6	6.8	4.7
Slave Lake-Wagner	5.7	9.1	6.6	6.0	5.5	4.9
Whitecourt	7.1	11.6	8.8	6.7	5.0	5.0
Alberta Avg.	6.5	10.6	8.4	6.9	6.0	5.2
Saskatchewan						
Cold Lake	8.4	16.9	15.1	10.6	8.7	9.1
N. Battleford	8.3	17.8	17.2	13.1	16.2	15.2
Prince Albert	8.2	17.6	16.1	14.5	14.8	13.0
Hudson Bay	5.6	11.9	11.6	10.1	9.7	7.9
Saskatchewan Avg.	7.6	16.1	15.0	12.1	12.4	11.3
Manitoba						
Winnipeg	8.4	14.8	15.6	14.6	15.0	13.1
Bisset-Gimli	5.5	10.6	10.8	10.6	10.0	8.0
The Pas	4.1	9.6	11.0	10.3	9.7	6.8
Dauphin	8.7	15.6	15.8	14.5	14.6	13.5
Thompson-Wabowden	4.2	7.3	9.5	8.4	7.2	3.8
Manitoba Avg.	6.2	11.6	12.5	11.7	11.3	9.0
Western Ontario						
Landsdowne House	2.0	3.9	6.2	5.5	5.1	2.9
Kenora	5.3	9.3	9.1	9.9	8.3	5.6
Sioux Lookout	4.1	7.9	8.4	8.6	6.9	3.4
Armstrong	2.6	6.2	7.5	6.5	5.2	2.8
Thunder Bay	4.6	8.5	7.6	9.4	7.8	4.5
Western Ontario Avg.	3.7	7.2	7.8	8.0	6.7	3.8

Table G1. (cont'd)

	April	May	June	July	Aug.	Sept.
Eastern Ontario						
Earlton	3.4	8.4	9.2	9.6	7.8	4.2
Kapuskasing	2.7	6.2	8.4	7.3	6.2	3.1
Timmins	3.9	7.3	10.1	10.0	7.0	3.3
Killaloe-Petawawa	5.3	9.4	10.4	11.1	9.9	6.0
Muskoka	4.4	7.1	8.3	9.4	7.3	4.2
Eastern Ontario Avg.	3.9	7.7	9.3	9.5	7.6	4.2
Quebec						
Maniwaki	3.7	8.4	7.7	7.6	6.6	3.4
Bagotville-Roberval	2.8	6.4	8.0	5.5	5.1	3.6
Val d'Or	2.3	6.8	7.9	6.9	5.0	2.5
Quebec Avg.	2.9	7.2	7.9	6.7	5.6	3.2
Atlantic Provinces						
Campbellton-Charlo	1.8	4.3	6.0	6.4	5.2	3.8
Gander	1.1	4.0	7.0	8.9	6.9	5.0
Goose Bay	1.4	3.7	6.4	7.1	5.7	4.4
Fredericton	4.0	7.4	9.7	9.9	9.0	6.1
Truro-Copperlake	2.5	4.3	5.6	6.1	6.5	4.9
Atlantic Provinces Avg.	2.2	4.7	6.9	7.7	6.7	4.8

APPENDIX G

Table G2. Mean monthly extreme FWI

	April	May	June	July	Aug.	Sept.
B.C.						
Victoria	9.6	17.9	21.0	26.3	30.5	20.9
Smithers	16.3	26.4	26.9	24.4	24.3	14.6
Fort Nelson	17.9	30.5	31.0	27.4	28.4	22.9
Kimberley-Cranbrook	18.9	37.6	40.1	48.4	49.8	41.1
Williams Lake	22.2	36.6	47.5	64.1	68.5	46.8
B.C. Avg.	17.0	29.8	33.3	38.1	40.3	29.3
Yukon-NWT						
Whitehorse	16.2	37.0	48.5	41.1	40.5	25.8
Fort Smith	14.0	33.8	41.3	39.8	33.0	19.7
Yellowknife	7.1	25.7	41.7	45.6	37.6	21.7
Fort Simpson	9.9	23.7	28.7	33.1	23.9	18.3
Dawson-Burwash	12.1	26.6	31.8	21.9	20.4	18.8
Yukon-NWT Avg.	11.9	29.4	38.4	36.3	31.1	20.9
Alberta						
Rocky Mountain House	17.5	31.4	27.6	21.6	20.3	19.8
Fort McMurray	19.1	38.8	34.0	28.0	22.0	18.8
Slave Lake-Wagner	16.3	32.6	23.7	22.2	18.5	20.6
Whitecourt	17.9	33.3	31.0	21.4	17.2	20.0
Alberta Avg.	17.7	34.0	29.1	23.3	19.5	19.8
Saskatchewan						
Cold Lake	23.4	53.5	48.3	36.1	29.9	33.8
N. Battleford	22.2	53.3	53.8	39.7	47.6	44.5
Prince Albert	21.3	51.7	49.9	40.6	41.9	39.4
Hudson Bay	16.6	39.0	36.1	29.8	28.6	29.4
Saskatchewan Avg.	20.9	49.4	47.0	36.5	37.0	36.8
Manitoba						
Winnipeg	28.5	52.7	49.0	40.0	42.4	45.8
Bisset-Gimli	20.5	41.3	38.8	35.6	31.9	30.3
The Pas	11.9	32.4	32.9	33.6	28.3	30.7
Dauphin	26.5	59.6	53.4	43.8	47.8	46.7
Thompson-Wabowden	12.8	24.7	30.8	29.9	22.6	15.7
Manitoba Avg.	20.0	42.1	41.0	36.6	34.6	33.8
Western Ontario						
Landsdowne House	7.1	18.2	24.5	21.2	21.0	14.6
Kenora	15.6	30.4	31.4	30.7	26.1	19.3
Sioux Lookout	12.6	30.5	27.7	26.7	22.5	14.4
Armstrong	9.1	22.6	28.5	23.9	19.1	13.6
Thunder Bay	16.7	34.5	27.8	31.3	27.0	18.6
Western Ontario Avg.	12.2	27.2	28.0	26.8	23.1	16.1

Table G2. (cont'd)

	April	May	June	July	Aug.	Sept.
Eastern Ontario						
Earlton	12.6	31.6	30.8	29.7	24.2	18.3
Kapuskasing	11.4	27.1	30.2	25.3	21.2	15.5
Timmins	13.2	28.4	34.8	28.8	23.3	15.9
Killaloe-Petawawa	16.2	31.5	30.3	31.5	28.1	20.1
Muskoka	14.6	24.3	23.5	23.8	20.8	14.2
Eastern Ontario Avg.	13.6	28.6	29.9	27.8	23.5	16.8
Quebec						
Maniwaki	13.9	27.4	25.6	21.8	19.0	13.8
Bagotville-Roberval	11.3	26.4	31.5	21.7	18.5	16.9
Val d'Or	9.2	25.9	27.4	22.3	17.2	11.8
Quebec Avg.	11.5	26.6	28.2	21.9	18.2	14.2
Atlantic Provinces						
Campbellton-Charlo	7.3	18.2	22.5	22.7	20.2	16.7
Gander	5.3	20.8	27.2	31.4	23.9	22.1
Goose Bay	6.5	18.2	28.3	30.8	24.9	19.3
Fredericton	14.4	27.7	34.2	30.0	25.4	20.4
Truro-Copperlake	8.7	17.4	20.7	20.3	21.9	17.4
Atlantic Provinces Avg.	8.4	20.5	26.6	27.0	23.3	19.2

APPENDIX H

Table H1. Mean monthly DSR

	April	May	June	July	Aug.	Sept.
B.C.						
Victoria	0.4	1.1	1.9	3.5	3.8	1.8
Smithers	1.0	2.0	2.3	2.1	2.0	0.6
Fort Nelson	1.4	2.8	2.7	2.1	2.2	1.1
Kimberley-Cranbrook	1.6	3.6	4.6	6.9	8.1	4.4
Williams Lake	1.7	3.5	5.4	9.9	12.4	5.7
B.C. Avg.	1.2	2.6	3.4	4.9	5.7	2.7
Yukon-NWT						
Whitehorse	1.3	4.7	7.1	5.1	4.5	2.0
Fort Smith	1.1	3.3	5.3	4.7	3.2	1.0
Yellowknife	0.3	1.8	6.1	6.9	4.4	1.5
Fort Simpson	0.4	1.9	2.7	3.1	2.0	1.0
Dawson-Burwash	0.7	2.3	2.9	1.6	1.4	1.2
Yukon-NWT Avg.	0.8	2.8	4.8	4.3	3.1	1.3
Alberta						
Rocky Mountain House	1.1	2.2	1.8	1.2	1.4	1.3
Fort McMurray	1.7	4.2	3.1	2.1	1.4	0.9
Slave Lake-Wagner	1.1	2.4	1.4	1.2	1.0	0.9
Whitecourt	1.5	3.3	2.3	1.5	1.0	0.9
Alberta Avg.	1.4	3.0	2.2	1.5	1.2	1.0
Saskatchewan						
Cold Lake	2.0	6.5	5.4	3.1	2.2	2.6
N. Battleford	2.1	6.5	6.5	4.0	5.8	5.6
Prince Albert	2.0	6.6	6.1	4.8	5.2	4.7
Hudson Bay	1.2	3.6	3.4	2.6	2.5	2.2
Saskatchewan Avg.	1.8	5.8	5.3	3.6	3.9	3.8
Manitoba						
Winnipeg	2.8	6.0	6.2	4.8	5.0	4.8
Bisset-Gimli	1.2	3.5	3.3	2.9	2.9	2.2
The Pas	0.7	2.5	3.0	2.6	2.3	1.8
Dauphin	3.1	6.7	6.0	4.8	5.2	5.1
Thompson-Wabowden	0.7	1.6	2.4	1.9	1.5	0.6
Manitoba Avg.	1.7	4.1	4.2	3.4	3.4	2.9
Western Ontario						
Landsdowne House	0.2	0.7	1.3	1.0	0.9	0.5
Kenora	1.1	2.5	2.4	2.6	2.0	1.1
Sioux Lookout	0.7	2.0	2.1	2.0	1.5	0.6
Armstrong	0.3	1.4	1.8	1.3	0.9	0.4
Thunder Bay	0.9	2.3	1.7	2.3	1.7	1.0
Western Ontario Avg.	0.6	1.8	1.9	1.8	1.4	0.7

Table H1. (cont'd)

	April	May	June	July	Aug.	Sept.
Eastern Ontario						
Earlton	0.5	2.1	2.4	2.4	1.7	0.7
Kapuskasing	0.4	1.5	2.1	1.6	1.2	0.5
Timmins	0.7	1.7	2.9	2.7	1.5	0.5
Killaloe-Petawawa	1.0	2.4	2.7	3.0	2.4	1.3
Muskoka	0.8	1.6	1.8	2.2	1.4	0.7
Eastern Ontario Avg.	0.7	1.9	2.4	2.4	1.6	0.7
Quebec						
Maniwaki	0.6	2.1	1.7	1.6	1.3	0.5
Bagotville-Roberval	0.4	1.4	1.9	1.0	0.9	0.6
Val d'Or	0.3	1.7	1.9	1.4	0.8	0.3
Quebec Avg.	0.4	1.7	1.8	1.3	1.0	0.5
Atlantic Provinces						
Campbellton-Charlo	0.2	0.7	1.2	1.3	1.0	0.6
Gander	0.1	0.8	1.7	2.2	1.7	0.9
Goose Bay	0.1	0.6	1.6	1.8	1.2	0.8
Fredericton	0.6	1.8	2.6	2.5	2.2	1.2
Truro-Copperlake	0.3	0.8	1.0	1.2	1.4	0.9
Atlantic Provinces Avg.	0.3	0.9	1.6	1.8	1.5	0.9

APPENDIX H

Table H2. Mean monthly extreme DSR

	April	May	June	July	Aug.	Sept.
B.C.						
Victoria	1.7	4.7	6.4	9.7	12.2	6.7
Smithers	4.1	9.7	10.2	8.6	8.9	3.7
Fort Nelson	5.2	12.3	12.6	10.5	11.3	8.8
Kimberley-Cranbrook	5.4	18.4	20.7	31.0	34.4	25.6
Williams Lake	7.3	17.0	28.2	45.5	53.3	28.2
B.C. Avg.	4.7	12.4	15.6	21.1	24.0	14.6
Yukon-NWT						
Whitehorse	4.0	17.4	28.1	22.0	21.1	9.8
Fort Smith	4.1	14.6	21.0	20.0	14.0	6.5
Yellowknife	1.1	9.6	21.1	24.6	17.8	7.4
Fort Simpson	2.1	7.9	10.8	14.1	8.4	5.8
Dawson-Burwash	3.0	10.2	13.9	7.1	7.1	7.3
Yukon-NWT Avg.	2.9	11.9	19.0	17.6	13.7	7.4
Alberta						
Rocky Mountain House	5.0	14.0	10.9	6.5	6.4	6.0
Fort McMurray	6.0	19.5	15.1	10.7	7.1	5.7
Slave Lake-Wagner	4.6	15.1	8.2	7.4	5.5	6.6
Whitecourt	5.2	14.7	12.7	7.0	5.1	6.4
Alberta Avg.	5.2	15.8	11.7	7.9	6.0	6.2
Saskatchewan						
Cold Lake	8.6	35.4	28.4	17.8	12.7	17.0
N. Battleford	8.0	33.5	34.0	20.5	29.0	28.1
Prince Albert	7.3	31.6	29.7	20.9	22.6	23.1
Hudson Bay	5.2	19.3	17.9	12.2	11.4	14.8
Saskatchewan Avg.	7.3	30.0	27.5	17.9	18.9	20.8
Manitoba						
Winnipeg	16.3	34.3	30.6	21.3	22.8	30.5
Bisset-Gimli	8.6	23.7	19.9	17.6	15.9	15.0
The Pas	2.9	14.5	14.6	14.8	10.9	17.9
Dauphin	14.4	44.0	33.8	24.7	30.9	28.4
Thompson-Wabowden	3.3	8.9	12.5	11.7	7.3	4.4
Manitoba Avg.	9.1	25.1	22.3	18.0	17.6	19.2
Western Ontario						
Landsdowne House	1.1	5.4	9.0	6.6	6.9	4.4
Kenora	4.3	12.9	13.2	13.4	9.9	6.1
Sioux Lookout	3.0	12.9	10.6	9.9	7.7	3.7
Armstrong	1.6	7.5	11.7	8.3	5.8	3.6
Thunder Bay	5.2	17.1	11.4	13.5	10.4	6.6
Western Ontario Avg.	3.0	11.2	11.2	10.3	8.1	4.9

Table H2. (cont'd)

	April	May	June	July	Aug.	Sept.
Eastern Ontario						
Earlton	3.1	13.0	13.0	11.9	8.6	5.1
Kapuskasing	2.5	10.4	12.1	9.2	6.8	4.1
Timmins	3.6	11.0	15.5	11.5	7.9	4.0
Killaloe-Petawawa	4.5	13.6	12.5	14.0	11.6	6.8
Muskoka	3.6	8.3	7.8	8.1	6.2	3.4
Eastern Ontario Avg.	3.5	11.3	12.2	10.9	8.2	4.7
Quebec						
Maniwaki	3.3	10.7	9.3	6.9	5.6	3.1
Bagotville-Roberval	2.5	10.2	13.2	7.0	5.3	4.8
Val d'Or	1.7	10.2	10.3	7.0	4.7	2.4
Quebec Avg.	2.5	10.4	10.9	7.0	5.2	3.4
Atlantic Provinces	1.1	5.0	7.3	7.5	6.4	4.8
Gander	0.7	7.0	10.4	13.0	8.6	7.6
Goose Bay	1.1	5.2	11.5	13.0	9.1	5.9
Fredericton	3.5	10.6	14.9	11.9	9.3	6.0
Truro-Copperlake	1.4	4.8	6.1	6.2	7.6	5.1
Atlantic Provinces Avg.	1.6	6.5	10.0	10.3	8.2	5.9

APPENDIX I

Table II. Expected extreme values of DMC for a return period of 10 years

	April	May	June	July	Aug.	Sept.
Victoria	32	67	82	112	138	98
Smithers	44	96	122	102	111	67
Fort Nelson	50	93	88	84	75	54
Kimberley-Cranbrook	51	105	123	139	197	163
Williams Lake	49	100	109	150	206	182
Whitehorse	34	94	143	124	110	59
Fort Smith	39	84	116	128	88	57
Yellowknife	17	52	110	139	115	76
Fort Simpson	28	78	100	102	80	72
Dawson-Burwash	24	67	96	84	73	42
Rocky Mountain House	46	80	82	60	66	71
Fort McMurray	53	109	106	75	55	44
Slave Lake	38	71	72	57	53	39
Whitecourt	48	92	92	75	62	52
Cold Lake	48	106	109	89	58	60
N. Battleford	44	101	116	99	96	106
Prince Albert	46	108	118	115	91	93
Hudson Bay	43	92	89	69	78	84
Winnipeg	47	104	128	130	88	83
Bisset-Gimli	40	86	91	87	71	54
The Pas	30	75	73	62	66	59
Dauphin	52	104	116	112	92	91
Thompson-Wabowden	30	59	81	66	52	37
Landsdowne House	20	40	51	53	41	35
Kenora	37	76	74	73	62	44
Sioux Lookout	34	68	73	67	55	36
Armstrong	22	62	61	58	42	33
Thunder Bay	27	61	59	62	52	48
Earlton	23	62	66	65	53	38
Kapuskasing	22	56	63	54	46	32
Timmins	29	62	70	72	52	36
Killaloe-Petawawa	35	77	70	82	74	59
Muskoka	32	62	64	73	60	41
Maniwaki	30	73	67	68	57	40
Bagotville-Roberval	20	47	53	43	35	28
Val d'Or	21	64	62	56	42	32
Campbellton-Charlo	13	40	47	53	42	32
Gander	11	31	46	55	56	30
Goose Bay	11	26	50	49	37	27
Fredericton	22	52	64	69	59	43
Truro-Copperlake	16	36	45	53	50	48

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Table 12. Expected extreme values of DMC for a return period of 100 years

	April	May	June	July	Aug.	Sept.
Victoria	49	103	120	174	207	160
Smithers	63	148	196	159	181	115
Fort Nelson	78	140	128	131	113	85
Kimberley-Cranbrook	78	163	185	218	324	282
Williams Lake	74	152	163	219	314	314
Whitehorse	52	137	207	190	173	93
Fort Smith	69	128	174	199	132	95
Yellowknife	30	78	162	217	180	129
Fort Simpson	47	121	148	151	122	122
Dawson-Burwash	39	104	152	140	121	68
Rocky Mountain House	73	125	127	92	103	122
Fort McMurray	86	169	165	114	83	69
Slave Lake	62	111	116	91	86	62
Whitecourt	75	140	142	126	105	86
Cold Lake	77	167	168	148	90	99
N. Battleford	73	151	175	156	149	178
Prince Albert	76	167	186	198	146	158
Hudson Bay	75	144	135	104	123	149
Winnipeg	83	178	219	228	138	141
Bisset-Gimli	69	141	143	143	115	91
The Pas	53	120	107	93	101	100
Dauphin	92	173	186	187	144	156
Thompson-Wabowden	50	91	123	98	75	61
Landsdowne House	35	65	75	79	62	60
Kenora	63	124	117	114	96	74
Sioux Lookout	58	107	113	101	86	60
Armstrong	36	105	93	91	66	56
Thunder Bay	43	96	90	92	75	84
Earlton	37	97	102	96	83	58
Kapuskasing	35	90	96	81	73	57
Timmins	47	96	106	114	83	59
Killaloe-Petawawa	55	119	100	126	115	97
Muskoka	52	95	94	111	93	66
Maniwaki	46	115	99	106	87	63
Bagotville-Roberval	30	71	79	64	53	42
Val d'Or	33	105	95	83	66	54
Campbellton-Charlo	20	63	67	82	66	51
Gander	19	48	67	84	92	47
Goose Bay	18	38	77	76	56	43
Fredericton	33	79	93	104	91	65
Truro-Copperlake	24	55	66	84	78	80

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Table 13. Expected extreme values of the FWI for a return period of 10 years

	April	May	June	July	Aug.	Sept.
Victoria	17	26	31	41	45	36
Smithers	25	41	44	40	42	27
Fort Nelson	31	46	45	44	46	46
Kimberley-Cranbrook	29	60	65	88	98	85
Williams Lake	36	54	78	94	110	81
Whitehorse	25	55	74	68	66	44
Fort Smith	32	49	61	61	48	38
Yellowknife	14	43	59	65	55	39
Fort Simpson	21	36	40	48	40	35
Dawson-Burwash	25	44	53	35	40	45
Rocky Mountain House	31	55	46	31	34	33
Fort McMurray	35	62	52	43	35	33
Slave Lake	31	58	39	37	33	35
Whitecourt	31	52	47	36	33	36
Cold Lake	43	91	76	63	51	65
N. Battleford	42	82	83	65	82	87
Prince Albert	39	78	76	64	69	79
Hudson Bay	35	60	64	48	46	64
Winnipeg	72	89	85	69	68	94
Bisset-Gimli	49	77	65	63	64	63
The Pas	25	54	53	52	43	75
Dauphin	67	106	83	74	90	82
Thompson-Wabowden	27	41	46	43	34	30
Landsdowne House	14	33	42	34	37	33
Kenora	29	51	49	54	44	35
Sioux Lookout	25	50	43	42	39	27
Armstrong	17	37	50	38	34	28
Thunder Bay	34	63	50	51	45	40
Earlton	25	46	50	46	41	29
Kapuskasing	22	44	45	42	35	28
Timmins	29	43	52	47	38	26
Killaloe-Petawawa	29	52	48	55	49	39
Muskoka	25	37	35	37	31	24
Maniwaki	24	45	41	34	32	21
Bagotville-Roberval	22	45	48	35	31	30
Val d'Or	18	47	42	33	28	19
Campbellton-Charlo	13	28	36	36	36	32
Gander	11	38	43	47	41	39
Goose Bay	15	30	48	50	42	33
Fredericton	25	43	50	44	42	31
Truro-Copperlake	15	29	30	33	40	32

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Table I4. Expected extreme values of FWI for a return period of 100 years

	April	May	June	July	Aug.	Sept.
Victoria	26	37	46	61	64	56
Smithers	36	61	66	60	67	43
Fort Nelson	49	66	65	66	70	78
Kimberley-Cranbrook	44	90	99	143	163	145
Williams Lake	55	79	120	134	167	127
Whitehorse	36	80	108	106	100	70
Fort Smith	56	69	88	90	69	62
Yellowknife	22	67	83	91	79	62
Fort Simpson	36	53	56	69	62	59
Dawson-Burwash	43	69	81	53	67	80
Rocky Mountain House	49	88	72	43	54	51
Fort McMurray	57	95	77	64	53	52
Slave Lake	51	92	54	58	52	55
Whitecourt	50	78	68	56	54	58
Cold Lake	71	142	115	99	80	107
N. Battleford	69	120	122	101	128	145
Prince Albert	64	115	111	96	106	134
Hudson Bay	59	89	102	73	71	112
Winnipeg	131	139	133	109	103	160
Bisset-Gimli	88	125	101	101	108	109
The Pas	43	84	81	78	64	135
Dauphin	122	168	124	115	147	130
Thompson-Wabowden	47	63	66	61	49	50
Landsdowne House	23	52	66	51	58	57
Kenora	48	79	74	86	69	57
Sioux Lookout	43	77	65	63	61	44
Armstrong	28	56	79	58	54	48
Thunder Bay	58	102	70	79	70	70
Earlton	43	66	77	69	63	44
Kapuskasing	37	68	66	64	53	44
Timmins	51	64	75	72	58	39
Killaloe-Petawawa	47	80	72	86	79	64
Muskoka	40	54	51	56	44	37
Maniwaki	37	70	60	50	49	31
Bagotville-Roberval	37	71	71	54	48	49
Val d'Or	29	75	52	47	44	29
Campbellton-Charlo	21	42	53	55	57	52
Gander	20	62	65	69	65	63
Goose Bay	28	46	75	77	64	52
Fredericton	39	65	71	63	65	45
Truro-Copperlake	24	45	42	49	65	52