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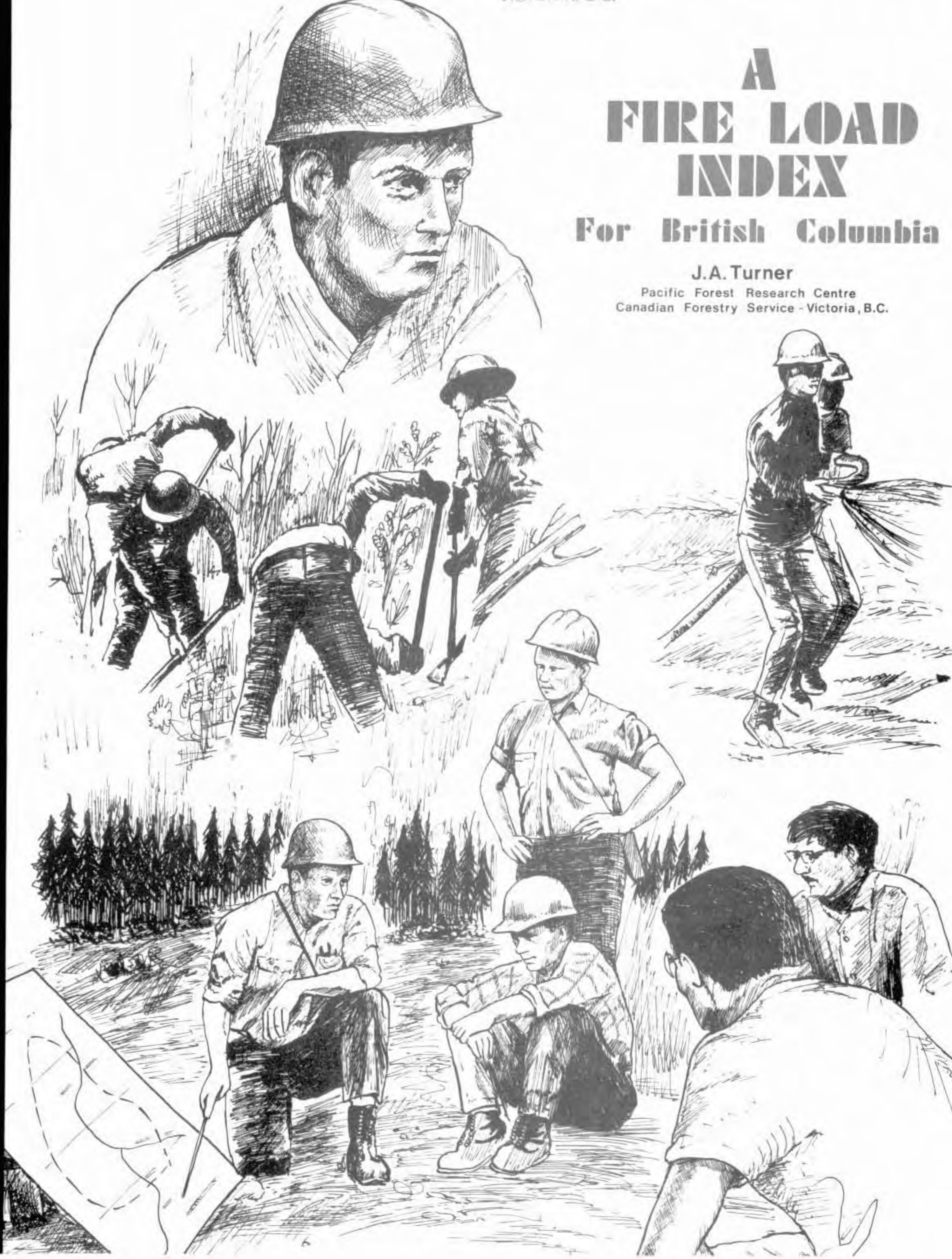

A FIRE LOAD INDEX FOR BRITISH COLUMBIA

(A provisional report on the calibration of the Fire Weather Index for B.C.)

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ABSTRACT

An index of potential fire load, defined as the product of fire occurrence density and the square root of the average fire size, is developed as a function of Fire Weather Index and Adjusted Duff Moisture Code for two distinct regions of British Columbia, using records of occurrence and final size of 6500 lightning-caused and 8700 man-caused fires over central and Southern B.C. during 1957-1966.

The resulting classes of Fire Load Index provide the forest manager with a useful guide for a wide range of operational decisions.

INTRODUCTION

The Fire Weather Index phase of the Canadian Forest Fire Behavior System (Anon., 1970) is being formally introduced by the British Columbia Forest Service this year as an operational system of fire danger rating. In order that the system may become an effective management guide, it is essential that the user be provided with clear indications of what the numbers mean in terms of fire control difficulty.

It is unrealistic to expect a single danger index to meet all needs of a forest manager. However, one that provides a reasonable estimate of the magnitude of the fire control job probably comes closest to this ideal.

This report presents such a Fire Load Index, based on records of fire occurrence and final size and their relationship to values of the Fire Weather Index and its components. These relationships have been determined as part of a general calibration program for the Fire Weather Index in British Columbia, for which a more comprehensive publication is planned in the near future.

ANALYSIS

Treatment of the data

Climatological data on magnetic tape, purchased by the British Columbia Forest Service from the Atmospheric Environment Service, was made available for this study, together with individual fire records from the Forest Service magnetic tape archives. Daily values of the Fire Weather Index (FWI) and its components were calculated for 20 first-order stations, using a modification of the computer program developed by Simard[1]. In general, the period May 1 to September 30 was used for the years 1957-1966 inclusive, although there were periods for which no data were available from three of the stations. Twenty areas (Fig. 1) were defined subjectively as being best represented by corresponding weather stations. Some areas were excluded from this study because they were not considered to be adequately represented by one of the available stations.

Fires occurring within each area were stratified according to classes of FWI and its components at the appropriate weather station for the date of origin. Some of the interim results from this study have been presented by Lawson (1972).

1/ Simard, A.J. 1970. "Computer Programs to calculate the Canadian Forest Fire Weather Index. Internal Report FF12 Canadian Forestry Service, Dept. Fish & Forest., Ottawa.

During the course of the study, the separation of the province into two recognized major climatic regions was verified on the basis of frequency of large values of FWI and of distinct differences in calibration of the index components.

Location of the boundaries between the two zones (Fig. 2) was made somewhat more precise by a study of the records for 1970-71 from the more extensive operational network of Forest Service fire weather stations.

Five descriptive classes were defined separately for FWI and ADMC values in each region (Table I).

TABLE I

Definition of FWI & ADMC Classes

	Region I		Region II	
Class	FWI	ADMC	FWI	ADMC
Very Low	0	0-20	0-4	0-50
Low	1-5	21-40	5-16	51-90
Moderate	6-12	41-65	17-27	91-140
High	13-25	66-110	28-46	141-200
Extreme	26+	110+	47+	201+

The frequency of occurrence of any given class will vary from place to place and from season to season, but the limits were chosen to give essentially the same proportion of days for that class in both major regions for each index component. Thus, Very Low will occur, on the average, about 25% of the time, while Extreme will be reported about 5% of the time between May 1 and September 30.

For purposes of this part of the study, areas 1, 3, 11, 12, 15, 16, 17, 18, 19 and 20 (Fig. 1) were assigned to Region I, and areas 2, 7, 8, 9, 10 and 13 were considered to be in Region II. Areas 4, 5, 6 and 14 were not included in this analysis because the low level of risk and the failure to detect small fires, produced statistics too biased to be of any value.

A selection of the available fire statistics was compiled separately for each major region for all available combinations of the ADMC and FWI classes (Table I).

Man-caused fire occurrence

The probability density (fires per hundred days per million acres) of man-caused[2] fires was determined for each combination of ADMC/FWI classes separately for each of the two regions. When these values were plotted against the corresponding mid-point values of ADMC and FWI, no significant difference was found between the relationships for the two regions. The resulting smoothed curves for both regions are shown in Fig. 3, and indicate the increased effect of FWI on fire occurrence at high values of ADMC. It arises mainly from the fact that the ADMC has already contributed to the FWI. Nevertheless, this interrelationship is a real one when these two indices are considered together.

Average fire size

As was done for fire occurrence, the average final fire size[3] was calculated by region for all combinations of ADMC and FWI classes. By contrast, the relationships between fire size and values of ADMC and FWI were distinctly different for the two regions (Figs. 4 and 5). For example, the average fire size for an ADMC of 100, FWI of 20 in Region I is about 130

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2 Lightning fire occurrence was not used in the determination of fire probability. Although ease of ignition is related to levels of ADMC and FWI, this relationship tends to be masked by the larger variations in lightning risk which do not follow the same pattern.

3 Average fire size was calculated, using both man- and lightning-caused fires. This could introduce a bias in the Very Low classes of ADMC and FWI where lightning fires tend to be smaller than man-caused fires (Table 3 and 4).

acres, whereas the corresponding size in Region II is somewhat less than 10 acres.

These differences can perhaps be explained by the fact that in Region I, which includes all of the coast and the north-central part of the province, there is generally no scarcity of continuous fuel at elevations represented by the available weather stations.

In Region II by contrast, the lighter more discontinuous fuel types at lower elevations almost preclude large fires without burning into higher elevations. In this region, the topographic contrasts are generally greater than they are over much of the rest of the province so that the effective value of the ADMC at these higher elevations will generally be much less than indicated by the low-level climatic station. This latter effect operates primarily through the Drought Code (Turner, 1972).

Estimating the fire load

The FIRE LOAD INDEX is defined here as the product of the fire probability density (fires/hundred days/million acres) times the square root of the average fire size (in $\sqrt{\text{acres}}$). Since the second factor is proportional to the average length of perimeter per fire, the product is proportional to the expected total length of fire line.

Index values obtained in this way were calculated for each combination of ADMC and FWI classes (Fig. 6).

Proposed fire-load classes

The heavy lines in Fig. 6 indicate the suggested limits for five levels of fire load, shown here by Roman numerals I to V in order of increasing load.

These limits were determined by plotting the logarithm of the index value against the appropriate value of ADMC and FWI, drawing smoothed contours through the points and choosing the available class boundaries conforming most closely to the contour values shown below.

TABLE II

Load Index Class Limits

Class Boundary	I-II	II-III	III-IV	IV-V
Logarithm of Load Index	0.5	1	1.5	2
Corresponding Index	3	10	32	100

It follows that each load index class spans approximately a three-fold increase in fire load.

Selected fire statistics by fire load classes

Tables 3(a) and 3(b) present a selection of useful fire statistics by fire load classes for the two principal regions based on the 1957-66 period.

A few selected examples of possible applications will serve to illustrate their use, allowing for the fact that any statistics such as these must reflect the average level of suppression activity for that period, and that changing techniques will be expected to modify these first estimates.

TABLE III

Regional Fire Statistics by Fire Load Classes

(a)
Region I

Fire Load Class Level	:	I	II	III	IV	V
% of total days in class	:	23	32	25	15	5
% of total burned area	:	0	2	9	40	49
% of MC fires in class	:	5	22	31	28	14
Avg MC fire size (FBP)	:	2	2	5	7	12
Avg MC fire size (Final)	:	3	7	16	32	147
% of MC fires reaching ¼ Ac.	:	26	34	38	41	40
MC fires/100 days/million Ac.	:	0.73	1.86	4.86	5.48	8.56
Avg LC fire size (FBP)	:	0.4	1	6	18	46
Avg LC fire size (Final)	:	0.5	6	43	190	357
% LC fires reaches ¼ A	:	10	13	23	36	47
Avg fire size (LC + MC)	:	1.3	6.6	26.1	107.1	245.5

Note: MC - Man-caused
LC - Lightning-caused
FBP - Value at end of first burning period.
(All fire sizes in Acres)

TABLE III

Regional Fire Statistics by Fire Load Classes

(b)
Region II

Fire Load Class Level	:	I	II	III	IV	V
% of total days in class	:	14	31	29	22	4
% of total burned area	:	0	6	7	48	39
% of MC fires in class	:	2	17	29	39	13
Avg MC fire size (FPB)	:	.5	3	2	8	19
Avg MC fire size (final)	:	1	4	5	29	105
% of MC fires reaching ¼ Ac.	:	32	41	44	44	49
MC fires/100 days/million Ac.	:	0.89	3.09	5.39	10.04	16.27
Avg LC fire size (FBP)	:	.2	.5	1	5	21
Avg LC fire size (Final)	:	.3	10	12	62	96
% LC fires reaching ¼ A	:	12	20	27	34	44
Avg fire size (LC + MC)	:	0.4	7.7	7.7	40.9	101.8

1. A manager in the Vancouver Forest District (Region I) would like to know the probable implications of a strict closure when Fire Load class V is reached. Without additional specific information for his own management area he could estimate that 5% of the days would fall in this class, so he could expect about 1 week's closure in a 5-month fire season. By doing so, he might eliminate 14% of his total man-caused fires - but these would be by far the largest ones, averaging 147 acres per fire. In fact, 49% of the total area burned is from fires starting on class V days.

2. A manager might wish to estimate the risks he would be taking by relaxing certain precautions whenever a Fire Load Index of class I was indicated. In Region I, this would mean about 23% of the days would be exempt. Five per cent of the total number of fires start on these days and only about one-quarter of those go beyond spot size, with negligible total acreage involved.

3. A lightning storm has been reported in Region II, with six known fires started. With the Fire Load Index at class IV, the manager knows that he can expect about 34% (two) of these to go beyond spot size. The average size (of the six fires) would be expected to reach 5 acres at the end of the first burning period, with a final size of 62 acres.

These examples illustrate a few of the applications that are possible. It should be pointed out, however, that these values, while they are quite specific, are averages over a large region and a specific 10-year period, and the absolute values should be considered as order of magnitude estimates.

SUMMARY

A FIRE LOAD INDEX has been developed in terms of ADMC and FWI classes. Five class levels are suggested for this index, and a selection of fire occurrence and fire-size statistics, based on a specific 10-year record, are presented for each of the major regions.

By choosing the appropriate values from Table 3 corresponding to the prevailing Fire Load class, the fire control officer is in a position to assign specific numbers to the consequences of some of his decisions.

ACKNOWLEDGMENTS

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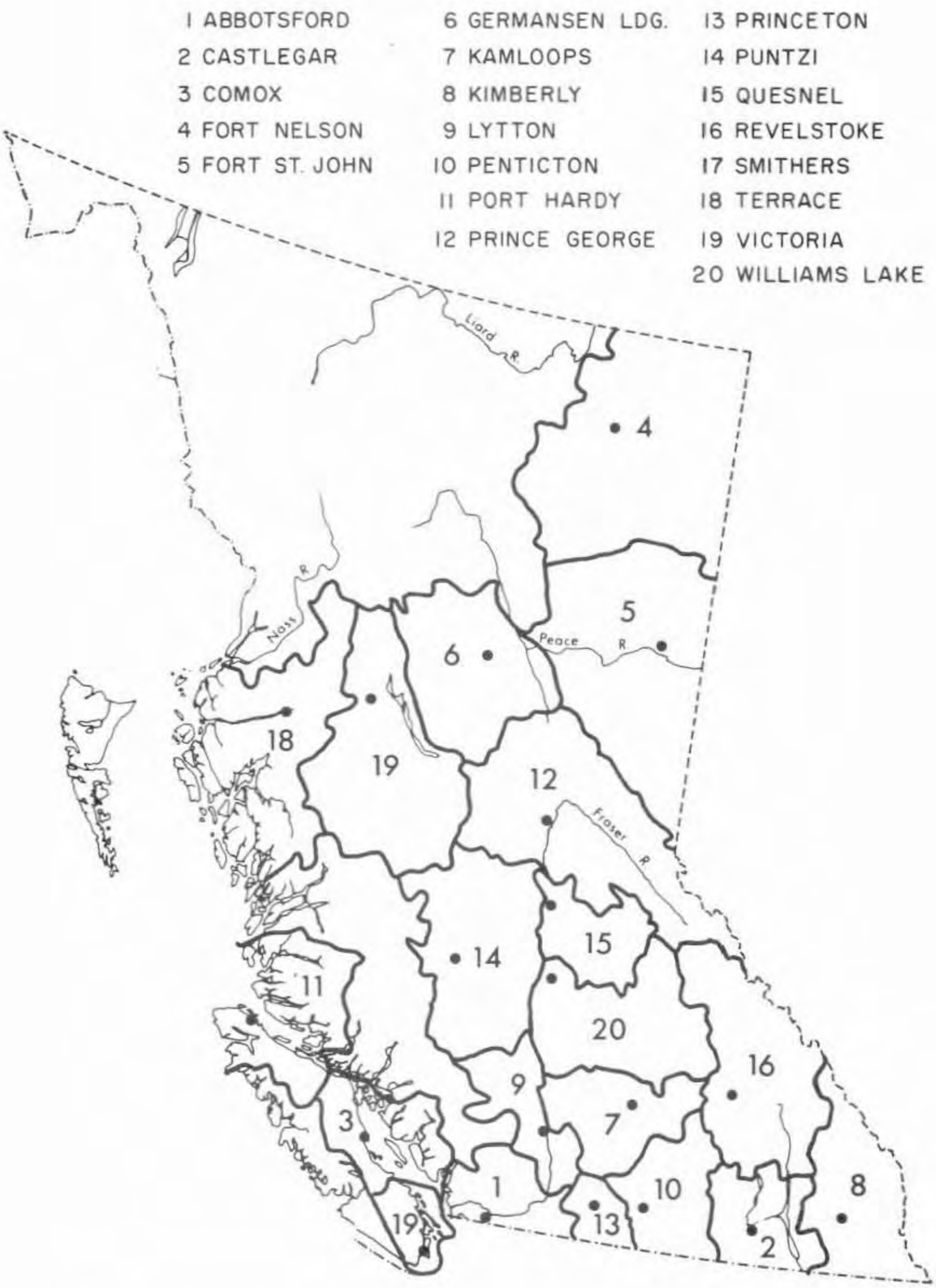
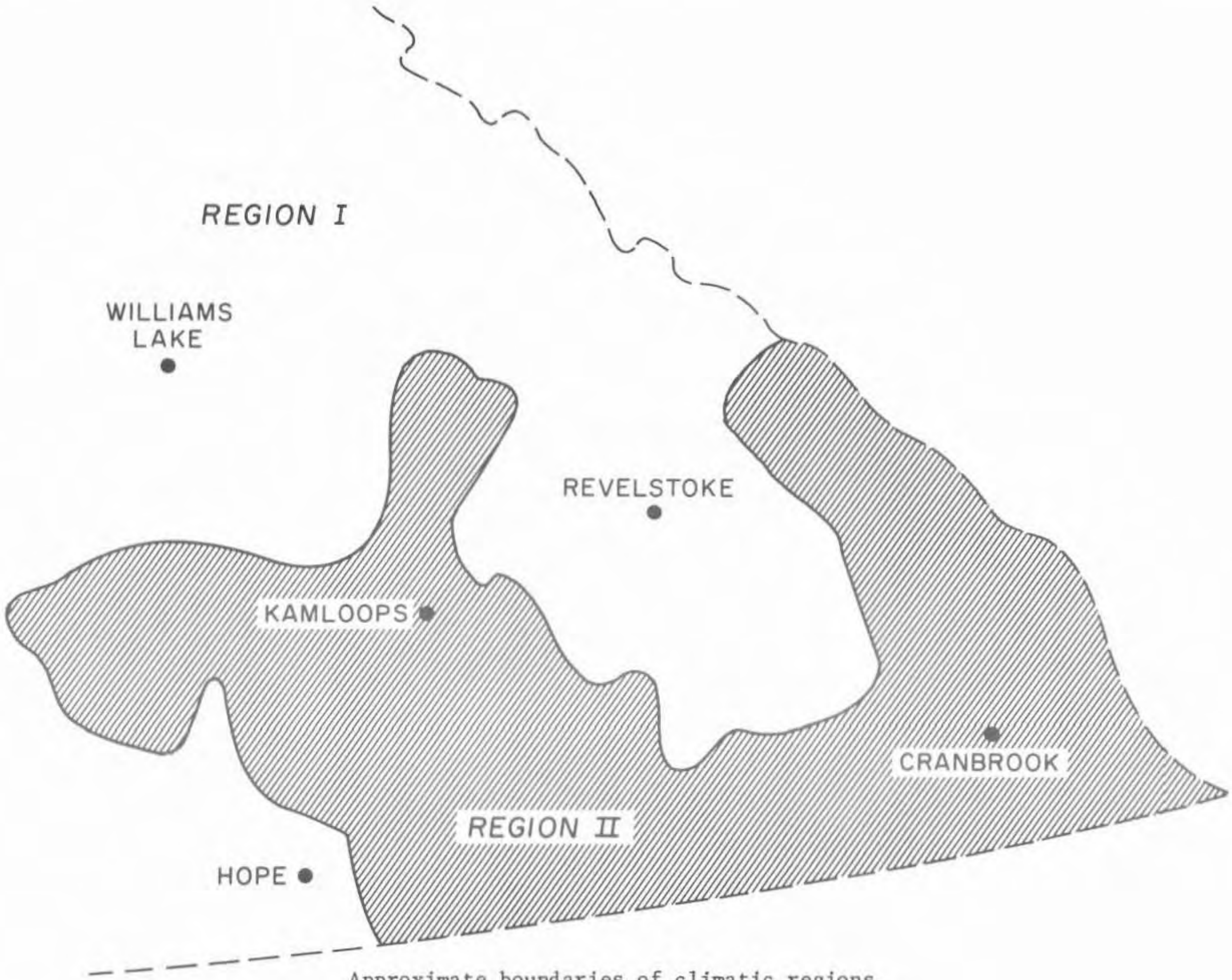
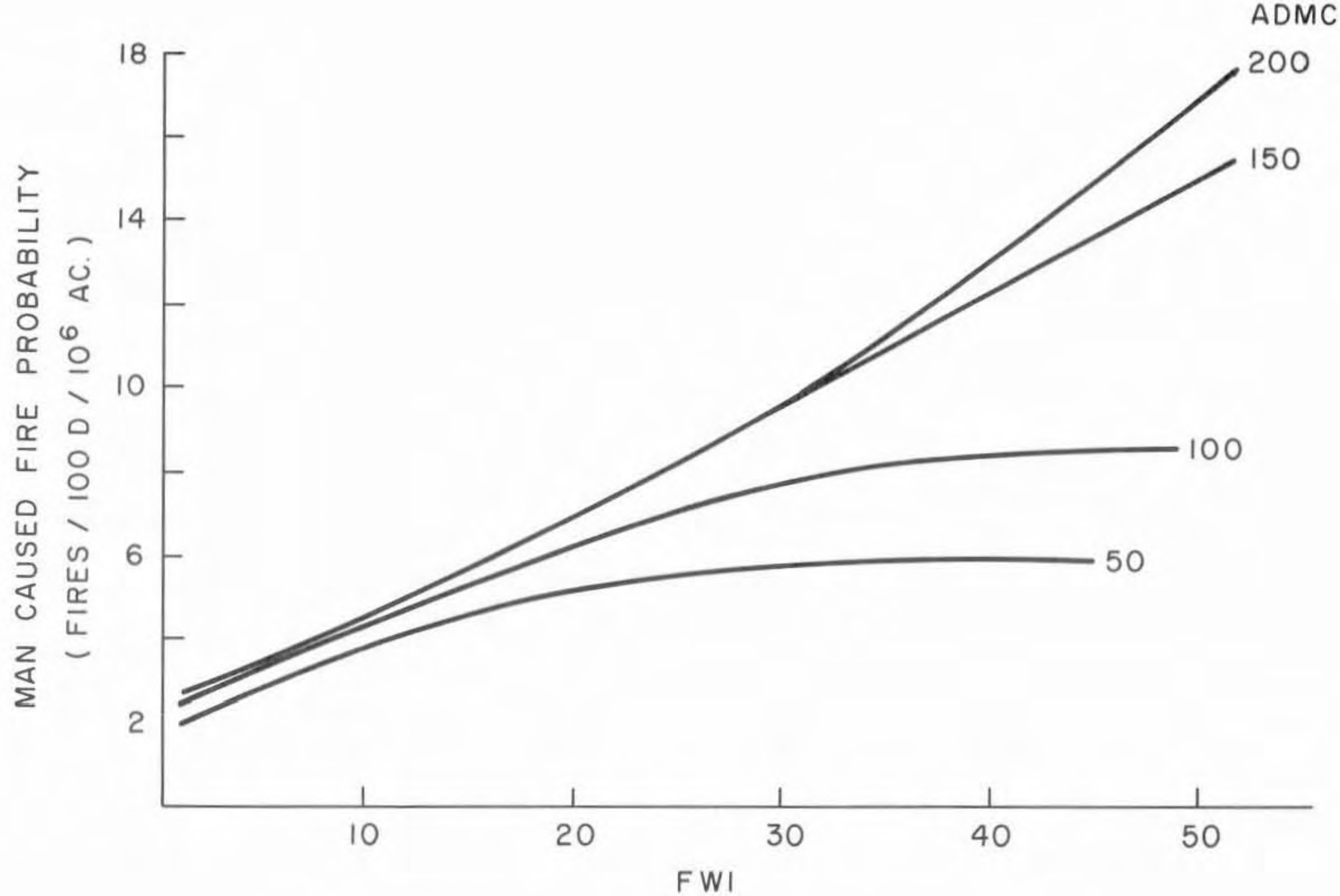


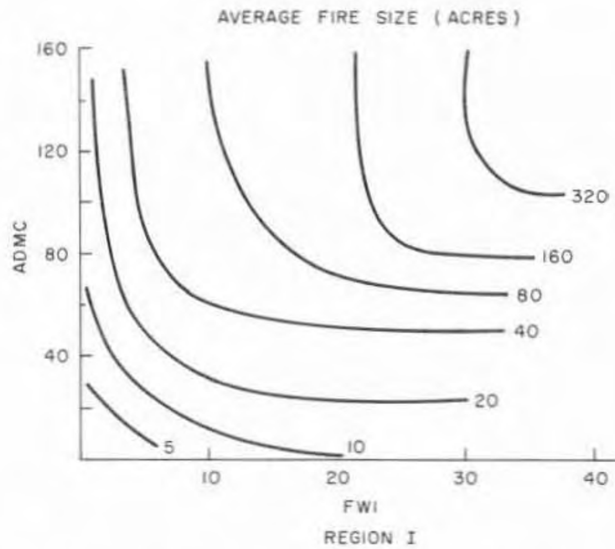
Area map showing climatic stations and areas used in calibration.



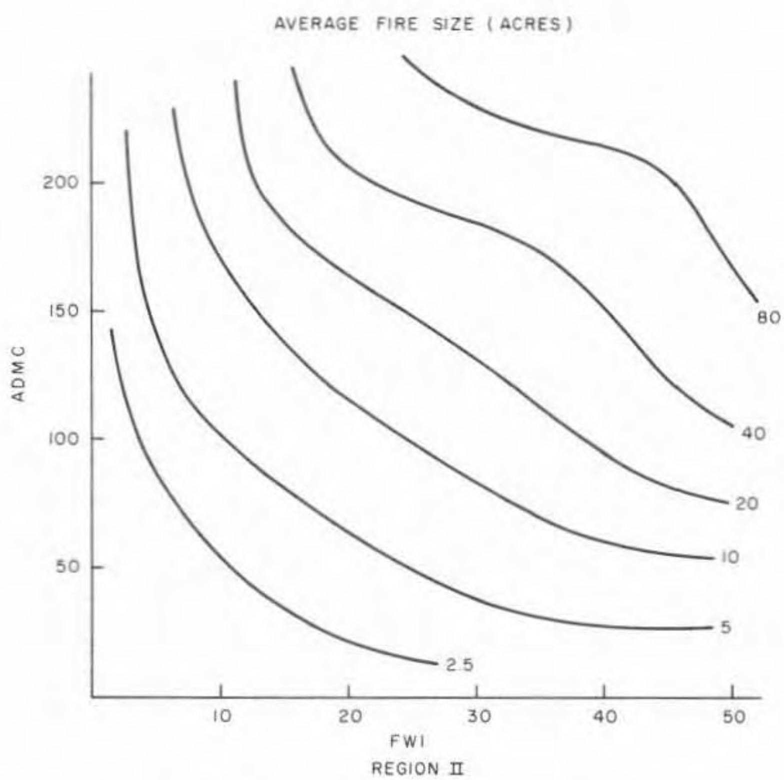
Approximate boundaries of climatic regions.



Man-caused fire occurrence by ADMC and FWI.



Average final fire sizes. Region I.



Average final fire sizes. Region II.

FWI

ADMC	0	1-5	6-12	13-25	26+
0-20	I 1	3	9	•	•
21-40	II 3	6	13	29	•
41-65	6	13	25	31	•
65-110	9	•	61	66	112
111+	III •	•	IV 49	V 105	160

REGION I

FWI

ADMC	0-4	5-16	17-27	28-46	47+
0-50	I .2	5	8	•	•
51-90	II 5	12	11	23	•
91-140	•	10	19	46	107
141-200	•	16	33	88	163
201+	III •	•	IV 35	76	V 175

REGION II

• INSUFFICIENT DATA

Fire Load Index by classes by ADMC and FWI.