

THE 1980 FOREST FIRE SEASON IN WEST-CENTRAL CANADA
- SOCIAL, ECONOMIC, AND ENVIRONMENTAL IMPACTS

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MARCH 1981

ACKNOWLEDGEMENTS

The cooperation and assistance of the following agencies and individuals in data acquisition, interpretation, and analysis is gratefully recognized:

Alberta Forest Service	- W.R. Dempster
Manitoba Department of Natural Resources	- C.A. Jeffrey
Northwest Territories Lands and Forests Service	- R.P. Checkley
Ontario Ministry of Natural Resources	- R.J. Drysdale, R.M. Monzon
Department of Northern Saskatchewan	- D.M. Taylor, K.E. Gorham, R. Thompson
Great Lakes Forest Research Centre (CFS)	- D.E. Ketcheson
Canadian Forestry Service Headquarters	- J. Ottens

PREFACE

During the spring of 1980 it became apparent that a large region of western and central Canada was experiencing one of the worst forest fire seasons in recent memory. Millions of hectares of productive forest land had been burned over, provincial fire management budgets were being over-expended, and a tremendous drain on fire suppression resources was being experienced across the country. At this time several provinces, through the Canadian Committee on Forest Fire Control, expressed interest in increased Federal Government involvement in future forest fire management, through an increased fire research capability and/or direct operational involvement in the form of financial assistance, a forest protection assistance program, or the development of a national forest fire coordination and management centre.

As a basis for determining future action by the Federal Government the Minister of the Environment requested an assessment of the economic, social, and environmental consequences of the 1980 fire season. Terms of reference were prepared for a proposed study initially intended to be carried out under contract. It was later determined that this assessment should be undertaken by a Task Force consisting of four Canadian Forestry Service (CFS) fire researchers and representatives from each of those provinces and territories most seriously affected in 1980. Representatives from Ontario, Manitoba, Alberta, Saskatchewan, and the Northwest Territories acted as contacts and coordinated the gathering of pertinent information within their respective regions. CFS representatives consolidated and analyzed these data and combined to write this report.

The collection of the baseline data required for this report proved to be very time-consuming and, as a result, slowed analysis considerably. In some cases information is incomplete due to lost or misplaced provincial records. Despite these problems, an attempt has been made to develop a report that is concise and yet deals with the 1980 forest fire season in perspective, through comparison with historical and recent fire and fire weather statistics. No attempt has been made to document fire control activities during 1980 as this information could not be provided upon request.

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INTRODUCTION

The 1980 forest fire season across Canada was the worst on record in terms of fire starts, area burned, and suppression expenditures. Several provinces in central and mid-western Canada experienced heavy fire loads concurrently, resulting in a shortage of aircraft, helicopters, and other suppression resources. More than 9000 fires burned over in excess of 4.84 million hectares and total fire management expenditures, for the country as a whole, exceeded \$190 million, in comparison to an annual average of \$116 million (expressed in 1980 \$) during the 1977-1979 period.

Table 1 presents 1980 fire statistics by individual provinces and agencies. From this table it is readily apparent that Quebec and the Maritimes experienced a very light forest fire year, while British Columbia and the Yukon Territory had relatively moderate fire seasons. Conversely, Alberta, Saskatchewan, Manitoba, Ontario and the Northwest Territories experienced severe fire problems during 1980, accounting for 90% of the national area burned and 72% of the fire management costs (fixed and variable) incurred throughout the country. Of the \$139 million expended in this central part of Canada in 1980, \$106 million was in the form of variable costs - those costs charged to direct suppression (overtime, food and shelter, short-term fixed wing and helicopter rental). Fixed costs are budgeted in advance and include permanent fire staff salaries and general operating costs - money that is expended regardless of the amount of fire activity in any given year.

The location of all 1980 fires in west-central Canada larger than 200 hectares in size (commonly referred to as Class E fires), a total of 346 fires (244 lightning and 102 man-caused), is shown in Figure 1. From this map it is evident that problem fires generally occurred in a broad band of boreal forest from the western Northwest Territories and northern Alberta and Saskatchewan through central Manitoba and northwestern Ontario, bounded generally on the north by sparsely treed tundra and to the south by grassland. Although the percentage of fires reaching 200 ha in size is relatively low (7.5% in this region in 1980), these fires generally account for an overwhelmingly large proportion of the total annual area burned (90% in 1980). It is obvious from Figure 1 that the large majority of fires reaching this

size are lightning-caused (71% in 1980) and occur in areas of limited protection. It should also be noted that large fires from Wood Buffalo National Park (Alberta) and one large fire from Riding Mountain National Park (Manitoba) are included in this map but not in further analysis. These were the only significant fires occurring on Parks Canada land in 1980.

Table 1. National Forest Fire Losses and Expenditures - 1980.

	<u># of Fires</u>	<u>Area Burned (ha)</u>	<u>Total Fire Management Cost* (millions of \$)</u>
British Columbia	1734	55,559	18.00
Yukon Territory	150	130,781	4.5 (2.00)
N.W.T.	345	1,214,396	15.22 (11.50)
Alberta	1353	639,737	44.75 (36.05)
Saskatchewan	742	1,340,738	13.68 (13.00)
Manitoba	1076	503,706	12.73 (10.31)
Ontario	1779	560,306	52.70 (35.00)
Quebec	861	13,176	21.87 (1.87)
New Brunswick	389	2,015	0.77 (0.53)
P.E.I.	1	65	0.04
Nova Scotia	439	979	2.13 (0.20)
Newfoundland	50	954	3.00
Parks Canada	103	275,000	3.20
TOTAL**	9032	4,348,212	192.54

*Includes fixed and variable costs (where available, variable costs are shown in brackets).

**Totals may be only a close approximation due to a few outstanding statistics.

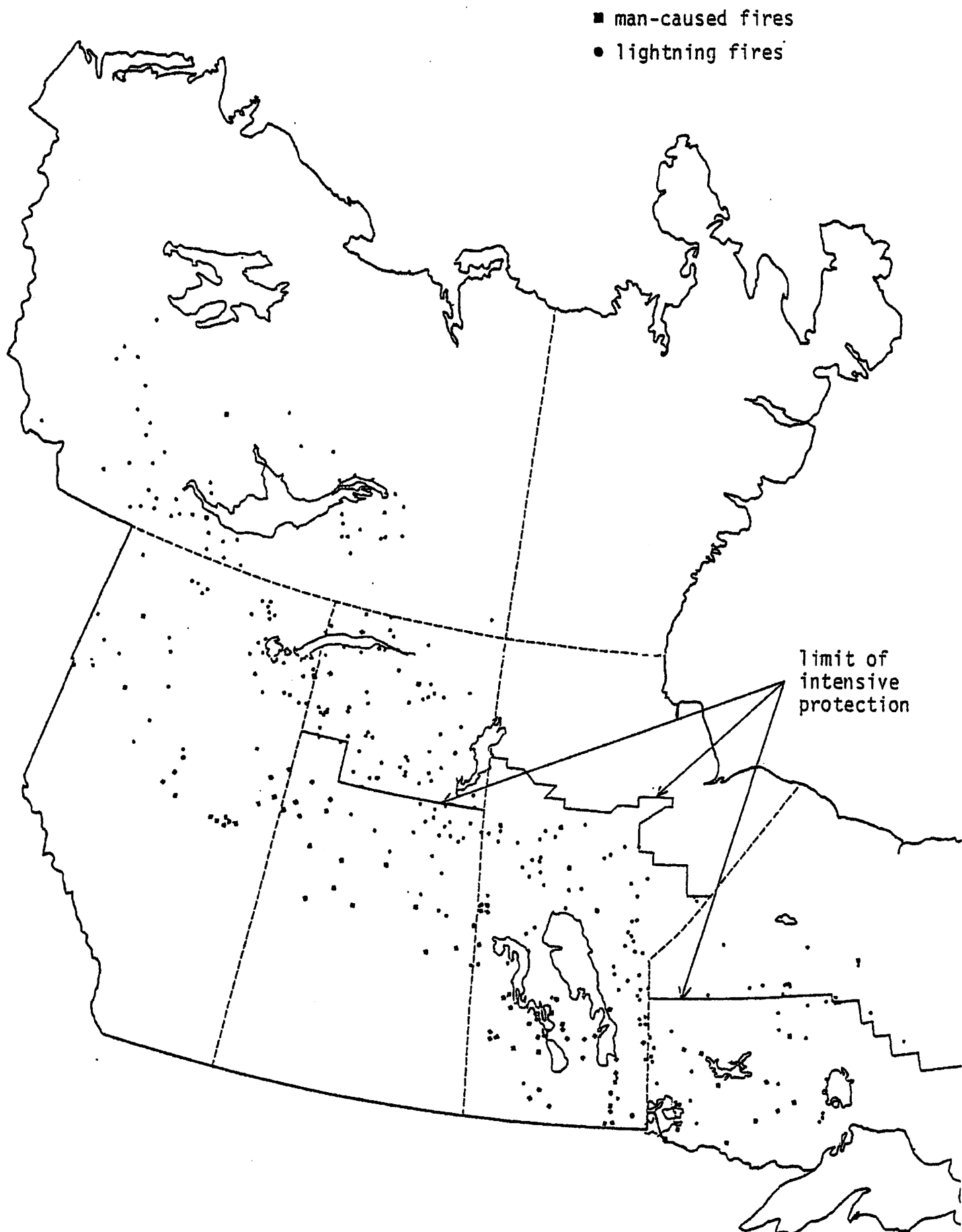


Figure 1: Location of 1980 fires > 200 ha. in west-central Canada

LONG-TERM TRENDS OF FOREST FIRE IN CANADA

The Canadian Forestry Service and its predecessors have been collecting national forest fire data since 1918, a total of 63 years including 1980. It is worthwhile to examine this historical record as a background for special consideration of 1980. The features that will be treated here are:

- (i) annual number of fires
- (ii) annual burned area
- (iii) the relations between lightning and man-caused fires.

We cannot be sure that these data are perfectly homogeneous. Trends in the efficiency of fire detection and cause determination, as well as in the overall area reported-on could affect the validity of comparison throughout the whole period. Nevertheless, we believe that within reason the data are worth analyzing, and that certain valid trends can be distinguished.

The Territories first provided fire data in 1946. The Prince Edward Island and Newfoundland records also began late. We have therefore adjusted the early years' data upwards to account for these missing pieces. The entire national record has therefore presumably been placed on the same total base, comprising all provinces and territories.

Figure 2 shows the adjusted average annual number of fires (NF) by 5-year periods from 1918 to 1980. After a relatively constant level throughout the first four decades, 6000 per year, the trend during the 1960's and 1970's has been steadily upward to about 9000, 1 1/2 times the original level. Possible reasons for this are (a) larger population, (b) more efficient fire detection, and (c) a gradual change in climate. Some additional data are:

Long-term average NF	- 6,762 fires
Highest annual NF	- 11,049 fires in 1976
Lowest annual NF	- 3,163 fires in 1954
Ratio of highest to lowest	- 3.5:1

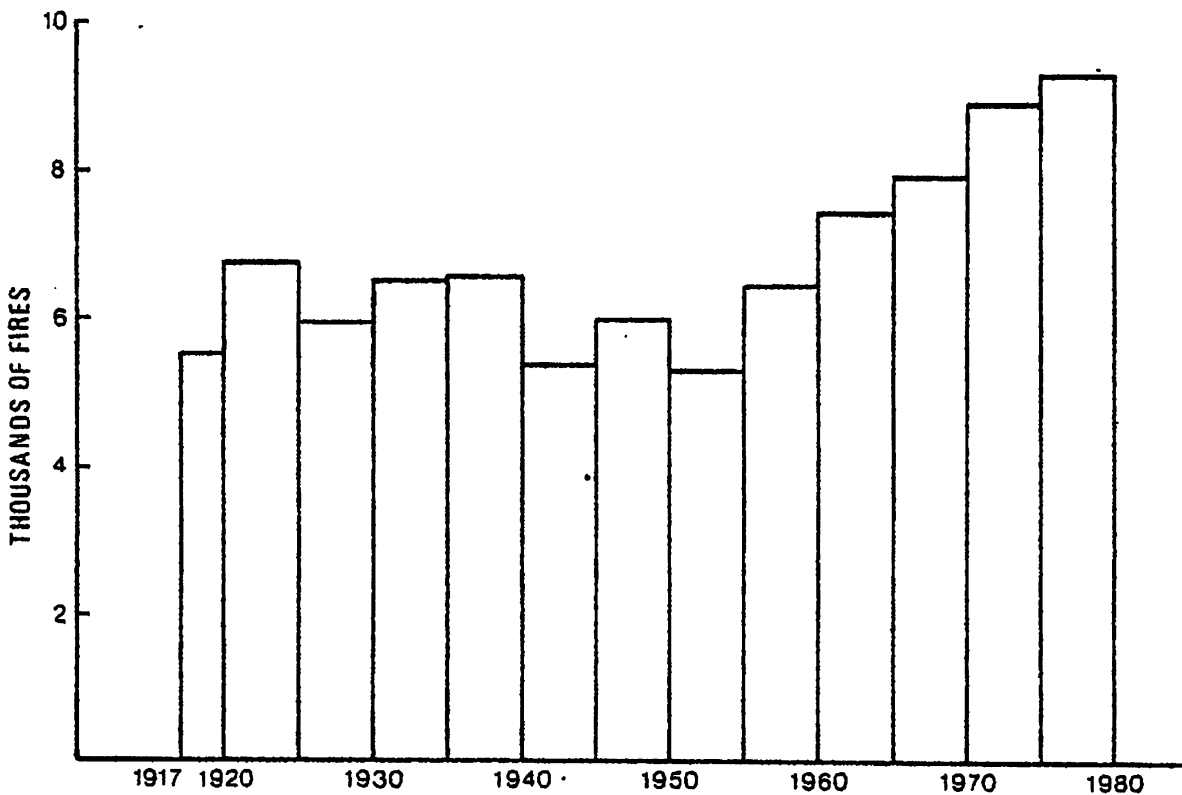


Figure 2: Adjusted average annual number of fires in Canada, graphed as 5-year averages.

Figure 3 shows the average annual burned area (BA) by 5-year periods from 1918 to 1980. The BA trend was generally downward during the first four decades, reaching its lowest level, about 800 000 ha, during the 1950's. The 1960's were marked by great variation from year to year, while the 1970's have seen a steadily rising trend, culminating in the highest 5-year average of the entire record, nearly 2 1/2 million ha, during 1976-1980. Although 1980's value has naturally affected this last average strongly, BA's in three of the other four recent years were also well above average. Some additional data are:

Long-term average BA	- 1 267 100 ha
Highest annual BA	- 4 832 000 ha in 1980
Lowest annual BA	- 190 400 ha in 1963
Ratio of highest to lowest	- 25:1

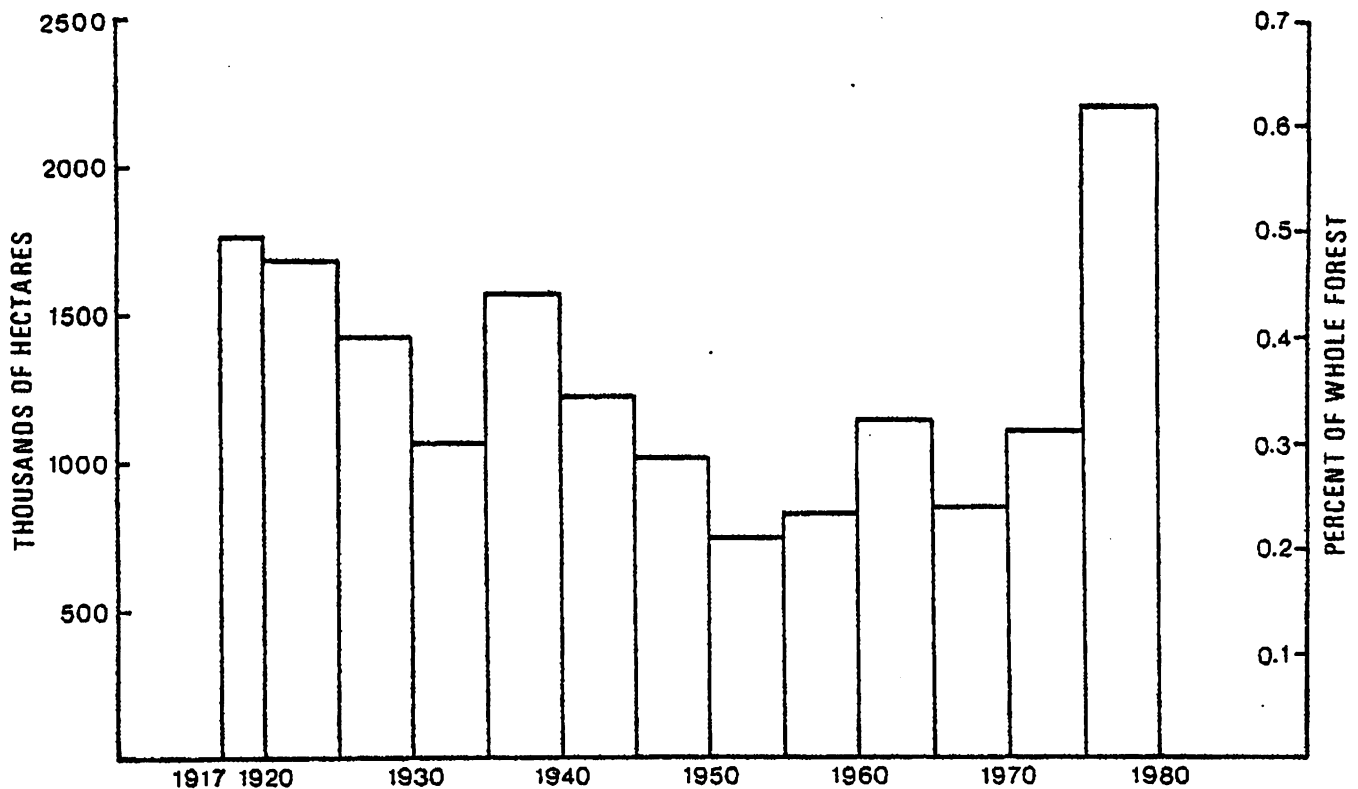


Figure 3: Adjusted annual area burned in Canada, graphed as 5-year averages.

Burned area, by comparison with number of fires, varies greatly from year to year in a manner that is somewhat obscured by a graph of 5-year averages, making the identification of real trends difficult. Nevertheless, the values of BA during the past five years suggest that the easier decades of the 1940's and 1950's were fundamentally different in some way from the 1970's. The most obvious possible factor is some trend in climate. The particular aspects of weather that result in large burned areas are (a) periods of several weeks with little or no rain, and (b) occasional days with very high wind and low humidity. A careful analysis of Canada's climate during the past 60 years, with special reference to fire weather, would be required to provide an answer to this question.

Further evidence of this large annual variation is in Table 2, which shows the five highest and five lowest annual BA's with the years of their occurrence.

Table 2. Extreme annual burned areas in Canada.

<u>Category</u>		<u>Burned Area</u> <u>ha</u>	<u>Year</u>
Five largest	1	4 832 000	1980
	2	3 769 300	1961
	3	3 498 500	1919
	4	2 934 900	1923
	5	2 866 900	1929
Five smallest	1	190 400	1963
	2	211 100	1965
	3	279 800	1959
	4	289 400	1978
	5	317 700	1947

To provide a complete impression of the impact of forest fire in Canada, burned area should also be expressed as percent of a whole. Figure 3 contains a scale of "percent of whole" as well as a scale of actual area. Annual burned areas for three time periods are listed below. Percentages are based on a national total of 3 564 000 km² of forested or protected area.

Long-term average BA, 1918-1980 - 1 267 100 ha (0.36%)

Ten-year average BA, 1970-1979 - 1 288 600 ha (0.36%)

1980 BA - 4 832 000 ha (1.36%)

The data record for lightning fires as a component of total forest fires is unfortunately not stable enough to justify an analysis of the whole 63-year record. In general, about 1/4 to 1/3 of all fires in Canada have been lightning-caused, and these have always accounted for the major proportion of burned area. The average picture during 1970 to 1979 was as follows:

Lightning fires - 32% of NF, 86% of BA

Man-caused fires - 68% of NF, 14% of BA

Average size - lightning fire, 383 ha

- man-caused fire, 28 ha

Ratio of average sizes - 14:1

It is readily evident that lightning-caused fires, although only half as numerous as man-caused fires, account for by far the greater proportion of total burned area. The primary reason is obvious, namely the pattern of location of the two categories of causal agent. Lightning fires may start anywhere, including

the most remote and inaccessible locations, and are therefore much more difficult to detect and suppress on the average than man-caused fires. These latter are concentrated near habitation or roads and are usually dealt with quickly and effectively.

These average fire size data obscure another important feature of forest fires in Canada, the immense variation in fire size and distribution by size class. In most years one or more fires exceed 100 000 ha in size, while the great majority of fires are controlled at less than 5 ha. In fact, the largest 3 percent of fires usually account for about 90 percent of total burned area.

The annual variation in burned area for Canada as a whole is very great and occasional very high or very low years are to be expected. The primary reason for this is the variation in weather from year to year. Furthermore, this variation in the national picture is accompanied by additional great variation in a regional sense. Thus, each province or territory has its own unique weather and fire record, whose trend may or may not match the national average.

How probable is another year like 1980? Several mathematical distributions were applied to the 63-year burned area record, and the log-normal distribution yielded the best fit. According to this test, a burned area as large as 1980's could be expected in Canada about once every 75 years, provided that some climatic or other trend were not exerting an effect.

1980 IN COMPARISON TO RECENT YEARS

(a) Selected Fire Statistics

(i) Large Fires

A detailed comparison of the 1980 fire season in west-central Canada with recent fire years during the 1970-1979 period provides an opportunity to assess the severity of the 1980 season in perspective. All jurisdictions within this region of Canada experienced one or more severe fire years during the past decade.

Table 3 compares 1980 fire numbers and area burned, by individual provinces and territories, with average figures for the 1970's. Once again, only fires larger than 200 hectares were considered and lightning and man-caused fires were separated. The following facts are readily apparent from Table 3:

1) With the exception of the Northwest Territories all provinces experienced many more large fires, both lightning and man-caused, in 1980 than was the case during the 1970-1979 period. Areas burned were correspondingly much larger.

2) Lightning fires generally grow much larger than man-caused fires and account for the majority of fires reaching 200 hectares in size. However, both Alberta and Northwestern Ontario experienced a greater number of large man-caused fires in 1980 than at any time during the 1970's.

3) The stratification of fires by size class shows readily that a relatively few very large fires contribute most significantly to total area burned. In 1980 many more very large fires (> 50,000 ha) occurred throughout the region than in any year during the previous decade.

(ii) Protection Levels

When analyzing past and present fire statistics it is important to separate data by protection zones. Many provinces stratify the area they protect, affording decreased levels of protection to sparsely populated, inaccessible, or low-value areas. As a result vast areas in the northern parts of Saskatchewan, Manitoba and Northwestern Ontario receive limited protection - most fires in these areas are lightning-caused and unless threatening communities, are allowed to burn freely. Provincial fire statistics summaries have not distinguished between fires inside and outside intensive protection

Table 3: Average number of large fires and burned area in west-central Canada: Comparison of 1980 with the 1970's.

		Number of fires		Area burned		Number of fires		Area burned		Number of fires		Area burned		Number of fires		Area burned	
		1980	1970's	1980	1970's	1980	1970's	1980	1970's	1980	1970's	1980	1970's	1980	1970's	1980	1970's
Large fires																	
Zone	Area ha	6,166 ^A (10)	5,884 (12.6)	18,774 (11)	5,250 (11.6)	10,960 (22)	1,767 (0.3)	6,202 (11)	2,729 (6.1)	7,317 (15)	7,955 (16.2)	49,359 (101)	25,586 (54.0)				
Zone	Area ha	13,023 (10)	40,445 (11.4)	116,005 (26)	29,047 (9.1)	130,179 (32)	40,001 (11.5)	25,945 (6)	11,028 (3.9)	46,171 (10)	93,094 (24.7)	173,073 (96)	215,715 (60.6)				
Zone	Area ha	99,400 (4)	73,365 (3.1)	36,076 (1)	30,504 (1.4)	307,211 (12)	66,430 (2.5)	97,031 (4)	11,915 (0.7)	250,021 (11)	226,091 (10.7)	794,297 (32)	419,125 (18.4)				
Zone	Area ha	111,517 (1)	60,907 (1.0)	144,473 (2)		301,663 (4)	42,974 (0.5)	352,177 (3)	0,679 (0.1)	542,142 (5)	250,650 (2.6)	1,516,173 (15)	171,290 (4.2)				
Total		262,914 (17)	100,601 (20.1)	316,878 (62)	71,001 (22.1)	470,951 (70)	151,972 (22.8)	401,555 (26)	36,371 (10.0)	674,651 (49)	570,590 (54.2)	2,752,901 (244)	1,011,216 (130.0)				
Non forested																	
Zone	Area ha	2,470 (6)	000 (1.6)	9,736 (26)	5,194 (11.4)	4,401 (9)	795 (1.0)	1,351 (0)	917 (2.2)	256 (1)	400 (1.1)	20,294 (50)	8,701 (10.1)				
Zone	Area ha	19,741 (5)	1,226 (1.0)	89,011 (15)	15,274 (5.6)	18,599 (7)	1,017 (0.5)	26,828 (8)	2,169 (0.6)	1,500 (1)	2,078 (1.0)	105,711 (36)	24,464 (8.7)				
Zone	Area ha	72,005 (1)	8,117 (0.4)	97,877 (7)	9,964 (0.5)	87,842 (3)	4,742 (0.2)	1,404 (0.1)		8,975 (0.7)		260,404 (9)	33,202 (1.9)				
Zone	Area ha	193,000 (2)		60,701 (1)		394,617 (3)	10,117 (0.1)	121,013 (1)				770,211 (7)	10,117 (0.1)				
Total		208,096 (16)	12,422 (3.0)	209,159 (45)	30,339 (17.5)	505,499 (22)	17,471 (2.6)	151,992 (17)	4,490 (2.9)	1,756 (2)	11,491 (2.0)	1,156,702 (107)	76,066 (20.0)				
Forest																	
Zone	Area ha	0,646 (24)	6,773 (14.2)	28,460 (59)	10,494 (21.0)	15,431 (11)	4,562 (10.1)	9,551 (21)	1,646 (0.3)	7,571 (16)	0,441 (1.7)	69,651 (151)	11,060 (12.9)				
Zone	Area ha	51,564 (19)	43,671 (12.4)	155,848 (41)	45,071 (14.7)	140,728 (39)	47,610 (12.0)	57,773 (14)	12,197 (4.5)	67,071 (19)	95,122 (25.7)	478,704 (172)	239,670 (69.3)				
Zone	Area ha	172,213 (7)	81,402 (3.5)	136,707 (4)	98,468 (1.9)	740,013 (15)	71,172 (2.7)	97,031 (4)	15,319 (0.0)	250,021 (11)	735,066 (11.4)	1,054,701 (41)	452,377 (20.3)				
Zone	Area ha	306,597 (3)	60,987 (1.0)	205,176 (3)		770,200 (7)	53,091 (0.6)	474,190 (4)	0,679 (0.1)	542,142 (5)	250,650 (2.6)	2,306,385 (22)	181,407 (4.3)				
Total		541,010 (53)	201,913 (31.1)	526,187 (107)	101,981 (39.6)	1,112,452 (42)	171,443 (25.4)	631,547 (43)	40,061 (11.7)	674,407 (51)	590,081 (57.0)	1,909,601 (346)	1,107,206 (166.0)				

^A1970's column represents a 7-year average (1970, 1971 & 1972 missing)

^B1970's column represents an 8-year average (1971 & 1973 data missing)

^C1970's column represents a 9-year average (1970 missing)

Area burned in hectares

Number of fires in brackets

zones (IIP and OIP fires) in the past and this distinction is essential to a valid assessment and interpretation of fire records. Table 4 compares the 1980 fire season with the previous decade for the inside and outside intensive protection zones of Manitoba, Saskatchewan and Northwestern Ontario. Alberta intensively protects all of the northern portion of that province, and the Northwest Territories has four not-easily separated priority zones - as a result neither of these jurisdictions is represented in Table 4.

Table 4: Fire Statistics by Protection Level - Saskatchewan, Manitoba and Northwestern Ontario.

	<u>Saskatchewan</u>		<u>Manitoba</u>		<u>Northwestern Ontario</u>	
	<u>1980</u>	<u>Annual average 1970 - 1979</u>	<u>1980</u>	<u>Annual average 1970 - 1979</u>	<u>1980</u>	<u>Annual average 1970 - 1979</u>
Outside Intensive Protection:						
number of fires	174	97	-	11	43	36
area burned (ha.)	988,793	146,543	-	17,250	5,885	119,441
average fire size (ha.)	5,683	1,511	-	1,568	137	3,309
total OIP area (ha.)	19,700,300	19,700,300	9,937,800	9,937,800	11,179,300	11,179,300
% of area burned annually	5.02	0.74	-	0.17	0.05	1.07
Inside Intensive Protection:						
number of fires	568	286	1,076	579	1,028	774
area burned (ha.)	351,945	25,223	603,706	63,307	545,638	92,123
average fire size (ha.)	620	92	561	109	531	119
total IIP area (ha.)	15,631,600	15,631,600	23,310,000	23,310,000	20,533,900	20,533,900
% of area burned annually	2.25	0.17	2.59	0.27	2.66	0.45

Note: Saskatchewan area includes water, Manitoba and Northwestern Ontario areas do not.

An examination of Table 4 yields the following facts:

1) During the 1970-1979 period only 8.1% of the fires that occurred in Manitoba, Saskatchewan, and Northwestern Ontario were OIP and yet these fires accounted for 60.9% of the area burned in this region. Average fire sizes are much larger, as would be expected, in OIP zones.

2) 1980 was a year unlike any during the previous decade. In Saskatchewan OIP fire starts and area burned were well above average, while Manitoba experienced no OIP fires at all and Northwestern Ontario recorded an average number of fires but a greatly reduced area burned in the OIP zone. On the other hand, all three provinces experienced area burned losses significantly above normal within their intensively protected regions in 1980.

(iii) Fire Management Costs

Total fire management costs for the 1970-1980 period in west-central Canada are shown in Figure 4. These expenditures are totalled for Ontario (whole province), Manitoba, Saskatchewan, Alberta and the Northwest Territories. Fixed and variable costs are separated and expenditures are

adjusted to 1980 \$ using the Government Current Expenditures on Goods and Services Price Index.

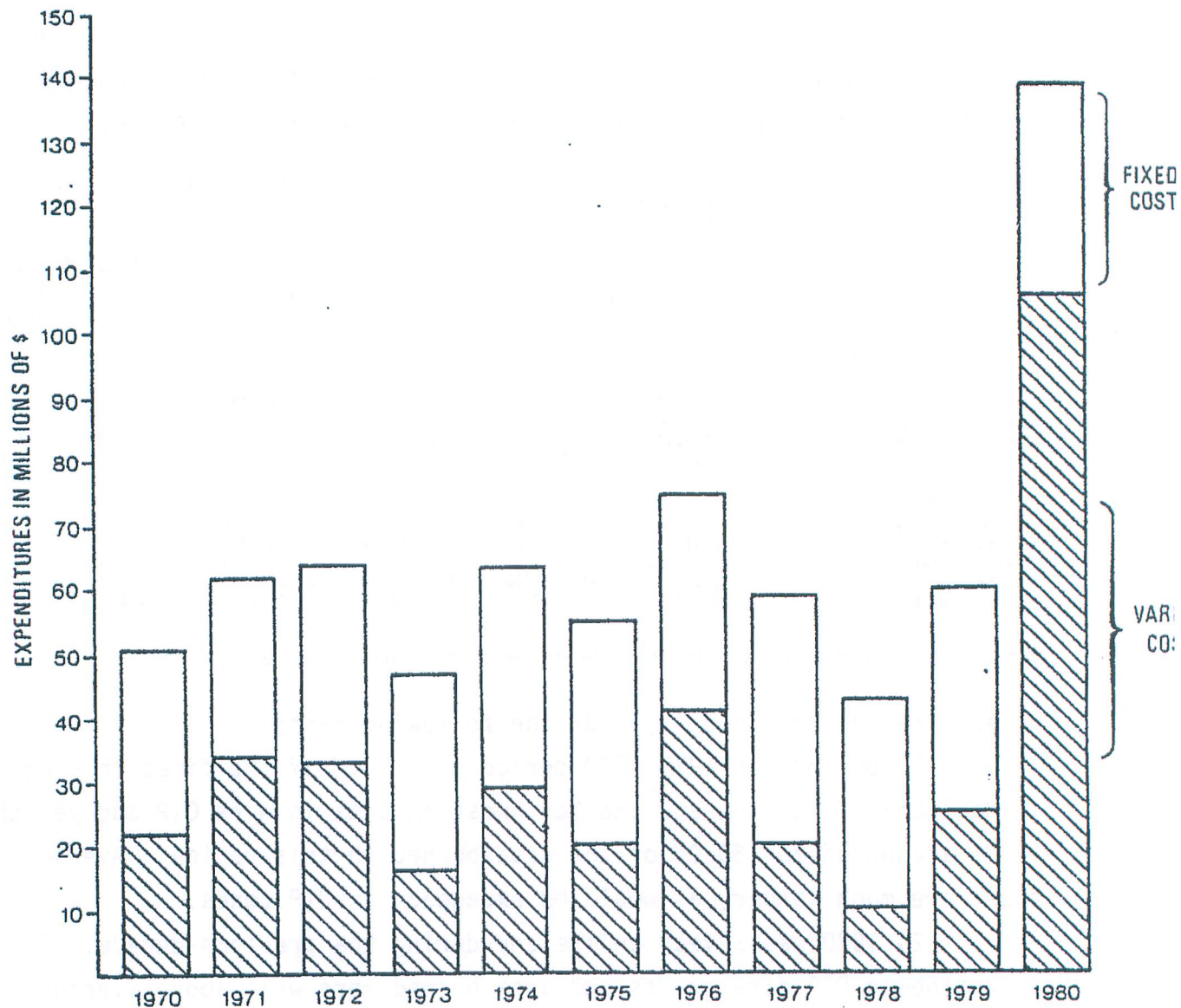


Figure 4: Total fire management costs (fixed + variable) for west-central Canada (Alberta, Saskatchewan, Manitoba, Ontario, and Northwest Territories).

One striking feature of this histogram is that, while variable costs fluctuated greatly from year to year (as might be anticipated), fixed costs have remained strikingly similar over the past decade. Other than adjusting for inflation, fixed fire management budgets have been maintained at the same level.

A second feature evident from this figure is the drastic increase in variable costs in 1980 - a four-fold increase from an average of \$25 million during the 1970-1979 period.

(b) Weather and Climate

(i) 1980 in General

The most important meteorological feature affecting Canadian weather during spring and summer of 1980 was a fairly stationary upper air high pressure system over central North America. This high pressure system became dominant in April and remained in place for many weeks with slight fluctuations. The movement of moist air into this area from west and south was effectively blocked and deflected, either north and east across the northern Northwest Territories, or northerly to the east of the Great Lakes. The duration and intensity of this high pressure system was most unusual, resulting in weather that was both much warmer and much drier than normal, and occasionally very windy as well.

Canada as a whole can be divided into three zones for a discussion of the 1980 forest fire season:

- Zone 1: Southern Mackenzie District, northern Alberta, most of Saskatchewan, the southern half of Manitoba, and the southern half of Northwestern Ontario. Extreme fire weather during much of April, May, June and July.
- Zone 2: Northern Manitoba, Ontario east of Lake Nipigon, Quebec, all Atlantic Provinces. Damp spring and summer, with no serious fire weather all season.
- Zone 3: British Columbia west of the Rockies. Damp spring and summer, with no serious fire weather all season.

The lines dividing these zones were remarkably sharp; thus the five jurisdictions forming Zone 1 sustained 90% of the national total burned area. The 1980 fire season was simply not a problem elsewhere in Canada.

All the required weather factors for a severe fire season were present at once in Zone 1: There was (1) thin snow cover during late winter, (2) a warm April that bared the ground two or three weeks earlier than usual, (3) three months with very little rain except scattered thunderstorms, and (4) frequent days with low humidity and strong wind. Timing varied somewhat, so that the most serious fires occurred first in Alberta, then eastward to Ontario,

and last in Mackenzie District.

(ii) Severity Ratings

How severe was the weather with respect to fire in 1980? The best measure is the Severity Rating, a component of the Canadian Forest Fire Danger Rating System. The Severity Rating (SR) is derived from the Fire Weather Index (FWI), the common index of daily fire danger used throughout Canada. The SR is designed specifically to be an indicator of the effort required to suppress a forest fire, and is thus suitable for averaging over any desired number of days. The SR incorporates all the features of the FWI, namely the weather on the day of measurement as well as the effect of past weather, especially rain, on the degree of forest flammability.

Two tables are presented, one (Table 5) to compare the 1980 fire season with those of recent years, the other (Table 6) to show the chronology of the 1980 season. These tables are based on weather records from five to ten selected stations in each jurisdiction. These stations were deliberately chosen from within Zone 1 in order to show the regional aspect of the 1980 fire season. Any SR over about 2, especially averaged for a month, represents weather favourable to fire. Table 5 lists monthly SR's by jurisdiction for May and June of the last 10 years including 1980. The Table is not complete, since some data were not readily available; nevertheless, it is clear that monthly average SR's in the range of 4 to 13 over such a large part of Canada have no parallel in the past decade. Such weather, coupled with frequent multiple fire starts on particular serious days, is sufficient explanation by itself for the record national burned area in 1980.

Table 6 portrays the course of the 1980 fire season by 10-day periods for the five affected jurisdictions. Average SR's and number of new fires are shown for each 10-day period, and burned area by month. Burned area may not match the chronology of the Severity Ratings perfectly for two possible reasons. One is that lightning storms may have been absent, whereas the man-caused fires were quickly controlled; another is that large fires, after their initial fast run, may continue to spread for some time in less severe weather. With a large amount of active fire perimeter in place, even slow spread rates may then greatly increase the burned area.

Table 5. Fire weather severity ratings for selected areas of the 5 jurisdictions most affected by fire in 1980. May and June only*.

Jurisdiction	1971	1972	1973	1974	1975	1976	1977	1978	1979	Past** Average	1980
Mackenzie District (NWT)											
May	1.8	0.9	2.2							1.6	6.8
June	5.8	4.3	6.7							5.6	6.0
Alberta											
May	5.0	3.5	1.4	0.8	1.8	5.7	1.3	1.4	1.7	2.5	7.2
June	1.8	3.1	1.2	2.9	1.5	1.2	2.0	1.9	1.3	1.9	2.0
Saskatchewan											
May						3.0	3.4	1.4	1.4	2.3	9.2
June						0.9	3.1	1.2	2.1	1.8	3.6
Manitoba (southern)											
May											13.7
June											6.5
Ontario (northwestern)											
May	1.0	1.1	1.3	0.2	1.7	3.7	1.7	1.0	0.7	1.4	4.7
June	1.6	2.4	0.9	2.2	0.6	3.2	0.1	1.5	1.7	1.6	2.9
Average of all above											
May	2.6	1.8	1.6	0.5	1.7	4.2	2.2	1.2	1.3	1.9	8.4
June	3.1	3.3	3.0	2.6	0.6	1.8	1.7	1.5	1.7	2.1	4.2

* some data not available.

** for a number of years shown in each case.

Table 6. Chronology of the 1980 fire season in the Northwest Territories, Alberta, Saskatchewan, Manitoba and Ontario (whole province).

Period	N.W.T			Alberta			Saskatchewan			Manitoba			Ontario		
	Severity Rating	No. of Fires	Burned Area	Severity Rating	No. of Fires	Burned Area	Severity Rating	No. of Fires Started	Burned Area	Severity Rating	No. of Fires Started	Burned Area	Severity Rating	No. of Fires Started	Burned Area
April 21 - 30	-	-	60	7.42	272	120,000	13.70	133	429,000	4.94	141	90,000	-	234	3,000
May 1 - 10	11.14	5	-	10.79	169	-	10.93	57	-	10.09	99	-	5.19	231	-
11 - 20	9.42	18	-	9.89	264	-	10.72	92	-	10.00	96	-	3.18	83	-
21 - 31	1.00	10	37,000	1.69	33	400,000	6.15	43	435,000	19.79	126	360,000	5.84	322	300,000
June 1 - 10	6.40	20	-	2.02	14	-	4.20	29	-	6.41	40	-	2.12	43	-
11 - 20	4.79	22	-	1.57	108	-	3.60	71	-	8.69	114	-	2.80	87	-
21 - 30	6.70	87	850,000	2.61	113	44,000	2.76	110	353,000	5.48	66	130,000	3.67	190	230,000
July 1 - 10	6.28	42	-	1.78	179	-	3.31	104	-	3.24	50	-	1.54	73	-
11 - 20	4.24	34	-	1.05	48	-	1.43	55	-	1.31	61	-	1.17	242	-
21 - 31	5.12	29	290,000	1.26	34	25,000	1.55	32	117,000	4.67	160	60,000	0.91	110	25,000
Aug. 1 - 10	4.32	10	-	0.64	32	-	0.54	10	-	0.56	65	-	1.00	79	-
11 - 20	3.97	25	-	0.68	10	-	1.03	7	-	0.20	45	-	0.25	30	-
21 - 31	2.21	9	37,000	0.31	7	56,000	0.59	5	12,000	0.54	1	60	0.20	11	300
Sept.	-	-	1,000	-	-	-	-	-	3,000	-	-	400	-	-	1,500
Oct.	-	-	-	-	-	38	-	-	-	-	-	-	-	-	-

*Monthly burned areas are not necessarily official monthly values. Totals may not match the seasonal totals in Table 1.

(iii) Climate Trends

To summarize, the special unique features of the 1980 fire weather season in the affected area were:

- 1) Very early start, several weeks before normal
- 2) Very long period with no general, widespread rain
- 3) Many days with very low humidity and very high wind.

Since the record national burned area was mainly a direct result of this weather pattern, it is probably fair to say that the same chance of a repetition applies to both the weather and the burned area associated with it. If so, then a year with such widespread severe fire weather can be expected, on the basis of past experience, about once every 75 years.

Any estimate of the probability of a year like 1980 based on past experience, depends on an assumption that the future will, on the average, be like the past. There is, however, an increasing body of opinion among climatologists that a trend to greater variability from year to year is in effect, and that the 1940's and 1950's were relatively benign compared with the decades before and since. Furthermore, this variability may be expressed as sharp contrasts from region to region in any one year. Thus, while 1980 fire weather set extreme records in central and northwestern Canada, eastern Canada and British Columbia were abnormally cool and damp. If all this is so, then the annual probability of a severe fire season in at least one Canadian region may be on the increase. The record of the last ten or twenty fire seasons would lend some support to such a conclusion.

IMPACT OF THE 1980 FOREST FIRE SEASON

(a) Economic Impact

The purpose of this section is to evaluate the economic impact of forest fires that occurred in mid-western Canada in 1980. Anything more than a superficial overview, however, is precluded by the broad scope and complexity of this mandate. In addition, there is a lack of available data which reflects both our time limitation and the absence of a firmly established methodology and related concepts.

It is customary to classify fire impacts into three categories: timber, non-timber, and life and property. In the absence of meaningful data on timber value losses, data on physical (specifically timber volume) impacts may be used to draw inferences about economic impacts. This is the approach used here. Government is by far the major landholder in the areas that were most affected by fire.

Scale is a prime consideration in the analysis of economic impact from forest fires, primarily because of the effects of substitution which allow impacts in one area to be offset in other areas. Table 7 provides rough data showing the apparent effect of the 1980 fire season on the annual allowable cut (AAC) in Alberta and Northwestern Ontario. The principal use of this information is to show general orders of magnitude of forest inventory, losses to fire, AAC and levels of harvesting.

From this broad regional view, no impact on timber supplies relative to utilization is apparent. Even with the enormous timber losses of 1980, total growing stock has been only marginally reduced with a slight effect on AAC. A large timber surplus still exists, therefore, even after harvest levels are adjusted upwards to take into account discrepancies between actual utilization standards and those assumed in the AAC.

These results must be viewed with caution because of deficiencies in the forest inventories and hence AAC; because of deficiencies in the method used to calculate AAC; because the use of a composite AAC masks the specific relationship between available supply and actual demand for a given species; because AAC ignores economic accessibility of the timber; and because there is an implicit assumption that any portion of this broad regional AAC may be freely substituted for any other.

Table 7. Impact of 1980 forest fires on the annual allowable cut in relation to utilization, Alberta and Northwestern Ontario (Gross merchantable volume, thousand cubic metres)

Province	Before 1980 Fire Season ^A				After 1980 Fire Season				
	AAC	Average Annual Harvest	Utilization (%)	Inventory	Timber Burned	Adjusted Inventory	AAC ¹	Average Annual Harvest	Utilization (%)
Alberta	24,916	6,784 ²	27	1,696,425	20,371 ^B	1,676,054	24,648 ³	6,784	28
NW Ontario ⁴	13,914	6,616 ⁵	48	1,160,185	33,800 ⁶ C	1,126,385	13,490 ⁷	6,616	49

1 $Y_A = 2G_A / (R - a)$ (Davis's (1966: 114) modification of Von Mantel's modification of Hundseshagen's formula).

2 Actual softwood and hardwood harvests adjusted upward by 25% and 100% respectively to conform to AAC utilization standard.

3 "a" assumed to equal 20 yr., "R" derived from pre-1980 inventory and AAC data using following relation:
 $R = (2G_A + a \times Y_A) / Y_A = 156 \text{ yr.}$

4 Zone 2, Reed and Associates (1978). This area is smaller than the current combined areas of the OMNR's NW and NC Regions.

5 Actual softwood and hardwood harvests adjusted upward by 13% and 100% respectively to conform to AAC utilization standard.

6 Actual volume loss data for eight major fires expanded by factor of 1.74 to yield figure reported here. The following assumptions are made: (1) that the relationship between area burned and volume lost is linear, and (2) that 1980 fires occurring inside the zone of "intensive protection" also occur within Reed's (1978) "zone 2".

7 $a = 20 \text{ yr}$; $R = 187 \text{ yr.}$ (calculated as in footnote 3).

A Reed and Associates (1978)

B Alberta Forest Service (1980) (correspondence)

C McIlale (1980: 34)

The preceding idea leads us to sharpen our focus at the level of the individual timber supply or management unit. To this end data are available from two sources. Alberta has recalculated coniferous AAC on 24 management units as a result of the 1980 fire season (Table 8). In no case is the post-1980 fire season AAC less than the volume allocated for harvesting. This is primarily attributable to present low levels of utilization, since reduction in AAC on individual management units amounts to as much as 60 percent. If we ignore the basic data problems pointed out above, and if we ignore the fact that this type of analysis views 1980 fire depletion out of context with all other factors contributing to forest depletion and growth over time, then we may conclude that 1980 forest fires had virtually no effect on reducing the amount of timber needed by industry. Confirmation of this finding, however, must await an analysis of individual operators.

In Ontario, a case study has been made of two large fires and their effects on the wood supplies in the applicable management units and in specific working groups (Ketcheson 1980). The "Ontario Wood Supply and Forest Productivity Model" was used to calculate allowable cuts for the units before and after fire losses. Findings from this Ontario study agree with those drawn from the Alberta data. Allowable cut is reduced but sufficient surplus is apparently available, even at this scale, to provide alternative sources of supply within the management unit, although "severe dislocation" of some small operators is "likely".

Non-timber impacts caused by 1980 forest fires are largely unknown. Users affected include tourists and other recreationists, commercial trappers, hunters and fishermen, residents including native peoples, and all others who directly make use of the goods and services provided by or found in association with forests.

A drop in business for tourist camps was reported by local officials in the Red Lake vicinity of Ontario as a result of the much publicized fire and evacuation that occurred there. The tourists involved are presumed to have made other arrangements, while those directly affected by the evacuation order may or may not have been compensated financially.

Property losses from forest fires in Northwestern Ontario amounted to approximately \$3.2 million in 1980 based on data from several sources. Included

Table 8. Impact of 1980 forest fires on coniferous annual allowable cuts in relation to annual volume allocation for selected forest management units, Alberta (Source: Alberta Forest Service, correspondence).

(Volumes in thousand cubic metres)

Forest	Forest Management Unit No.	Annual Net Allowable Cut			Annual Volume Allocation
		Before 1980 Fires.	After 1980 Fires	Reduction ¹ (%)	
Athabaska	A- 6	48	33	1.0	0
	A- 7	223	221	1.0	48
	A- 8	103	103	0.1	6
	A-11	91	84	8.0	0
	A-12	209	100	52.3	20
	A-13	111	109	2.0	0
Edson	E-4-N	221	221	0.2	221
Footner Lake	F- 1	155	150	3.0	0
	F-10	23	21	8.5	0
Grande Prairie	G- 1	115	115	0.1	115
Lac La Biche	L- 1	99	98	0.2	24
	L- 3	290	290	0.1	71
	L- 5	82	38	53.4	0
	L- 9	85	76	10.9	0
Peace River	P- 1	237	233	1.9	53
	P- 2	194	163	15.9	62
	P- 3	50	50	0.1	27
	P- 4	56	56	0.1	41
	P- 6	163	153	5.9	73
	P- 7	114	46	60.1	0
	P-10	67	65	2.4	30
Slave Lake	S- 4	132	131	0.4	63
	S- 6	122	119	2.8	48
	S-15	126	123	2.8	68
TOTALS ²		3118	2799	10.2	970

¹ Apparent discrepancies are due to rounding of AAC data.

² Totals do not agree with those in previous table for the following reasons: (a) this table includes only those management units experiencing fire in 1980; (b) this table excludes hardwoods; and (c) this table excludes cull volume.

in this figure is the replacement cost of approximately 70 buildings, 15 vehicles and 21,000 cords of cut wood, as well as the repair cost of expensive transmission facilities. Compared to the total cost of fire suppression in Ontario in 1980 - \$53 million - property value losses were very small.

As far as is known, three lives were lost in the effort to control forest fires in 1980. All were in Northwestern Ontario in two separate incidents.

Forest fires also have an indirect impact in time and space as effects translate into economic impacts that filter through the economy. To cite some examples: primary, secondary and even tertiary wood-using industries may be forced to reduce production; forest closings or evacuations will cause shut-downs of industrial and commercial activities; destroyed communications, transportation and transmission infrastructures will disrupt numerous activities; merchandising, service and trade will be affected; and insurance pay-outs for property loss claims will also represent losses to society as a whole.

Unfortunately, in general almost no data are available to assess these secondary effects. An exception is the case of Red Lake-14 and its impact on various communities in late May of 1980. For up to 12 days, approximately 3550 residents were evacuated from Red Lake, Ontario, and surrounding communities to Winnipeg and other locations. Personal compensation to evacuees amounted to \$0.2 million, while compensation was expected to approach \$0.5 million or more for the Province of Manitoba and City of Winnipeg and \$0.1 million or more for the Canadian Armed Forces - a total of \$0.8 million (Monzon 1980). Monzon was unable to provide a detailed breakdown of these costs. In addition, excluded from consideration are business losses and the extra expenses incurred by the more than 16 other government agencies that played some role in the evacuation.

(b) Social Impact

Broadly speaking, "economics" concerns human needs and wants, their relationships to each other and to the resources that satisfy them. In this sense the twin concepts of social and economic impact are one, giving rise to the term "socio-economic" impact. For purposes of analysis, however, it is useful to maintain the distinction on the basis that social impacts can be defined as *non-market human impacts*. These include effects on the psychological and physiological well-being of people (or "quality of life"), and effects on

human population dynamics. Possible specific examples of such forest fire impacts include destruction of the livelihood of a family income earner, or perhaps even enhancement of the view from someone's living room window.

This discussion is in fact academic since no data are available on the social impact of the 1980 fire season. Rather, it is included so as to shed light on the scope and meaning of socio-economic impact analysis, as well as for the sake of completeness. Methods are even more poorly developed than for economic impact analysis, which reflects the fact that the predictive capability of the social sciences is limited and therefore largely speculative in nature.

(c) Environmental Impact

An assessment of the environmental effect of the 1980 fire season must be based mainly on the scientific literature; no one has collected information specific to 1980. However, these sources are nearly unanimous in regarding the northern Canadian forests as fire-dependent ecosystems that have evolved under the influence of periodic fire and are normally cycled and renewed by fire in their natural state. This means that the forest tree species and all associated vegetation are adapted to regenerate after fire, and that post-fire forests can be expected, on the average, to equal the pre-fire ones in character and quality. Wildlife inhabiting these regions is likewise adapted to a cycle of vegetation development from fire to fire; species and populations shift, wax, and wane in tune with it.

Furthermore, because the landscape has been subjected to periodic fire for thousands of years, it has presumably long since stabilized against appreciable further change or erosion due to fire. Any effect on water quality within large burned areas is slight and temporary.

Forest fire smoke is a minor part (about 10% on the average) of the total pollution load entering the Canadian atmosphere. It affects few inhabited areas and then only sporadically for short periods. Studies in Canada (including one at Thunder Bay in 1980) and elsewhere have concluded that even when a smoky odour is evident forest fire smoke has only a non-toxic nuisance value.

Provided that 1980 is considered only as one in a stream of fire seasons that together subject the northern forests to a natural or normal amount of fire, then the environmental impact of the 1980 fires can be considered neutral. The great variation in annual burned area will presumably balance the high years with corresponding low ones.

This ecological dependence of the northern ecosystems on fire, plus the ease with which they burn in a dry year, suggests that economic activity in the north should strike a rational compromise with fire rather than regard it simply as an enemy that can and should be eliminated.

SUMMARY AND CONCLUSIONS

1. The 1980 forest fire season produced the largest annual burned area on record in Canada, primarily due to a period of very unusual spring weather characterized by an early disappearance of snow and long, nearly rainless periods over much of west-central Canada.
2. The provinces of Alberta, Saskatchewan, Manitoba, and Ontario (northwestern portion), as well as the Mackenzie District of the Northwest Territories, accounted for 89% of the area burned in Canada in 1980, and 72% of the total fire management costs expended nationally.
3. In 1980, as in previous years, a relatively small number of very large fires accounted for the vast majority of the area burned in west-central Canada. The majority of these fires were lightning-caused, although many more significant man-caused fires occurred in 1980, particularly in Alberta and Northwestern Ontario, than in the previous decade.
4. In recent years, fires in zones of limited or reduced protection usually accounted for a large proportion of the annual area burned. This was the case in 1980 in Saskatchewan, but not in Manitoba or Northwestern Ontario. In all jurisdictions in west-central Canada the area burned inside areas of intensive protection was much higher than usual.
5. Variable fire-fighting costs in west-central Canada in 1980 were four times the 1970-1979 average. Fixed costs have remained constant for the past decade.
6. Fire weather in May and June of 1980, as reflected by average Severity Ratings, was much more severe in west-central Canada than at anytime during the previous decade, and this, coupled with multiple fire starts explains the record burned area in 1980. The fire record of the past decade suggests the possibility of a climatic trend producing gradually more frequent weather favourable to forest fire.
7. Environmentally, the 1980 fire season can be regarded as neutral. Forests and other vegetation in the affected regions are parts of

depend to some extent on periodic fire for their continued existence. Post-fire forest stands on the 1980 burned areas can be expected, on the average, to equal the pre-fire ones in character and quality. Wildlife inhabiting these regions is likewise adapted to a cycle of vegetation development from fire to fire; species and populations shift, wax, and wane in tune with it. Furthermore, because the landscape has been subject to periodic fire for thousands of years, it has presumably long since stabilized against further permanent change or erosion due to fire. Forest fire smoke is a minor part of the total pollution load entering the Canadian atmosphere; it affects few inhabited areas and then for only short periods of time. It may have a temporary nuisance value but is considered non-toxic. There is no doubt that a continuous string of seasons like 1980 for decades on end would place a severe ecological strain on all life in the affected regions. There is equally no doubt that seasons like 1980 are very unusual and that the ecological impact of the expected amount of fire, averaged year by year, is environmentally neutral.

8. The economic impact of the 1980 fire season on the timber industry is difficult to isolate and measure. A more meaningful question might be "How are forest harvests and other benefits affected year after year by forest fire, taking special account of 1980"? Unfortunately, methods, and even basic concepts, are not completely in place to permit such an analysis. What has been done here suggests that allowable annual cuts and planned harvests have not been seriously affected by the 1980 season, except in certain limited working areas; the larger the scale, the less the effect. The basic reason for this is that considerably less than the total annual wood growth is currently being harvested in the affected regions. Then, if fire is regarded as an ecologically normal cycling agent, it is not until the forest comes under intensive management, and the annual harvest approaches the annual increment, that fire begins to have a primary direct economic impact. Meanwhile the average combined forest area renewed annually by harvesting plus fire together must not exceed a certain reasonable value, which can only be arrived at rationally by a joint consideration of both ecology and the costs of fire control. A fire year like 1980 may produce some local dislocation in harvest plans,

but the overall impact is diffused over several decades in the stream of annual harvested and burned areas.

9. The economic impact of non-timber forest benefits, such as recreation, wildlife and environmental quality, is virtually impossible to quantify on the basis of available data. It may only be said that such economic impacts are local and of relatively minor importance in the remote regions where most forest fires burn.

LITERATURE CITED

1. Davis, K.P. 1966. Forest management. McGraw-Hill Book Co., Toronto. 519 pp.
2. Ketcheson, D.E. 1980. Impact of Kenora 23 and Ignace 27 wild fires on wood supply and forest values - 1980. Env. Can., Can. For. Serv., Gt. Lakes For. Res. Ctr., Internal Report. 7 pp.
3. McHale, D.E. (Chairman). 1980. Issues - 1980 fire season. Ontario Min. Nat. Res. Internal Report. 37 pp.
4. Monzon, R.M. 1980. The evacuation of Red Lake, Cochenour, Balmertown, and surrounding area as a result of forest fire #14, Red Lake District, 1980. Ontario Min. Nat. Res., Submission to Cabinet Comm. on Emerg. Planning. 8 pp.
5. Reed, F.L.C. and Associates. 1978. Forest management in Canada. Vol. I. Prepared for Env. Can., Can. For. Serv., For. Mgt. Inst. Info. Rep. FMR-X-102. 155 pp.