Forest Research Branch

A PROBLEM ANALYSIS OF FOREST FIRE RESEARCH IN ALBERTA

(REVISED)

by

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ABSTRACT

A problem analysis of forest fire research in Alberta is made based on a review of literature, an analysis of forest fire statistics, discussions with officials of government and forest industry, and a field reconnaissance carried out in 1962-63. The paper reports on the area and values affected by forest fires and describes the fire problems in terms of prevention, danger rating, fire weather, forest fuels, and slash hazard reduction. A forest fire research program, aligned with the needs and requests of the provincial protection organization and forest industry, is outlined.

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INTRODUCTION

Annually in Alberta, forest fires burn substantial areas of valuable forest and range land. An average fire-year for the period 1944 to 1963 shows 296 fires burned approximately 309,000 acres, with suppression costs of over four hundred thousand dollars. In addition, the damage to soil, stream-flow, wildlife, and recreational values must be considered in the final assessment of losses.

The Alberta Department of Lands and Forests is responsible for the protection of the forests against fire and since 1956 action has been taken on all fires constituting a threat to the forest area. The increased protection effort has outstripped fire research and there is now a lack of research information to aid judgement and experience. Fire losses may be reduced by the intelligent application of knowledge of forest fires gained by experience and by scientific study. The need for more intensive fire research is recognized by the provincial and federal government agencies and forest industry (Rocky Mountain Section of the Canadian Institute of Forestry, 1955, 1962) and substantiated by recent discussions among fire control officials.

The objectives of this paper are to:

(1) report on the area and values affected by forest fires and to

(2) describe the fire problems in Alberta.

This problem analysis is based on a literature review, analysis of forest fire statistics, discussions with officials of the provincial government and forest industry, and a field reconnaissance carried out in 1962-63. It is concerned only with problems relating to forest fire research. Although a wide range of research topics are discussed, the implementation of a research program is, in the final analysis, dependent on available personnel, research facilities, and the needs of the Province and forest industry.

THE FORESTS OF ALBERTA

Rowe (1959) has classified the forest cover of Alberta into distinct Forest Regions. Three Regions comprise the greater part of the forested area. The Boreal Region, biggest of the three, covers approximately 75 per cent of the land area, and the Subalpine and Montane cover about seven per cent. The remainder of Alberta is predominantly grassland. Total forest land exceeds 159,000 square miles of which 116,000 square miles is productive forest (Dominion Bureau of Statistics 1964). Nearly 90 per cent of this is unoccupied forest land.

Conifers comprise 30.9 billion cubic feet and deciduous species 24.1 billion cubic feet (Dominion Bureau of Statistics 1964). The annual utilization of deciduous species has never exceeded five per cent of the total production. Only 24 per cent of the forested area is fully stocked, with an average volume of 2,440 cubic feet per acre (Alberta Department of Lands and Forests 1961). The gross allowable annual cut in the Forest

Divisions is 1,260 million cubic feet. Annual depletion is estimated as 0.65 per cent of the total growing stock of which 0.30 per cent is lost through fire, 0.15 per cent to decay and the remainder utilized in forest production.

The topography is variable with plains and gently rolling hills, except locally in the Rocky Mountains and the adjacent East Slope foothills where it is extreme. The altitude of the plains area ranges from 700 feet in the north to over 2,000 feet near the foothills. In the Rocky Mountains elevations rise to over 10,000 feet. This mountain range is the source of the major rivers, which drain to the east and north-east.

Alberta has a continental climate with strong contrast between summer and winter temperatures. Climatic summaries for several selected stations, representing the Boreal, Supalpine and Montane Forest Regions, are shown in Table 1.

Table 1. Alberta Climatic Summaries

	Boreal Forest			Subalpine Forest		Montane Forest
Statistics	Keg River	Grande Prairie	Fort McMurray	Nordegg	Lake Louise	Jasper
Mean annual temp. degrees F.	31	35	34	34	31	37
Mean temp. degrees F. Jan.	0	5	2	12	4	16
Mean temp. degrees F. July	60	61	63	55	54	59
Annual precipitation in inches	14.95	18.30	17.71	21.02	23.83	13.06

Annual precipitation ranges from 12 to 24 inches, of which about 60 per cent falls in the six-month period April to September. Moderating westerly "chinook" winds, which are most obvious during the winter months occur frequently in the southern half of Alberta and may occasionally extend northward.

HISTORY OF FOREST FIRES AND FOREST FIRE PROTECTION IN ALBERTA

Information about forest fires is available for only the past 60 years. First records are available from the annual reports of the federal Department of the Interior, and recent records from reports of the Alberta Departments of Lands and Mines and Lands and Forests.

The federal government assumed responsibility for forest fire protection in the Rocky Mountains Forest Reserve in 1910. In 1930 the forests of Alberta were placed under provincial administration. The provincial protection organization has, since assuming responsibility for protecting the forest against fire, grown by increasing the field staff, acquiring more and better equipment, and improving fire fighting methods and techniques.

Prior to 1964 two major regions - the Rocky Mountains Forest Reserve and the Northern Alberta Forest Divisions - comprised the forested land (Figure 1). The area of the Reserve was 8,953 square miles, divided into three Forests. The Northern Alberta Forest Divisions totalled seven covering 149,718 square miles. In this problem analysis, the forest fire statistics have been separated for these two major regions. Alberta's forested lands are now divided into ten administrative Forests (Figure 1).

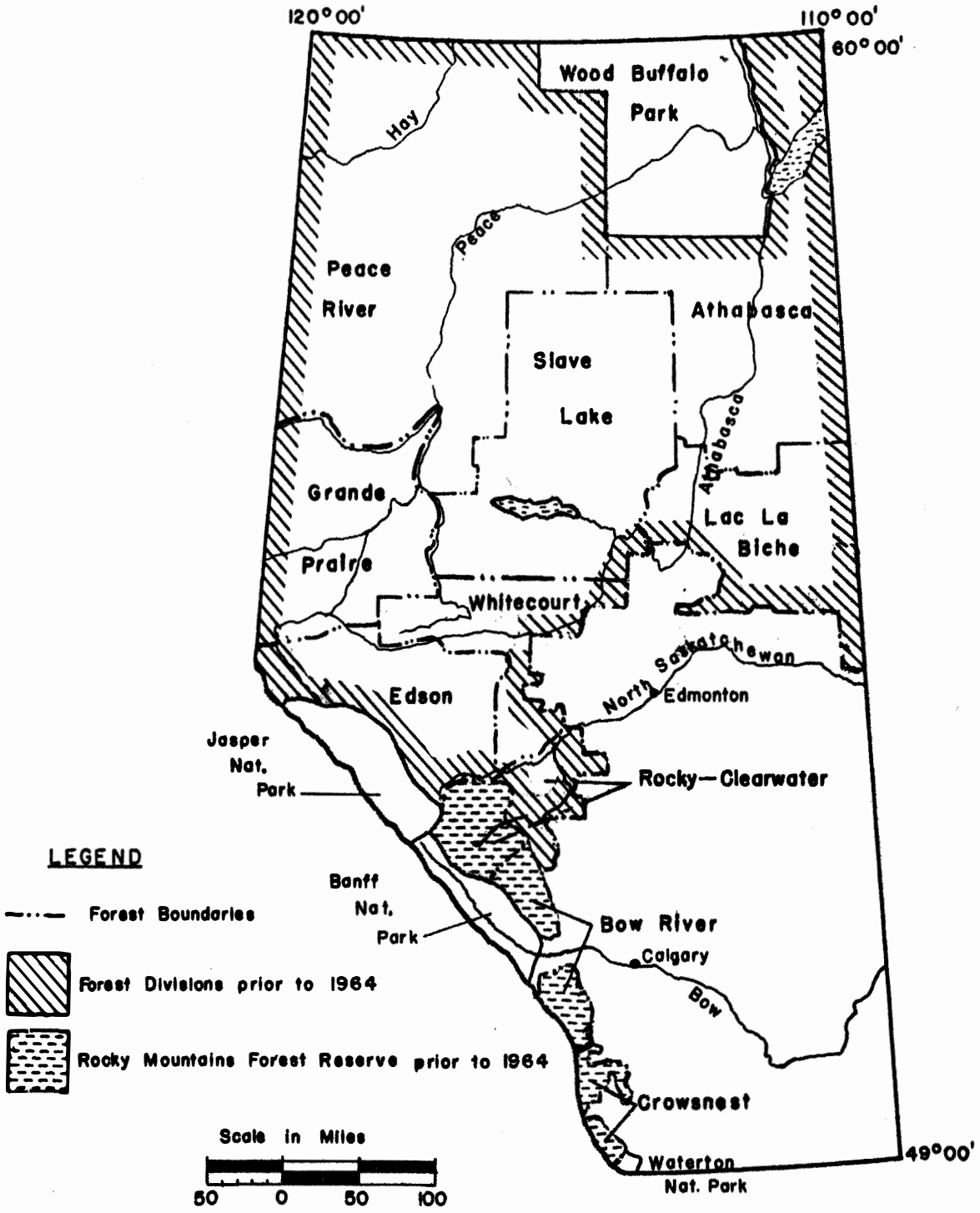

FIGURE I. ALBERTA FORESTS (1964)

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The long-term statistics indicate a downward trend in the annual total acreage burned but there is a definite increase in suppression costs and a recent upward trend in the number of fires (Table 2). More fires are spotted today and certainly many more are fought than in earlier times. The average number of fires per year for the whole Province, during the 20-year period 1944-63 was 296. The total area burned during the past 20 years was about 6 per cent of the forested area, or 0.30 per cent annually. Not all of the fires are in forested areas. For example, during the twelve-year period 1951 to 1962 inclusive, a total of 2,419,398 acres burned. Of this total 763,392 acres, or 32 per cent, was non-forested land.

Table 2. Long-term Forest Fire Statistics in Alberta, 1943-62[1]

Period	Fires Reported	Total Area Burned	Forested Area Burned	Suppression Costs	Suppression Costs/Acre on Area Burned
	No.	M. Acres	Per Cent	$.000	$
1943-47	254	361	0.36	49.8	0.18
1948-52	204	594	0.58	154.3	0.43
1953-57	179	275	0.27	243.7	2.26
1958-62	496	107	0.10	1,342.7	12.75
Yearly Averages	283	334	0.33	447.6	3.91

1 Annual Reports of the Department of Lands and Forests of the Province of Alberta.

A preliminary analysis of the 1957-63 forest fire reports revealed some interesting trends and relationships. The results may not agree with those published by the Alberta Department of Lands and Forests as some reports were not used for this analysis.

From a total of 3,039 fire reports analyzed, 2,028 were man-caused fires and the remainder were attributed to lightning; a ratio of about 2 to 1. During the seven-year period covered, there was a total of 449,700 acres of forest and grassland burned over, or 64,200 acres annually. The average size of a man-caused fire was 107 acres and a lightning fire 230 acres.

The normal forest fire season in Alberta lasts from April to November and consists of three periods - spring, summer and fall. The spring period starts when fires are able to run in the open and lasts until the aspen and birch leaves are fully developed. The summer period lasts until one-quarter of the aspen and birch leaves have fallen or when a thinning of the tree crowns first becomes noticeable. The fall season continues until snow prevents fire spread.

The seasonal distribution of man-caused fires and area burned is indicated in Figure 2. In the Rocky Mountains Forest Reserve fire occurrence was evenly distributed between spring, summer and fall, but 65 per cent of the area is burned in the fall. In the Northern Alberta Forest Divisions both fire occurrence and area burned were highest in the spring. This is attributed to a large number of grass and brush fires before the start of the growing season.

Figures 3 and 4 indicate that classes D and E fires are

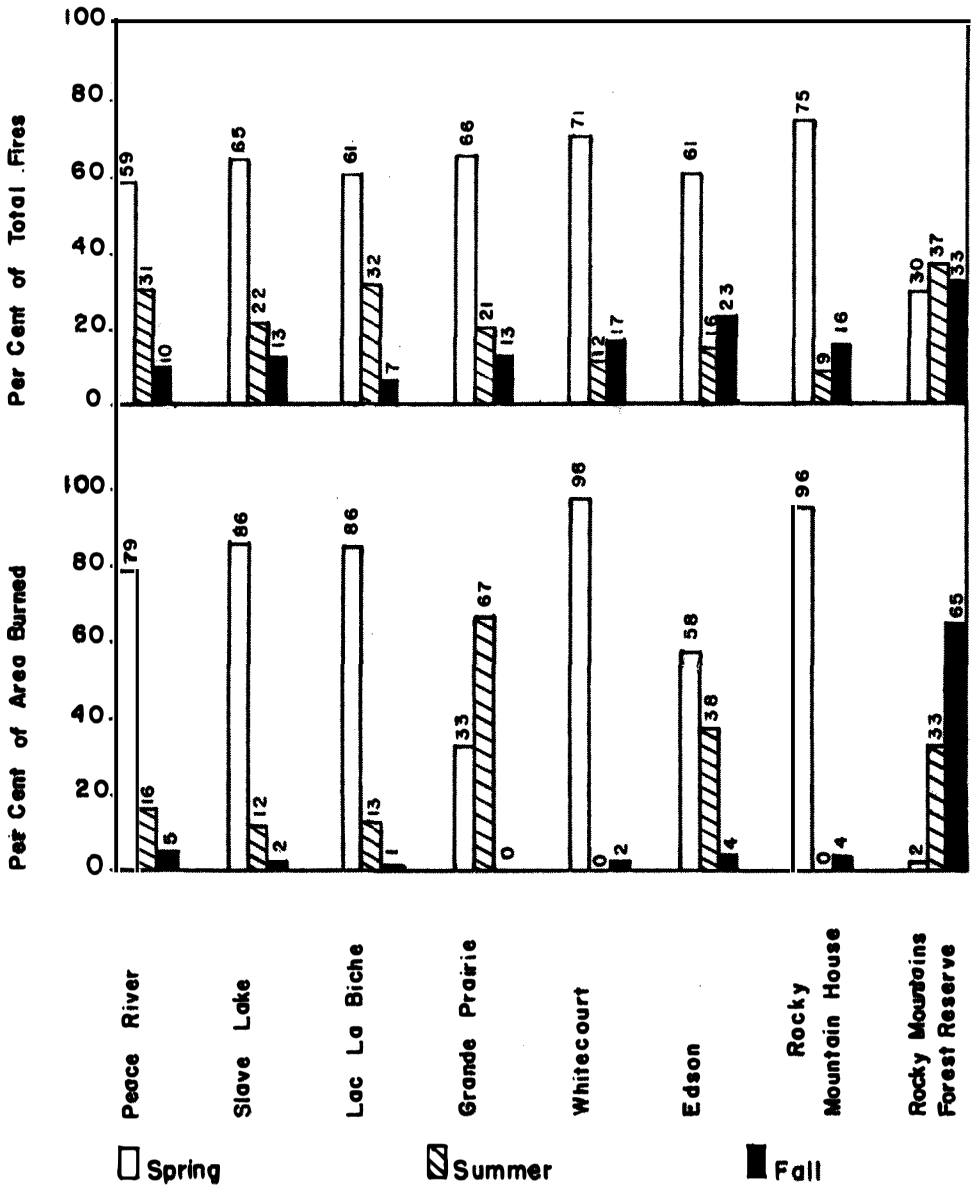

FIGURE 2. FIRE OCCURRENCE AND AREA BURNED BY MAN-CAUSED FIRES, 1957-1963

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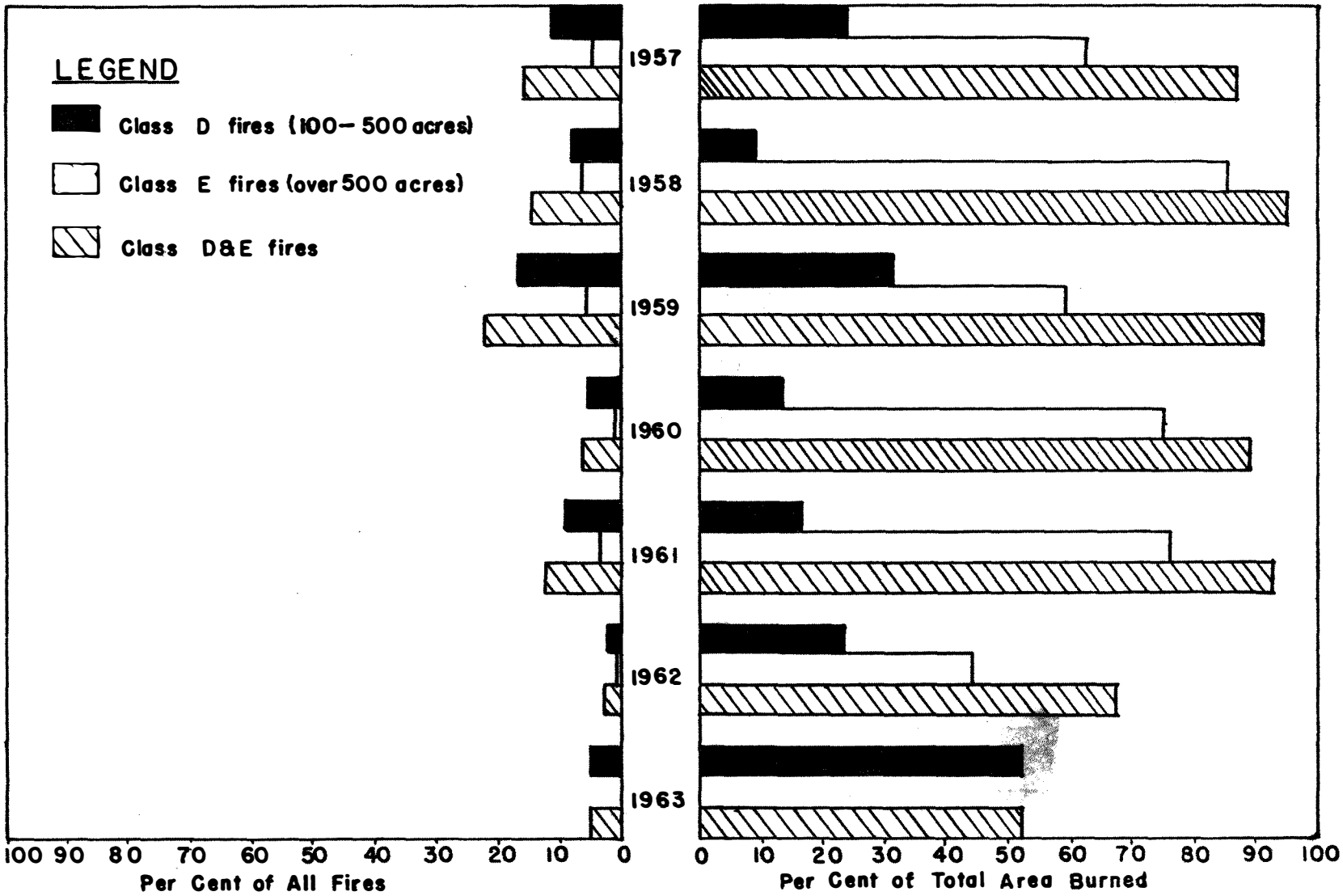

FIGURE 3. FIRE OCCURRENCE AND AREA BURNED – D & E FIRES MAN–CAUSED FIRES, 1957–1963.

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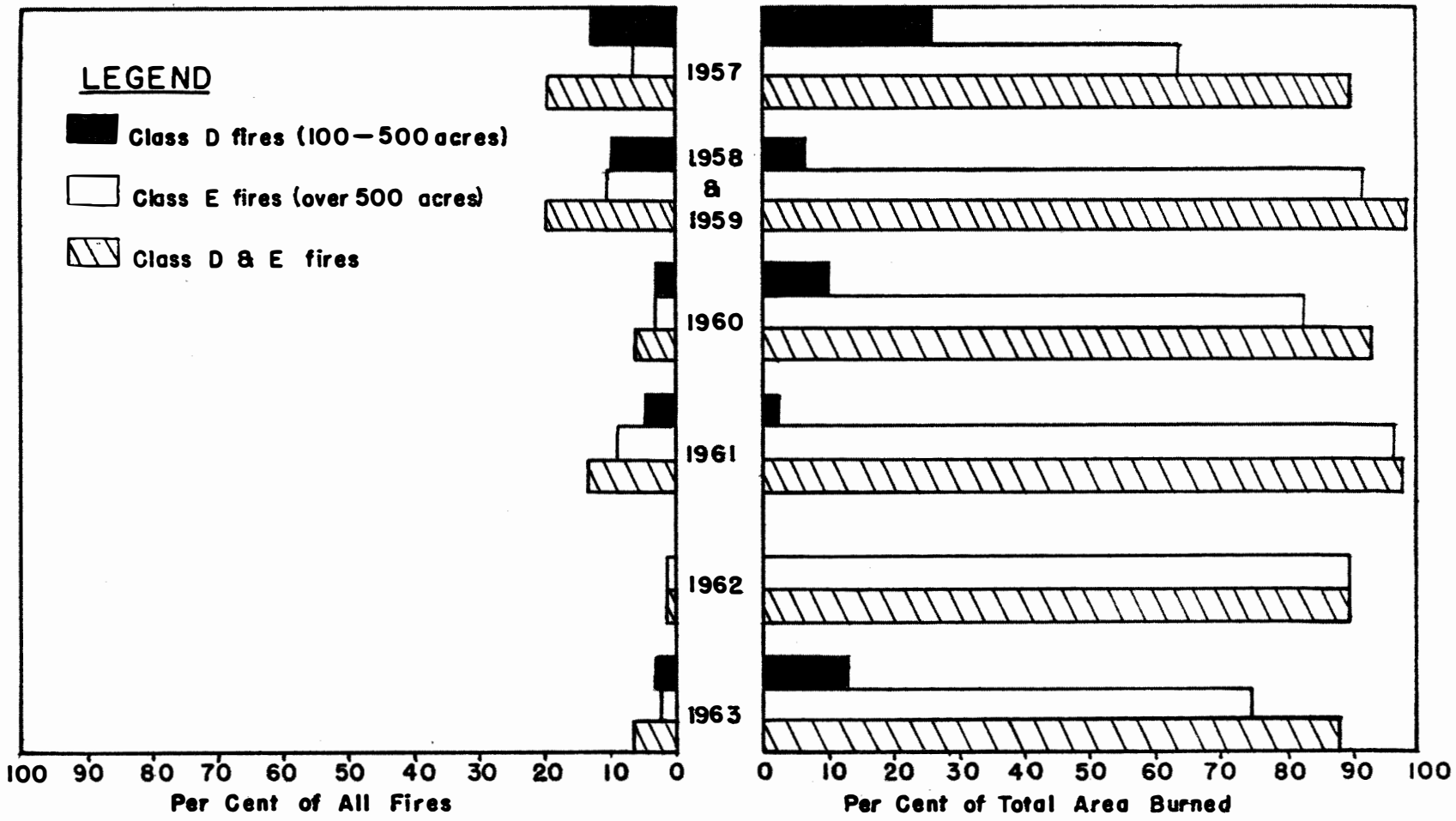

FIGURE 4. FIRE OCCURRENCE AND AREA BURNED — D & E FIRES LIGHTNING — CAUSED FIRES, 1957—1963.

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responsible for most of the area burned by both man-caused and lightning fires. It is apparent that the per cent of D and E fires is decreasing, but the total area burned by these fires is still substantial.

FOREST FIRE PROBLEMS IN ALBERTA

Prevention

Over 75 per cent of all forest fires in Alberta are caused by human agencies and are theoretically preventable (Table 3). The remainder are caused by lightning, and for the present time at least, nothing can be done to eliminate them. Man-caused fires, on the other hand, can be reduced through education and legislation. For these measures to be effective the public should understand the fire danger in the forest, the effects of fire, and what can be done to prevent fires. This is the responsibility of the Alberta Department of Lands and Forests with the aid of the forest industry, the federal government and other forest protection agencies.

Table 3. Fire Causes in Alberta for the Periods 1943-61 and 1957-61[1]

Cause	1943-61	1957-61	Change
	- - - - - - - - Per Cent - - - - - - - -		
Campfires	22.2	19.6	- 2.6
Smokers	10.7	11.3	+ 0.6
Settlers	14.9	13.7	- 1.2
Railways	10.8	2.5	- 8.3
Lightning	11.5	24.6	+ 13.1
Industrial Operations	6.2	8.1	+ 1.9
Incendiary	9.0	12.5	+ 3.5
Public Works	1.2	2.1	+ 0.9
Others	13.4	5.6	- 7.8

1 Annual Reports of the Department of Lands and Forests of the Province of Alberta.

Presuppression

Forest Fire Danger Rating

A contribution by the Department of Forestry to fire control organizations throughout Canada has been the preparation of forest fire danger tables, filling a basic need by providing a consistent and reliable measure of the potential fire danger from day to day. There are two sets of tables for Alberta known as Alberta East Slope and Alberta (Canada, Forestry Branch 1957, 1959). Recently a Cladonia Fire Hazard Table (Mactavish 1963) was prepared specially for jack pine types where almost continuous beds of cladonia cover wide areas. A prototype forest fire danger meter, using the same information available in the regular danger tables, has been developed by Paul (1962).

The application and reliability of forest fire danger and hazard tables in Canada have been analyzed by comparing actual fire occurrence and area burned with each class of danger (Beall 1939a, 1939b, 1941, 1950 and Williams 1962). A similar analysis of fire experience in relation to danger classes would be of value in verifying the Alberta and Alberta East Slope tables.

A summary of a preliminary analysis of records of fire occurrence and area burned by man-caused fires is presented in Table 4. Of all man-caused fires in the Forest Divisions during the seven-year period 1957 to 1963 inclusive, 66 per cent occurred in the spring, burning over 169 thousand acres of forest and grassland. It should be noted, however, that many grass fires may be allowed to burn and may do little or no damage to forests. Of the total number of fires in the spring and fall,

Table 4. Fire Occurrence and Area Burned by Man-caused Fires in Alberta for the Period 1957-63

Danger Class	Northern Alberta Forest Divisions[1] Number of Fires	Area Burned in Acres	Average Size of Fires (ac.)	Rocky Mountains Forest Reserve[2] Number of Fires	Area Burned in Acres	Average Size of Fires (ac.)
			SPRING			
Nil	6	0	0	1	0	0
Low	157	1,500	10	5	0	0
Moderate	383	36,700	96	23	14	1
High	456	93,400	205	26	95	4
Extreme	205	37,600	183	3	1	0
Totals	1,207	169,200	140	58	110	2
			SUMMER			
Nil	2	0	0	2	0	0
Low	44	400	9	12	0	0
Moderate	115	700	6	17	5	0
High	152	5,400	36	20	55	3
Extreme	59	30,900	524	21	1,853	88
Totals	372	37,400	101	72	1,913	27
			FALL			
Nil	6	0	0	2	1	0
Low	115	600	5	13	1	0
Moderate	100	3,400	34	20	44	2
High	34	1,200	35	16	65	4
Extreme	2	0	0	11	3,705	337
Totals	257	5,200	20	62	3,816	62
			ALL SEASONS COMBINED			
Nil	14	0	0	5	1	0
Low	316	2,500	8	30	1	0
Moderate	598	40,800	68	60	63	1
High	642	100,000	156	62	215	3
Extreme	266	68,500	258	35	5,559	159
Totals	1,836	211,800	115	192	5,839	30

1, 2 Using Alberta and Alberta East Slope Forest Fire Danger Tables, respectively.

70 and 75 per cent burned primarily in grass and brush. The corresponding figure for the summer period was only 29 per cent.

Seasonal variation in flammability of fuels is evident between a coniferous and a hardwood stand; vegetation in the coniferous stand changes little but there is a profusion of green vegetation under a hardwood stand which inhibits the drying of the surface fuels and increases the moisture content of the heavier fuels. The feasibility should be investigated of separating the summer tables into two-conifer and hardwood.

Hazard tables specially prepared for such types should be used where fine, fast-drying fuels, such as grass and brush are typical. There are extensive areas of fast-drying fuels in Alberta. The use of a general danger index in areas supporting these fuels leads to a false sense of security and eventual loss of faith in the entire rating system. Continued education and instruction in the proper use and application of the tables, and the reasons for doing so, are considered of high priority. In general, the tables have a far greater potential in presuppression activities than presently utilized. Additional modifications of the forest fire danger tables should be contingent on the proper and full evaluation of the existing ones.

Forest Fire Weather

The Alberta Forest Service obtains weather data from its own network of over 170 fire weather stations, supplemented by regular Department of Transport weather observations and forecasts. These stations, manned by Forest Service personnel, usually maintain Department of Transport specifications for all instruments and observations.

Under the present fire weather network in the Province, each station provides coverage within a 17 mile radius. The density of the network is greatest in the southern half of the Province, decreasing toward the north. In New Brunswick, Beall (1950) concluded that the danger index was reliable within a radius of 25 miles from a weather station. At distances between 25 and 100 miles from a weather station the index may be useful, but not reliable. Williams (1962) reached the same conclusions of danger index reliability in British Columbia. So-called reliable distances vary from area to area, depending on local topography. The weather station network should be much denser in mountainous terrain than in relatively flat country, owing to usually greater climatic variations over shorter distances.

A most important requirement of fire danger measurement is the need to standardize the weather instrumentation by using instruments of uniform accuracy and adjustment. The weather observer should be fully trained and aware of the effects of weather readings on the danger index.

The need for intensified fire danger forecasting is becoming increasingly important for foresters engaged in fire control and in silviculture. Local forecasts are particularly valuable for prescribed burning, slash disposal, burning of debris, disposition of aircraft and other fire control activities.

Forest Fuels

Any measure or classification of forest fuels must consider the

fuel from a fire behaviour viewpoint, i.e. what kind of fire spread and intensity that can be expected in a particular fuel complex. This was first attempted by Hornby (1936) in the northern Rocky Mountains and his general principles of fuel type mapping have been applied and extended in other areas, but not extensively.

Most of the spruce stands of Alberta support litter that is compact and poorly aerated, and exhibits good moisture holding properties. In contrast, the litter under a lodgepole pine stand is usually coarse, well aerated and a poor retainer of moisture. Aspen and birch stands are good retainers of moisture, particularly during the summer months. Other fuels are found in these stands in varying quantities, depending on land and stand characteristics. Areas of open grassland are characterized by fine, fast-drying fuels. As stressed earlier, grass fires in Alberta are responsible for a large proportion of the total area burned, mainly in spring and fall.

Quantitative and qualitative methods of measuring and classifying forest fuels and fuel complexes are required, particularly for cutover areas, as they would enable the fire control agency to plan and carry out its protection effort on the basis of past and expected fire behaviour. What are the burning potentials under a variety of forest and fuel conditions? What fuel characteristics affect flammability, and how? How does the fuel complex change as the forest grows? How can a measure of the fuel complex be used as a measure of predicting fire behaviour?

Slash fuels create a specially high fire hazard by increasing the quantity and continuity of the fuels. The controversy concerned with

slash stems from the large number of variables influencing its flammability and the fact that slash, because of its heterogenous nature, cannot easily be broken down into components that determine the fire hazard. The fire hazard of slash fuels in the northern Rocky Mountains has been studied by Lyman (1947), Olson (1953), Steele (1960), and Fahnestock and Dieterich (1962). Fahnestock (1960) reported that it is differences in the physical characteristics of species of slash that determine its relative burning potential. Before fire behaviour can be measured and predicted with accuracy, research must provide objective means of measuring fuels.

Slash Hazard Reduction

Slash fires are relatively difficult to control, depending on fuel quantity, size, arrangement, distribution, age and the effect of the increased desiccating influence of weather factors in a cutover. Some investigators report that slash treatment and disposal is essential for effective fire protection (Mitchell 1921, Munger and Matthews 1941, McCulloch 1944), while others contend that slash is not an extreme hazard (Cheyney 1939). The scale and importance of the slash fire hazard varies within areas, depending on forest cover type, type of logging operation, the degree of utilization, and weather influences.

Slash hazard studies in Canada have been limited. Wright (1939) reported on preliminary fire-hazard studies on cut-over lands of eastern Canada and developed slash hazard tables for use in balsam fir and spruce slash. Williams (1955), at the Sandilands Forest Reserve in Manitoba

examined the comparative fire hazard in jack pine slash in similar areas where different slash treatments had been employed and the variations in hazard which occur as slash ages. He found that burning jack pine slash reduces the fire hazard to a level comparable to that of the unburned forest and to about one-third of that of unburned slash. The same investigator carried out two burns on the KVP Company Ontario limits and found that the severe slash hazard was eliminated and sufficient heat was developed to open the cones in the seed trees.

Existing legislation in Alberta requires that slash must be either lopped and scattered, or treated in a manner deemed satisfactory to reduce the hazard to within safe limits. The requirements are the same throughout the Province, for all types of forest cover, methods of logging and degrees of utilization. The premise is that by lopping and scattering the slash is brought into contact with the ground where it will more readily absorb moisture, thereby hastening the rate of decay. While this theory is generally accepted, there is an urgent need to investigate the effect of other factors such as quantity, size, arrangement, and condition of slash upon the rate of decay and deterioration. Possibly one or more of these have a greater effect on total slash hazard than proximity to ground moisture.

The physical characteristics of slash provide a basis for appraisal of flammability. Fine fuel components, with a high ratio of surface area to volume, have the greatest influence on fire spread and intensity. These can be identified and studied while the tree is standing. Immediately following felling, the bole and branches start to lose moisture

at a rate depending on species, size of fuel, degree of cutting, and weather factors. The fine material dries quickly, thereby increasing the hazard. Slash is most hazardous while the needles are drying on the branches and twigs, but once they have dropped to the ground the hazard is reduced considerably.

Loman (1959) found that ground-contact slash had a consistently higher moisture content than suspended slash but the differences were not great. This is important as moisture content, along with air movement and heat, controls the rate of decay. Childs (1939) considered this matter and suggested that during much of the summer, parts of the debris are fully exposed to sunlight and, in the absence of substantial amounts of rain, may be too dry to decay. The retention of bark and the development of shade from minor vegetation may hasten the decay of slash, particularly in clear-cut areas.

Knowledge of slash characteristics and flammability is a prerequisite for determining the need for slash treatment and later the effectiveness of any treatment. It is paramount that an evaluation of slash characteristics and flammability be as objective as possible and based on sound scientific measurements. What effect does slash size have on the potential rate of fire spread? How important is continuity, depth and density in relation to other fuel characteristics? What climatic factors influence the march of moisture and the incidence of decay? How can flammability and fire intensity be best evaluated? Answers to these and other questions are needed: the use of prescribed fire, along with a study of physical slash characteristics, offers the best chance of success.

From a silvicultural viewpoint prescribed burning might be applied in Alberta to the following situations: (1) preparation of seedbed and release of seed in jack pine and lodgepole pine types, (2) large-scale site preparation for planting or artificial seeding on cut-over areas, (3) reduction of hardwood and shrub competition, and (4) improvement of humus and soil conditions where there is a rapid build-up of raw humus. Seedbed preparation for regeneration especially is a high priority problem recognized by industrial, provincial and federal forest agencies.

The use of prescribed fire must be judged objectively. Prescribed burning procedures have been and are being developed for a wide range of conditions. Knowledge and experience gained in other areas should form the basis for experimentation in Alberta. The basic need in Alberta is to develop prescriptions for a variety of fuel and weather conditions. Once a certain degree of confidence and efficiency in the use of fire has been achieved, specific studies can be undertaken with a minimum of risk.

RESEARCH PROGRAM

The need for a forest fire research program has been established and it is recognized that past research has been inadequate in view of the values involved and the advances made in forest fire control activities. Subsequently, the forest fire control policy of the Alberta Forest Service is based primarily on experience gained by other services throughout North America and modified for the forest and fire conditions in the Province. The primary objective of a research program is to provide the

protection organization with an insight into fire behaviour and for planning fire control activities.

The active participation of all interested parties is essential to keep up with the increasing protection requirements. This will ensure that all problems peculiar to each agency are recognized and acted on with a minimum of duplication and a maximum of useful knowledge becoming available. The proposed fire research program of the Department has been aligned with the needs and requests of the provincial protection organization and forest industry, but its implementation will depend on available personnel, facilities and equipment. The major phases are listed below:

1. Active studies concerned with measuring slash fuels were initiated at the request of the provincial protection organization. The amount and kind of fuels resulting from a logging operation, and seasonal and yearly changes must be known before the fire hazard can be evaluated objectively. Does lopping and scattering, or any other slash treatment, reduce the fire hazard enough to warrant the extra work? If so, which treatment does the best job for the least cost?

2. The application of prescribed fire in slash as a hazard reduction and a silvicultural tool is a high priority problem recognized by forest industry, and provincial and federal fire protection agencies. Prescribed burning experiments will provide an opportunity to observe and assess forest fuels, weather effects, and fire behaviour under controlled conditions. The results may be used to evaluate the effectiveness of fire as a method of slash disposal; to determine if effort is being directed against hazards in proportion to their severity; to

develop procedures for prescribed burning experiments; and to study the effect of fire on regeneration silviculture.

3. The Alberta and Alberta East Slope forest fire danger tables need to be verified in the light of fire experience. Analyses of fire occurrence, fire size, rate of spread and other fire characteristics in relation to the degree of fire danger would indicate the usefulness of the rating system. Does the danger rating system reflect daily, seasonal and yearly changes in fire load? Are the danger tables utilized to their fullest potential in presuppression activities?

4. Quantitative and qualitative methods of measuring and classifying forest fuels and fuel complexes in terms of fire spread and intensity would enable the fire control agency to plan and carry out its protection effort on the basis of past and expected fire behaviour. How does the fuel complex change as the forest grows? What fuel characteristics affect flammability, and how? Can existing fuel type mapping methods be modified and adapted for use in Alberta? These are a few of the questions to be answered.

5. The need for more intensified fire danger forecasting is becoming increasingly important for foresters engaged in fire control and in silviculture. Local forecasts are particularly valuable for prescribed burning, slash disposal and disposition of aircraft. Appraisal and improvement of forest-fire weather instrumentation and measurement are considered essential for improved fire danger measurement. This work should be carried out in co-operation with the Alberta fire weather officer.

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