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DISTRIBUTION AND COMPOSITION OF RESIDUAL VEGETATION ASSOCIATED WITH LARGE FIRES IN ALBERTA

by

© KEVIN E. EBERHART

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ABSTRACT

Sixty-nine fires that burned in Alberta between 1970 and 1983 were studied. These fires ranged in size from 21 ha to 17,770 ha. Distribution and composition of residual vegetation were compared among five fire size classes and among six preburn vegetation types based on dominant preburn species composition. Fires in the smallest size class did not contain any islands of unburned vegetation. Percent of area within the fire perimeter that was actually disturbed decreased with increasing fire size. Number of unburned islands per 100 ha was highest for the third and fourth largest fire size classes. Median island area per fire, fire shape index, and habitat diversity index increased with fire size. Percentages of burned area within 100, 200, 300, 400, and 500 m of residual vegetation decreased with increasing fire size. Composition of residual vegetation did not differ among fire size classes.

Percent of area actually burned, number of islands per 100 ha, median island area, fire shape index, and habitat diversity index did not differ significantly among preburn vegetation types. Percentages of burned area within 100, 200, 300, and 400 m of residual vegetation did not differ significantly among preburn vegetation types. Percent of burned area within 500 m of residual vegetation differed among preburn vegetation types but the differences were barely significant. Percentages of fire perimeter and

island area associated with each of three general vegetation types and five forest species composition classes differed significantly among preburn vegetation types with two exceptions that may have been related to a small sample size for one of the preburn vegetation types. The general trend was for the highest percentages of residual vegetation in a given general vegetation type or forest species composition class to occur in the corresponding preburn vegetation type. For example the highest percentages of fire perimeter bordering lowland openings were for fires in the lowland opening preburn vegetation type. The density and height of residual forest generally did not differ among preburn vegetation types.

General conclusions were that the distribution of residual vegetation varied among fire size classes but not among preburn vegetation types and that the composition of residual vegetation differed among preburn vegetation types but not among fire size classes.

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Table of Contents

LIST OF TABLES

LIST OF FIGURES

I. INTRODUCTION

Every year thousands of hectares of forest land in Alberta are burned by large forest fires. Although a very small percentage of these fires exceed 200 ha in size, those that do account for a very large percentage of the annual area burned (Figure 1). Large forest fires are usually viewed by the news media and the public as being very destructive to all natural resources within the fire perimeter. While the potential for damage may increase with fire size and intensity (Figure 2; Noste and Davis 1975), large fires seldom if ever kill all vegetation within the main fire perimeter and few animals are directly killed by wildfires (Lyon *et al.* 1978). Residual vegetation surrounding and within the perimeter of large fires may provide valuable seed sources for natural reforestation of the burned area (Zasada 1971) and refugia for wildlife that will repopulate the burn as it becomes revegetated (Bendell 1974). The impact of residual vegetation on reforestation and wildlife habitat may be affected by many variables including: distances to residual vegetation, amount of edge between burned and unburned areas, size of residual islands within the fire perimeter, and the composition of residual vegetation.

Distances to residual vegetation affect its availability as a seed source for revegetation of the burned area (Zasada 1971, Viereck and Schandelmeier 1980) and as

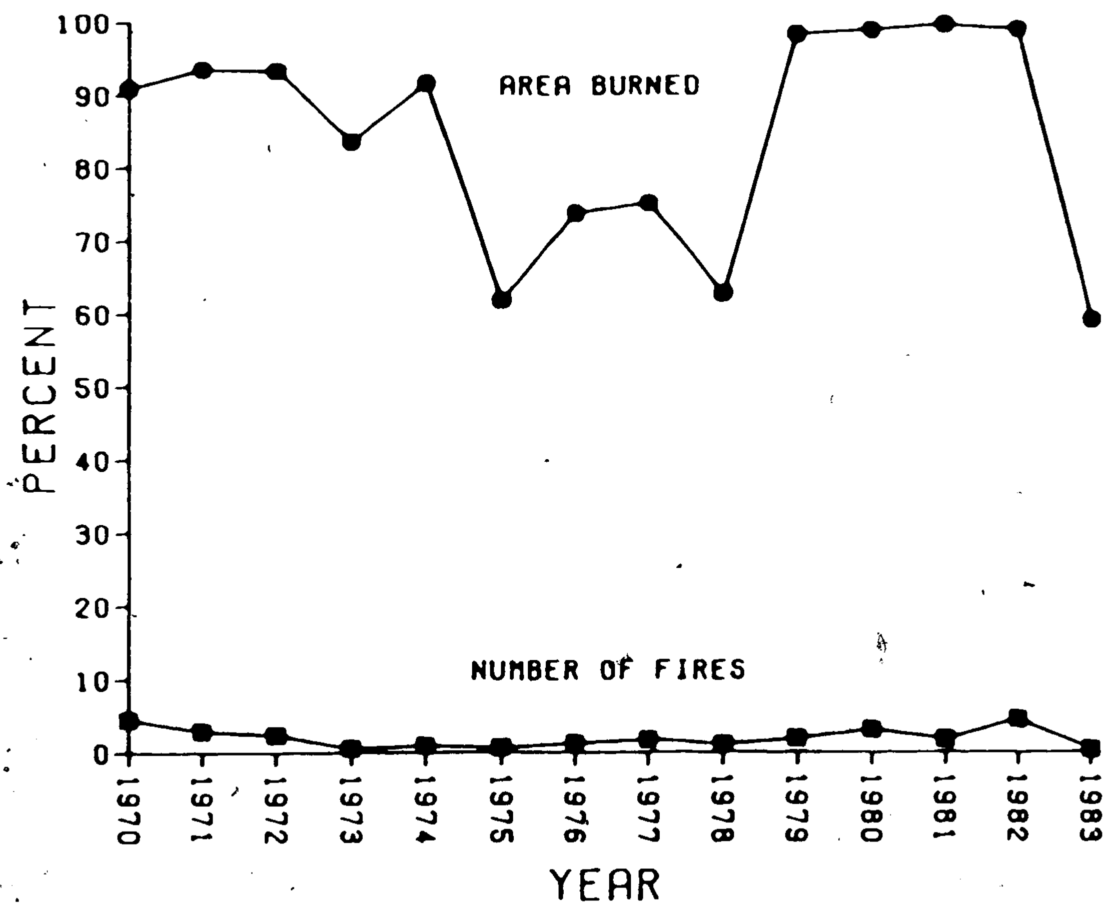


Figure 1. Percent of fires and areas burned by class E fires (>200 ha) in Alberta from 1970 to 1983 (data from fire statistics compiled and maintained by the Alberta Forest Service).

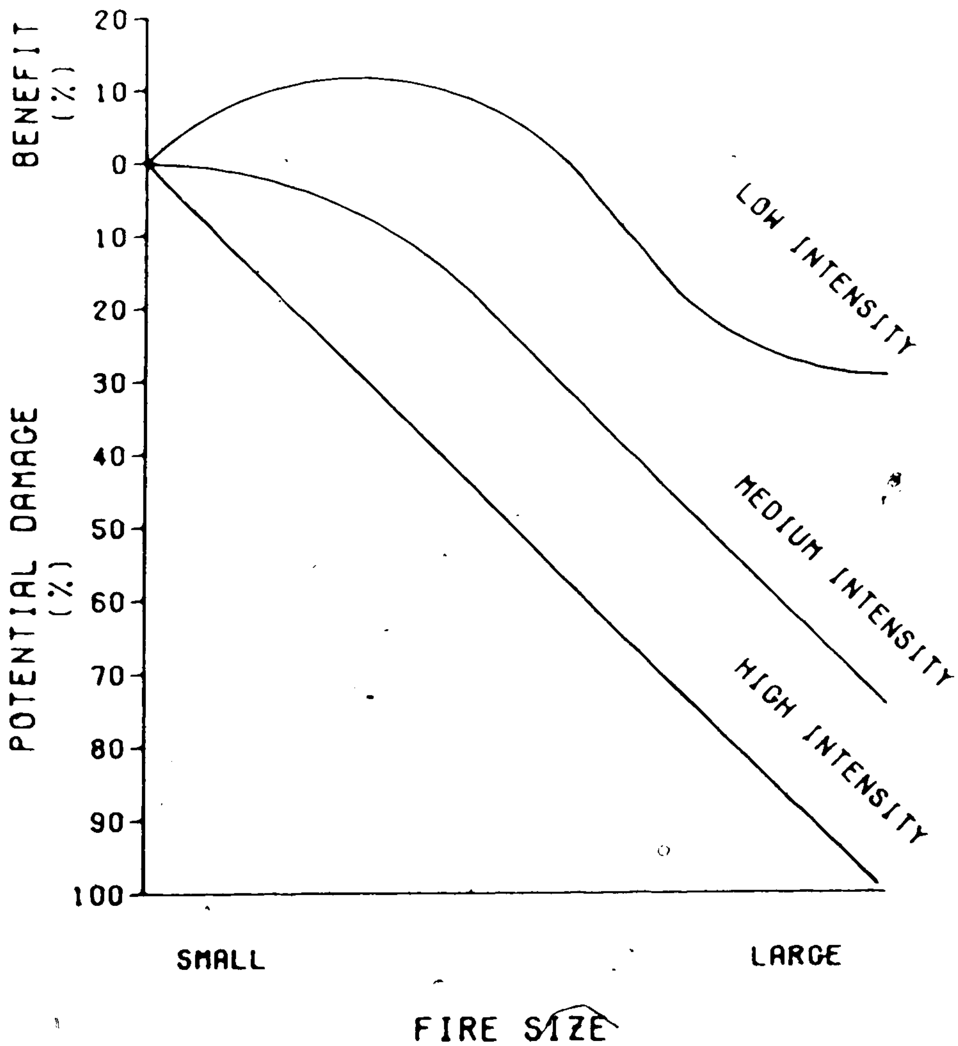
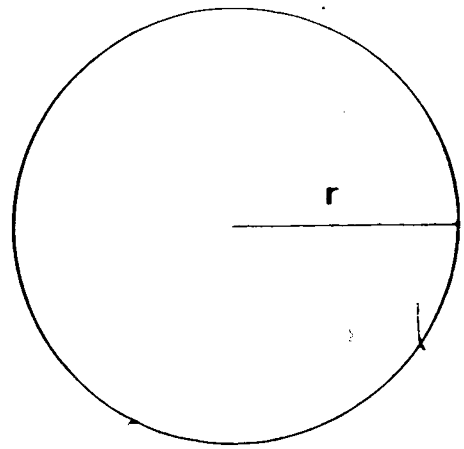


Figure 2. Stylized representation of potential fire damage/benefit as a function of fire size at low, medium, and high fire intensities (modified from Noste and Davis 1975).

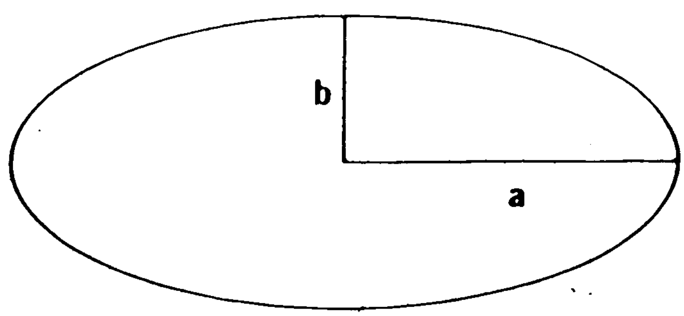
escape cover for wildlife feeding on seral vegetation that will eventually resprout in the burn (Bendell 1974, Lyon *et al.* 1978). Most coniferous tree species have a maximum seed dispersal distance of approximately 100 m (Zasada 1971, Dobbs 1972, Lotan 1975). Distances to residual vegetation are less critical for deciduous tree species that have extremely long seed dispersal distances and may also reproduce profusely by vegetative means after fire if propagules survive (Zasada 1971, Viereck and Schandelmeier 1980). It has been suggested that distances to cover in optimum ungulate habitat should not exceed 200 m (Oldemeyer and Regelin 1980, Euler 1981).

Distances to residual vegetation are affected by the shape of the disturbed area as well as its size. Although the circle and ellipse in Figure 3 are of equal area (28.27 ha), the maximum distance from the center to the edge of the circle is 300 m while no point in the ellipse is greater than 200 m from the edge.

The amount of habitat edge created by a fire may be extremely important in determining the impact of the fire on local ungulate use (Bendell 1974, Bangs and Bailey 1980). The amount of edge between burned and unburned areas is affected by fire size, number and size of unburned islands, and fire shape. A circular fire containing no unburned islands has the least possible amount of edge per unit area. The amount of edge increases as fire shape becomes longer



$r = 300$ m
Area $= \pi r^2 = 28.27$ ha
Perimeter $= 2\pi r = 1885$ m



$a = 450$ m $\quad b = 200$ m
Area $= \pi ab = 28.27$ ha
Perimeter $\simeq 2\pi\sqrt{(a^2+b^2)+2} = 2188$ m

Figure 3. Stylized representation of the effect of fire shape on distances to residual vegetation and amount of edge.

and narrower. Although the circle and ellipse in Figure 3 are of equal area, the ellipse has approximately 16% more edge (2188 m) than the circle does (1885 m). The interspersion of burned and unburned areas associated with increased edge provides a heterogenous environment that may increase wildlife species diversity (Lyon *et al.* 1978).

An excellent example of the importance of unburned islands to ecological impacts of large fires was provided by Gasaway and DuBois (1985), who found that a 500 km² fire had little effect on the home ranges of moose whose prefire home ranges overlapped the burned area. However, 67% of the moose observed within the fire perimeter after burning were located in unburned islands even though such islands represented only 15% of the total area within the fire perimeter. The size of such islands may determine their value as thermal and escape cover for ungulates. Euler (1981) recommended islands of cover habitat for moose be three to five hectares in size and Thomas *et al.* (1976) recommended patches of cover should be at least 12 ha in size to accommodate a herd of elk.

The value of residual vegetation within and surrounding fires as thermal and escape cover for ungulates is also affected by its composition. Thomas *et al.* (1976) suggested plant communities should have at least 75% crown closure and should be at least 12 m in height if these areas are to provide adequate thermal cover for elk. Cover habitat for moose should have at least 50% crown closure and be at least 10 m in height (Telfer 1984). Welsh *et al.* (1980) reported that use of mixedwood stands by moose declined if the coniferous component was less than 20% and Telfer (1984) described good moose cover as being less than 50% deciduous.

Despite the importance of residual vegetation in determining the ecological impacts of large fires, previous research into fire effects has been devoted almost entirely to study of the disturbed area and little is known about the characteristics of residual vegetation surrounding and within large fires. This project attempts to fill this gap. It describes the distribution and composition of residual stands surrounding large fires (20 ha to 20,000 ha) and of islands of residual vegetation within the perimeters of large fires in Alberta. Twenty hectares was chosen as the minimum fire size to be studied because the maximum possible distance to the edge of such a fire is only 250 m. Therefore, fire shape and presence of unburned islands may not be ecologically important for smaller fires. Fires larger than 20,000 ha were considered too costly to analyze in terms of time and materials available for this study. For the purposes of this study, an unburned island was defined as any area of unburned vegetation at least one hectare in size and entirely enclosed within the fire perimeter. Distribution and composition of residual vegetation were analyzed to determine if burning patterns differ significantly among fire size classes.

Flammability varies among vegetation types (Viereck and Schandelmeier 1980, Fischer and Clayton 1983, Van Wagner 1983). Coniferous species are generally more flammable than deciduous hardwoods which will support a fire only under extremely dry conditions (Brown and Davis 1973). Therefore, the distribution and composition of residual vegetation might be influenced by preburn vegetation type. Although dominant preburn vegetation type could be determined from the fire maps used as a data base for this study, the maps were not available for examination prior to purchasing them. Therefore, fires could not be stratified by preburn vegetation type prior to selection for this study. However, it was still deemed useful to compare the distribution and composition of residual vegetation among dominant preburn vegetation types, once the preburn types had been determined from the fire maps. More valuable insights may have been provided by comparing the composition of residual vegetation to the actual composition of preburn vegetation. However, the time required to obtain a detailed description of the composition of preburn vegetation from the data base used for this study would have been prohibitive.

Many other factors including weather, number of burning days, level of fire suppression effort, and minor topographical variation may affect burning patterns of large fires. It was assumed the sample size for this study was large enough to prevent the results from being affected by these factors. By restricting fire selection to the northern half of Alberta, areas with extreme topography were not included in the study area.

An understanding of the distribution and composition of residual vegetation following a large fire is just as valuable as knowledge of what was destroyed by the fire because it provides managers with knowledge of the on-site resources available to them for rehabilitation of the disturbed area. This project is the first step towards providing that understanding. It also introduces a basic methodology on which to base more detailed studies in the future.

II. OBJECTIVES AND HYPOTHESES

The objectives of this project were:

O_1: To determine the spatial distribution of residual vegetation in and around large fires in Alberta.

O_2: To determine the composition of residual vegetation surrounding large fires and of unburned islands of vegetation within large fires in Alberta.

O_3: To determine if the distribution and composition of residual vegetation vary among fire size classes.

O_4: To determine if the distribution and composition of residual vegetation vary among dominant preburn vegetation types.

In order to achieve the third objective, the following null hypotheses were examined:

Ho_1: The percent of area within the fire perimeter that is actually disturbed does not differ significantly among fire size classes.

Ho_2: The number of unburned islands per unit area does not differ significantly among fire size classes.

Ho_3: The size of unburned islands does not differ significantly among fire size classes.

Ho_4: Fire shape does not differ significantly among fire size classes.

Ho_5: The amount of edge between disturbed and residual areas, relative to the minimum possible amount, does not differ significantly among fire size classes.

Ho_6: The percentages of the disturbed area within 100, 200, 300, 400, and 500 m of residual vegetation do not differ significantly among fire size classes.

Ho_7: The composition of residual vegetation surrounding and within large fires does not differ significantly among fire size classes.

In order to achieve the fourth objective, these seven null hypotheses were retested in search of differences among dominant preburn vegetation types rather than among fire size classes.

III. STUDY AREA

The study area for this project consisted of the following provincial forests in Alberta: Footner Lake Forest, Peace River Forest, Grande Prairie Forest, Slave Lake Forest, Whitecourt Forest, Athabasca Forest, and Lac La Biche Forest (Figure 4). The Bow-Crow Forest, Rocky-Clearwater Forest, and Edson Forest were not included in order to avoid complications in burning patterns due to extremely varied topography in the foothill and Rocky Mountain regions of Alberta.

The entire study area is within the Boreal Forest Region described by Rowe (1972). Most of the study area is within the Mixedwood section of the Boreal Forest Region (Rowe 1972). Other major sections of the Boreal Forest Region that are found in the study area include the Hay River section in the northern part of the study area and the Lower Foothills section in the western part of the study area (Rowe 1972).

Major tree species found throughout the area include white spruce (*Picea glauca* (Moench)Voss), black spruce (*Picea mariana* (Mill.)B.S.P.), tamarack (*Larix laricina* (Du Roi)K. Koch), trembling aspen (*Populus tremuloides* Michx.), balsam poplar (*Populus balsamifera* L.), white birch (*Betula papyrifera* Marsh.), and water birch (*Betula occidentalis* Hook.) (Hosie 1979). Lodgepole pine (*Pinus contorta* var. *latifolia* Engelm.) and alpine fir (*Abies lasiocarpa*

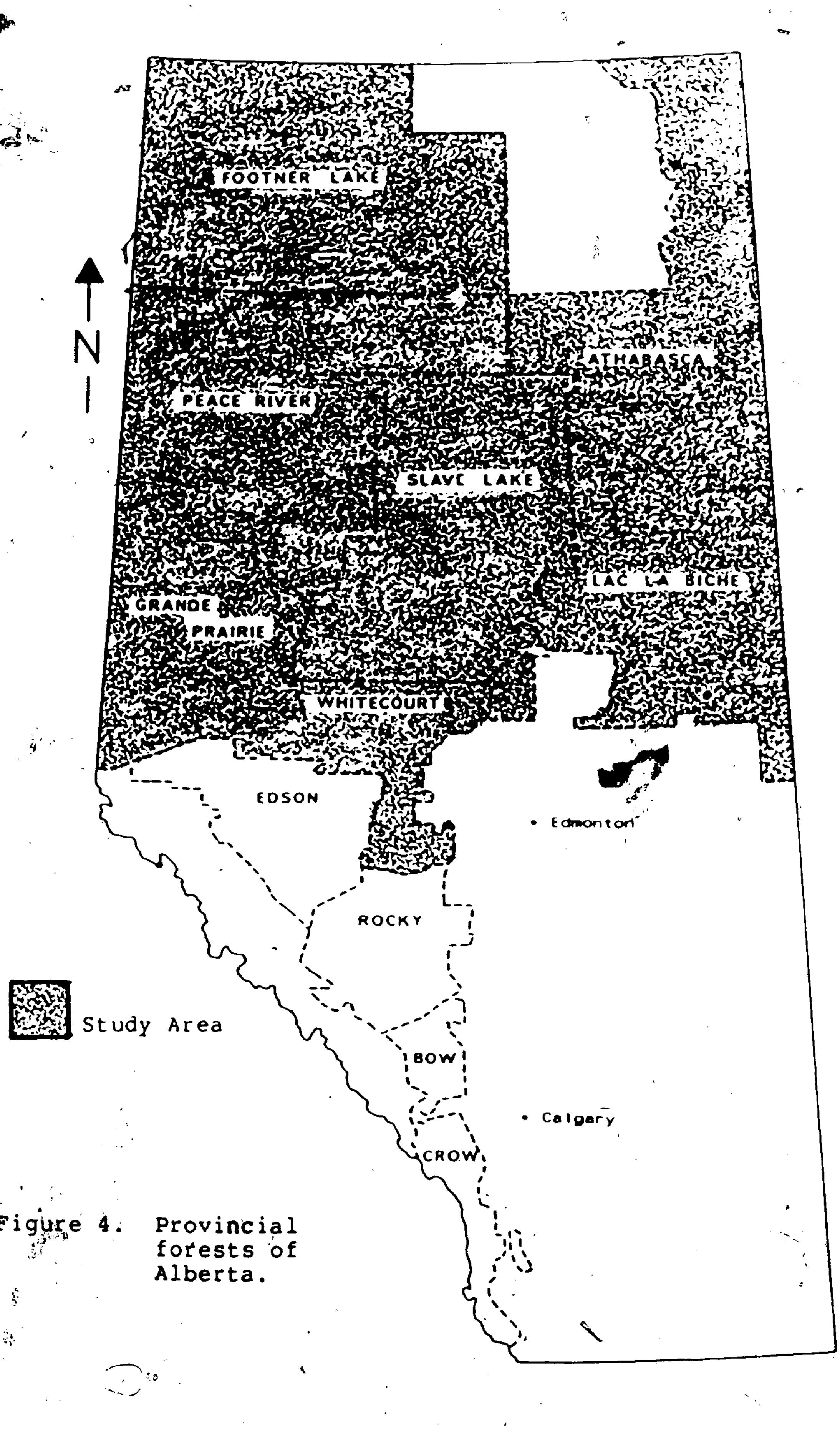


Figure 4. Provincial forests of Alberta.

(Hook.)Nutt.) occur in the western parts of the study area while jack pine (*Pinus banksiana* Lamb.) and balsam fir (*Abies balsamea* (L.)Mill.) are found in eastern and central parts of the study area (Hosie 1979). There is a large area of overlap of the two species of pine in the central portion of the study area (Hosie 1979).

The following description of physiography, soils, and climate was summarized from information contained in the Atlas of Alberta (Government of Alberta and The University of Alberta 1969). Most of the study area lies within the Interior Plains physiographic region. The area in the northeast corner of the study area, lying east of Wood Buffalo National Park, belongs to the Canadian Shield physiographic region. Elevation of the study area ranges from less than 300 m above mean sea level in the northeast to 1800 m above mean sea level in the southwest.

Soils in the study area are predominantly Grey Luvisols and many of these Luvisols are classified as Organic. Areas of Dark Grey Chernozems and Dark Grey Luvisols occur near the border between Grande Prairie Forest and Peace River Forest. Many of these dark grey soils are also Solonetzic. Smaller areas of Dark Grey Luvisols occur farther north along the Peace River.

Mean January temperatures range from -25°C in the northeast corner of the study area to -12°C in the southwest portion of the study area. Mean July temperatures range from 11°C in the southwest corner of the study area to 17°C in the northeast part of the study area. Maximum monthly temperatures at Alberta Forest Service lookouts and ranger stations throughout the forested regions of the province were summarized by Stashko (1971*a*) for the months May through September. There are fewer than 120 frost-free days per year throughout the study area and far northern and northwestern parts of the study area experience fewer than 60 frost-free days annually.

Annual precipitation ranges from 360 mm in the northeast part of the study area to 610 mm in the southwest part of the study area. Precipitation during the growing season (April through August) varies from 180 to 460 mm. Monthly precipitation at individual lookouts and ranger stations was summarized by Stashko (1971*b*) for the months May through September. Annual snowfall ranges from 130 to 200 cm.

IV. METHODS

The data base for this study consisted of air photos and fire maps obtained from the Alberta Government, Department of Energy and Natural Resources. Large fires in Alberta are photographed during and shortly after burning. Fire boundaries are located on these air photos and transferred onto cover type maps by the Alberta Forest Service (AFS). Most of the photos and maps have a scale of 1:15,000 (10 cm = 1.5 km) or 1:15,840 (4 inches = 1 mile), but some of the very large fires are photographed and mapped at scales of 1:30,000 or 1:31,680. A list of all fire maps (referred to as stick plans by AFS) prepared from 1954 through 1983 was obtained from AFS. This list included the stick plan number, fire number, date, location, and fire size for each map. Although AFS began photographing and mapping fires in 1954, many of the photographs prior to 1970 are no longer available. Therefore, only those fires that occurred between 1970 and 1983 were considered for this study.

The Alberta Forest Service classifies fires into five size classes (Table 1). The size classification used for this study was based on the AFS classification (Table 1). Size classes A and B and part of size class C as defined by AFS were below the minimum fire size included in this study. Because of the open-ended nature of class E as defined by AFS, it was desirable to subdivide this class. Boundaries

Table 1. Fire size classes (ha) used by the Alberta Forest Service, this study, and Chandler *et al.* (1983).

Alberta Forest Service		This Study		Chandler *et al.* (1983)	
A:	< 0.1	A :	N/A †	A:	< 0.1
B:	0.1 - 4	B :	N/A	B:	0.1 - 3.5
C:	4.1 - 40	C :	20 - 40	C:	3.6 - 40
D:	41 - 200	D :	41 - 200	D:	41 - 120
E:	> 200	E_1:	201 - 400	E:	121 - 400
		E_2:	401 - 2000	F:	401 - 2000
		E_3:	2001 -20,000	G:	> 2000

† N/A = not applicable.

for this subdivision were chosen to divide the class E fires documented by AFS between 1970 and 1983 into three groups containing approximately equal numbers of fires. The boundaries between classes E_1, E_2, and E_3 also correspond to size class boundaries proposed by Chandler *et al.* (1983) (Table 1); however this similarity is coincidental.

Fifteen AFS fire maps were randomly selected for each of the five fire size classes used in this study. Several of the maps selected included more than one fire number. AFS fire records were examined to establish the date and cause of ignition and the initiation point of each fire. This information was used to determine whether maps with more than one fire number should be treated as one fire or split into separate fires. In five cases it was necessary to separate fires shown on the same map. One of these cases involved 8 separate fires ranging in size from 0.8 to 6.1 ha. These were all lightning-caused fires and all started on the same date. Because of the small size of these fires, they were eliminated from further analyses. The other four maps contained two fires each. In two cases one of the two fires was eliminated because of the minimum size requirement. In the other two cases, both fires were accepted for analysis but were treated separately. Two of the maps initially selected were eliminated from analysis because of incomplete map and photo coverage of the fires involved. Following these separations and eliminations, 74 fires remained for further analysis.

Air photos of the fires were examined stereoscopically and the perimeters of the main fire, spot fires, and unburned islands were marked on the photographs. The largest continuous burned area on each fire map was considered to be the main fire. All other burned areas were considered to be spot fires. The fire and island perimeters were transferred onto transparent overlays of the AFS fire maps using a zoom transfer scope. Cover type boundaries were marked off along the main fire perimeter and spot fire perimeters; thus breaking these polygons into line segments associated with specific residual cover types. Cover type boundaries were also marked within unburned islands. All of this cover type information was traced onto the overlays directly from the AFS maps. Each line segment on the overlay was given a code number indicating the type of polygon it belonged to: (1) main fire perimeter, (2) spot fire perimeter, (3) perimeter of a spot fire within an unburned island, (4) perimeter of an unburned island, or (5) perimeter of an individual stand within an unburned island. The code number for each line segment also contained information pertaining to the composition of residual vegetation bordering that line segment and a three digit number that identified the polygon to which the line segment belonged.

The completed overlays were digitized using a CALCOMP 9000 digitizing table. The digitizer was operated in the increment mode with x and y increments of 0.3 cm. Thus the x and y coordinates of a new point were entered into the data file when the cursor had been moved 0.3 cm in either the x or y direction from the last point. The increment of 0.3 cm was chosen to approximate a distance of 100 m on maps with scales of 1:30,000 or 1:31,680. Each time a new polygon or line segment was begun its code number was manually entered into the digitizer. The digitizer then recorded the code number into the data file as a z value associated with each point.

Computer programs were written in FORTRAN to read the data files (arranged with the z, x, and y values for a single point on each line of the file), separate the data into individual polygons, and calculate the area (ha) and perimeter (m) of each polygon on the map. The lengths (m) of individual line segments on the fire perimeter corresponding to separate cover types were also calculated.

The total fire size was determined as the area of the main fire plus the areas of all spot fires outside the perimeter of the main fire. The total residual island area was calculated as the sum of the areas of unburned islands minus the sum of the areas of spot fires within islands. The residual island area was subtracted from the fire size to determine the area that actually burned; hereafter referred to as the disturbed area. The disturbed area was converted to a percentage of the total fire size and is referred to as the percent disturbed area. Water bodies that were entirely within the fire perimeter were included in the the disturbed area rather than in the residual island area. This was done because the residual areas were analyzed in terms of their value as seed sources for reforestation or as cover habitat for ungulates and water was not of value as either.

The number of unburned islands was counted for each fire and expressed as number of unburned islands per 100 ha of total fire size. Mean island area and standard deviation were calculated for each fire. After analyzing only a few fires it became evident that a few extremely large islands were contributing to very large standard deviations. When extreme outliers are present in a set of observations, the median provides a better measurement of central tendancy than does the mean (Sokal and Rohlf 1981). Therefore, the minimum, maximum, and median island areas were also determined for each fire. The median value was used in comparisons among fire size classes and preburn vegetation types.

A fire shape index (*FSI*) was calculated for each fire as:

$$FSI = P \div (2 \times \sqrt{(\pi \times A)}), \text{ where:} \quad (1)$$

P is the length (m) of the perimeter of the main fire and *A* is the area (m^2) enclosed by the main fire perimeter. This index is modelled after the diversity index described by Thomas *et al.* (1979) and, as used in this study, is a ratio of the main fire perimeter to the perimeter of a circle of equal area. Anderson (1983) discussed the use of such a ratio as a description of fire shape. A perfectly circular fire gives the minimum value of 1.0. The more elliptical the fire becomes or the more irregular the edge, the greater the fire shape index value. The fire shape index value for the ellipse in Figure 3 (p. 5) is 1.16.

A habitat diversity index (*HDI*) was calculated for each fire using equation 1. In this case, *P* represents the total amount of edge between burned and unburned areas (main fire perimeter plus spot fire perimeters plus island perimeters plus perimeters of spot fires within islands) and *A* represents the total fire size. The habitat diversity index is a ratio of the total length of edge between burned and unburned areas to the perimeter of a circle with an area equal to the total fire size. The perimeter of such a circle is the minimum amount of edge that could be created by a fire of that size.

Isopleths were constructed 100, 200, 300, 400, and 500 m from residual vegetation (Appendix A). The area enclosed by each isopleth was calculated and used to calculate the area within each of the five distances of residual vegetation as follows:

$A_n = AD - (A_i - A_o)$, where: (2)

A_n is the area within n meters of residual vegetation, AD is the area disturbed, A_i is the sum of areas enclosed by isopleths n meters inside the fire perimeter, and A_o is the sum of areas enclosed by isopleths n meters outside unburned islands. The areas within each of the five distances of residual vegetation were converted to percentages of the disturbed area.

The percent of the length of fire edge (main fire perimeter plus spot fire perimeters) bordering each of the following three general vegetation types was calculated:

1. Lowland Openings (areas mapped as muskeg, treed muskeg, or flooded land),
2. Upland Openings (areas mapped as coniferous scrub, deciduous scrub, cleared or cultivated land, grassland, or old burns), and
3. Forested (any area given a forest type designation on the AFS fire map).

The percent of the length of fire edge bordering water was determined in order to account for 100% of the fire edge. Forested edge was further described as the percent of forested edge bordering each of four density classes, four height classes, and five species composition classes.

The density and height classes used to describe residual forest were those of the AFS "broad inventory" (Table 2). Over a period of years during the 1970's, AFS

Table 2. Forest density classes (% crown closure) and height classes for Alberta Forest Service broad inventory and Phase III inventory.

CLASS	BROAD INVENTORY	PHASE III INVENTORY
Density A	0 - 30%	6 - 30%
Density B	31 - 70%	31 - 50%
Density C	71 - 100%	51 - 70%
Density D	>100% (overstocked)	71 - 100%
Height 0	N/A †	0 - 6 m
Height 1	0 - 9 m	6 - 12 m
Height 2	9 - 18 m	12 - 18 m
Height 3	18 - 24 m	18 - 24 m
Height 4	> 24 m	24 - 30 m
Height 5	N/A	> 30 m

† N/A = not applicable.

switched from their old broad inventory system to their current "Phase III Inventory." Fifty six of the 74 fires studied were mapped with broad inventory cover types while the other 18 fires were mapped using Phase III inventory cover types. Analysis of cover type data for this study was complicated by differences in forest density and height classes between the two inventory methods. Phase III density classes were reassigned to the broad inventory classes as follows: (1) Phase III B density and C density were combined and included in broad inventory B density and (2) Phase III D density was placed in broad inventory C density. Combining height classes between the two inventory types would have resulted in classes that were too broad to be meaningful. Therefore, only those fires mapped with broad inventory cover types were considered when analyzing forest height data.

Tree species in a stand are coded in decreasing order of abundance on AFS cover type maps. Species accounting for less than 10% of the of the forest cover of a stand are not included on maps and symbols for species accounting for 11 to 20% of the forest cover are enclosed in parentheses. Thus, it was possible to determine the dominant tree species for each stand and to determine which species represented greater than 20% of the forest cover. The five species composition classes used in this study to describe the forested edge were:

DF : deciduous forest (80-100% deciduous),

DM : deciduous mixedwood (>20% coniferous but the dominant species was deciduous),

CM : coniferous mixedwood (>20% deciduous but the dominant species was coniferous),

Sw/P: white spruce or pine (80-100% coniferous and dominant species was white spruce or pine), and

Sb : black spruce (80-100% coniferous and dominant species was black spruce or tamarack).

The cover types of unburned islands were classified using the same categories. Water was not included in the description of unburned islands because water bodies within the fire perimeter were included in the disturbed area as previously explained. The percent of island area occupied by each general vegetation type and the percent of forested island area occupied by each density, height, and species composition class were calculated.

Based on occular estimation from the AFS fire maps, the dominant preburn vegetation type for each fire was described as either lowland openings, upland openings, or one of the five forest species composition classes.

A map of each fire was plotted showing the perimeters of the main fire, all spot fires including those inside of islands, unburned islands, and individual cover types within unburned islands. Isopleths 100, 200, 300, 400, and 500 m from residual vegetation were also plotted on the maps.

These maps provided a visual check of the accuracy of the digitizing process.

Statistical analyses of the data were performed using the Statistical Package for the Social Sciences (SPSSx). All data were tested for normality using the Kolmogorov-Smirnov test for goodness of fit. Because the mean and variance of the expected normal distribution were estimated from the sample, the "most extreme absolute difference" given in the SPSSx output was compared to critical values given by Lilliefors (1967). Variables that were not normally distributed were transformed using the arcsine transformation for variables expressed as percentages and the square root transformation for variables expressed as counts or areas (Sokal and Rohlf 1981). Kolmogorov-Smirnov tests were repeated on the transformed data to determine whether the transformation was effective in achieving normality. Normally distributed variables were compared among the five fire size classes using one-way analysis of variance and the Student-Newman-Keuls test. Variables for which neither the raw data nor the transformed data were normally distributed were compared among fire size classes using the nonparametric Kruskal-Wallis test. This procedure was also used to compare variables among the seven preburn vegetation types. A significance level of $p \leq 0.0500$ was used for all statistical analyses.

V. RESULTS

The fire boundaries determined for this study were usually more detailed than those shown on the AFS fire maps. Although the fire boundaries determined by AFS are precise enough for their planning purposes, this study required greater precision in order to accurately determine amounts of edge between burned and unburned areas. In many cases the fire size calculated for this study was less than that given by AFS because of the difference in the precision of determining fire boundaries. The fire sizes calculated for the 74 fires initially selected for study ranged from 9 ha to 17,770 ha. Five of the 74 fires were eliminated from further analysis because the fire size determined for this study was less than the 20 ha minimum size established in the study design. This reduced the number of fires studied to 69 and increased the smallest fire size calculated for this study to 21 ha. The original distribution of 15 fires per size class was altered because of the differences between the fire sizes calculated for this study and those recorded by AFS (Table 3). The geographic distribution of the 69 fires studied is shown by fire size class in Figure 5.

Only one of the fires studied occurred in the deciduous mixedwood preburn vegetation type. Therefore, the deciduous mixedwood and coniferous mixedwood preburn types were combined into one class and referred to simply as mixedwood

Table 3. Distribution of fires studied by fire size class and by dominant preburn vegetation type (large fires in northern Alberta, 1970-1983).

DOMINANT PREBURN VEGETATION TYPE	FIRE SIZE CLASS †					TOTAL
	C	D	E_1	E_2	E_3	
Lowland Openings	1	6	2	3	0	12
Upland Openings	1	3	4	3	3	14
Deciduous Forest	1	2	0	3	2	8
Mixedwood	1	4	3	1	0	9
White Spruce or Pine	4	3	3	3	6	19
Black Spruce	0	2	1	3	1	7
Total	8	20	13	16	12	69

† Fire size class C = 20-40 ha, D = 41-200 ha, E_1 = 201-400 ha, E_2 = 401-2000 ha, E_3 = 2001-20,000 ha.

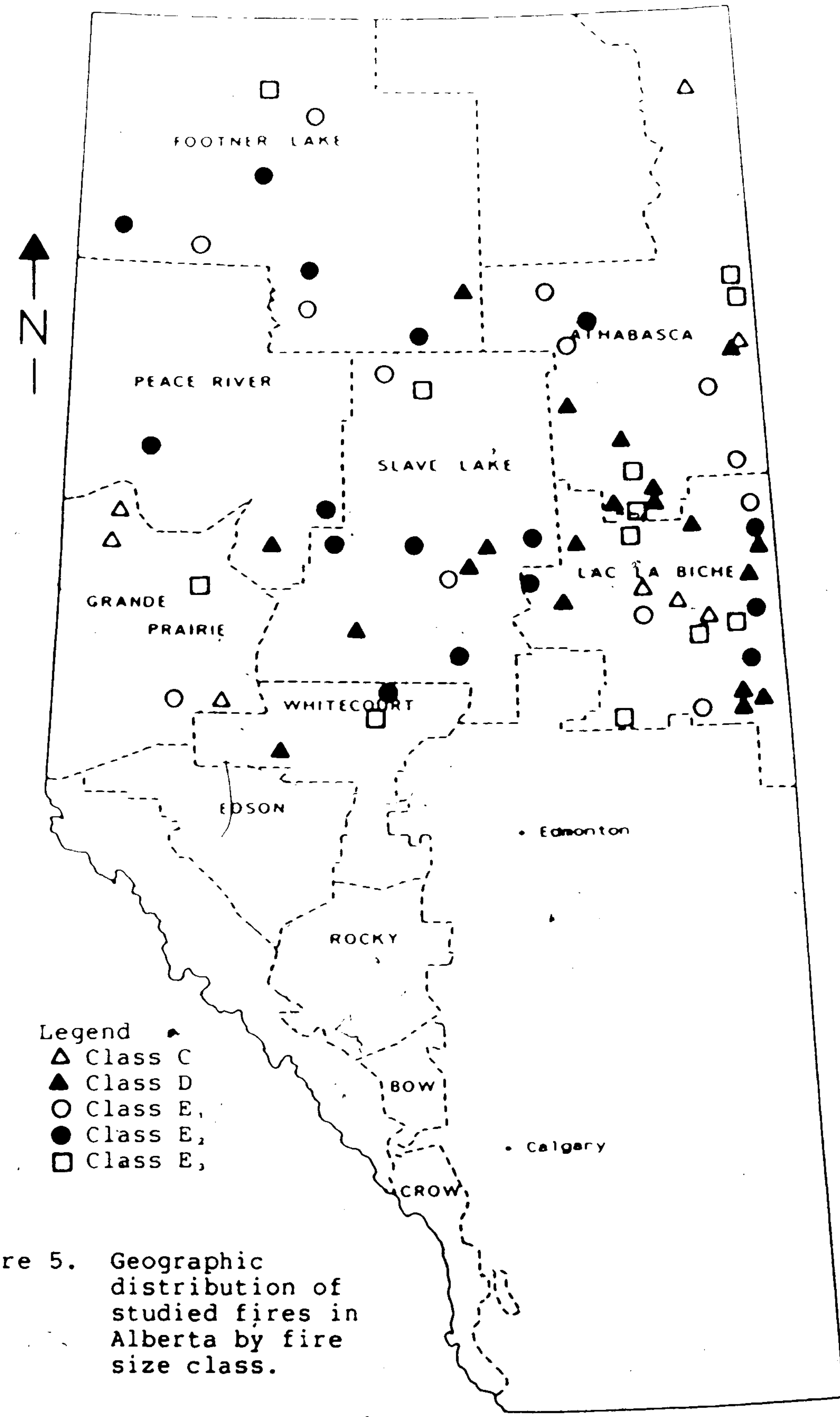


Figure 5. Geographic distribution of studied fires in Alberta by fire size class.

(Table 3). This combination was made only for preburn vegetation types. Deciduous mixedwood and coniferous mixedwood remained as separate species composition classes for describing residual vegetation.

Kolmogorov-Smirnov tests for normality revealed that none of the parameters measured were normally distributed, even after transformation. Therefore, all comparisons among fire size classes as well as among preburn vegetation types were made using the Kruskal-Wallis test that examines differences in mean ranks rather than mean values.

A. COMPARISONS OF RESIDUAL VEGETATION DISTRIBUTION AMONG FIRE SIZE CLASSES

The value of percent disturbed area was 100% for each of the eight fires studied in size class C. Because of the small sample size and lack of variation within this size class, it was not included in Kruskal-Wallis tests for differences among size classes in percent disturbed area and number of unburned islands per 100 ha. Median island area was considered to be undefined for fires that did not contain any islands. Therefore, fire size class C was also excluded from statistical tests involving median island area. Percent disturbed area decreased significantly ($p=0.0000$) with increasing fire size (Figure 6(A)). Mean values (SD) (SD = standard deviation) for percent disturbed area were 99.3 (1.1), 96.3 (4.5), 96.6 (2.4), and 94.8 (4.0)

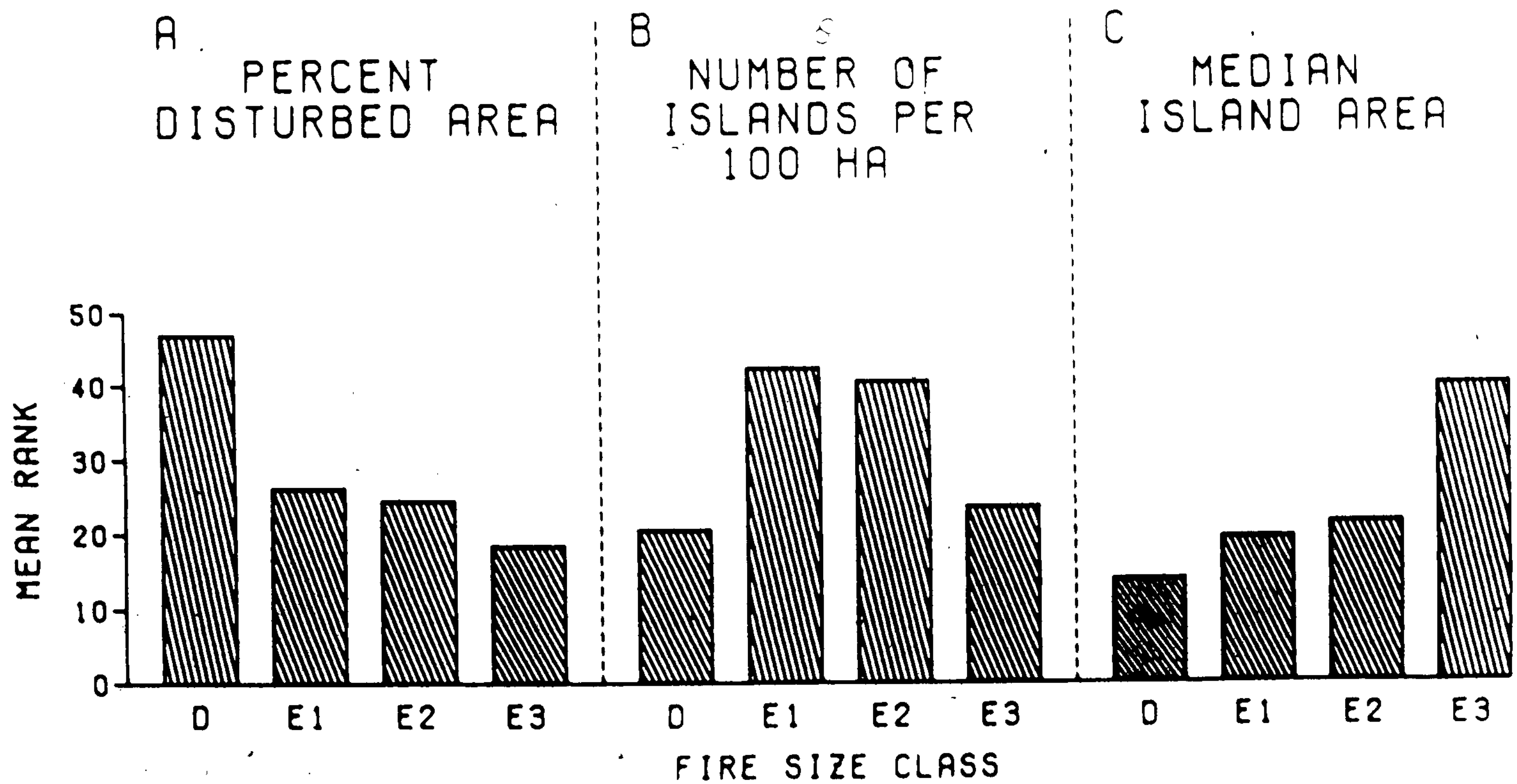


Figure 6. Mean rank of percent disturbed area, number of unburned islands per 100 ha, and median island area by fire size class for large fires in northern Alberta, 1970-1983.
(Fire size classes D = 41-200 ha, E1 = 201-400 ha, E2 = 401-2000 ha, E3 = 2001-20 000 ha)
(A Percent Disturbed Area n=61, Kruskal-Wallis H = 25 5026, p=0 0000)
(B Number of Islands / 100 ha n=61; Kruskal-Wallis H = 19 0112; p=0 0003)
(C Median Island Area n=48; Kruskal-Wallis H = 21 3891; p=0 0001)

for fire size classes D through E_3, respectively (Appendix Table B.1). The decrease in percent disturbed area was largely due to a significant increase (p=0.0001) in median island area with increased fire size (Figure 6(C)). Only 7 of the 20 class D fires studied (35%) contained islands. The other 13 fires were not included in analysis of median island area because this variable was considered to be undefined for a fire that did not contain islands. Mean values (SD) of median island area were 2.29 (1.91) ha, 2.50 (1.20) ha, 2.59 (1.03) ha, and 9.39 (8.84) ha for fire size classes D through E_3, respectively (Appendix Table B.1). Numbers of islands per 100 ha were greatest for fire size classes E_1 and E_2 and considerably lower for size classes D and E_3 (Figure 6(B)) and differences among fire size classes were significant (p=0.0003). Mean number of islands per 100 ha (SD) were 0.38 (0.63), 0.96 (0.50), 0.87 (0.41), and 0.39 (0.20) for fire size classes D through E_3, respectively (Appendix Table B.1). The low values of percent disturbed area for fire size class E_3 indicate that the large increases in island area more than compensated for the decreased number of islands per 100 ha in this size class. Number of islands per 100 ha and median island area and therefore percent disturbed area were very similar for size classes E_1 and E_2 (Figure 6).

The fire shape index and habitat diversity index increased significantly (p=0.0000 in both cases) with fire size (Figure 7). Mean values (SD) of the fire shape index were 1.79 (0.61), 2.40 (0.54), 2.36 (0.68), 2.96 (0.60), and 3.78 (0.99) for fire size classes C through E_3, respectively (Appendix Table B.2). Mean values (SD) of the habitat diversity index were 2.17 (0.91), 3.29 (1.12), 3.48 (1.34), 5.11 (2.17), and 7.47(3.16) for fire size classes C through E_3, respectively (Appendix Table B.2).

Percentages of burned area within 100, 200, 300, 400, and 500 m of residual vegetation all decreased significantly (p=0.0000 for all five distances) as fire size increased (Figure 8). For fire size class C, mean values (SD) of percent of burned area within 100 m and 200 m of residual vegetation were 82.5 (11.5) and 99.9 (0.2), respectively (Appendix Table B.3). All class C fires had maximum distances to residual vegetation of less than 300 m. Therefore, class C was not included in statistical tests for distances of 300, 400, and 500 m. Fire size class D had mean values (SD) of percent of burned area within 100, 200, 300, 400, and 500 m of residual vegetation of 77.3 (14.0), 96.3 (6.7), 99.3 (3.0), 99.8 (1.1), and 100.0 (0.1); respectively (Appendix Table B.3). Only one class D fire contained any burned area beyond 500 m from residual vegetation and this amounted to only 0.5% of the area disturbed in this fire. Mean values (SD) of percent of burned area within 100, 200, 300, 400, and 500 m of residual vegetation for fire size class E_1 were 56.1 (14.7), 83.1

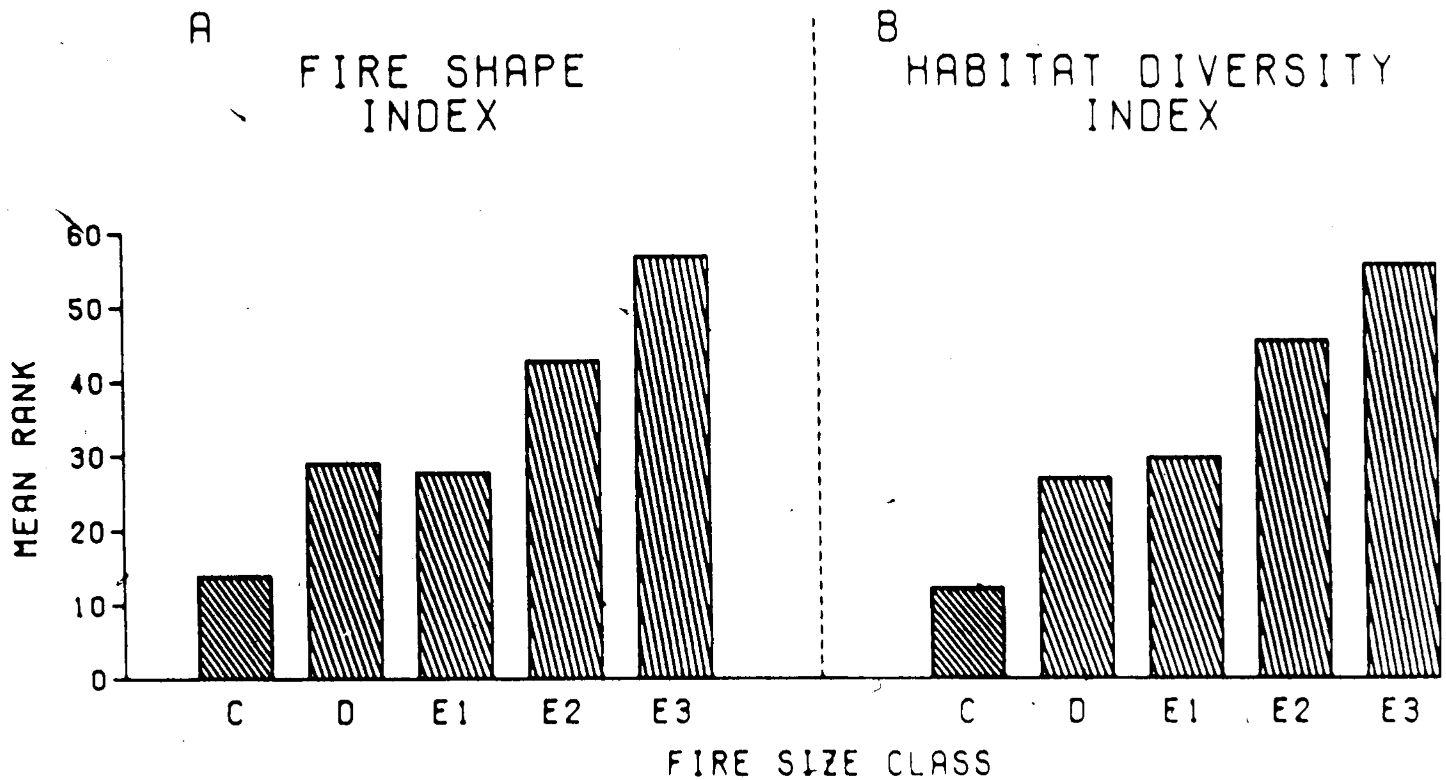


Figure 7. **Mean rank of fire shape index and habitat diversity index by fire size class for large fires in northern Alberta, 1970-1983.**
(Fire size classes: C = 20-40 ha, D = 41-200 ha, E1 = 201-400 ha, E2 = 401-2000 ha, E3 = 2001-20 000 ha)
(A Fire Shape Index n=69, Kruskal-Wallis H = 28.9804, p=0.0000)
(B Habitat Diversity Index n=69, Kruskal-Wallis H = 31.6381, p=0.0000)

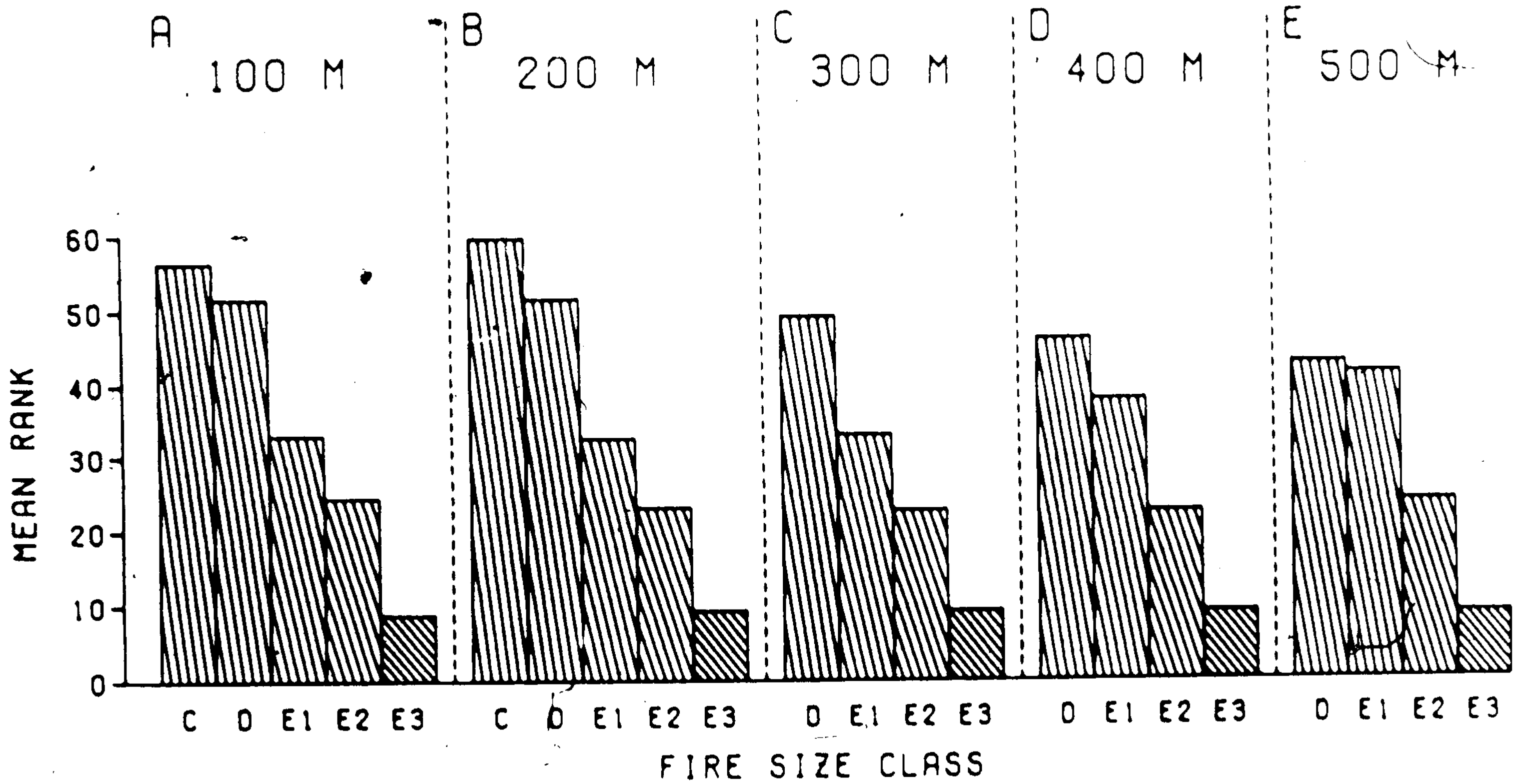


Figure 8. Mean rank of percentages of burned area within 100, 200, 300, 400, and 500 m of residual vegetation by fire size class for large fires in northern Alberta, 1970-1983.
(Fire size classes: C = 20-40 ha, D = 41-200 ha, E1 = 201-400 ha, E2 = 401-2000 ha, E3 = 2001-20 000 ha)
(A: % burned area within 100 m of residual vegetation, n=69, Kruskal-Wallis H = 47.6693, p=0.0000)
(B: % burned area within 200 m of residual vegetation, n=69, Kruskal-Wallis H = 51.7336, p=0.0000)
(C: % burned area within 300 m of residual vegetation, n=61, Kruskal-Wallis H = 43.2693, p=0.0000)
(D: % burned area within 400 m of residual vegetation, n=61, Kruskal-Wallis H = 42.4010, p=0.0000)
(E: % burned area within 500 m of residual vegetation, n=61, Kruskal-Wallis H = 42.6932, p=0.0000)

(13.0), 94.4 (8.5), 98.4 (4.9), and 99.4 (2.1); respectively (Appendix Table B.3). For fire size class E_2, mean values (SD) of percent of burned area within 100, 200, 300, 400, and 500 m of residual vegetation were 47.1 (12.3), 72.8 (12.6), 86.2 (10.9), 93.0 (8.8), and 96.1 (6.8); respectively (Appendix Table B.3). All class E_1 and E_2 fires had maximum distances to residual vegetation in excess of 200 m. Fire size class E_3 had mean values (SD) of percent of burned area within 100, 200, 300, 400, and 500 m of residual vegetation of 30.8 (7.1), 53.2 (10.7), 68.4 (12.2), 78.7 (12.3), and 86.1 (11.2); respectively (Appendix Table B.3). All class E_3 fires had maximum distances to residual vegetation in excess of 500 m.

B. COMPARISONS OF RESIDUAL VEGETATION COMPOSITION AMONG FIRE SIZE CLASSES

The composition of residual vegetation generally did not differ significantly among fire size classes. Mean rank of percent of fire perimeter bordering water increased significantly ($p=0.0204$) with fire size (Figure 9). However, this trend was not seen in mean values of percent of fire perimeter bordering water which were (SD): 4.3 (12.2), 0.4 (1.5), 3.3 (6.2), 2.3 (4.0), and 3.5 (5.6) for fire size classes C through E_3, respectively (Appendix Table B.4). Significant differences among fire size classes were not found for percentages of fire perimeter bordered by

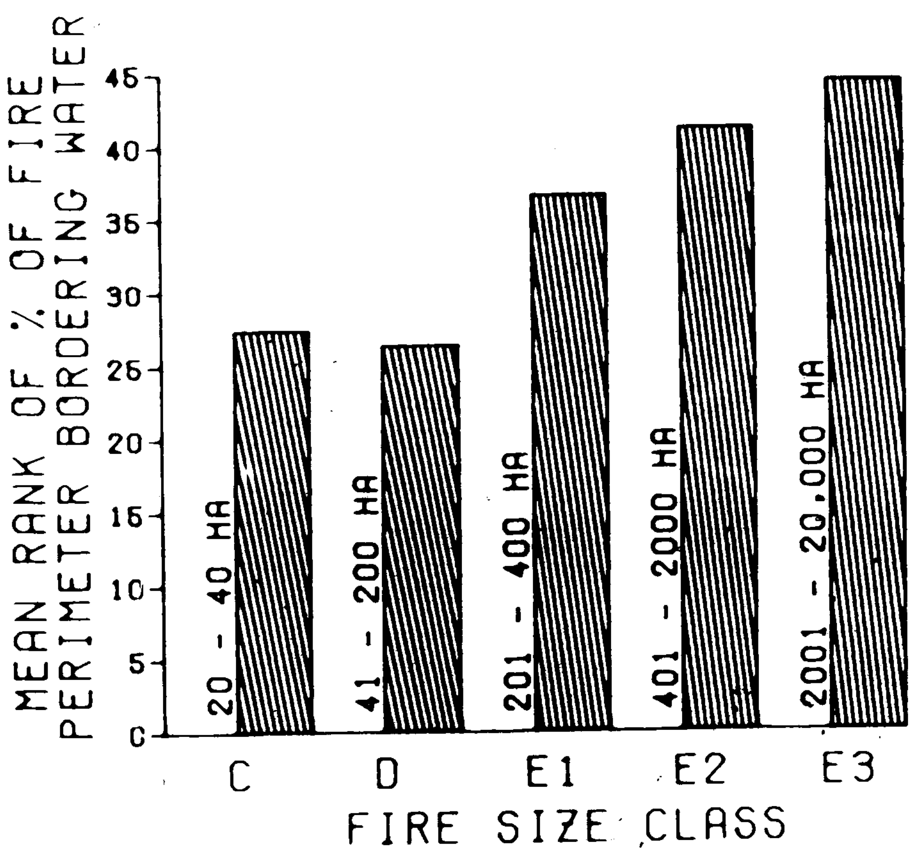


Figure 9. Mean rank of percent of fire perimeter bordering water by fire size class for large fires in northern Alberta, 1970-1983. (n=69; Kruskal-Wallis H = 11.6220; p=0.0204)

lowland openings, upland openings, and forest (Appendix Table B.4).

Forest density classes C (71-100% crown closure) and D (>100% crown closure; overstocked) were combined for all statistical analyses because only one fire had any residual forest in the D density class and only three percent of the forested perimeter of this fire bordered D density stands. Combining these two broad inventory density classes was justified because the combined class is exactly equivalent to density class D in the Phase III inventory (Table 2). Furthermore, there is no widely accepted understanding of what constitutes greater than 100% crown closure (E. Winquist, AFS Timber Management Branch; personal communication).

Significant differences among fire size classes were not found for percentages of forested fire perimeter bordering any of the three forest density classes or four forest height classes (Appendix Tables B.5 and B.6). Percent of forested fire perimeter bordering deciduous mixedwood stands increased through size class E_2 (Figure 10). The mean rank for size class E_3 lay between those for classes D and E_1 (Figure 10). These differences in mean rank among fire size classes were significant ($p=0.0419$). Significant differences among fire size classes were not found for percentages of forested fire perimeter bordering deciduous forest, coniferous mixedwood, white

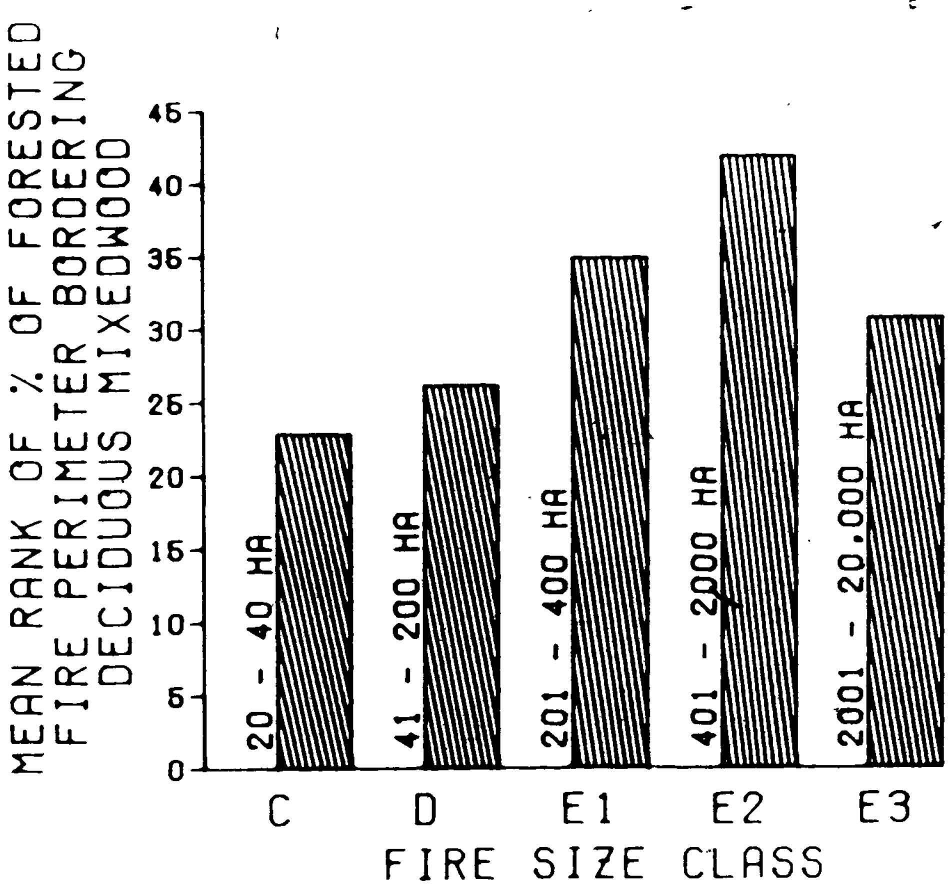


Figure 10. Mean rank of percent of forested fire perimeter bordering deciduous mixedwood by fire size class for large fires in northern Alberta, 1970-1983. (n=63; Kruskal-Wallis H = 9.9137; p=0.0419)

spruce or pine, or black spruce (Appendix Table B.7).

Percentages of unburned island area occupied by lowland openings, upland openings, and forest did not differ significantly among fire size classes (Appendix Table B.8). Percentages of forested island area in density class A (0-30% crown closure) were higher for fire size classes D and E_3 than for fire size classes E_1 and E_2 (Figure 11) and differences among size classes were significant (p=0.0302). Significant differences among fire size classes were not found for percentages of island area in density classes B (31-70% crown closure) or C (71-100% crown closure) (Appendix Table B.9). Percentages of forested island area in height class 1 (0-9 m) increased significantly (p=0.0147) with fire size (Figure 12). Percentages of forested island area in height classes 2 (9-18 m), 3 (18-24 m), and 4 (>24 m) did not differ significantly among fire size classes (Appendix Table B.10). Significant differences among fire size classes were not found for percentages of forested island area in any of the five species composition classes (Appendix Table B.11).

C. COMPARISONS OF RESIDUAL VEGETATION DISTRIBUTION AMONG DOMINANT PREBURN VEGETATION TYPES

Percent disturbed area, number of unburned islands per 100 ha, median island area, fire shape index, and habitat diversity index did not differ significantly among dominant

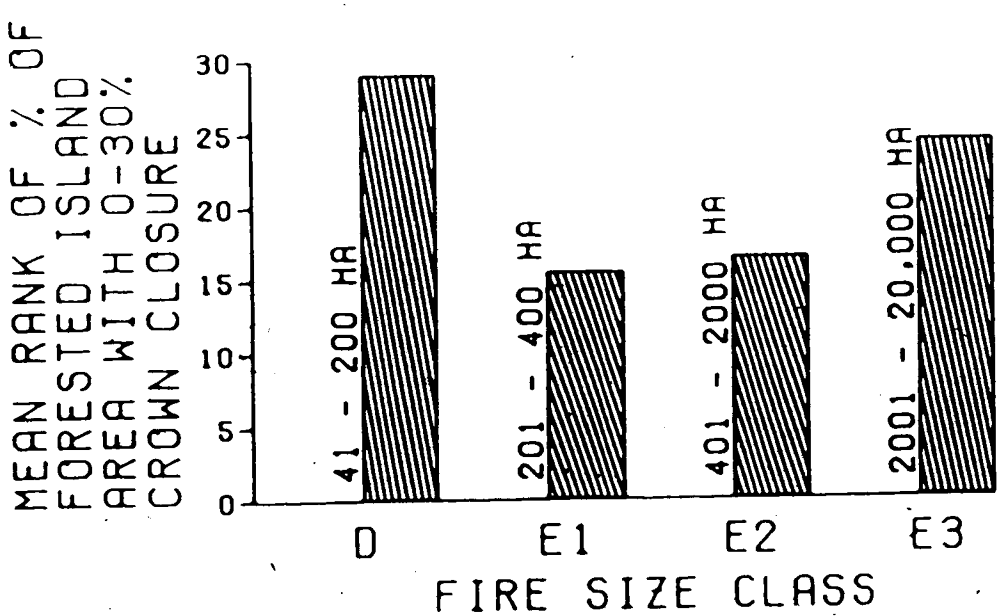


Figure 11. Mean rank of percent of forested island area with 0-30% crown closure by fire size class for large fires in northern Alberta, 1970-1983. (n=40; Kruskal-Wallis H = 8.9306; p=0.0302)

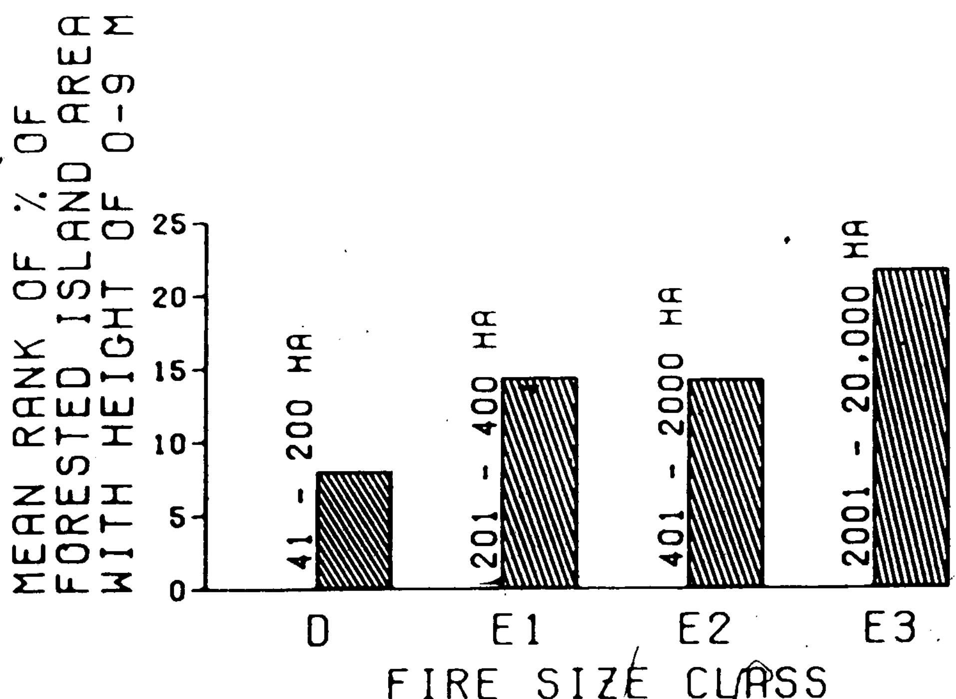


Figure 12. Mean rank of percent of forested island area with height of 0-9 m by fire size class for large fires in northern Alberta, 1970-1983. (n=29; Kruskal-Wallis H = 10.5118; p=0.0147)

preburn vegetation types (Appendix Tables B.12 and B.13). Significant differences among preburn vegetation types were not found for percentages of burned area within 100, 200, 300, or 400 m of residual vegetation (Appendix Table B.14). Percentages of burned area within 500 m of residual vegetation differed significantly among preburn vegetation types (p=0.0484). The highest values were for the lowland opening preburn vegetation type followed in descending order by mixedwood, upland opening, black spruce, white spruce or pine, and deciduous forest preburn vegetation types (Figure 13).

D. COMPARISONS OF RESIDUAL VEGETATION COMPOSITION AMONG DOMINANT PREBURN VEGETATION TYPES

Most variables describing the composition of residual vegetation differed significantly among dominant preburn vegetation types. Percentages of fire perimeter bordering water did not differ significantly among preburn vegetation types (Appendix Table B.15). Significant differences among preburn vegetation types were found for percentages of fire perimeter bordering lowland openings, upland openings, and forest (p=0.0000 in all three cases). The highest percentages of fire perimeter bordering lowland openings occurred in the lowland opening preburn vegetation type (Figure 14(A)). Similarily the highest percentages of fire perimeter bordering upland openings and forest were found in

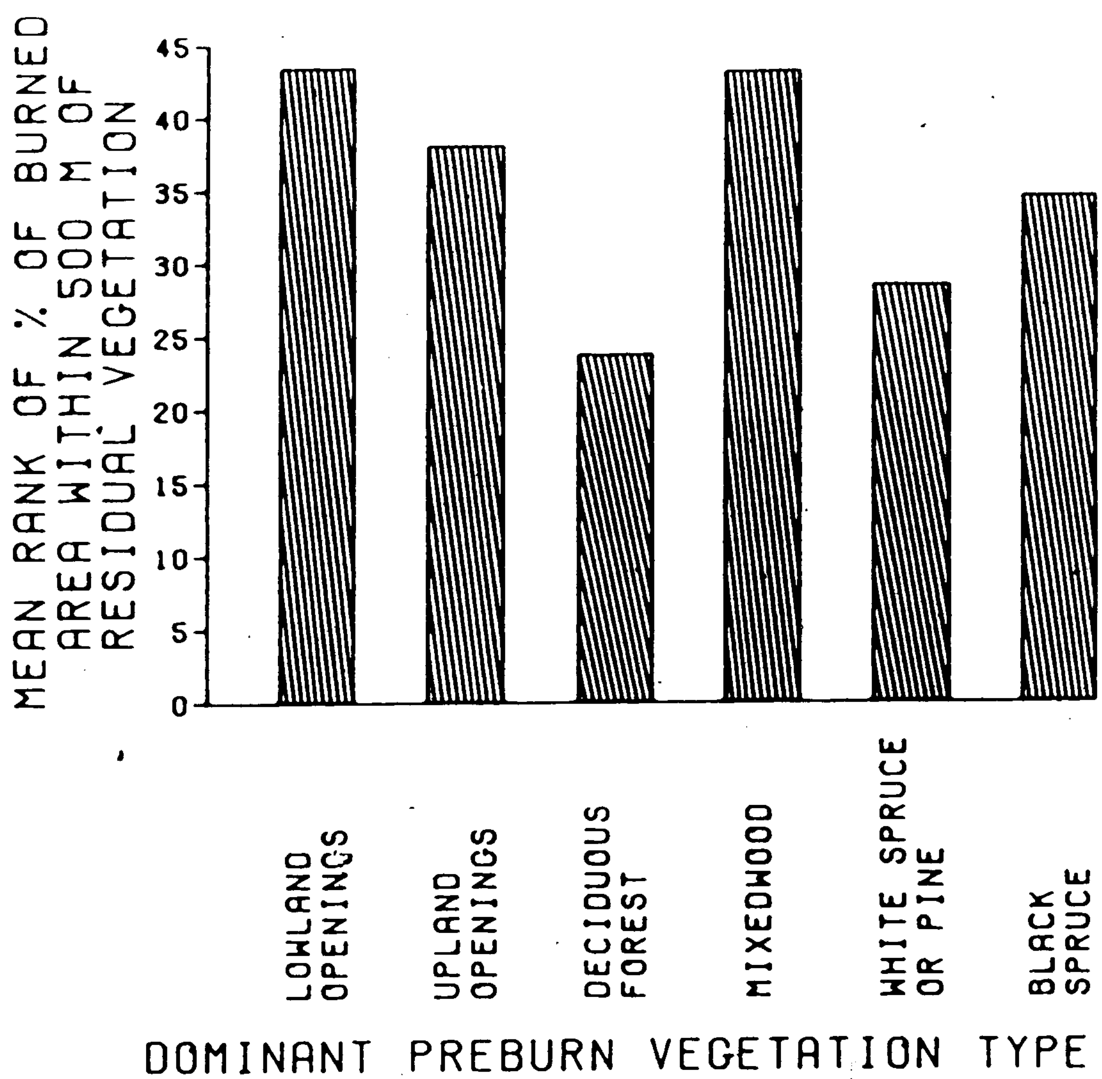


Figure 13. Mean rank of percent of burned area within 500 m of residual vegetation by dominant preburn vegetation type for large fires in northern Alberta, 1970-1983. (n=69; Kruskal-Wallis H = 11.1524; p=0.0484)

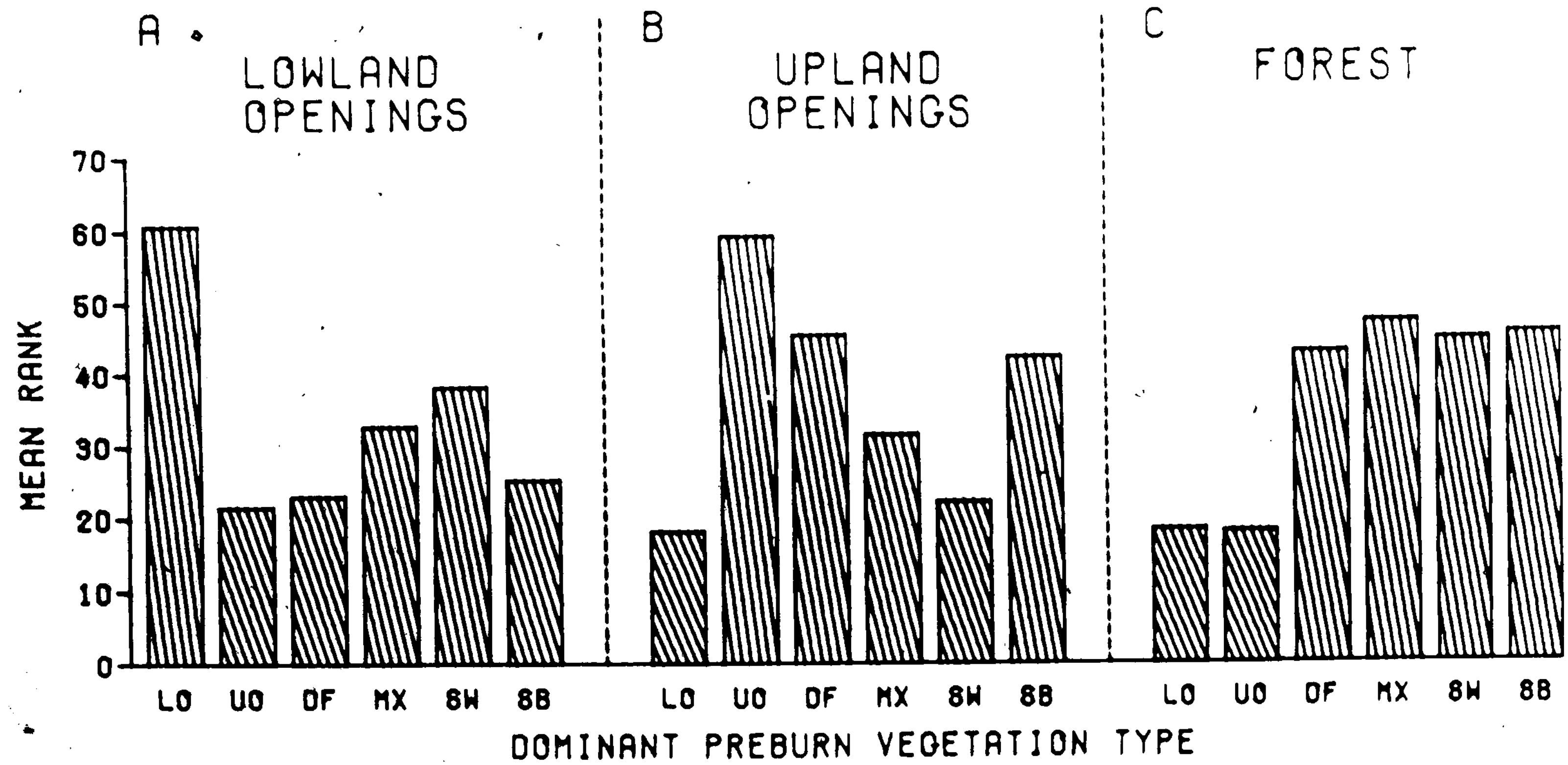


Figure 14. Mean rank of percentages of fire perimeter bordering lowland openings, upland openings, and forest by dominant preburn vegetation type for large fires in northern Alberta, 1970-1983.
(Preburn Vegetation Types: LO = Lowland Openings, UO = Upland Openings, DF = Deciduous Forest, MX = Mixedwood, SW = White Spruce or Pine, SB = Black Spruce)
(A. Lowland Openings: n=69; Kruskal-Wallis H = 31.4014; p=0.0000)
(B. Upland Openings: n=69; Kruskal-Wallis H = 40.9876; p=0.0000)
(C. Forest: n=69; Kruskal-Wallis H = 29.3743; p=0.0000)

the upland opening and forest preburn vegetation types, respectively (Figure 14(B and C)).

Percentages of forested fire perimeter bordering forest density classes A (0-30% crown closure) and B (31-70% crown closure) differed significantly among preburn vegetation types (p=0.0419 and 0.0241, respectively). The highest percentages of forested perimeter bordering A density stands were found in the lowland opening preburn vegetation type followed in descending order by upland opening, white spruce or pine, mixedwood, deciduous forest, and black spruce preburn vegetation types (Figure 15(A)). The highest percentages of forested perimeter bordering B density stands occurred in the black spruce type followed in descending order by mixedwood, deciduous forest, white spruce or pine, upland opening, and lowland opening preburn vegetation types (Figure 15(B)). Percentages of forested perimeter bordering forest density class C (71-100% crown closure) did not differ significantly among preburn vegetation types (Appendix Table B.16).

Significant differences among preburn vegetation types were not found for percentages of forested fire perimeter bordering any of the four forest height classes (Appendix Table B.17). The seven fires that occurred in the black spruce preburn vegetation type were all mapped with Phase III cover types. Because Phase III height data did not fit into the classification used for this study, the black

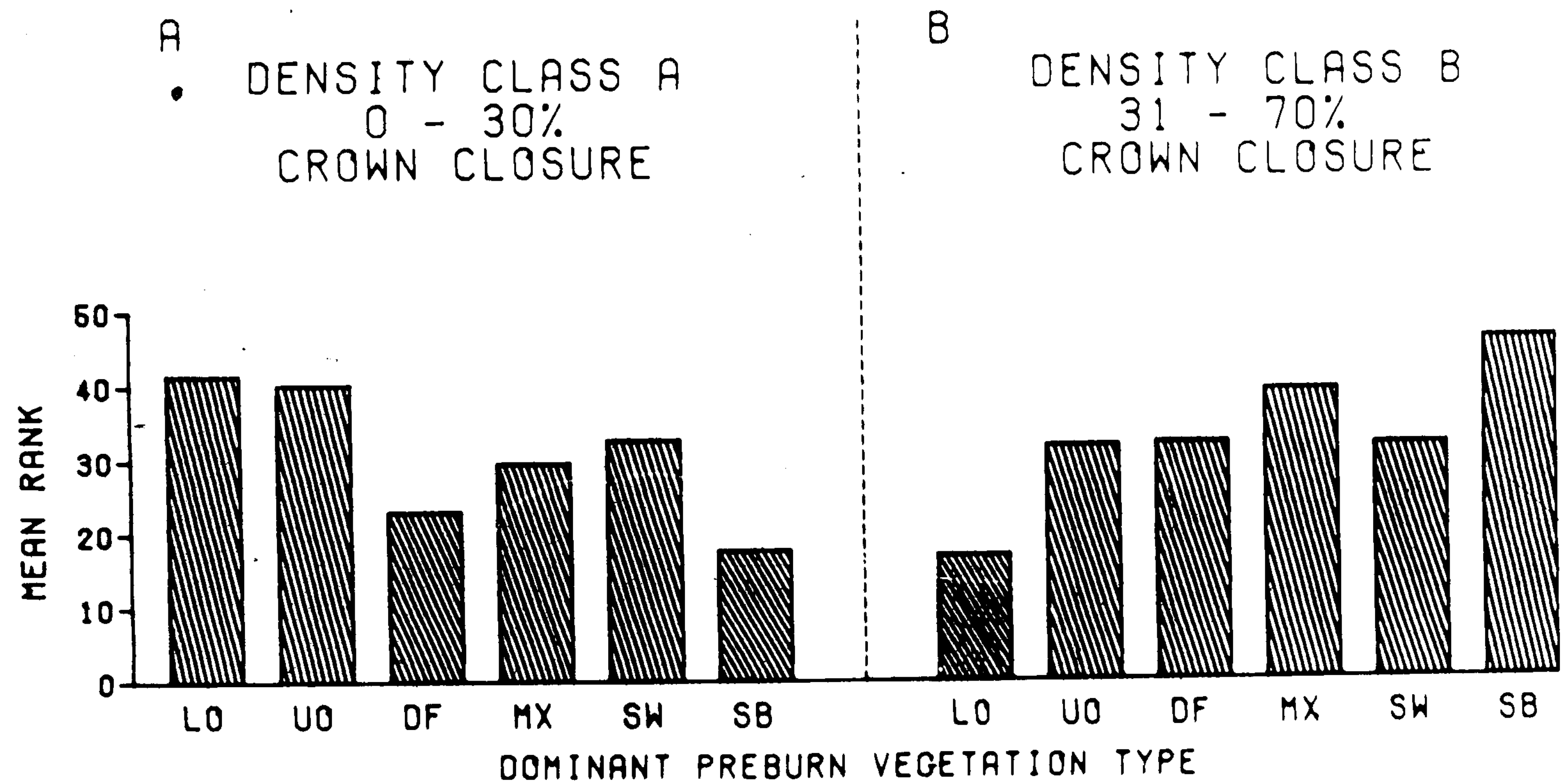


Figure 15. Mean rank of percentages of forested fire perimeter bordering forest density classes A and B by dominant preburn vegetation type for large fires in northern Alberta, 1970-1983.
(Preburn Vegetation Types. LO = Lowland Openings, UO = Upland Openings, DF = Deciduous Forest
MX = Mixedwood, SW = White Spruce or Pine, SB = Black Spruce)
(A Density Class A (0-30% crown closure) n=63; Kruskal-Wallis H = 11.5241, p=0.0419)
(B Density Class B (31-70% crown closure) n=63, Kruskal-Wallis H = 12.9194, p=0.0241)

spruce preburn vegetation type could not be included in the analysis of forest height data.

Percentages of forested fire perimeter bordering deciduous mixedwood did not differ significantly among preburn vegetation types (Appendix Table B.18). Percentages of forested perimeter bordering deciduous forest, coniferous mixedwood, white spruce or pine, and black spruce all differed significantly among preburn vegetation types (p=0.0001, 0.0039, 0.0000, and 0.0007; respectively). The highest percentages of forested fire perimeter bordering each of these four forest species composition classes occurred in the corresponding preburn vegetation types (Figure 16).

Significant differences among preburn vegetation types were found for percentages of island area occupied by lowland openings (p=0.0030), upland openings (p=0.0000), and forest (p=0.0000). The highest percentages of island area occupied by each general vegetation type were found in the corresponding preburn vegetation type (Figure 17).

Significant differences among preburn vegetation types were not found for percentages of forested island area in any of the three forest density classes (Appendix Table B.20). Percentages of forested island area in height classes 1 (0-9 m), 2 (9-18 m), and 3 (18-24 m) did not differ significantly among preburn vegetation types (Appendix Table B.21). Percentages of forested island area

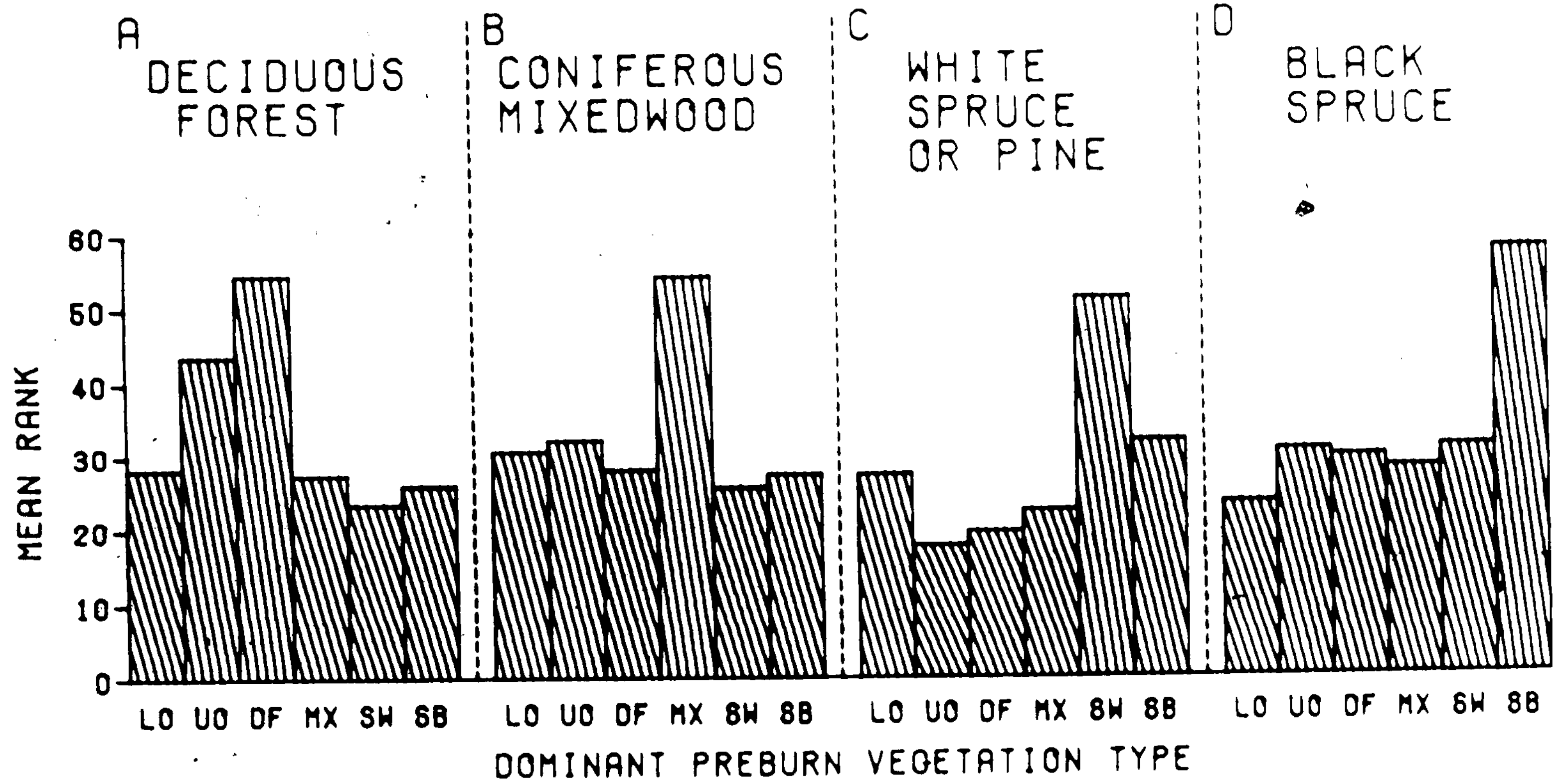


Figure 18. **Mean rank of percentages of forested fire perimeter bordering species composition classes by dominant preburn vegetation type for large fires in northern Alberta, 1970-1983**
(Preburn Vegetation Types LO = Lowland Openings, UO = Upland Openings, DF = Deciduous Forest
MX = Mixedwood, SW = White Spruce or Pine, SB = Black Spruce)
(A Deciduous Forest n=63; Kruskal-Wallis H = 24.9899, p=0.0001)
(B Coniferous Mixedwood n=63; Kruskal-Wallis H = 17.3396, p=0.0039)
(C White Spruce or Pine n=63; Kruskal-Wallis H = 33.7736, p=0.0000)
(D Black Spruce n=63; Kruskal-Wallis H = 21.3324, p=0.0007)

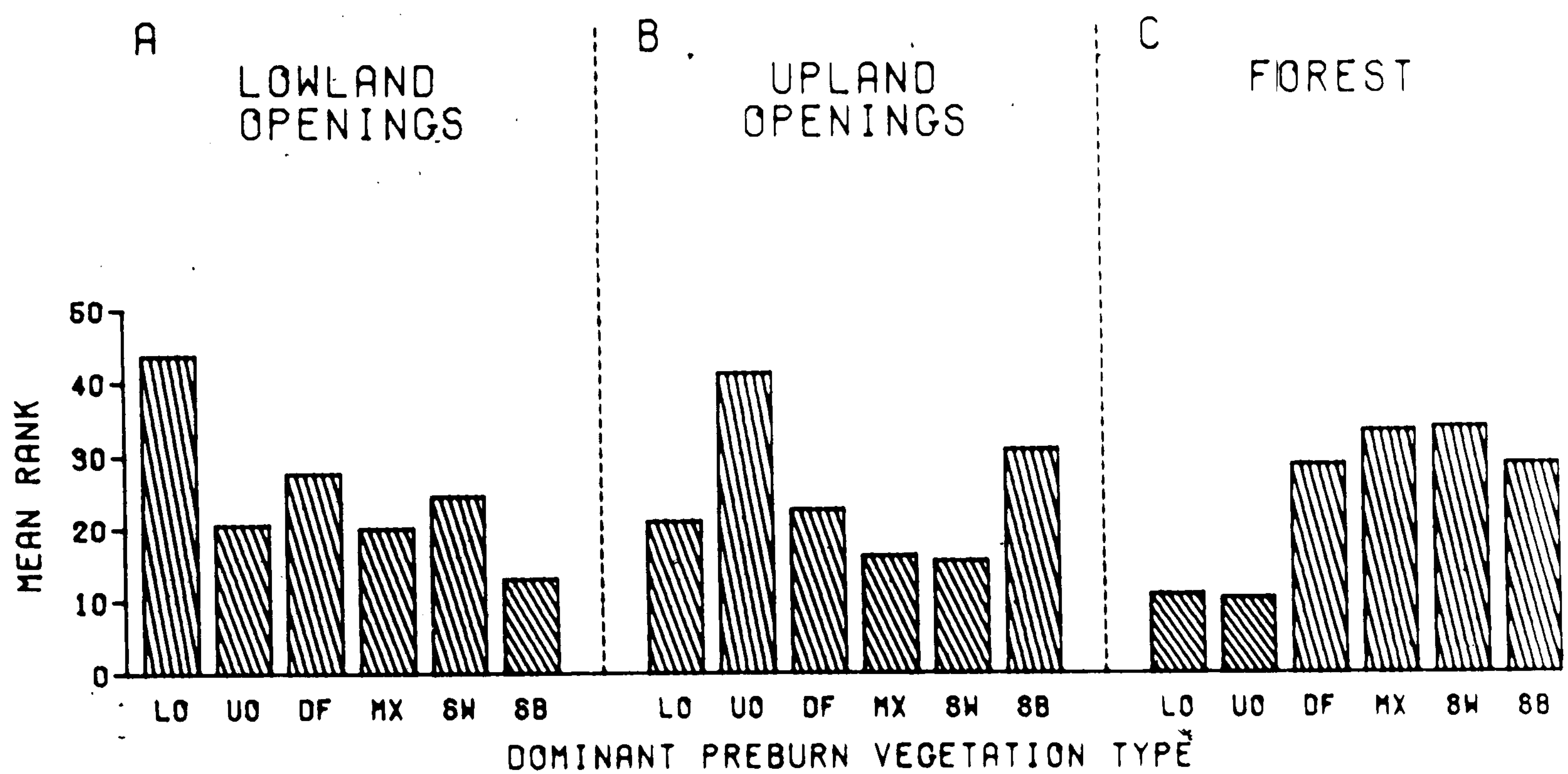


Figure 17. Mean rank of percentages of island area occupied by lowland openings, upland openings and forest by dominant preburn vegetation type for large fires in northern Alberta, 1970-1983.
(Preburn Vegetation Types: LO = Lowland Openings, UO = Upland Openings, DF = Deciduous Forest, MX = Mixedwood, SW = White Spruce or Pine, SB = Black Spruce)
(A Lowland Openings: n=48; Kruskal-Wallis H = 17.9270; p=0.0030)
(B Upland Openings: n=48; Kruskal-Wallis H = 28.8224; p=0.0000)
(C Forest: n=48; Kruskal-Wallis H = 27.5682; p=0.0000)

in height class 4 (>24 m) differed significantly among preburn vegetation types (p=0.0202) (Figure 18).

Percentages of island area occupied by deciduous forest, coniferous mixedwood, white spruce or pine, and black spruce differed significantly among preburn vegetation types (p=0.0101, 0.0222, 0.0054, and 0.0088; respectively). The highest percentages of forested island area occupied by each of these species composition classes occurred in the corresponding preburn vegetation types (Figure 19). Percentages of forested island area occupied by deciduous mixedwood did not differ significantly among preburn vegetation types (Appendix Table B.22).

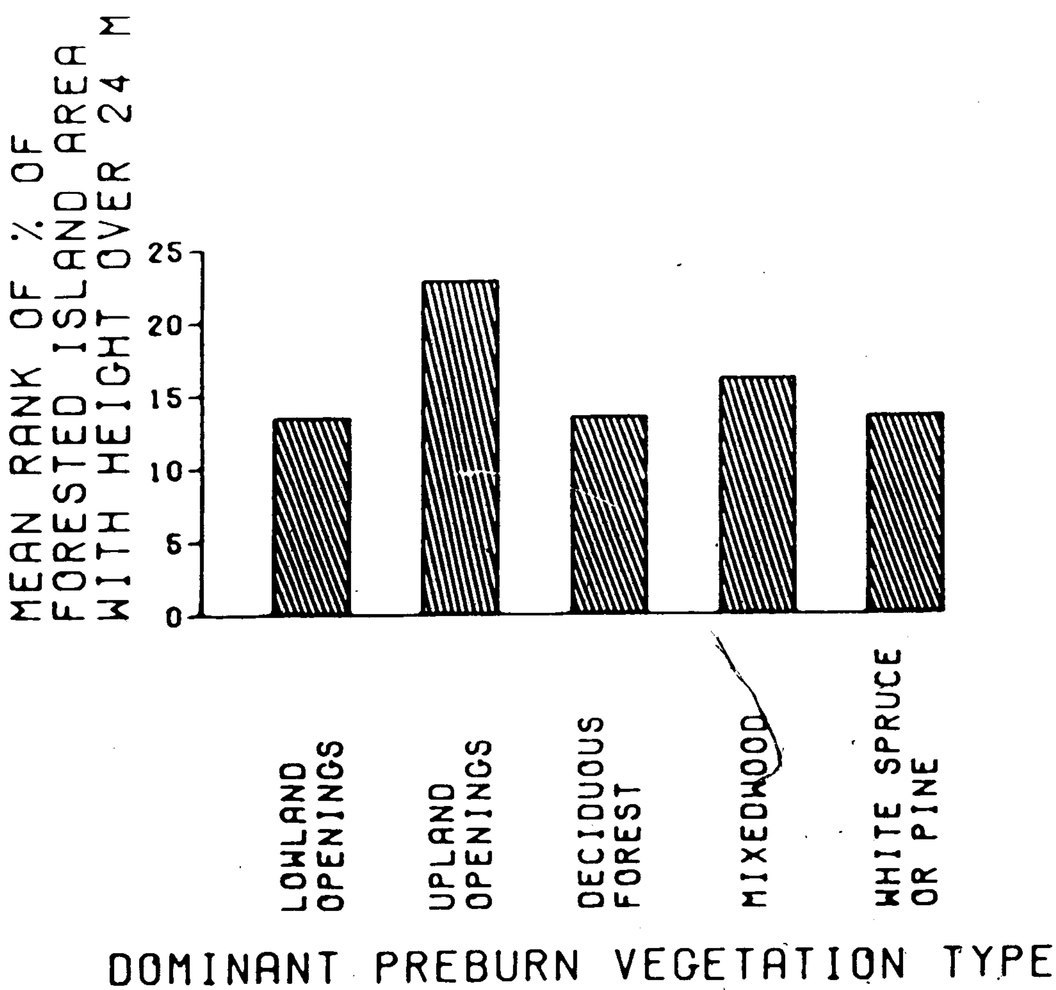


Figure 18. Mean rank of percent of forested island area with height over 24 m by dominant preburn vegetation type for large fires in northern Alberta, 1970-1983.
(n=29; Kruskal-Wallis H = 11.6502; p=0.0202)

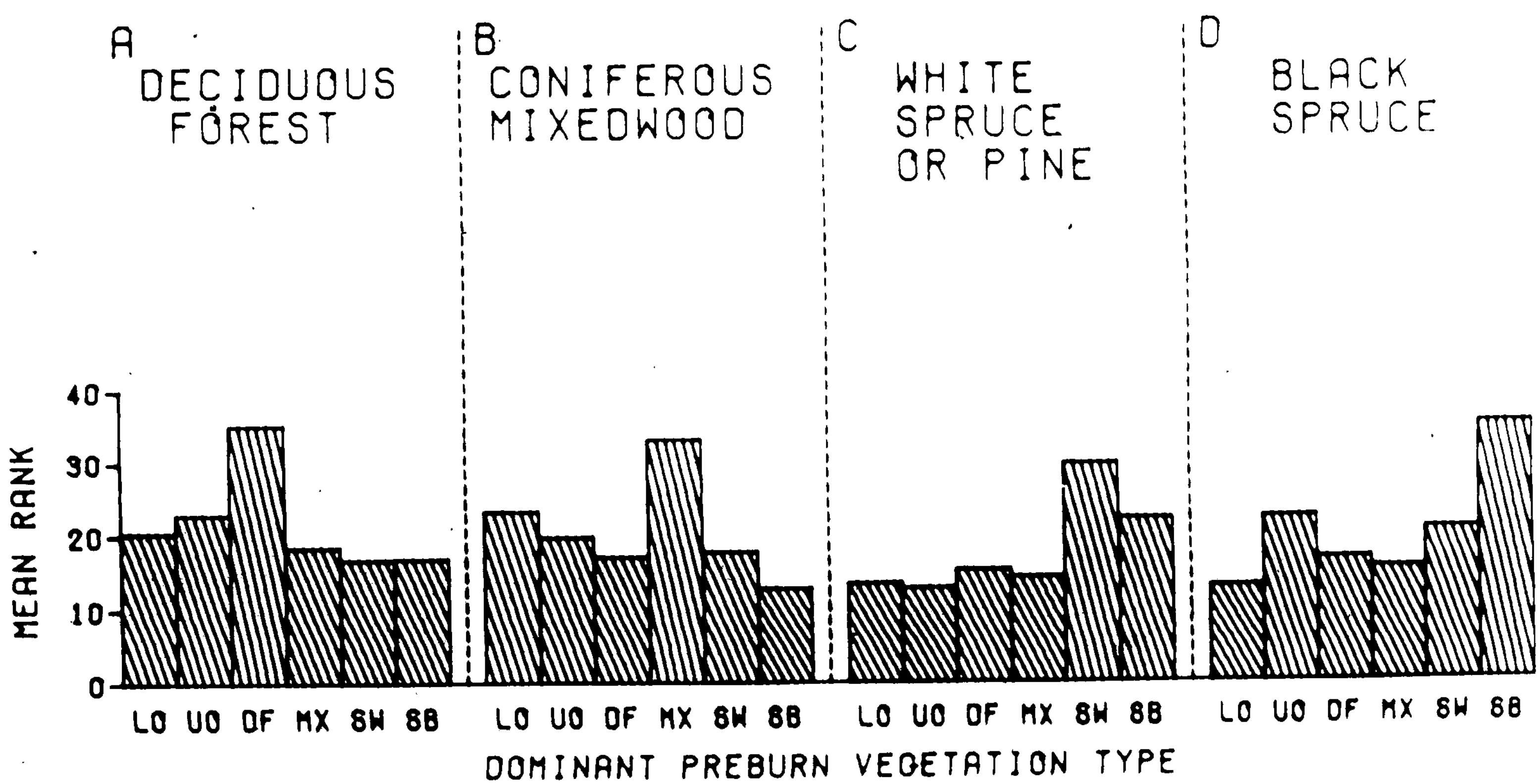


Figure 19. Mean rank of percentages of forested island area occupied by species composition classes by dominant preburn vegetation type for large fires in northern Alberta, 1970-1983
(Preburn Vegetation Types LO = Lowland Openings, UO = Upland Openings, DF = Deciduous Forest
MX = Mixedwood, SW = White Spruce or Pine, SB = Black Spruce)

(A Deciduous Forest n=40; Kruskal-Wallis H = 15.0616, p=0.0101)
(B Coniferous Mixedwood n=40; Kruskal-Wallis H = 13.1267, p=0.0222)
(C White Spruce or Pine n=40; Kruskal-Wallis H = 16.5778, p=0.0054)
(D Black Spruce n=40; Kruskal-Wallis H = 15.3921, p=0.0088)

VI. DISCUSSION

A. COMPARISONS AMONG FIRE SIZE CLASSES

Although many studies have acknowledged the presence of unburned islands of vegetation within large fires, few have speculated on the reasons for the existence of these islands. Quirk and Sykes (19[illegible]) found that unburned patches of 200 year-old white spruce occurred in slight depressions having higher soil moisture than adjacent 34-year-old stands that had originated after fires. Rowe and Scotter (1973) and Van Wagner (1983) also suggested topography may play a part in the formation of unburned islands. Variations in wind and the location of wetlands and water bodies may also affect the formation of unburned islands (Rowe and Scotter 1973). Foster (1983) suggested most narrow stringers of residual vegetation formed downwind of fuel breaks but he found no pattern in the distribution of larger islands. Fuel breaks may include water bodies, areas of bare soil or rock, or any other feature that disrupts the continuity of the fuel bed.

As fire size increases, the probability of encountering fuel breaks or topographic features that may be associated with island formation also increases. Increased burning time subjects large fires to variable winds (Foster 1983) that may also contribute to the formation of unburned islands. Many of the smaller fires examined during this study may not have covered a large enough area to encounter conditions associated with island formation or burned over a long enough time period to be subjected to variable winds. The total absence of unburned islands in fires in size class C (20-40 ha) and in 65% of fires in size class D (41-200 ha) is not surprising in view of the fact that the mean number of islands per 100 ha was less than 1.0 for each of the fire size classes (Appendix Table B.1). The decrease in number of islands per 100 ha for fires in size class E_3 (2001-20,000 ha) relative to those in size class E_2 (401-2000 ha) is not as easily explained. Perhaps these extremely large fires burned over such long periods of time that changes in wind direction were substantial enough to blow the fire back over areas that had previously escaped burning. Another possible explanation is that extremely large fires may be associated with long periods of drought that would leave very few areas moist enough to escape burning.

Increases in median island area with increased fire size (Figure 6(C)) could be explained by a tendancy for islands to occur downwind of fuel breaks. Large fires could burn around or spot over large fuel breaks that would stop smaller fires. These larger fuel breaks could conceivably result in the formation of larger islands.

Mean values of percent disturbed area for all five fire size classes exceeded the value of 85% reported by Gasaway and DuBois (1985) for a 500 km^2 (50,000 ha) fire in Alaska. This should be expected because the area of the Alaskan fire was 2.8 times the area of the largest fire examined for this study and the results of this study indicated that percent disturbed area decreased with increasing fire size. The minimum value of 82% found during this study (Appendix Table B.1) compares favorably to the value reported for the Alaskan fire.

Anderson (1983), referring to earlier studies, reported average fire shape index equalled 1.5 and 92% of fires had values less than 2.0. The mean value for class C fires in the present study was 1.69 and the mean values for size classes D through E_3 all exceeded 2.0 (Appendix Table B.2). The values given in the literature were based on elliptical approximations of fire shape that underestimated the actual fire perimeter (Anderson 1983). Because of the irregular nature of the fire edge, approximations of the actual perimeter measured for this study resulted in larger fire shape index values than previously reported. Anderson (1983) measured length to width ratios of elliptical approximations of fires at various stages of growth. Length to width ratios increased for some fires as they grew but remained relatively constant for others. The fact that the length to width ratio sometimes increased with fire size agrees with the increases in fire shape index associated with increased fire size in this study. Increases in fire shape index with increased fire size also agree with the suggestion by Foster (1983) that very large fires may have more complex shapes than smaller fires because they are exposed to greater variations in wind during their longer burning period. Unfortunately, the combined effects of the length to width ratio and irregularity of the fire edge on the fire shape index used in this study cannot be separated.

Increases in the habitat diversity index with increasing fire size (Figure 7(B)) closely paralleled similar increases for the fire shape index (Figure 7(A)). LeResche *et al.* (1974) reported 59 km of edge between mature stands and seral vegetation on a 2.5 km² sample of a 127,600 ha fire in Alaska. The habitat diversity index calculated with their data is 10.53, which is within the range of values measured for fire size class E_3 during the present study (1.76-14.31; Appendix Table B.2). The Alaskan value is above the mean values calculated for this study but this is to be expected because of the very large size of the Alaskan fire.

Increasing the number or size of unburned islands or the elongation or irregularity of fire shape (increased fire shape index) will, for a given size of fire, increase the percent of burned area within a given distance of residual vegetation. Increasing the size of a fire with a constant shape and constant number and size of islands will decrease the percent of burned area within a given distance of residual vegetation. Increases in number of islands per 100 ha, median island area, and fire shape index did not appear to be proportional to increases in total fire size (Appendix Tables B.1 and B.2) (this was not statistically tested). Therefore, the percentages of burned area within 100 200, 300, 400, and 500 m of residual vegetation declined significantly with increasing fire size (Figure 8), even though these decreases were partially countered by increases in number and size of islands and increases in elongation and irregularity of fire shape.

Significant differences in the composition of residual vegetation among fire size classes should not be expected unless preburn vegetation differed among fire size classes. There were no obvious associations between fire size class and dominant preburn vegetation types (Table 1) and the number of fires studied was not large enough to allow statistical analysis of such associations. The increase in mean rank of percent of fire perimeter bordering water with increasing fire size (Figure 9) may be misleading. Median values for percent of fire perimeter bordering water were 0.0 for all five fire size classes (Appendix Table B.4), no trends in mean percentages were observed with increasing fire size, and the standard deviations exceeded mean values for every fire size class. Therefore, it appears the trend of increased mean rank with increased fire size may be due to some problem with the data rather than differences in fire behavior.

Differences among fire size classes in mean rank of percent of forested fire perimeter bordering deciduous mixedwood were barely significant (p=0.0419). This combined with the reversal of the increasing trend in mean rank between fire size classes E_2 and E_3 (Figure 10), the lack of a consistent trend in mean values with increasing fire size (Appendix Table B.7), and the lack of significant differences among fire size classes for percent of forested fire perimeter bordering other species composition classes suggest the observed differences in mean rank may not be ecologically important. In view of the association found between residual species composition and dominant preburn vegetation type, it is possible that the results for percent of fire perimeter bordering deciduous mixedwood were affected by the fact that only one fire occurred in an area dominated by deciduous mixedwood prior to burning. There is no way to determine whether this small sample was due to chance associated with the random selection of fires or to an actual low occurrence of fires in areas dominated by deciduous mixedwood.

Differences among fire size classes in percent of forested island area in density class A (0-30% crown closure) and percent of forested island area in height class 1 (0-9 m) may be related to the small number and size of islands in class D fires. Only six class D fires contained residual forest within the fire perimeter. Each of these six fires contained only one island and each of these islands contained only one forested cover type. Therefore, for each class D fire, percentages of forested island area in each density, height, and species composition class were either 0 or 100. Thus, the high mean rank of percent of forested island area in density class A (Figure 11) and the low mean rank of percent of forested island area in height class 1 (Figure 12) for fire size class D may be due to extreme values resulting from small numbers and sizes of unburned islands for this fire size class. If the significant differences found among size classes for percent of forested island area in density class A were between fire size class D and the other three size classes, the differences may have been due to the small number and size of islands in fire size class D rather than actual differences in vegetation characteristics. The same is true in regard to differences in percent of forested island area in height class 1. Unfortunately, the results of Kruskal-Wallis tests do not reveal which individual size classes were different from each other.

B. COMPARISONS AMONG DOMINANT PREBURN VEGETATION TYPES

Burning patterns as described by percent disturbed area, number of islands per 100 ha, median island area, fire shape index, and habitat diversity index did not differ among preburn vegetation types. This lack of differences was not expected in view of the fact that flammability varies among tree species and therefore among forest types dominated by different tree species (Viereck and Schandelmeier 1980, Fischer and Clayton 1983, Van Wagner 1983). However, differences in flammability may simply affect the length of drying period necessary to support a crown fire (Van Wagner 1983). Under severe environmental conditions fire behavior in lowland forest types (e.g. black spruce) that have relatively low flammability is similar to that in upland forest types (e.g. white spruce or pine) that have relatively high flammability (Van Wagner 1983). This hypothesis is supported by the similarity in burning patterns among preburn vegetation types in this study.

The significant difference among preburn vegetation types in percent of burned area within 500 m of residual vegetation appears to contradict other results of this study. The percent of burned area within a given distance of residual vegetation varies directly with number of unburned islands, size of unburned islands, and fire shape index and varies inversely with fire size. Differences among preburn vegetation types in percent of burned area within 500 m of residual vegetation must be related to differences in fire size because number of unburned islands, size of unburned islands, and fire shape index did not differ among preburn vegetation types. However, differences among fire size classes for number of islands, size of islands, and fire shape index were highly significant. Therefore, if fire size varied among preburn vegetation types, corresponding variations should have been noted in number of islands, size of islands, and fire shape index – but they were not.

Comparisons of residual vegetation composition among dominant preburn vegetation types consistently showed that the highest percentages of fire perimeter bordering any given general vegetation type or forest species composition class occurred in the corresponding preburn type (Figures 14 and 16). The same trend was evident in the composition of island vegetation (Figures 17 and 19). The only two exceptions to this trend involved the percentages of forested fire perimeter and forested island area associated with the deciduous mixedwood species composition class. These two percentages did not differ significantly among preburn vegetation types. Based on results for other species composition classes, the highest percentages of residual forest associated with deciduous mixedwood should have been expected to occur in the mixedwood preburn vegetation type. However, only one fire occurred in an area dominated by deciduous mixedwood prior to burning; the other eight fires in the mixedwood preburn type occurred in areas dominated by coniferous mixedwood. The two exceptions to the general trend may have been due to this small sample size, from areas dominated by deciduous mixedwood.

The trend for composition of residual vegetation to correspond to the dominant preburn vegetation type suggests in a very general way that fires are not more readily stopped by some vegetation types than by others. Rather, the amount of fire edge bordering a particular vegetation type is roughly proportional to the occurrence of that vegetation type before burning. A much stronger statement could be made in this regard if the actual percentages of area occupied by each vegetation type before the fire were known. In order to obtain these percentages it would have been necessary to digitize every preburn stand within the fire perimeter. The time required for this task would have been prohibitive for this study.

Differences among preburn vegetation types in percent of forested fire perimeter bordering density class A (0-30% crown closure) and density class B (31-70% crown closure) (Figure 15) may have been due to the association of particular density classes with particular species composition classes rather than to differences in fire behavior. Residual forest in lowland opening and upland opening preburn vegetation types had a low density as indicated by these preburn types having high percentages of forested fire perimeter bordering stands with 0-30% crown closure (Figure 15(A)). Residual forest associated with forested preburn types, especially the black spruce preburn type, tended to be more closed as indicated by these preburn types having high percentages of forested fire perimeter bordering stands with 31-70% crown closure (Figure 15(B)).

The statistically significant difference among preburn vegetation types for mean rank of percent of forested island area in height class 4 (>24 m) may not be biologically important. This argument is based on the fact that fires occurring in the lowland opening, deciduous forest, and white spruce or pine preburn vegetation types did not contain any forested island stands with trees over 24 m in height. Further, the maximum percentages of forested island area occupied by stands with trees over 24 m in height were only five percent and eight percent for upland opening and mixedwood preburn vegetation types, respectively (Appendix Table B.21).

VII. CONCLUSIONS

The null hypothesis: *the percent of area within the fire perimeter that is actually burned does not differ significantly among fire size classes* was rejected. Percent disturbed area decreased significantly with increased fire size (p=0.0000).

The second null hypothesis stated: *the number of unburned islands per unit area does not differ significantly among fire size classes.* This hypothesis was also rejected. No islands occurred in any of the class C fires. Number of unburned islands per 100 ha were considerably higher for fire size classes E_1 (201-400 ha) and E_2 (401-2000 ha) than for size classes D (41-200 ha) and E_3 (2001-20,000 ha) and these differences were significant (p=0.0003).

The null hypothesis: *the size of unburned islands does not differ significantly among fire size classes* was also rejected. Median island area per fire increased significantly with fire size (p=0.0000).

The null hypothesis: *fire shape does not differ significantly among fire size classes* was rejected. The fire shape index, a ratio of the length of the main fire perimeter to the perimeter of a circle of equal area, increased significantly with fire size (p=0.0000). This means that as fire size increased, fire shape became more elongate or more irregular.

The null hypothesis: *the amount of edge between disturbed and residual areas, relative to the minimum possible amount, does not differ significantly among fire size classes* was rejected. This variable was described with a habitat diversity index that is a ratio of the total amount of edge between burned and unburned areas to the perimeter of a circle with an area equal to the total fire size. This index increased significantly with fire size (p=0.0000).

The null hypothesis: *the percentages of the disturbed area within 100, 200, 300, 400, and 500 m of residual vegetation do not differ significantly among fire size classes* was rejected. The percentage of disturbed area within each of the five distances of residual vegetation decreased significantly with increased fire size (p=0.0000 for all five distances).

Only one null hypothesis was proposed to examine differences in composition of residual vegetation: *the composition of residual vegetation surrounding and within large fires does not differ significantly among fire size classes.* This hypothesis was not rejected. Thirty-one separate statistical tests were performed to examine this null hypothesis. Percentages of fire perimeter bordering water and each of three general vegetation types were examined for differences among fire size classes. Percentages of forested fire perimeter in each of three density classes, four height classes, and five species composition classes were also examined for differences among fire size classes. The same tests were repeated for percentages of island area in each category except that water was not included in the description of unburned islands. Only 4 of the 31 tests revealed significant differences among fire size classes. Three of these four significant differences may have been due to small sample sizes. The fourth (percentage of fire perimeter bordering water) remains unexplained. The mean rank of this percentage increased significantly with increasing fire size. However, mean values showed no trend and standard deviations were larger than the means for all five fire size classes.

The same seven null hypotheses were examined in terms of differences among preburn vegetation types rather than among fire size classes, even though the original selection of fires was not stratified by preburn vegetation type. None of the six null hypotheses pertaining to the distribution of residual vegetation could be rejected for comparisons among preburn vegetation types. Percent of area actually burned, number of unburned islands per 100 ha, median island area, fire shape index, and habitat diversity index did not differ significantly among preburn vegetation types (p=0.9917, 0.8813, 0.9211, 0.4789, and 0.8105; respectively). Percentages of burned area within 100, 200, 300, and 400 m of residual vegetation did not differ significantly among preburn vegetation types (p=0.0592, 0.1390, 0.1262, and 0.0984; respectively). The percent of burned area within 500 m of residual vegetation differed significantly among preburn vegetation types (p=0.0484). However, this difference is barely significant and remains unexplained in view of other findings in regard to the distribution of residual vegetation.

The hypothesis: *the composition of residual vegetation surrounding and within large fires does not differ significantly among preburn vegetation types* was rejected. Percent of fire perimeter bordering water did not differ significantly among preburn vegetation types. The percentages of fire perimeter and island area associated with the three general vegetation types and the forested species composition classes differed among preburn vegetation types. The general trend was for the highest percentages of fire perimeter or island area associated with a given general vegetation type or forest species composition class to occur in the corresponding preburn vegetation type. There were two exceptions to this trend. Percentages of forested fire perimeter and forested island area associated with the deciduous mixedwood species composition class did not differ significantly among preburn vegetation types. This may have been due to a small sample size for fires occurring in areas dominated by deciduous mixedwood prior to burning. With three exceptions, percentages of forested fire perimeter and forested island area associated with the three density classes and four height classes did not differ significantly among preburn vegetation types. Percentages of forested fire perimeter bordering A density stands (0-30% crown closure) and B density stands (31-70% crown closure) differed significantly among preburn vegetation types (p=0.0419 and 0.0241 respectively). These differences were probably due to the association of particular density classes with particular species composition classes rather than to differences in fire behavior. The percent of forested island area in height class 4 (>24 m) differed significantly among preburn vegetation types (p=0.0202). However, this height class was present in the island vegetation of only two preburn vegetation types and represented less than 10% of the forested island area in each of these types.

Four objectives were set for this study. The first two were: (O_1) *to determine the spatial distribution of residual vegetation in and around large fires in Alberta* and (O_2) *to determine the composition of residual vegetation surrounding large fires and of unburned islands within large fires in Alberta.* These two objectives were accomplished. The third and fourth objectives were: (O_3) *to determine if the distribution and composition of residual vegetation vary among fire size classes*, and (O_4) *to determine if the* *distribution and composition of residual vegetation vary among dominant preburn vegetation types.* Two general conclusions can be made regarding the last two objectives of this study. The distribution of residual vegetation varied among fire size classes but not among preburn vegetation types. The composition of residual vegetation varied among preburn vegetation types but not among fire size classes.

VIII. MANAGEMENT IMPLICATIONS

A. IMPLICATIONS TO FOREST REGENERATION

Natural reforestation of burned areas can result from seeds and vegetative propagules that survive within the disturbed area or from seeds that disperse from stands of residual vegetation (Martin 1955, Lyon and Stickney 1974, Johnson 1975, Moore and Wein 1977, Archibold 1979, Archibold 1980). The relative importance of propagules surviving within the disturbed area versus seeds dispersed from residual stands varies among tree species. The success of regeneration decreases with increasing distance from the seed source for species that depend on dispersal of seed from residual stands (Zasada 1971, Viereck and Schandelmeier 1980).

Trembling aspen regenerates profusely through suckering from root tissue after fires (Zasada 1971, Archibold 1979, Archibold 1980). Aspen also produces large amounts of very light seed that can be dispersed extremely long distances by wind (Viereck and Schandelmeier 1980). Therefore, distance to residual vegetation is relatively unimportant to the establishment of trembling aspen in burned areas. White birch is also capable of vegetative reproduction following fire but the basal buds from which this regeneration originates are more easily killed by fire than are the roots of aspen (Zasada 1971). Most postburn reproduction of white birch is from seed (Zasada 1971). Although birch seed can disperse great distances, most falls within 100 m of the parent tree (Archibold 1980). Regeneration of white spruce is usually dependent on seeds dispersed from residual stands (Archibold 1980, Viereck and Schandelmeier 1980) and the maximum seed dispersal distance for this species is approximately 100 m (Dobbs 1972). Maximum seed dispersal distances for lodgepole pine and black spruce are also about 100 m (Zasada 1971, Lotan 1975). Lodgepole pine and jack pine often release viable seeds from serotinous cones on burned trees (Lotan 1975, Cayford and McRae 1983). Very intense fires may kill seeds stored in serotinous cones (Brown 1975). The cones of black spruce are semi-serotinous and clumps of cones in tops of trees often contain viable seeds after burning (Zasada 1971, Viereck 1983). Thus, successful regeneration of lodgepole pine, jack pine, and black spruce often is not dependent on seed dispersal from residual stands unless the fire was very intense.

The percent of burned area within 100 m of residual vegetation decreased with increasing fire size (Figure 8(A); Appendix Table B.3). Therefore, the potential for natural reforestation of the entire burned area by tree species that depend on dispersal of seed from residual areas also decreases with increasing fire size. Despite the decreasing potential for natural reforestation with increasing fire size, even the largest burns contain substantial areas that can be reforested from natural seed sources. Considerable time and money can be saved if this is taken into account when planning planting programs for the rehabilitation of burned areas. The percentages of burned area within 100 m of residual vegetation that are presented in Appendix Table B.3 do not take into account stands of residual vegetation less than one hectare in size. Although such islands did exist and are potential seed sources, they were too small to be mapped at the scales used in this study. Therefore, the percentages of burned area within 100 m of residual vegetation that are presented in Appendix Table B.3 are minimum percentages of burned area that can be revegetated by seeds dispersed from residual vegetation.

To determine the proportion of burned area that can potentially be revegetated by a particular tree species, the proportion of burned area within 100 m of residual vegetation must be multiplied by the proportion of residual vegetation that was forest and the proportion of residual forest associated with the species of interest. For example, if 80% of the disturbed area for a particular fire was within 100 m of residual vegetation, 50% of the residual vegetation was forest, and 60% of the residual forest was white spruce, then 24% of the burned area could potentially be revegetated by white spruce ($0.8 \times 0.5 \times 0.6 = 0.24$). Generalizations involving the mean percentages of residual vegetation associated with forest and mean percentages of residual forest associated with particular species composition classes would be of little value because of the high standard deviations associated with these means (Appendix Tables B.15, B.18, B.19, and B.22). Therefore, the potential for regeneration of a particular species must be analyzed for each individual fire.

B. IMPLICATIONS TO UNGULATE HABITAT

Use of foraging areas by ungulates decreases as distance to cover increases and it has been suggested that distances to cover in optimum ungulate habitat should not exceed 200 m (Oldemeyer and Regelin 1980, Euler 1981). Percentages of burned area within 200 m of residual vegetation decreased with increasing fire size (Figure 8(B); Appendix Table B.3). Therefore, although larger fires produce larger foraging areas, the percent of foraging habitat that is close enough to cover to receive optimum use decreases with increasing fire size. The percentages of burned area within 200 m of residual vegetation that are presented in Appendix Table B.3 are the maximum percentages of burned area that could provide optimal foraging habitat if all residual vegetation provided suitable cover.

Median island areas for fire size classes D, E_1, and E_2 (Appendix Table B.1) were slightly below the optimal size of three to five hectares recommended by Euler (1981) for islands of cover habitat for moose and considerably below the minimum size of 12 ha recommended by Thomas *et al.* (1976) for elk. Median island areas for fire size class E_4 (Appendix Table B.1) meet the requirements for cover habitat for moose. Although the mean value of median island area for fire size class E_3 was less than the minimum requirement for cover habitat for elk, the maximum value (35.11 ha; Appendix Table B.1) indicates that some of the islands in fires in this size class are large enough to provide elk with suitable cover.

Several authors have suggested that increased amounts of habitat edge are beneficial to wildlife (Thomas *et al.* 1979, Bangs and Bailey 1980). The habitat diversity index, a measure of the length of edge in a given area relative to the minimum possible amount, increased with fire size (Figure 7(B)), suggesting benefits to wildlife habitat may increase with fire size. However, this apparent benefit to wildlife habitat was countered by increasing percentages of burned area beyond 200 m from cover.

Thomas *et al.* (1976) suggested adequate thermal cover for elk should have at least 75% crown closure and Telfer (1984) suggested at least 50% crown closure for cover habitat for moose. In terms of the density classes used in this study, density class C (71-100% crown closure) meets these requirements. Some stands in density class B (31-70% crown closure) may also provide adequate cover. Adequate thermal cover for elk is at least 12 m in height (Thomas *et al.* 1976) and adequate cover for moose is at least 10 m in height (Telfer 1984). Thus, adequate cover should be provided by height classes 2 (9-18 m), 3 (18-24 m), and 4 (>24 m). The lower extreme of class 2 may be marginal.

Welsh *et al.* (1980) reported that use of mixedwood stands by moose declined if the coniferous component was less than 20% and Telfer (1984) described good moose cover as being less than 50% deciduous. In terms of the forest species composition classes used for this study, coniferous mixedwood, white spruce or pine, and black spruce should provide suitable cover. The greatest percentages of residual forest associated with these species composition classes occurred in the mixedwood, white spruce or pine, and black spruce preburn vegetation types, respectively. Therefore, fires in these preburn vegetation types have greater potential for improving ungulate habitat than do fires occurring in the lowland opening, upland opening, or deciduous forest preburn vegetation types. Actual percentages of residual vegetation associated with particular general vegetation types and percentages of residual forest associated with particular density, height, and species composition classes were extremely variable within as well as among dominant preburn vegetation types (Appendix Tables B.15 through B.22). Therefore, the suitability of the composition of residual vegetation for cover habitat must be assessed for each individual fire.

IX. FUTURE RESEARCH

Many of the results of this study merit further examination. Ground truthing of residual vegetation is needed to assess damage that cannot be seen on aerial photographs. Ground fires may inflict potentially lethal damage to the trunks and lower crowns of trees without immediately disturbing the upper canopy. Such damage could not be determined from the air photos used in this study because the fires were photographed almost immediately after burning. Ground truthing should also assess wind damage to small islands and to narrow pockets of residual vegetation extending into the burned area. Ground truthing should be done at least one year after burning to allow time for these potential reductions in the amount of residual vegetation to manifest themselves. It may also be possible to assess these factors by examining later air photos. However, it may be difficult to distinguish residual vegetation from regrowth in many cases.

I have mentioned several times the importance of comparing the composition of residual vegetation to the actual composition of preburn vegetation. With the data base used for this study, it would have been necessary to digitize every preburn stand on the AFS fire maps in order to determine the actual composition of preburn vegetation. This would simply have been too time consuming for this study. Recently developed Geographic Information Systems that are now being used by many natural resource agencies have data storage and retrieval capabilities that will make it very easy to determine the actual composition of preburn vegetation for future studies.

More work is needed to explain why islands of unburned vegetation occur. This should involve mapping the positions of water bodies and other fuel breaks relative to the location of unburned islands. An attempt should also be made to determine wind conditions at the time the fire front passed the location of islands. Topographic variations associated with island occurrence should also be more closely examined.

A great deal of work is necessary in the evaluation of use of residual cover habitat by ungulates. Much work has been done on the use of burned areas by ungulates. However, most published descriptions of what constitutes suitable cover habitat in terms of island size and vegetation characteristics seem to be based largely on speculation. Field work is also needed to evaluate relationships between the habitat diversity index and wildlife population responses.

X. LITERATURE CITED

Anderson, H.E. 1983. Predicting wind-driven wild land fire size and shape. USDA For. Serv. Research Paper INT-305, Intermountain Forest and Range Exp. Stn., Ogden, Utah. 26 pp.

Archibold, O.W. 1979. Buried viable propagules as a factor in postfire regeneration in northern Saskatchewan. Can. J. Bot. 57:54-58.

Archibold, O.W. 1980. Seed input into a postfire site in northern Saskatchewan. Can. J. For. Res. 10:129-134.

Bangs, E.E. and T.N. Bailey. 1980. Interrelationships of weather, fire, and moose on the Kenai National Moose Range, Alaska. Proc. N. Am. Moose Conf. Workshop 16:255-274.

Bendell, J.F. 1974. Effects of fire on birds and mammals. Chpt. 4, pp. 73-138 in T.T. Kozlowski and C.E. Ahlgren (eds.). Fire and Ecosystems. Academic Press, New York.

Brown, Arthur A. and Kenneth P. Davis. 1973. Forest Fire: Control and Use (2nd ed.). McGraw Hill BooK Co., New York. 686 pp.

Brown, James K. 1975. Fire cycles and community dynamics in lodgepole pine forests. pp. 429-456 in D.M. Baumgartner (ed.). Management of Lodgepole Pine Ecosystems - Symposium Proceedings. Washington State University Cooperative Extension Service, Pullman.

Cayford, J.H. and D.J. McRae. 1983. The ecological role of fire in jack pine forests. Chpt. 10, pp. 183-199 in Ross W. Wein and David A. MacLean (eds.). The Role of Fire in Northern Circumpolar Ecosystems. John Wiley and Sons, New York.

Chandler, Craig, Phillip Cheney, Philip Thomas, Louis Trabaud, and Dave Williams. 1983. Fire in Forestry. Volume 2: Forest Fire Management and Organization. John Wiley and Sons, New York. 298 pp.

Dobbs, Robert C. 1972. Regeneration of white and Engelmann spruce: a literature review with special reference to the British Columbia interior. CFS Info. Rept. BC-X-69, Pacific Forest Research Centre, Victoria. 77 pp.

Euler, D. 1981. A moose habitat strategy for Ontario. *Alces* 17:180-192.

Fischer, William C. and Bruce D. Clayton. 1983. Fire ecology of Montana forest habitat types east of the continental divide. USDA For. Serv. Gen. Tech. Rept. INT-141, Intermountain Forest and Range Exp. Stn., Ogden, Utah. 83 pp.

Foster, David R. 1983. The history and pattern of fire in the boreal forest of southeastern Labrador. Can. J. Bot. 61:2459-2471.

Gasaway, William C. and Stephen D. DuBois. 1985. Initial response of moose to a wildfire in interior Alaska.

Can. Field Nat. 99:135-140.

Government of Alberta and The University of Alberta. 1969. Atlas of Alberta. University of Alberta Press, Edmonton and University of Toronto Press, Toronto. 158 pp.

Hosie, R.C. 1979. Native Trees of Canada (8th ed.). Fitzhenry and Whiteside Limited, Don Mills, Ontario. 380 pp.

Johnson, E.A. 1975. Buried seed populations in the subarctic forest east of Great Slave Lake, Northwest Territories. Can. J. Bot. 53:2933-2941.

LeResche, R.E., R.H. Bishop, and J.W. Coady. 1974. Distribution and habits of moose in Al[illegible] Naturaliste can. 101:143-178.

Lilliefors, H.W. 1967. The Kolmogorov-Smirnov test for normality with mean and variance unknown. J. Amer. Stat. Assoc. 62:399-402.

Lotan, James E. 1975. The role of cone serotiny in lodgepole pine forests. pp. 471-495 in D.M. Baumgartner (ed.). Management of Lodgepole Pine Ecosystems – Symposium Proceedings. Washington State University Cooperative Extension Service, Pullman.

Lyon, L. Jack and Peter F. Stickney. 1974. Early vegetal succession following large northern Rocky Mountain wildfires. Proc. Tall Timbers Fire Ecol. Conf. 14:355-375.

Lyon, L. Jack, Hewlette S. Crawford, Eugene Czuhai, Richard L. Fredricksen, Richard F. Harlow, Louis J. Metz, and Henry A. Pearson. 1978. Fire Effects on Fauna: a State of Knowledge Review. USDA For. Serv. Gen. Tech. Rept. WO-6. 22 pp.

Martin, J. Lynton. 1955. Observations on the origin and early development of a plant community following a forest fire. For. Chron. 31:154-161.

Moore, Janice M. and Ross W. Wein. 1977. Viable seed populations by soil depth and potential site recolonization after disturbance. Can. J. Bot. 55:2408-2412.

Noste, N.V. and J.B. Davis. 1975. A critical look at fire damage appraisal. J. For. 73:715-719.

Oldemeyer, J.L. and W.L. Regelin. 1980. Response of vegetation to tree crushing in Alaska. Proc. N. Am. Moose Conf. Workshop 16:429-443.

Quirk, William A. and Dwane J. Sykes. 1971. White spruce stringers in a fire-patterned landscape in interior Alaska. pp. 179-197 in C.W. Slaughter, Richard J. Barney, and G.M. Hansen (eds.). Fire in the Northern Environment - A symposium. USDA For. Serv., Pacific Northwest Forest and Range Exp. Stn., Portland, Oregon.

Rowe, J.S. 1972. Forest Regions of Canada. Canadian Forestry Service Publication No. 1300, Department of Fisheries and the Environment, Ottawa. 172 pp.

Rowe, J.S. and G.W. Scotter. 1973. Fire in the boreal forest. Quat. Res. 3:444-464.

Sokal, Robert R. and F. James Rohlf. 1981. Biometry - The Principles and Practice of Statistics in Biological Research (2nd ed.). W.H. Freeman and Company, San Francisco. 859 pp.

Stashko, E.V. 1971*a*. Probable 30 Year Normal Maximum Temperatures, Alberta Forestry Stations, May to September. Alberta Forest Service, Edmonton. 14 pp.

Stashko, E.V. 1971*b*. Precipitation Means, Alberta Forestry Stations, May to September. Alberta Forest Service, Edmonton. 32 pp.

Telfer, E.S. 1984. Circumpolar distribution and habitat requirements of moose (*Alces alces*). pp. 145-182 in Rod Olson, Ross Hastings, and Frank Geddes (eds.). Northern Ecology and Resource Management. University of Alberta Press, Edmonton.

Thomas, J.W., R.J. Miller, H. Black, J.E. Rodiek, and C. Maser. 1976. Guidelines for maintaining and enhancing wildlife habitat in forest management in the Blue Mountains of Oregon and Washington. Trans. N. Am. Wildl. Conf. 41:452-476.

Thomas, J.W., C. Maser, and J.E. Rodiek. 1979. Edges. Chpt. 4, pp. 48-59 in: J.W. Thomas (ed.). Wildlife Habitats in Managed Forests - The Blue Mountains of Oregon and Washington. USDA For. Serv. Agriculture

Handbook No. 553. U.S. Department of Agriculture, Washington, D.C.

Van Wagner, C.E. 1983. Fire behavior in northern conifer forests and shrublands. Chpt. 4, pp. 65-80 in Ross W. Wein and David A. MacLean (eds.). The Role of Fire in Northern Circumpolar Ecosystems. John Wiley and Sons, New York.

Viereck, L.A. 1983. The effects of fire in black spruce ecosystems of Alaska and northern Canada. Chpt. 11, pp. 201-220 in Ross W. Wein and David A. MacLean (eds.). The Role of Fire in Northern Circumpolar Ecosystems. John Wiley and Sons, New York.

Viereck, Leslie A. and Linda A. Schandelmeier. 1980. Effects of fire in Alaska and adjacent Canada - a literature review. US Dept. of the Interior, BLM-Alaska Tech. Rept. No. 6, Bureau of Land Management, Anchorage, Alaska. 124 pp.

Welsh, D.A., K.P. Morrison, K. Oswald, and E.R. Thomas. 1980. Winter utilization of habitat by moose in relation to forest harvesting. Proc. N. Am. Moose Conf. Workshop 16:398-428.

Zasada, John C. 1971. Natural regeneration of interior Alaska forests - seed, seedbed, and vegetative reproduction considerations. pp. 231-246 in C.W. Slaughter, Richard J. Barney, and G.M. Hansen (eds.). Fire in the Northern Environment - A Symposium. USDA

For. Serv., Pacific Northwest Forest and Range Exp.
Stn., Portland, Oregon.

XI. APPENDIX A: METHOD OF DETERMINING AREAS WITHIN GIVEN DISTANCES OF RESIDUAL VEGETATION

The data file for each fire studied contained x and y coordinates for sets of points which when joined together formed simple closed polygons representing the perimeters of the main fire, spot fires, and unburned islands. In order to calculate areas within 100, 200, 300, 400, and 500 m of residual vegetation, five new sets of points were determined for each polygon; one set for each distance from residual vegetation.

The angle (0-360°) of a line perpendicular to the perimeter of a polygon at a point in the original data set was determined by bisecting the angle formed by joining that point to the next point on each side of it (Figure A.1). The procedure that was used calculated the appropriate direction into the burned area (inside fire perimeters and outside island perimeters) only if the polygons were digitized in a clockwise direction. If polygons were digitized counter-clockwise, the direction calculated for the perpendicular extended into residual vegetation (outside the fire perimeter and inside island perimeters). The x and y components of a distance corresponding to 100 m in the direction of the perpendicular were calculated (Figure A.1). These components were added to the x and y coordinates of the original point to obtain the x and y coordinates of a new point 100 m from residual vegetation. To obtain the x

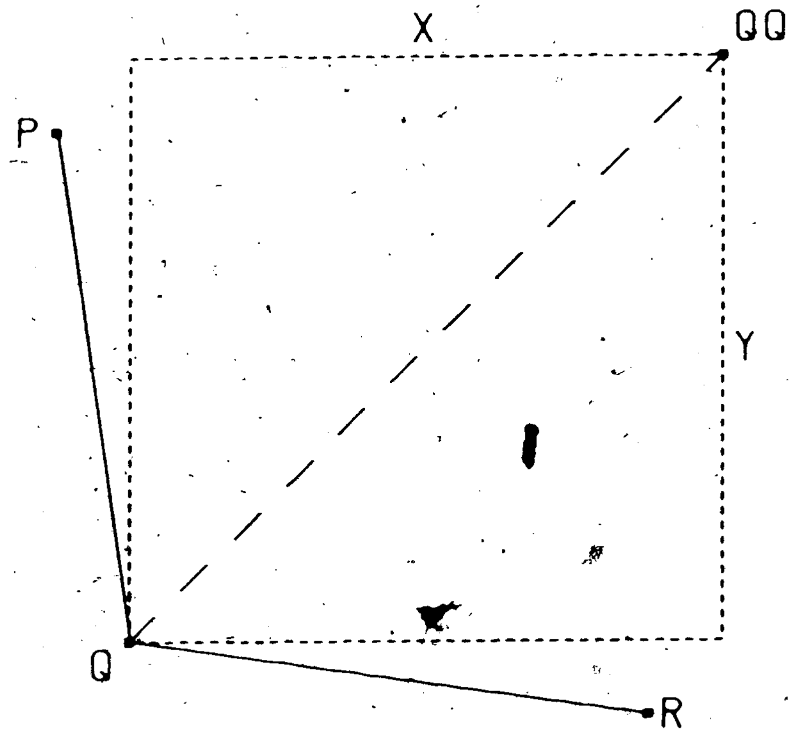


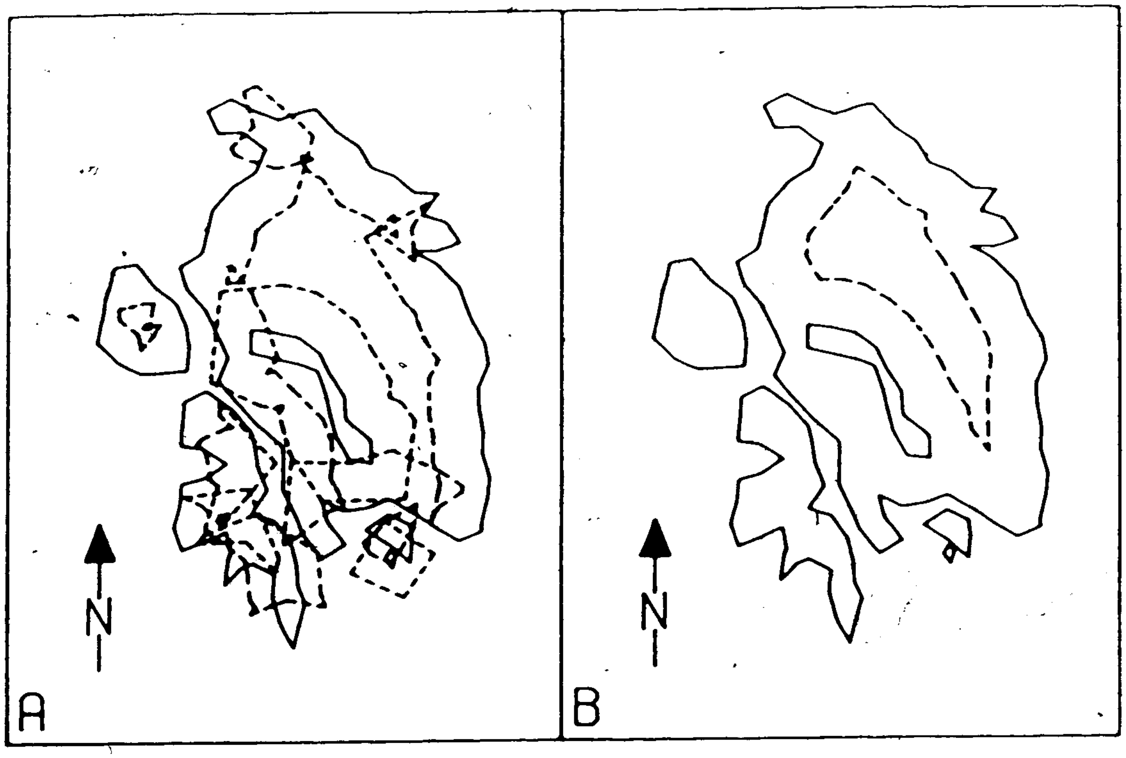
Figure A.1. Determination of points 100 m from residual vegetation.

P, Q, and R are consecutive points in the original data.
QQ is a point 100 m from residual vegetation at point Q.
X - the x component of the 100 m line segment.
Y - the y component of the 100 m line segment.

and y coordinates of points 200, 300, 400, and 500 m from residual vegetation, the x and y components of the 100 m segment were multiplied by two, three, four, and five respectively and added to the x and y coordinates of the original point. This procedure was repeated for each point in the original data set.

The new points for each polygon were joined to form isopleths each of the five distances from residual vegetation. These isopleths were not simple closed polygons and often crossed isopleths associated with other polygons (Figure A.2(A)). Appropriate portions of the isopleths were digitized to provide sets of points which when joined together formed non-overlapping simple closed polygons, the perimeters of which were 100, 200, 300, 400, or 500 m from residual vegetation (Figure A.2(B)). The area of each of these simple closed polygons was calculated.

The area greater than 100 m from residual vegetation was calculated as the sum of the areas of polygons defined by points 100 m inside fire perimeters minus the sum of the areas of polygons defined by points 100 m outside perimeters of unburned islands. The area greater than 100 m from residual vegetation was subtracted from the total area burned to get the area within 100 m of residual vegetation. This procedure was repeated for distances of 200, 300, 400, and 500 m.



STICK PLAN #3.05-529.   FIRE # DF1-48-80

SCALE = 1:15000.

——— FIRE OR ISLAND PERIMETER

---------- 100 METERS FROM RESIDUAL VEGETATION

Figure A.2. Fire map showing:
A. overlapping complex isopleths 100 m from residual vegetation and
B. non-overlapping simple isopleth 100 m from residual vegetation.

XII. APPENDIX B: TABLES

Table B.1. **Percent disturbed area, number of unburned islands per 100 ha, and median island area by fire size class for large fires in northern Alberta, 1970-1983.**

VARIABLE	FIRE SIZE CLASS	N	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	MEAN RANK
PERCENT OF AREA ACTUALLY BURNED	C (20 - 40 ha)	8	100	100	100.0	100.00	0.00	---
	D (41 - 200 ha)	20	96	100	100.0	99.31	1.13	46.92
	E1 (201 - 400 ha)	13	82	100	97.0	96.33	4.47	26.15
(K-W H = 25.5026)+	E2 (401 - 2000 ha)	16	92	99	96.5	96.60	2.36	24.47
(p = 0.0000)‡	E3 (2001 - 20000 ha)	12	88	99	95.5	94.77	4.04	18.42
	TOTAL	69	82	100	98.0	97.41	3.35	
NUMBER OF UNBURNED ISLANDS PER 100 ha	C (20 - 40 ha)	8	0.00	0.00	0.00	0.00	0.00	---
	D (41 - 200 ha)	20	0.00	2.19	0.00	0.38	0.63	20.50
	E1 (201 - 400 ha)	13	0.33	2.15	0.96	0.96	0.50	42.23
(K-W H = 19.0112)	E2 (401 - 2000 ha)	16	0.21	1.86	0.85	0.87	0.41	40.50
(p = 0.0003)	E3 (2001 - 20000 ha)	12	0.09	0.74	0.42	0.39	0.20	23.67
	TOTAL	69	0.00	2.19	0.45	0.56	0.55	
MEDIAN ISLAND AREA (ha)	D (41 - 200 ha)	7	1.03	6.08	1.39	2.29	1.91	13.88
	E1 (201 - 400 ha)	13	1.02	5.74	2.28	2.50	1.20	19.50
(K-W H = 21.3891)	E2 (401 - 2000 ha)	16	1.48	4.98	2.46	2.59	1.03	21.50
(p = 0.0001)	E3 (2001 - 20000 ha)	12	2.82	35.11	7.16	9.39	8.84	40.13
	TOTAL	48	1.02	35.11	2.62	4.22	5.34	

\+ Kruskal-Wallis H statistic.

‡ significance level of K-W H ($p \leq 0.0500$ indicates significant differences among fire size classes)

Table B.2. Fire shape index and habitat diversity index by fire size class for large fires in northern Alberta, 1970-1983.

VARIABLE	FIRE SIZE CLASS	N	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	MEAN RANK
FIRE SHAPE INDEX	C (20 - 40 ha)	8	1.21	2.93	1.56	1.79	0.61	13.94
	D (41 - 200 ha)	20	1.48	3.30	2.37	2.40	0.54	28.95
(K-W H = 28.9804)+	E1 (201 - 400 ha)	13	1.51	3.63	2.35	2.36	0.68	27.65
(p = 0.0000)‡	E2 (401 - 2000 ha)	16	2.12	4.30	2.90	2.96	0.60	42.66
	E3 (2001 - 20000 ha)	12	1.41	5.09	3.73	3.78	0.99	58.88
	TOTAL	69	1.21	5.09	2.68	2.69	0.90	
HABITAT DIVERSITY INDEX	C (20 - 40 ha)	8	1.32	3.92	1.97	2.17	0.91	12.19
	D (41 - 200 ha)	20	2.06	6.01	2.98	3.29	1.12	28.92
	E1 (201 - 400 ha)	13	1.73	6.87	3.11	3.48	1.34	29.62
(K-W H = 31.6381)	E2 (401 - 2000 ha)	16	2.80	9.34	4.14	5.11	2.17	45.25
(p = 0.0000)	E3 (2001 - 20000 ha)	12	1.76	14.31	6.98	7.47	3.16	55.83
	TOTAL	69	1.32	14.31	3.43	4.34	2.51	

+ Kruskal-Wallis H statistic
‡ significance level of K-W H ($p \leq 0.0500$ indicates significant differences among fire size classes)

Table B.3. Percentages of burned area within 100, 200, 300, 400, and 500 m of residual vegetation by fire size class for large fires in northern Alberta, 1970-1983.

DISTANCE FROM RESIDUAL VEGETATION	FIRE SIZE CLASS	N	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	MEAN RANK
100 m	C (20 - 40 ha)	8	71	100	79.5	82.46	11.46	56.44
	D (41 - 200 ha)	20	45	100	77.5	77.29	13.98	51.63
(K-W H = 47.6693)+	E1 (201 - 400 ha)	13	29	83	54.0	56.09	14.74	33.08
(p = 0.0000)‡	E2 (401 - 2000 ha)	16	28	80	45.0	47.12	12.25	24.72
	E3 (2001 - 20000 ha)	12	11	38	32.0	30.82	7.07	8.79
	TOTAL	69	11	100	57.0	58.82	22.04	
200 m	C (20 - 40 ha)	8	99	100	100.0	99.92	0.23	59.63
	D (41 - 200 ha)	20	72	100	99.5	96.28	6.65	51.50
(K-W H = 51.7336)	E1 (201 - 400 ha)	13	50	99	87.0	83.09	12.95	32.62
(p = 0.0000)	E2 (401 - 2000 ha)	16	49	98	73.0	72.85	12.58	23.31
	E3 (2001 - 20000 ha)	12	23	63	54.0	53.21	10.72	9.25
	TOTAL	69	23	100	87.0	81.29	18.95	
300 m	C (20 - 40 ha)	8	100	100	100.0	100.00	0.00	---
	D (41 - 200 ha)	20	86	100	100.0	99.26	3.03	49.05
(K-W H = 43.2693)	E1 (201 - 400 ha)	13	68	100	97.0	94.41	8.50	33.19
(p = 0.0000)	E2 (401 - 2000 ha)	16	64	100	89.0	86.24	10.92	22.97
	E3 (2001 - 20000 ha)	12	34	79	69.5	68.38	12.21	9.25
	TOTAL	69	34	100	97.0	90.04	13.87	
400 m	C (20 - 40 ha)	8	100	100	100.0	100.00	0.00	---
	D (41 - 200 ha)	20	95	100	100.0	99.75	1.13	46.17
(K-W H = 42.4010)	E1 (201 - 400 ha)	13	82	100	100.0	98.42	4.89	37.96
(p = 0.0000)	E2 (401 - 2000 ha)	16	73	100	96.5	93.04	8.77	22.81
	E3 (2001 - 20000 ha)	12	44	90	81.0	78.67	12.25	9.08
	TOTAL	69	44	100	100.0	94.31	10.25	
500 m	C (20 - 40 ha)	8	100	100	100.0	100.00	0.00	---
	D (41 - 200 ha)	20	100	100	100.0	99.98	0.11	42.90
(K-W H = 42.6932)	E1 (201 - 400 ha)	13	93	100	100.0	99.43	2.07	41.54
(p = 0.0000)	E2 (401 - 2000 ha)	16	79	100	98.5	96.13	6.82	24.19
	E3 (2001 - 20000 ha)	12	54	96	88.5	86.09	11.18	8.83
	TOTAL	69	54	100	100.0	96.57	7.55	

\+ Kruskal-Wallis H statistic.

‡ significance level of K-W H ($p \leq 0.0500$ indicates significant differences among fire size classes)

Table B.4. Percentages of fire perimeter bordering general vegetation types by fire size class for large fires in northern Alberta, 1970-1983.

VEGETATION TYPE	FIRE SIZE CLASS	N	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	MEAN RANK
WATER	C (20 - 40 ha)	8	0	34	0.0	4.30	12.17	27.44
	D (41 - 200 ha)	20	0	7	0.0	0.44	1.50	28.42
(K-W H = 11.6220)+	E1 (201 - 400 ha)	13	0	21	0.0	3.31	6.23	38.62
(p = 0.0204)‡	E2 (401 - 2000 ha)	16	0	15	0.0	2.25	4.02	41.18
	E3 (2001 - 20000 ha)	12	0	19	0.5	3.52	5.62	44.38
	TOTAL	69	0	34	0.0	2.39	5.77	
LOWLAND OPENINGS	C (20 - 40 ha)	8	0	100	16.0	28.10	35.83	32.38
	D (41 - 200 ha)	20	0	94	28.5	33.17	33.13	38.50
(K-W H = 0.2652)	E1 (201 - 400 ha)	13	0	89	11.0	24.00	26.25	35.12
(p = 0.9919)	E2 (401 - 2000 ha)	16	0	76	11.0	24.93	27.79	34.41
	E3 (2001 - 20000 ha)	12	0	55	14.0	22.42	20.74	34.92
	TOTAL	69	0	100	13.0	27.09	28.60	
UPLAND OPENINGS	C (20 - 40 ha)	8	0	93	8.5	24.37	33.08	34.06
	D (41 - 200 ha)	20	0	100	4.5	19.57	28.73	31.55
(K-W H = 1.9187)	E1 (201 - 400 ha)	13	0	100	14.0	23.24	33.01	32.54
(p = 0.7507)	E2 (401 - 2000 ha)	16	0	100	13.0	27.98	31.60	39.18
	E3 (2001 - 20000 ha)	12	0	77	22.5	24.96	24.38	38.50
	TOTAL	69	0	100	9.0	23.71	29.36	
FOREST	C (20 - 40 ha)	8	0	100	42.5	43.23	33.98	33.13
	D (41 - 200 ha)	20	0	93	48.0	46.81	26.58	35.17
(K-W H = 0.5816)	E1 (201 - 400 ha)	13	0	97	55.0	49.44	35.42	37.85
(p = 0.9651)	E2 (401 - 2000 ha)	16	0	84	41.0	44.68	25.44	32.66
	E3 (2001 - 20000 ha)	12	16	91	43.0	49.02	22.47	38.00
	TOTAL	69	0	100	47.0	46.78	27.69	

+ Kruskal-Wallis H statistic

‡ significance level of K-W H (p≤0.0500 indicates significant differences among fire size classes)

Table B.5. Percentages of forested fire perimeter bordering density classes by fire size class for large fires in northern Alberta, 1970-1983.

DENSITY CLASS	FIRE SIZE CLASS	N	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	MEAN RANK
A	C (20 - 40 ha)	6	0	62	0.0	11.67	24.83	22.17
0-30% CROWN CLOSURE	D (41 - 200 ha)	19	0	100	4.0	37.40	44.77	34.00
	E1 (201 - 400 ha)	11	0	100	3.0	21.75	32.84	29.14
(K-W H = 2.6637)+	E2 (401 - 2000 ha)	15	0	74	6.0	23.55	26.82	34.43
(p = 0.6156)‡	E3 (2001 - 20000 ha)	12	0	55	17.5	19.91	20.07	33.33
	TOTAL	63	0	100	4.0	25.59	33.33	
B	C (20 - 40 ha)	6	20	100	67.0	64.41	39.31	38.75
31-70% CROWN CLOSURE	D (41 - 200 ha)	19	0	100	30.0	39.24	38.65	25.29
	E1 (201 - 400 ha)	11	0	100	49.0	55.34	36.80	34.09
(K-W H = 4.7498)	E2 (401 - 2000 ha)	15	0	100	62.0	58.14	25.83	37.13
(p = 0.3139)	E3 (2001 - 20000 ha)	12	7	97	45.5	48.97	26.43	30.92
	TOTAL	63	0	100	47.0	50.80	33.58	
C	C (20 - 40 ha)	6	0	72	1.5	23.91	35.82	30.00
71-100% CROWN CLOSURE	D (41 - 200 ha)	19	0	100	0.0	23.36	35.97	27.18
	E1 (201 - 400 ha)	11	0	78	13.0	22.90	28.79	30.55
(K-W H = 4.0245)	E2 (401 - 2000 ha)	15	0	50	20.0	18.30	16.51	33.67
(p = 0.4027)	E3 (2001 - 20000 ha)	12	0	93	26.5	31.12	27.27	39.92
	TOTAL	63	0	100	13.0	23.61	28.71	

\+ Kruskal-Wallis H statistic.
‡ Significance level of K-W H ($p \leq 0.0500$ indicates significant differences among fire size classes)

Table B.8. Percentages of forested fire perimeter bordering height classes by fire size class for large fires in northern Alberta, 1970-1983.

HEIGHT CLASS	FIRE SIZE CLASS	N	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	MEAN RANK
1: 0 - 9 m	C (20 - 40 ha)	6	0	100	33.5	44.66	50.30	26.50
	D (41 - 200 ha)	16	0	100	0.0	22.56	34.86	20.13
(K-W H = 4.6782)+	E1 (201 - 400 ha)	9	0	100	13.0	24.57	32.74	23.22
(p = 0.3219)‡	E2 (401 - 2000 ha)	9	0	72	17.0	24.54	24.20	25.00
	E3 (2001 - 20000 ha)	8	2	84	46.5	44.51	29.84	32.63
	TOTAL	48	0	100	15.0	29.73	34.14	
2: 9 - 18 m	C (20 - 40 ha)	6	0	100	17.5	35.88	44.07	18.17
	D (41 - 200 ha)	16	0	100	71.5	60.33	41.00	27.75
(K-W H = 4.5577)	E1 (201 - 400 ha)	9	0	100	68.0	63.45	27.86	28.17
(p = 0.3358)	E2 (401 - 2000 ha)	9	0	100	65.0	56.52	33.58	25.17
	E3 (2001 - 20000 ha)	8	16	53	37.0	36.10	14.24	17.88
	TOTAL	48	0	100	53.0	53.11	35.00	
3: 18 - 24 m	C (20 - 40 ha)	6	0	35	0.0	9.13	14.89	22.00
	D (41 - 200 ha)	16	0	70	0.0	14.12	24.02	22.53
(K-W H = 1.5095)	E1 (201 - 400 ha)	9	0	24	7.0	8.30	8.92	24.33
(p = 0.8250)	E2 (401 - 2000 ha)	9	0	53	7.0	14.82	18.09	28.17
	E3 (2001 - 20000 ha)	8	0	73	4.5	19.38	29.06	26.38
	TOTAL	48	0	73	0.0	13.41	20.41	
4: over 24 m	C (20 - 40 ha)	6	0	62	0.0	10.32	25.28	25.92
	D (41 - 200 ha)	16	0	48	0.0	2.99	11.96	23.09
(K-W H = 3.0273)	E1 (201 - 400 ha)	9	0	25	0.0	3.68	8.48	26.61
(p = 0.5533)	E2 (401 - 2000 ha)	9	0	31	0.0	4.12	10.38	26.61
	E3 (2001 - 20000 ha)	8	0	0	0.0	0.00	0.00	21.50
	TOTAL	48	0	62	0.0	3.75	12.34	

+ Kruskal-Wallis H statistic.
‡ significance level of K-W H ($p \leq 0.0500$ indicates significant differences among fire size classes)

Table B.7. **Percentages of forested fire perimeter bordering species composition classes by fire size class for large fires in northern Alberta, 1970-1983.**

SPECIES COMPOSITION	FIRE SIZE CLASS	N	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	MEAN RANK
DECIDUOUS FOREST	C (20 - 40 ha)	6	0	100	0.0	17.95	40.31	28.08
	D (41 - 200 ha)	19	0	100	0.0	18.53	32.93	29.03
(K-W H = 1.9470)+	E1 (201 - 400 ha)	11	0	100	0.0	18.64	33.57	31.14
(p = 0.7455)‡	E2 (401 - 2000 ha)	15	0	56	7.0	16.03	18.81	35.63
	E3 (2001 - 20000 ha)	12	0	100	1.0	25.87	38.76	34.92
	TOTAL	63	0	100	0.0	19.30	31.39	
DECIDUOUS MIXEDWOOD	C (20 - 40 ha)	6	0	8	0.0	1.35	3.31	22.92
	D (41 - 200 ha)	19	0	56	0.0	7.99	18.40	26.18
(K-W H = 9.9137)	E1 (201 - 400 ha)	11	0	100	0.0	19.74	31.82	34.91
(p = 0.0419)	E2 (401 - 2000 ha)	15	0	88	9.0	18.72	25.59	41.87
	E3 (2001 - 20000 ha)	12	0	10	0.5	2.83	4.12	30.75
	TOTAL	63	0	100	0.0	10.98	21.59	
CONIFEROUS MIXEDWOOD	C (20 - 40 ha)	6	0	100	0.0	20.65	40.03	25.87
	D (41 - 200 ha)	19	0	100	15.0	29.20	35.28	33.32
(K-W H = 4.5594)	E1 (201 - 400 ha)	11	0	68	21.0	25.74	25.07	38.73
(p = 0.3356)	E2 (401 - 2000 ha)	15	0	77	13.0	19.79	21.56	35.87
	E3 (2001 - 20000 ha)	12	0	27	1.0	6.59	8.76	24.17
	TOTAL	63	0	100	11.0	21.23	27.85	
WHITE SPRUCE OR PINE	C (20 - 40 ha)	6	0	100	80.0	60.05	48.99	40.33
	D (41 - 200 ha)	19	0	100	0.0	31.38	41.67	27.79
(K-W H = 3.5956)	E1 (201 - 400 ha)	11	0	100	11.0	27.75	32.24	30.09
(p = 0.4635)	E2 (401 - 2000 ha)	15	0	72	15.0	25.63	26.91	31.00
	E3 (2001 - 20000 ha)	12	0	100	23.0	43.03	39.10	37.50
	TOTAL	63	0	100	17.0	34.33	37.52	
BLACK SPRUCE	C (20 - 40 ha)	6	0	0	0.0	0.00	0.00	19.50
	D (41 - 200 ha)	19	0	100	0.0	12.89	25.93	30.84
(K-W H = 9.3710)	E1 (201 - 400 ha)	11	0	68	0.0	8.13	20.85	25.86
(p = 0.0525)	E2 (401 - 2000 ha)	15	0	84	1.0	19.83	28.47	38.57
	E3 (2001 - 20000 ha)	12	0	76	3.0	21.68	28.97	40.00
	TOTAL	63	0	100	0.0	14.16	25.34	

\+ Kruskal-Wallis H statistic.
‡ significance level of K-W H (p≤0.0500 indicates significant differences among fire size classes)

Table B.8. Percentages of island area in general vegetation types by fire size class for large fires in northern Alberta, 1970-1983.

VEGETATION TYPE	FIRE SIZE CLASS	N	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	MEAN RANK
LOWLAND OPENINGS	D (41 - 200 ha)	7	0	93	0.0	28.12	44.31	**22.71**
	E1 (201 - 400 ha)	13	0	100	8.0	27.67	36.73	**24.77**
(K-W H = 0.4856)+	E2 (401 - 2000 ha)	16	0	79	8.0	20.31	26.99	**23.53**
(p = 0.9221)‡	E3 (2001 - 20000 ha)	12	0	67	20.0	24.50	24.92	**28.54**
	TOTAL	48	0	100	6.5	24.49	31.36	
UPLAND OPENINGS	D (41 - 200 ha)	7	0	100	0.0	24.44	42.56	**21.07**
	E1 (201 - 400 ha)	13	0	100	0.0	19.16	32.74	**21.50**
(K-W H = 1.9969)	E2 (401 - 2000 ha)	16	0	100	15.0	31.67	38.20	**27.19**
(p = 0.5731)	E3 (2001 - 20000 ha)	12	0	90	5.5	21.78	28.44	**28.17**
	TOTAL	48	0	100	2.5	24.76	34.45	
FOREST	D (41 - 200 ha)	7	0	100	28.0	47.44	46.60	**23.93**
	E1 (201 - 400 ha)	13	0	100	67.0	53.16	46.02	**24.96**
(K-W H = 0.3235)	E2 (401 - 2000 ha)	16	0	100	51.5	48.02	33.78	**23.19**
(p = 0.9556)	E3 (2001 - 20000 ha)	12	9	100	53.0	53.72	31.13	**28.08**
	TOTAL	48	0	100	53.0	50.75	37.64	

\+ Kruskal-Wallis H statistic.
‡ significance level of K-W H ($p \leq 0.0500$ indicates significant differences among fire size classes)

Table B.9. Percentages of forested island area in density classes by fire size class for large fires in northern Alberta, 1970-1983.

DENSITY CLASS	FIRE SIZE CLASS	N	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	MEAN RANK
A	D (41 - 200 ha)	6	0	100	100.0	66.67	51.64	29.00
0-30% CROWN CLOSURE	E1 (201 - 400 ha)	8	0	43	0.0	6.78	15.22	15.50
	E2 (401 - 2000 ha)	14	0	95	0.0	12.17	27.14	18.43
(K-W H = 8.9306)+	E3 (2001 - 20000 ha)	12	0	100	14.0	23.63	30.61	24.33
(p = 0.0302)‡	TOTAL	40	0	100	0.0	22.70	35.82	
B	D (41 - 200 ha)	6	0	100	0.0	33.33	51.64	14.83
31-70% CROWN CLOSURE	E1 (201 - 400 ha)	8	0	100	94.0	61.93	49.65	24.00
	E2 (401 - 2000 ha)	14	0	100	47.5	52.05	36.02	21.21
(K-W H = 2.2755)	E3 (2001 - 20000 ha)	12	0	100	56.5	49.83	36.53	20.17
(p = 0.5172)	TOTAL	40	0	100	50.0	50.55	40.82	
C	D (41 - 200 ha)	6	0	0	0.0	0.00	0.00	10.50
71-100% CROWN CLOSURE	E1 (201 - 400 ha)	8	0	100	0.0	31.29	45.20	20.08
	E2 (401 - 2000 ha)	14	0	100	34.5	35.78	34.92	23.82
(K-W H = 6.5242)	E3 (2001 - 20000 ha)	12	0	100	22.0	26.53	29.65	21.92
(p = 0.0887)	TOTAL	40	0	100	6.5	26.74	34.13	

+ Kruskal-Wallis H statistic.
‡ significance level of K-W H ($p \leq 0.0500$ indicates significant differences among fire size classes)

Table B.10. Percentages of forested island area in height classes by fire size class for large fires in northern Alberta, 1970-1983.

HEIGHT CLASS	FIRE SIZE CLASS	N	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	MEAN RANK
1: 0 - 9 m	D (41 - 200 ha)	6	0	0	0.0	0.00	0.00	8.00
	E1 (201 - 400 ha)	6	0	100	0.0	33.33	51.64	14.33
(K-W H = 10.5118)+	E2 (401 - 2000 ha)	9	0	100	0.0	23.10	39.55	14.22
(p = 0.0147)‡	E3 (2001 - 20000 ha)	8	2	100	36.0	45.88	38.97	21.63
	TOTAL	29	0	100	0.0	26.72	39.68	
2: 9 - 18 m	D (41 - 200 ha)	6	0	100	100.0	66.67	51.64	17.83
	E1 (201 - 400 ha)	6	0	100	77.5	59.24	49.02	18.08
(K-W H = 2.1703)	E2 (401 - 2000 ha)	9	0	100	66.0	55.28	43.50	15.39
(p = 0.5378)	E3 (2001 - 20000 ha)	8	0	69	32.0	34.36	28.35	11.63
	TOTAL	29	0	100	58.0	52.68	42.38	
3: 18 - 24 m	D (41 - 200 ha)	6	0	100	0.0	33.33	51.64	15.83
	E1 (201 - 400 ha)	6	0	40	0.0	6.69	16.38	11.75
(K-W H = 1.6777)	E2 (401 - 2000 ha)	9	0	65	9.0	20.78	26.53	16.67
(p = 0.6419)	E3 (2001 - 20000 ha)	8	0	78	0.0	19.07	33.87	14.94
	TOTAL	29	0	100	0.0	19.99	32.99	
4: over 24 m	D (41 - 200 ha)	6	0	0	0.0	0.00	0.00	13.50
	E1 (201 - 400 ha)	6	0	4	0.0	0.74	1.81	15.75
(K-W H = 0.8931)	E2 (401 - 2000 ha)	9	0	8	0.0	0.83	2.50	15.22
(p = 0.8271)	E3 (2001 - 20000 ha)	8	0	5	0.0	0.63	1.77	15.31
	TOTAL	29	0	8	0.0	0.58	1.80	

\+ Kruskal-Wallis H statistic.
‡ significance level of K-W H ($p \leq 0.0500$ indicates significant differences among fire size classes).

Table B.11. Percentages of forested island area in species composition classes by fire size class for large fires in northern Alberta, 1970-1983.

SPECIES COMPOSITION	FIRE SIZE CLASS	N	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	MEAN RANK
DECIDUOUS FOREST	D (41 - 200 ha)	6	0	0	0.0	0.00	0.00	14.00
	E1 (201 - 400 ha)	8	0	55	0.0	7.49	19.18	18.38
(K-W H = 5.0316)+	E2 (401 - 2000 ha)	14	0	100	0.0	18.56	32.01	21.18
(p = 0.1695)‡	E3 (2001 - 20000 ha)	12	0	100	0.0	29.57	40.01	24.38
	TOTAL	40	0	100	0.0	16.87	31.17	
DECIDUOUS MIXEDWOOD	D (41 - 200 ha)	6	0	0	0.0	0.00	0.00	14.00
	E1 (201 - 400 ha)	8	0	31	0.0	3.85	10.88	17.13
(K-W H = 5.4201)	E2 (401 - 2000 ha)	14	0	67	0.0	10.87	18.49	23.21
(p = 0.1435)	E3 (2001 - 20000 ha)	12	0	22	0.5	5.66	7.67	22.83
	TOTAL	40	0	67	0.0	6.27	12.91	
CONIFEROUS MIXEDWOOD	D (41 - 200 ha)	6	0	100	100.0	66.67	51.64	27.83
	E1 (201 - 400 ha)	8	0	100	28.0	39.49	42.98	22.31
(K-W H = 5.2965)	E2 (401 - 2000 ha)	14	0	100	12.0	30.44	37.95	20.64
(p = 0.1513)	E3 (2001 - 20000 ha)	12	0	32	0.0	8.25	11.69	15.46
	TOTAL	40	0	100	10.0	31.03	39.52	
WHITE SPRUCE OR PINE	D (41 - 200 ha)	6	0	100	0.0	33.33	51.64	18.67
	E1 (201 - 400 ha)	8	0	100	2.0	31.69	43.94	19.88
(K-W H = 1.1335)	E2 (401 - 2000 ha)	14	0	83	15.5	20.86	24.46	19.21
(p = 0.7690)	E3 (2001 - 20000 ha)	12	0	100	23.0	35.83	37.55	23.33
	TOTAL	40	0	100	12.0	29.39	36.44	
BLACK SPRUCE	D (41 - 200 ha)	6	0	0	0.0	0.00	0.00	13.00
	E1 (201 - 400 ha)	8	0	100	0.0	17.49	36.15	18.75
(K-W H = 5.2718)	E2 (401 - 2000 ha)	14	0	83	0.0	19.27	33.04	21.50
(p = 0.1529)	E3 (2001 - 20000 ha)	12	0	92	1.5	20.68	29.56	24.25
	TOTAL	40	0	100	0.0	16.45	29.92	

+ Kruskal-Wallis H statistic.
‡ significance level of K-W H ($p \leq 0.0500$ indicates significant differences among fire size classes)

Table B.12. Percent disturbed area, number of unburned islands per 100 ha, and median island area by dominant preburn vegetation type for large fires in northern Alberta, 1970-1983.

VARIABLE	DOMINANT PREBURN VEGETATION TYPE	N	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	MEAN RANK
PERCENT OF AREA ACTUALLY BURNED	LOWLAND OPENINGS	12	92	100	98.5	97.84	2.60	37.67
	UPLAND OPENINGS	14	94	100	98.0	98.03	1.82	35.36
	DECIDUOUS FOREST	8	88	100	97.5	96.98	4.26	35.63
(K-W H = 0.5117)+	MIXEDWOOD	9	82	100	98.0	96.42	5.46	31.67
(p = 0.9917)‡	WHITE SPRUCE OR PINE	19	88	100	98.0	97.26	3.41	34.29
	BLACK SPRUCE	7	92	100	98.0	97.62	2.93	35.21
NUMBER OF UNBURNED ISLANDS PER 100 ha	LOWLAND OPENINGS	12	0.00	2.19	0.44	0.65	0.76	35.58
	UPLAND OPENINGS	14	0.00	2.15	0.44	0.62	0.61	38.64
	DECIDUOUS FOREST	8	0.00	1.02	0.46	0.45	0.44	31.88
(K-W H = 1.7598)	MIXEDWOOD	9	0.00	1.49	0.66	0.72	0.55	41.67
(p = 0.8813)	WHITE SPRUCE OR PINE	19	0.00	1.86	0.41	0.46	0.49	32.21
	BLACK SPRUCE	7	0.00	0.78	0.55	0.46	0.34	33.29
MEDIAN ISLAND AREA (ha)	LOWLAND OPENINGS	6	1.50	2.95	2.56	2.46	0.52	21.75
	UPLAND OPENINGS	11	1.23	6.70	2.48	3.26	1.86	24.55
	DECIDUOUS FOREST	5	1.55	8.51	2.95	3.81	2.72	27.60
(K-W H = 1.4287)	MIXEDWOOD	7	1.03	6.08	1.87	3.05	2.10	20.29
(p = 0.9211)	WHITE SPRUCE OR PINE	14	1.02	35.11	3.67	6.74	9.17	26.61
	BLACK SPRUCE	5	1.48	7.62	2.10	3.49	2.50	24.60

+ Kruskal-Wallis H statistic.
‡ significance level of K-W H ($p \leq 0.0500$ indicates significant differences among preburn vegetation types)

Table B.13. Fire shape index and habitat diversity index by dominant preburn vegetation type for large fires in northern Alberta, 1970-1983.

VARIABLE	DOMINANT PREBURN VEGETATION TYPE	N	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	MEAN RANK
FIRE SHAPE INDEX	LOWLAND OPENINGS	12	1.48	4.30	2.30	2.57	0.95	31.00
	UPLAND OPENINGS	14	1.32	4.32	2.76	2.72	0.88	38.00
	DECIDUOUS FOREST	8	1.41	4.77	2.72	2.67	1.05	33.81
(K-W H = 4.5074)+	MIXEDWOOD	9	1.51	3.30	2.44	2.25	0.63	25.00
(p = 0.4789)‡	WHITE SPRUCE OR PINE	19	1.21	4.97	2.93	2.85	0.92	39.74
	BLACK SPRUCE	7	2.12	5.09	2.77	3.02	1.00	41.21
HABITAT DIVERSITY INDEX	LOWLAND OPENINGS	12	2.20	9.34	3.87	4.64	2.41	37.54
	UPLAND OPENINGS	14	1.32	14.31	3.38	4.31	3.24	32.79
	DECIDUOUS FOREST	8	1.76	8.60	3.35	3.75	2.14	30.13
(K-W H = 2.2708)	MIXEDWOOD	9	1.99	4.57	3.19	3.30	0.86	29.50
(p = 0.8105)	WHITE SPRUCE OR PINE	19	1.34	9.43	3.92	4.86	2.69	38.53
	BLACK SPRUCE	7	2.18	10.12	3.50	4.52	2.64	38.14

+ Kruskal-Wallis H statistic.
‡ significance level of K-W H ($p \leq 0.0500$ indicates significant differences among preburn vegetation types)

Table B.14. Percentages of burned area within 100, 200, 300, 400, and 500 m of residual vegetation by dominant preburn vegetation type for large fires in northern Alberta, 1970-1983.

DISTANCE FROM RESIDUAL VEGETATION	DOMINANT PREBURN VEGETATION TYPE	N	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	MEAN RANK
100 m	LOWLAND OPENINGS	12	46	100	76.5	73.67	16.26	**49.29**
	UPLAND OPENINGS	14	28	88	50.5	55.26	19.07	**31.68**
	DECIDUOUS FOREST	8	11	80	43.0	48.39	24.12	**28.08**
(K-W H = 10.6299)+	MIXEDWOOD	9	28	98	66.0	67.55	22.86	**42.33**
(p = 0.0592)‡	WHITE SPRUCE OR PINE	19	27	100	45.0	54.66	23.52	**30.50**
	BLACK SPRUCE	7	32	82	46.0	52.46	19.11	**30.14**
200 m	LOWLAND OPENINGS	12	71	100	96.5	93.21	9.57	**47.42**
	UPLAND OPENINGS	14	51	100	79.5	80.73	17.16	**32.93**
	DECIDUOUS FOREST	8	23	100	66.5	70.26	26.85	**28.00**
(K-W H = 8.3301)	MIXEDWOOD	9	49	100	91.0	87.83	16.30	**41.11**
(p = 0.1390)	WHITE SPRUCE OR PINE	19	47	100	73.0	76.92	19.96	**30.95**
	BLACK SPRUCE	7	56	100	77.0	78.07	16.97	**31.29**
300 m	LOWLAND OPENINGS	12	84	100	100.0	97.70	4.80	**47.50**
	UPLAND OPENINGS	14	66	100	95.0	91.33	12.13	**35.38**
	DECIDUOUS FOREST	8	34	100	81.0	79.59	22.67	**25.63**
(K-W H = 8.5988)	MIXEDWOOD	9	64	100	99.0	94.67	11.88	**39.22**
(p = 0.1262)	WHITE SPRUCE OR PINE	19	60	100	[illegible]9.0	86.77	13.98	**30.42**
	BLACK SPRUCE	7	72	100	[illegible]0.0	89.20	10.55	**30.57**
400 m	LOWLAND OPENINGS	12	92	100	100.0	99.12	2.36	**44.63**
	UPLAND OPENINGS	14	76	100	99.5	95.48	8.68	**35.82**
	DECIDUOUS FOREST	8	44	100	90.5	85.55	19.20	**25.44**
(K-W H = 9.2803)	MIXEDWOOD	9	73	100	100.0	96.96	8.84	**43.83**
(p = 0.0984)	WHITE SPRUCE OR PINE	19	71	100	96.0	92.41	9.35	**29.95**
	BLACK SPRUCE	7	83	100	98.0	95.44	6.74	**30.14**
500 m	LOWLAND OPENINGS	12	96	100	100.0	99.65	1.20	**43.48**
	UPLAND OPENINGS	14	85	100	100.0	97.39	5.51	**38.04**
	DECIDUOUS FOREST	8	54	100	94.5	89.55	15.95	**23.75**
(K-W H = 11.1524)	MIXEDWOOD	9	80	100	100.0	97.78	6.66	**43.11**
(p = 0.0484)	WHITE SPRUCE OR PINE	19	79	100	99.0	95.90	6.18	**28.47**
	BLACK SPRUCE	7	90	100	100.0	97.94	3.90	**34.57**

+ Kruskal-Wallis H statistic.
‡ significance level of K-W H ($p \leq 0.0500$ indicates significant differences among preburn vegetation types).

Table B.15. Percentages of fire perimeter bordering general vegetation types by dominant preburn vegetation type for large fires in northern Alberta, 1970-1983.

PERIMETER VEGETATION TYPE	DOMINANT PREBURN VEGETATION TYPE	N	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	MEAN RANK
WATER	LOWLAND OPENINGS	12	0	6	0.0	0.86	1.74	32.25
	UPLAND OPENINGS	14	0	4	0.0	0.73	1.47	29.11
	DECIDUOUS FOREST	8	0	15	0.0	3.52	5.48	39.88
(K-W H = 4.1918)+	MIXEDWOOD	9	0	11	0.0	2.22	3.99	37.17
(p = 0.5222)‡	WHITE SPRUCE OR PINE	19	0	34	0.0	3.63	8.78	34.89
	BLACK SPRUCE	7	0	21	0.0	3.87	7.72	43.43
LOWLAND OPENINGS	LOWLAND OPENINGS	12	36	100	73.5	71.12	19.89	60.83
	UPLAND OPENINGS	14	0	55	2.5	9.48	15.56	21.64
	DECIDUOUS FOREST	8	0	39	2.5	11.12	16.83	23.06
(K-W H = 31.4014)	MIXEDWOOD	9	0	68	22.0	20.88	20.88	32.67
(p = 0.0000)	WHITE SPRUCE OR PINE	19	0	59	31.0	28.15	22.92	38.24
	BLACK SPRUCE	7	0	40	7.0	10.14	13.95	25.29
UPLAND OPENINGS	LOWLAND OPENINGS	12	0	19	0.0	2.99	5.94	18.25
	UPLAND OPENINGS	14	13	100	70.5	66.41	28.62	59.21
	DECIDUOUS FOREST	8	7	58	22.5	28.72	18.88	45.38
(K-W H = 40.9876)	MIXEDWOOD	9	0	54	9.0	13.71	16.92	31.50
(p = 0.0000)	WHITE SPRUCE OR PINE	19	0	50	0.0	7.62	14.41	22.34
	BLACK SPRUCE	7	3	59	19.0	24.63	19.73	42.29
FOREST	LOWLAND OPENINGS	12	0	55	21.5	24.82	16.46	18.38
	UPLAND OPENINGS	14	0	87	17.5	23.38	27.41	18.11
	DECIDUOUS FOREST	8	39	84	52.5	56.61	15.82	43.00
(K-W H = 29.3743)	MIXEDWOOD	9	25	82	63.0	63.20	19.53	47.33
(p = 0.0000)	WHITE SPRUCE OR PINE	19	32	100	55.0	60.60	23.73	44.84
	BLACK SPRUCE	7	29	93	57.0	61.35	21.19	45.57

\+ Kruskal-Wallis H statistic

‡ significance level of K-W H ($p \leq 0.0500$ indicates significant differences among preburn vegetation types)

Table B.16. Percentages of forested fire perimeter bordering density classes by dominant preburn vegetation type for large fires in northern Alberta, 1970-1983

PERIMETER FOREST DENSITY CLASS	DOMINANT PREBURN VEGETATION TYPE	N	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	MEAN RANK
A	LOWLAND OPENINGS	11	0	100	59.0	49.18	40.96	**41.50**
0-30% CROWN CLOSURE	UPLAND OPENINGS	9	1	100	31.0	32.60	33.67	**40.22**
	DECIDUOUS FOREST	8	0	47	2.0	7.54	16.08	**23.25**
(K-W H = 11.5241)+	MIXEDWOOD	9	0	100	1.0	25.11	40.74	**29.58**
(p = 0.0419)‡	WHITE SPRUCE OR PINE	19	0	78	18.0	25.50	28.39	**32.71**
	BLACK SPRUCE	7	0	4	0.0	0.97	1.60	**17.71**
B	LOWLAND OPENINGS	11	0	100	0.0	23.52	34.15	**17.14**
31-70% CROWN CLOSURE	UPLAND OPENINGS	9	0	92	47.0	50.61	29.63	**31.94**
	DECIDUOUS FOREST	8	7	100	44.0	51.85	32.03	**32.19**
(K-W H = 12.9194)	MIXEDWOOD	9	0	100	72.0	63.60	38.48	**39.33**
(p = 0.0241)	WHITE SPRUCE OR PINE	19	18	100	42.0	51.81	30.39	**31.87**
	BLACK SPRUCE	7	50	100	65.[illegible]	73.53	19.41	**48.14**
C	LOWLAND OPENINGS	11	0	100	2.0	27.30	40.72	**30.64**
71-100% CROWN CLOSURE	UPLAND OPENINGS	9	0	78	1.0	16.79	26.50	**27.58**
	DECIDUOUS FOREST	8	0	93	41.5	40.61	34.01	**42.25**
(K-W H = 5.1781)	MIXEDWOOD	9	0	44	0.0	11.29	15.69	**24.44**
(p = 0.3945)	WHITE SPRUCE OR PINE	19	0	72	15.0	22.69	26.25	**32.84**
	BLACK SPRUCE	7	0	50	31.0	25.49	18.88	**35.57**

+ Kruskal-Wallis H statistic.
‡ significance level of K-W H ($p \leq 0.0500$ indicates significant differences among preburn vegetation types)

Table B.17. Percentages of forested fire perimeter bordering height classes by dominant preburn vegetation type for large fires in northern Alberta, 1970-1983.

PERIMETER FOREST HEIGHT CLASS	DOMINANT PREBURN VEGETATION TYPE	N	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	MEAN RANK
1: 0 - 9 m	LOWLAND OPENINGS	11	0	100	4.0	25.85	38.95	21.73
	UPLAND OPENINGS	5	0	37	0.0	8.93	16.00	15.80
(K-W H = 5.9631)+	DECIDUOUS FOREST	6	0	100	40.0	43.32	36.36	30.67
(p = 0.2019)‡	MIXEDWOOD	8	0	52	10.5	17.75	21.51	20.25
	WHITE SPRUCE OR PINE	18	0	100	24.5	38.67	36.54	28.44
2: 9 - 18 m	LOWLAND OPENINGS	11	0	100	80.0	70.45	37.23	31.45
	UPLAND OPENINGS	5	19	100	68.0	70.02	33.41	31.20
(K-W H = 6.2738)	DECIDUOUS FOREST	6	0	100	36.5	42.58	33.21	19.92
(p = 0.1796)	MIXEDWOOD	8	1	100	43.0	51.08	37.57	23.88
	WHITE SPRUCE OR PINE	18	0	90	42.0	42.22	30.95	20.19
3: 18 - 24 m	LOWLAND OPENINGS	11	0	22	0.0	3.71	7.79	18.82
	UPLAND OPENINGS	5	0	73	0.0	19.47	31.88	25.50
(K-W H = 3.1969)	DECIDUOUS FOREST	6	0	53	4.5	13.14	20.81	24.92
(p = 0.5254)	MIXEDWOOD	8	0	70	7.0	21.27	26.99	28.69
	WHITE SPRUCE OR PINE	18	0	57	6.5	14.27	18.66	25.69
4: over 24 m	LOWLAND OPENINGS	11	0	0	0.0	0.00	0.00	21.50
	UPLAND OPENINGS	5	0	8	0.0	1.59	3.55	26.00
(K-W H = 3.0547)	DECIDUOUS FOREST	6	0	6	0.0	0.96	2.35	25.08
(p = 0.5487)	MIXEDWOOD	8	0	48	0.0	9.90	18.85	27.75
	WHITE SPRUCE OR PINE	18	0	62	0.0	4.84	15.43	24.28

+ Kruskal-Wallis H statistic.
‡ significance level of K-W H ($p \leq 0.0500$ indicates significant differences among preburn vegetation types)

Table B.18. Percentages of forested fire perimeter bordering species composition classes by dominant preburn vegetation type for large fires in northern Alberta, 1970-1983

PERIMETER FOREST SPECIES COMPOSITION	DOMINANT PREBURN VEGETATION TYPE	N	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	MEAN RANK
DECIDUOUS FOREST	LOWLAND OPENINGS	11	0	100	0.0	14.80	30.73	28.18
	UPLAND OPENINGS	9	0	100	21.0	40.94	41.62	43.72
	DECIDUOUS FOREST	8	29	100	51.0	62.82	27.91	54.63
(K-W H = 24.9899)+	MIXEDWOOD	9	0	52	0.0	7.68	17.15	27.39
(p = 0.0001)‡	WHITE SPRUCE OR PINE	19	0	55	0.0	4.97	13.30	23.58
	BLACK SPRUCE	7	0	14	0.0	2.61	5.14	25.88
DECIDUOUS MIXEDWOOD	LOWLAND OPENINGS	11	0	100	0.0	21.28	33.67	35.09
	UPLAND OPENINGS	9	0	88	1.0	21.02	31.30	38.72
	DECIDUOUS FOREST	8	0	53	4.5	11.32	18.17	35.00
(K-W H = 5.1787)	MIXEDWOOD	9	0	51	[illegible]	10.50	18.69	32.17
(p = 0.3945)	WHITE SPRUCE OR PINE	19	0	22	0.0	2.95	5.79	28.11
	BLACK SPRUCE	7	0	21	0.0	3.92	7.70	29.57
CONIFEROUS MIXEDWOOD	LOWLAND OPENINGS	11	0	100	0.0	27.58	37.95	30.73
	UPLAND OPENINGS	9	0	59	12.0	18.06	19.84	32.22
	DECIDUOUS FOREST	8	0	52	3.5	14.38	19.48	28.00
(K-W H = 17.3396)	MIXEDWOOD	9	16	100	63.0	60.58	27.98	54.22
(p = 0.0039)	WHITE SPRUCE OR PINE	19	0	28	2.0	8.18	9.92	25.53
	BLACK SPRUCE	7	0	21	0.0	8.01	9.57	27.29
WHITE SPRUCE OR PINE	LOWLAND OPENINGS	11	0	100	4.0	27.26	40.78	27.27
	UPLAND OPENINGS	9	0	22	0.0	4.78	7.50	17.78
	DECIDUOUS FOREST	8	0	21	1.0	[illegible]	8.17	19.75
(K-W H = 33.7736)	MIXEDWOOD	9	0	62	0.0	16.24	22.71	22.58
(p = 0.0000)	WHITE SPRUCE OR PINE	19	24	100	82.0	76.68	24.40	51.11
	BLACK SPRUCE	7	0	52	17.0	24.86	18.60	32.00
BLACK SPRUCE	LOWLAND OPENINGS	11	0	100	0.0	9.09	30.15	23.45
	UPLAND OPENINGS	9	0	76	0.0	15.20	30.10	30.67
	DECIDUOUS FOREST	8	0	42	0.0	6.15	14.69	29.69
(K-W H = 21.3324)	MIXEDWOOD	9	0	30	0.0	4.99	10.36	28.11
(p = 0.0007)	WHITE SPRUCE OR PINE	19	0	34	0.0	7.21	11.46	30.97
	BLACK SPRUCE	7	42	84	63.0	60.60	13.98	57.57

+ Kruskal-Wallis H statistic
‡ significance level of K-W H ($p \leq 0.0500$ indicates significant differences among preburn vegetation types)

Table B.19. Percentages of island area in general vegetation types by dominant preburn vegetation type for large fires in northern Alberta, 1970-1983.

ISLAND VEGETATION TYPE	DOMINANT PREBURN VEGETATION TYPE	N	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	MEAN RANK
LOWLAND OPENINGS	LOWLAND OPENINGS	6	50	100	85.5	78.20	21.94	43.83
	UPLAND OPENINGS	11	0	58	0.0	15.59	22.58	20.55
	DECIDUOUS FOREST	5	0	53	19.0	22.07	19.28	27.70
(K-W H = 17.9270)+	MIXEDWOOD	7	0	93	0.0	17.02	34.02	20.14
(p = 0.0030)‡	WHITE SPRUCE OR PINE	14	0	68	8.0	21.43	26.01	24.46
	BLACK SPRUCE	5	0	5	0.0	1.06	2.37	13.00
UPLAND OPENINGS	LOWLAND OPENINGS	6	0	40	1.5	8.17	15.68	21.00
	UPLAND OPENINGS	11	33	100	81.0	72.33	28.51	41.27
	DECIDUOUS FOREST	5	0	48	2.0	10.78	20.60	22.60
(K-W H = 28.8224)	MIXEDWOOD	7	0	71	0.0	10.15	26.86	18.14
(p = 0.0000)	WHITE SPRUCE OR PINE	14	0	27	0.0	2.74	7.40	15.43
	BLACK SPRUCE	5	0	79	29.0	36.05	28.51	30.80
FOREST	LOWLAND OPENINGS	6	0	46	7.0	13.62	17.80	10.83
	UPLAND OPENINGS	11	0	67	0.0	12.07	20.62	10.27
	DECIDUOUS FOREST	5	44	81	77.0	67.15	17.81	28.80
(K-W H = 27.5682)	MIXEDWOOD	7	7	100	91.0	72.83	38.42	33.43
(p = 0.0000)	WHITE SPRUCE OR PINE	14	32	100	86.0	75.83	25.44	33.93
	BLACK SPRUCE	5	21	100	65.0	62.89	28.28	29.00

\+ Kruskal-Wallis H statistic.
‡ significance level of K-W H ($p \leq 0.0500$ indicates significant differences among preburn vegetation types)

Table B.20. Percentages of forested island area in density classes by dominant preburn vegetation type for large fires in northern Alberta, 1970-1983.

ISLAND FOREST DENSITY CLASS	DOMINANT PREBURN VEGETATION TYPE	N	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	MEAN RANK
A	LOWLAND OPENINGS	4	0	100	47.5	48.79	56.37	23.75
0-30% CROWN CLOSURE	UPLAND OPENINGS	5	0	22	0.0	5.93	9.51	17.20
	DECIDUOUS FOREST	5	0	19	0.0	4.43	8.21	18.60
(K-W H = 5.6331)+	MIXEDWOOD	7	0	100	0.0	30.15	47.89	20.71
(p = 0.3436)‡	WHITE SPRUCE OR PINE	14	0	100	22.0	31.66	35.61	24.57
	BLACK SPRUCE	5	0	7	0.0	1.38	3.08	13.40
B	LOWLAND OPENINGS	4	0	100	2.0	26.21	49.24	14.13
31-70% CROWN CLOSURE	UPLAND OPENINGS	5	4	100	65.0	66.44	39.11	25.80
	DECIDUOUS FOREST	5	0	100	62.0	58.62	37.89	21.90
(K-W H = 2.9053)	MIXEDWOOD	7	0	100	88.0	58.30	49.14	22.07
(p = 0.7146)	WHITE SPRUCE OR PINE	14	0	100	40.5	43.60	41.82	18.71
	BLACK SPRUCE	5	20	100	46.0	54.69	29.56	21.70
C	LOWLAND OPENINGS	4	0	100	0.0	25.00	50.00	17.63
71-100% CROWN CLOSURE	UPLAND OPENINGS	5	0	96	16.0	27.63	39.62	20.80
	DECIDUOUS FOREST	5	0	100	37.0	36.95	41.25	23.80
(K-W H = 4.8361)	MIXEDWOOD	7	0	81	0.0	11.55	30.56	14.14
(p = 0.4362)	WHITE SPRUCE OR PINE	14	0	100	15.5	24.73	30.25	20.93
	BLACK SPRUCE	5	0	80	53.0	[illegible]3.93	30.19	26.90

+ Kruskal-Wallis H statistic.
‡ significance level of K-W H (p≤0.0500 indicates significant differences among preburn vegetation types)

Table B.21. Percentages of forested island area in height classes by dominant preburn vegetation type for large fires in northern Alberta, 1970-1983.

ISLAND FOREST HEIGHT CLASS	DOMINANT PREBURN VEGETATION TYPE	N	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	MEAN RANK
1: 0 - 9 m	LOWLAND OPENINGS	4	0	100	0.0	25.00	50.00	12.75
	UPLAND OPENINGS	3	0	2	0.0	0.63	1.10	11.00
(K-W H = 5.5374)+	DECIDUOUS FOREST	3	21	100	27.0	49.48	43.86	22.00
(p = 0.2365)‡	MIXEDWOOD	6	0	100	0.0	16.67	40.82	11.17
	WHITE SPRUCE OR PINE	13	0	100	3.0	32.66	40.54	18.77
2: 9 - 18 m	LOWLAND OPENINGS	4	0	100	83.0	66.65	47.14	17.38
	UPLAND OPENINGS	3	15	100	55.0	56.96	42.30	16.17
(K-W H = 1.7113)	DECIDUOUS FOREST	3	0	67	13.0	26.97	35.55	10.17
(p = 0.7887)	MIXEDWOOD	6	0	100	41.0	47.10	51.98	13.58
	WHITE SPRUCE OR PINE	13	0	100	58.0	55.91	41.70	15.77
3: 18 - 24 m	LOWLAND OPENINGS	4	0	33	0.0	8.35	16.70	12.83
	UPLAND OPENINGS	3	0	78	40.0	39.26	38.83	19.83
(K-W H = 4.0136)	DECIDUOUS FOREST	3	0	65	5.0	23.39	36.24	17.83
(p = 0.4042)	MIXEDWOOD	6	0	100	4.5	34.98	50.51	17.58
	WHITE SPRUCE OR PINE	13	0	70	0.0	11.42	24.58	12.77
4: over 24 m	LOWLAND OPENINGS	4	0	0	0.0	0.00	0.00	13.50
	UPLAND OPENINGS	3	0	5	4.0	3.15	2.74	22.83
(K-W H = 11.6502)	DECIDUOUS FOREST	3	0	0	0.0	0.00	0.00	13.50
(p = 0.0202)	MIXEDWOOD	6	0	8	0.0	1.25	3.07	18.08
	WHITE SPRUCE OR PINE	13	0	0	0.0	0.00	0.00	13.50

\+ Kruskal-Wallis H statistic.
‡ significance level of K-W H ($p \leq 0.0500$ indicates significant differences among preburn vegetation types)

Table B.22. Percentages of forested island area in species composition classes by dominant preburn vegetation type for large fires in northern Alberta, 1970-1983.

ISLAND FOREST SPECIES COMPOSITION	DOMINANT PREBURN VEGETATION TYPE	N	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	MEAN RANK
DECIDUOUS FOREST	LOWLAND OPENINGS	4	0	100	0.0	25.00	50.00	20.38
	UPLAND OPENINGS	5	0	98	0.0	31.13	45.03	23.00
	DECIDUOUS FOREST	5	32	100	61.0	62.24	24.64	35.30
(K-W H = 15.0616)+	MIXEDWOOD	7	0	10	0.0	2.15	3.92	18.43
(p = 0.0101)‡	WHITE SPRUCE OR PINE	14	0	55	0.0	6.59	17.09	18.71
	BLACK SPRUCE	5	0	1	0.0	0.11	0.25	18.80
DECIDUOUS MIXEDWOOD	LOWLAND OPENINGS	4	0	67	0.0	16.65	33.29	20.50
	UPLAND OPENINGS	5	0	2	0.0	0.33	0.73	18.80
	DECIDUOUS FOREST	5	0	26	13.0	14.57	10.18	30.80
(K-W H = 7.2214)	MIXEDWOOD	7	0	31	0.0	4.40	11.63	17.57
(p = 0.2047)	WHITE SPRUCE OR PINE	14	0	22	0.0	3.88	7.15	19.29
	BLACK SPRUCE	5	0	17	0.0	4.93	7.41	21.40
CONIFEROUS MIXEDWOOD	LOWLAND OPENINGS	4	0	100	50.0	50.00	57.74	23.25
	UPLAND OPENINGS	5	0	100	0.0	39.11	53.58	19.70
	DECIDUOUS FOREST	5	0	24	7.0	8.86	9.96	17.00
(K-W H = 13.1267)	MIXEDWOOD	7	11	100	100.0	77.91	33.35	33.14
(p = 0.0222)	WHITE SPRUCE OR PINE	14	0	61	4.5	16.34	21.24	17.68
	BLACK SPRUCE	5	0	27	0.0	5.43	12.15	12.80
WHITE SPRUCE OR PINE	LOWLAND OPENINGS	4	0	33	0.0	8.35	16.70	13.50
	UPLAND OPENINGS	5	0	8	0.0	2.45	3.57	12.80
	DECIDUOUS FOREST	5	0	34	0.0	9.46	14.96	15.20
(K-W H = 16.5778)	MIXEDWOOD		0	89	0.0	14.37	33.18	14.29
(p = 0.0054)	WHITE SPRUCE OR PINE	14	0	100	64.5	60.96	37.75	29.64
	BLACK SPRUCE	5	0	60	21.0	25.70	21.73	22.20
BLACK SPRUCE	LOWLAND OPENINGS	4	0	0	0.0	0.00	0.00	13.00
	UPLAND OPENINGS	5	0	92	0.0	26.98	40.87	22.40
	DECIDUOUS FOREST	5	0	24	0.0	4.87	10.88	18.60
(K-W H = 15.3921)	MIXEDWOOD	7	0	8	0.0	1.18	3.11	15.29
(p = 0.0088)	WHITE SPRUCE OR PINE	14	0	100	0.0	12.24	28.46	20.71
	BLACK SPRUCE	5	40	83	73.0	63.82	20.99	35.20

+ Kruskal-Wallis H statistic

‡ significance level of K-W H (p≤0.0500 indicates significant differences among preburn vegetation types)