# FIRE HAZARD CLASSIFICATION FOR WATERTON LAKES NATIONAL PARK

by

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## ABSTRACT

A fire hazard classification in the form of maps with overlays and color coded, was prepared to serve as a planning and operational aid in fire management decision-making in Waterton Lakes National Park. The hazard classification scheme consists of a fuel type map and rate of spread and resistance to control ratings for each of nine fuel types in a range of burning conditions. The nine fuel types were delineated on the basis of implied differences in fire behavior between 19 forest cover types. For each season, fuel type and fire danger index class, rate of spread and resistance to control (available fuel for burning) were rated as Low, Moderate, High or Extreme. Applications of the fuel type map and the fire hazard ratings in fire management planning, day-to-day decision-making on aspects of fire control and prescribed burning are described.

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## INTRODUCTION

Fire management agencies prepare and use fire control plans to describe the resources required for the various phases of fire management, namely prevention, detection and suppression. This report describes a fire hazard classification for Waterton Lakes National Park. It was prepared at the request of the National and Historic Parks Branch of the Department of Indian Affairs and Northern Development. The classification is intended to serve as a planning and operational aid in fire management decision-making in the Park. In developing the classification, the overriding consideration was the need to keep it reasonably simple in content and format to encourage and facilitate its use by planners and fire managers. The result is therefore not a fire control plan but rather a practical planning aid relevant to the needs of Waterton Lakes National Park. The development of this type of planning aid requires a forest cover type map. This has been provided by the Forest Management Research Institute, Canadian Forestry Service, Department of the Environment (Lopoukhine, 1970).

## GENERAL DESCRIPTION OF AREA

Waterton Lakes National Park is located in the southwest corner of the Province of Alberta, bordered by the Province of British Columbia on the west and the State of Montana on the south. Total area is 190 square miles. The topography is mainly mountainous running to over 9,000

feet in elevation on the west and decreasing to near 4,000 feet on the eastern boundary. The mountains in the Park consist mainly of hard compact Precambrian and Lower Paleozoic quartzites, shales, slates and limestones (McKay, 1952). Exposed bedrock covers 23 per cent of the total area (Lopoukhine, 1970).

Waterton Lakes National Park is in the path of a major Pacific storm path which has influenced its climate and vegetation to a considerable extent. Annual precipitation exceeds 20 inches and approaches 40 inches or more at the Continental Divide (Weir and Matthews, 1971). About eight inches of rain falls in the four-month period from April to July and the mean annual snowfall amounts to 100 inches. The frost-free period with minimum daily temperatures in excess of 32°F ranges between 80 and 100 days. The entire region is subject to frequent westerly high winds, which in the winter modify temperatures upwards and cause extreme drying. This effect sometimes shows up as "red belt" in conifer tree crowns on middle and upper slopes.

The forest cover consists of pure and mixed stands of spruces, firs and pines at elevations above 5,000 feet altitude. At lower levels and in main valleys, relatively recent fires have helped to maintain lodgepole pine, Douglas fir, poplar and grassland types. Nineteen major forest subtypes were recognized by Lopoukhine (1970). The major tree species are lodgepole pine (Pinus contorta Dougl. var. latifolia Engelm.), alpine fir (Abies lasiocarpa (Hook) Nutt.), spruce (Picea glauca (Moench) Voss var. albertiana (S. Brown) Sarg., P. engelmanii Parry), Douglas fir

(Pseudotsuga taxifolia var. glauca), whitebark pine (Pinus albicaulis Engelm.) and poplars (Populus tremuloides Michx., P. trichocarpa Torr. and Gray, P. balsamifera L.). Douglas maple (Acer glabrum, Torr, var. douglessii (Hook) Dipp.), thimbleberry (Rubus parviflorus Nutt.) and green alder (Alnus crispa (Ait.) Pursh) are the most important shrubs and early meadow rue (Thalictrum venulosum), heartleaf arnica (Arnica cordifolia Hook) and sedges (Carex sp.) the most prevalent herbs. Area coverage by major vegetation types is given in Table 1.

TABLE 1. PLANT COVER OF WATERTON LAKES NATIONAL PARK IN AREA PER CENT (FROM LOPOUKHINE, 1970)

| Classification | Per Cent of Total Area | Classification | Per Cent of Total Area |
|---|---|---|---|
| Lodgepole Pine | 17 | Deciduous | 7 |
| Alpine Fir | 14 | Upland Vegetation | 22 |
| Spruce | 4 | Rock | 23 |
| Douglas Fir | 2 | Miscellaneous non-forest | 3 |
| Whitebark Pine | 2 | Water | 4 |
| Mixedwood | 2 | | |
| | | Total | 100 |

Fire has unquestionably played a major role in determining the composition and extent of the vegetation in the Park. Roughly 50 per cent of the forest cover consists of pioneer species such as pine and

aspen. Fires during the past 50 to 100 years have generally been confined to the valleys and the grassland-aspen types in the north-eastern corner of the Park. Forest inventory data indicate also that many of the stands which have escaped fire in recent time are developing toward a spruce-fir or fir-spruce climax. The older stands of alpine fir and spruce are at the higher elevations in the western half of the Park.

## DEVELOPMENT OF THE FIRE HAZARD CLASSIFICATION

In drawing up the fire hazard classification for Waterton Lakes National Park, we accepted as a necessary guideline the fact that the hazard rating scheme must be easy to apply and factual. This necessitated a reduction in forest types from the 19 recognized by Lopoukhine (1970) to 9, by grouping these types according to fuel characteristics such as loading, arrangement and surface area-volume ratios. This approach resulted in a standard technique for fuel typing and should have application in other National Parks.

A review of relevant information, discussions with Parks personnel and a field reconnaissance led to the decision to proceed with the development of the rating scheme in two main phases, namely: a fuel type classification in written and map form, and a fire hazard rating to account for the effect of important weather factors on fire behavior and control difficulty in written and map form. The hazard classification would be related to the Initial Spread Index (ISI) and the Adjusted Duff Moisture Code (ADMC) of the new Canadian Fire Behavior Rating System

(Anon. 1970). A 100-foot-interval contour map overlay would be added to the fuel type map to facilitate determination of slope in percent and aspect.

The final results would be in the form of a large-scale wall map depicting fuel types on a scale of 4 inches to the mile, a wall chart with photographs of the nine fuel types, rate of spread and resistance to control charts to reflect differences in fire behavior between fuel types, an overlay depicting slope, aspect and elevation, a hand-held slope-class interpreter, and a written statement outlining relevant data important to interpretation of the maps and charts.

Fuel Type Map

Familiarization with the 19 forest cover types and the over 4,000 stands depicted by the forest cover type maps.(Lopoukhine, 1970) was carried out in the form of a field reconnaissance. Stands were delineated on the basis of species, height and density (Appendix I) and ranged in size from one-half to several hundred acres. Stands in each forest cover type believed to contain fuels likely to cause important differences in fire behavior between and within types were inspected by members of the study team. Stand descriptors such as species, height, age, density and minor vegetation were related to fuel loading, horizontal and vertical continuity, compactness, ratio of live versus dead fuels, surface area-volume ratios, effect of stand on the fuel moisture regime and seasonal variation in vegetative composition and condition. Significant differences in stand and fuel parameters and implied effects of these on

fire behavior formed the basis for the initial fuel type classification into nine major types. The implied differences in fire behavior between fuel types were based on burning conditions at high fire hazard, i. e., ISI of 10 and ADMC of 50 (Anon, 1970).

Following the preparation of a preliminary fuel type map, an intensive field reconnaissance was carried out to determine if the designated fuel types were in fact indicative of important differences in fire behavior. For the final fuel type map, minimum size of a separate fuel type to be mapped was set as 20 acres, with the exception of blowdowns and salvaged stands where the minimum was set as 10 acres.

The fuel type map on a scale of four inches to the mile was colored according to the criteria outlined in Appendix I and II. A small-scale color reproduction of the fuel type map for Waterton Lakes National Park is included in this report (Figure 1). Highways, secondary roads and lakes are also shown.

## Fire Hazard Classification

As a day-to-day aid in fire management planning and operations, separate hazard ratings were developed to reflect the effect of weather factors such as wind and fuel moisture on fire spread and available fuel for burning. We decided that the most useful fire and control effort descriptors relate to rate of fire spread and the fuel available for burning in a range of burning conditions. The initial fire hazard rating scheme was to assign a relative point-rating of from 1 to 10 for each fuel type for each of four ISI and ADMC classes.

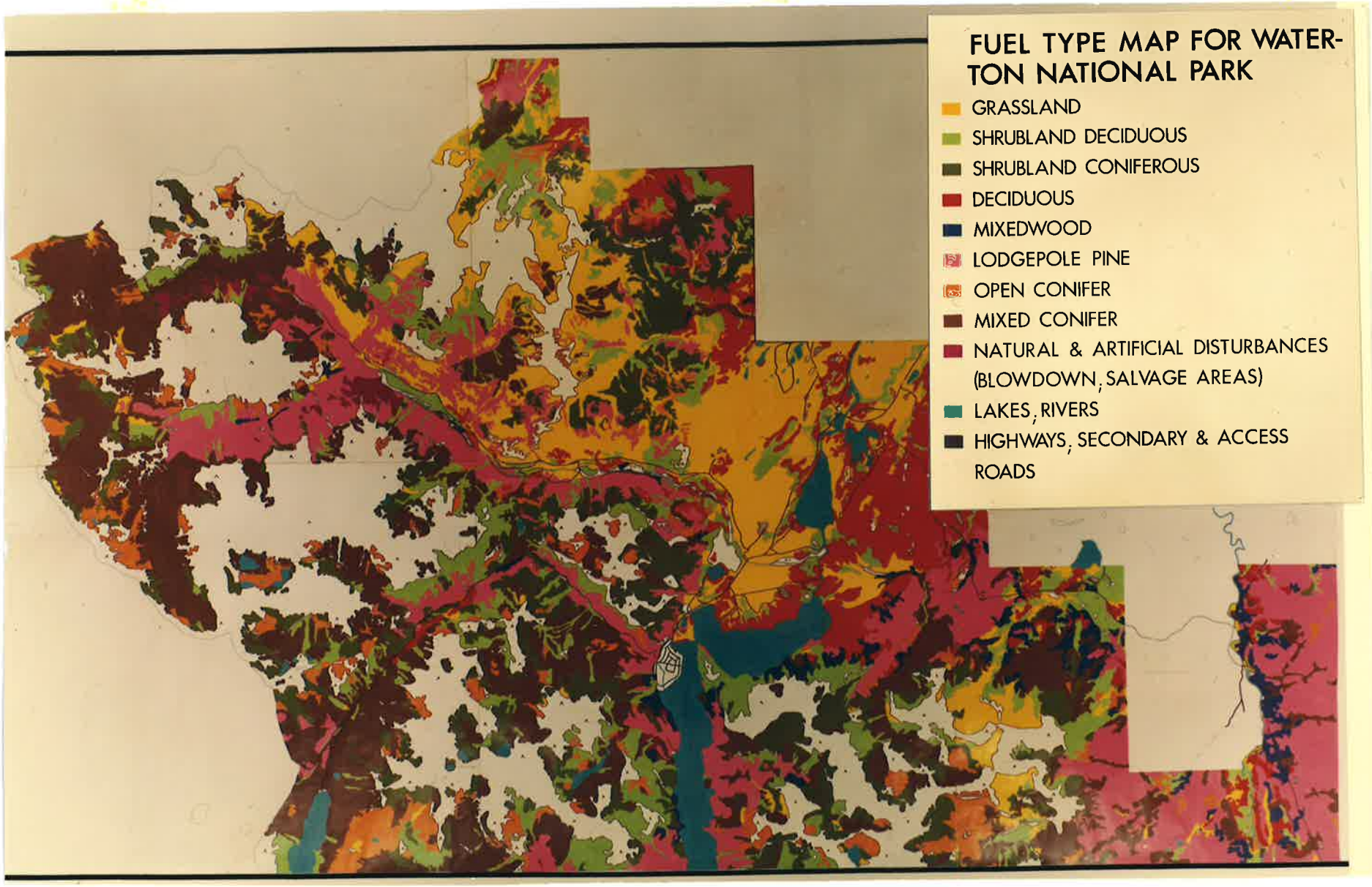

FUEL TYPE MAP FOR WATERTON NATIONAL PARK
GRASSLAND
SHRUBLAND DECIDUOUS
SHRUBLAND CONIFEROUS
DECIDUOUS
MIXEDWOOD
LODGEPOLE PINE
OPEN CONIFER
MIXED CONIFER
NATURAL & ARTIFICIAL DISTURBANCES (BLOWDOWN; SALVAGE AREAS)
LAKES; RIVERS
HIGHWAYS; SECONDARY & ACCESS ROADS

Figure 1.

The final rate of spread and resistance to control ratings were subsequently modified by incorporating the individual point ratings into relative hazard classes of Low, Moderate, High, and Extreme. Thus, for each season, fuel type, ISI and ADMC class, the hazard was rated as either Low, Moderate, High, or Extreme. The criteria followed in preparing the fire hazard (rate of spread and resistance to control) classifications are shown in Appendix III. The resulting rate of spread and resistance to control ratings are shown in Figures 2 and 3.

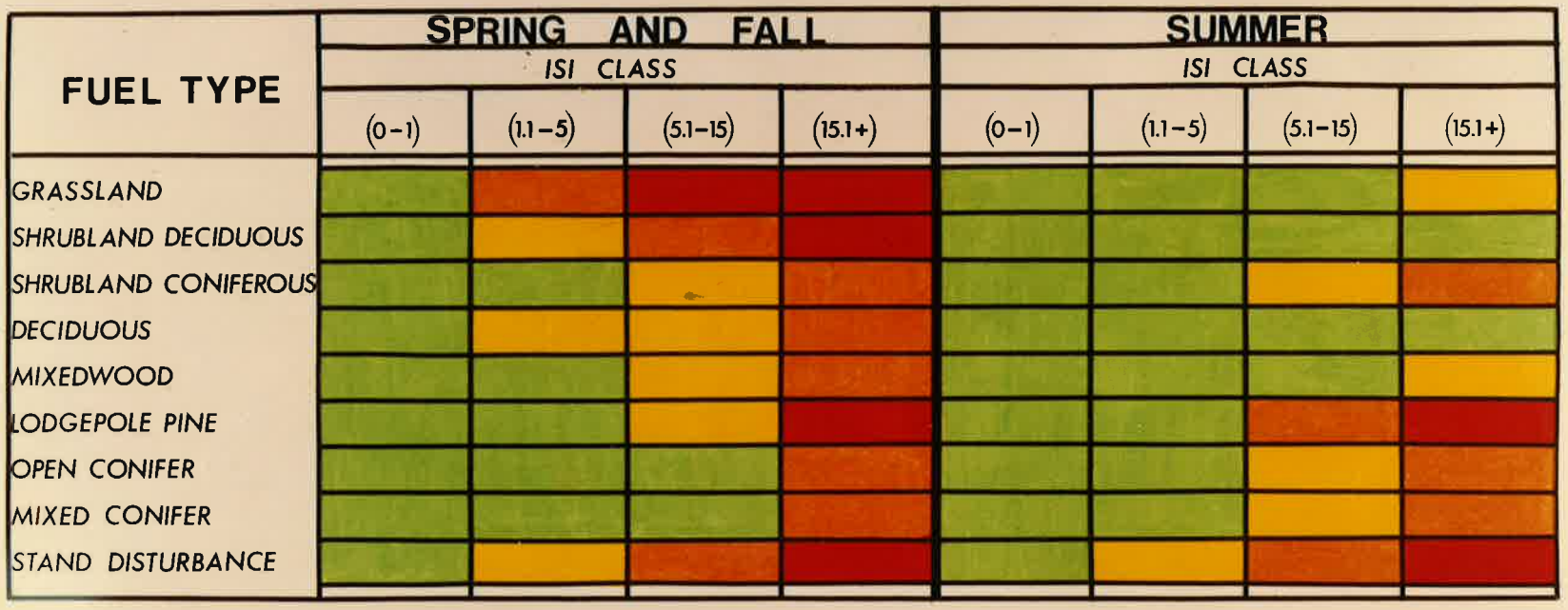
Rate of Spread (ISI) and Adjusted Duff Moisture Code (ADMC) were delineated on the basis of frequency distributions for a number of fire weather stations in the East Slopes of the Rocky Mountains. For both indices, the Low, Moderate, High, and Extreme classes can be expected to occur about 45, 35, 15, and 5 per cent of the time, respectively.

Slope and Aspect

To account for differences in slope and aspect and their effect on fire behavior and management considerations, a large-scale (4" = 1 mi.) contour map was obtained to be used as an overlay on the fuel type map. A Slope Determination Guide was prepared to facilitate estimation of the per cent slope in three classes, namely:

| | |
|---|---|
| Class 1 | Less than 15% |
| Class 2 | 16 to 30% |
| Class 3 | Greater than 31% |

## RATE OF SPREAD RATING FOR THE WATERTON LAKES NATIONAL PARK




RATE OF SPREAD

LOW
MODERATE
HIGH
EXTREME

*Use Spring and Fall Table when at least 50 per cent of minor vegetation is cured.*

*Use Summer Table when at least 50 per cent of minor vegetation is green.*

Figure 2.

## RESISTANCE TO CONTROL RATING FOR WATERTON LAKES NATIONAL PARK

| FUEL TYPE | SPRING AND FALL ADMC CLASS | | | | SUMMER ADMC CLASS | | | |
|---|---|---|---|---|---|---|---|---|
| | (0-20) | (21-40) | (41-75) | (76+) | (0-20) | (21-40) | (41-75) | (76+) |
| GRASSLAND | LOW | LOW | LOW | MODERATE | LOW | LOW | LOW | MODERATE |
| SHRUBLAND DECIDUOUS | LOW | LOW | MODERATE | MODERATE | LOW | LOW | LOW | MODERATE |
| SHRUBLAND CONIFEROUS | LOW | LOW | LOW | MODERATE | LOW | LOW | LOW | MODERATE |
| DECIDUOUS | LOW | LOW | MODERATE | MODERATE | LOW | LOW | LOW | LOW |
| MIXEDWOOD | LOW | LOW | MODERATE | HIGH | LOW | LOW | LOW | MODERATE |
| LODGEPOLE PINE | LOW | LOW | MODERATE | HIGH | LOW | LOW | MODERATE | HIGH |
| OPEN CONIFER | LOW | LOW | MODERATE | MODERATE | LOW | LOW | MODERATE | MODERATE |
| MIXED CONIFER | LOW | LOW | MODERATE | HIGH | LOW | LOW | LOW | HIGH |
| STAND DISTURBANCE | LOW | MODERATE | EXTREME | EXTREME | LOW | MODERATE | EXTREME | EXTREME |

RESISTANCE TO CONTROL

LOW
MODERATE
HIGH
EXTREME

*The Resistance to Control Rating is based primarily on the available fuel for burning.*

*Use Spring and Fall Table when at least 50 per cent of minor vegetation is cured.*

*Use Summer Table when at least 50 per cent of minor vegetation is green.*

Figure 3.

Aspect and elevation can be determined by reference to the contour map. Slope and aspect will indicate to the fire manager something of the terrain in the Park and what types of resources are likely to be needed if a fire starts.

## APPLICATION OF THE FIRE HAZARD CLASSIFICATION

### Fire Management Planning

The fire hazard classification should be useful to the resource management planner and the fire manager in assessing the type and extent of the vegetation in relation to fire and in determining the policy and resource requirements for effective fire management. Since the enjoyment of National Parks is closely tied to the makeup of the vegetation and wildlife populations, much emphasis needs to be placed on fire management (including manipulation of vegetation) as well as fire control, the primary objective of which is fire suppression. The fuel type map indicates the location and relative distribution of major vegetation groups, permitting an assessment of the successional stage of each. The fire hazard ratings should prove of greatest value in planning and carrying out the short-term aspects of prevention, detection and suppression, including prescribed burning.

### Specific Applications

The fuel type map itself implies differences in fire behavior between types but does not rate them. Knowledge of where these fuel

types are found should be useful in deciding where detection is needed at different times during the fire season. A scrutiny of the fuel type map further indicates that fire incidence and area burned has been greatest in the valleys and the eastern extremities of the Park where grassland, deciduous, and lodgepole pine fuels predominate; this pattern is likely to recur in the future.

To increase the usefulness of the fuel type map to the fire manager, relative rate of spread and resistance to control ratings were prepared for each fuel type. These ratings, related to various indices in the new Canadian Fire Behavior System (1970) account for the effect of weather factors on fire behavior. The rate of spread ratings are indicative of the relative length of the fire perimeter and should be of greatest value in dispatching of men and equipment to ensure prompt fire containment. The resistance to control rating indicates the available fuel for burning and should therefore be important in deciding on the suppression strategy and tactics, including kinds and quantities of equipment. Also, it can be used as an indicator of drought buildup and subsequently as a planning aid in preparing for potentially serious fire situations.

It is conceivable that prescribed fire will be used in National Parks to achieve specific resource management objectives such as a balanced distribution of forest communities, reduction of unacceptable fire hazards, improvement of wildlife habitat, and the training of fire control personnel. The fuel type map and the hazard ratings should form the

basis for planning and conducting such work. For example, burns in grassland and deciduous fuels can be scheduled for spring or fall when fire spread is unlikely in conifer fuel types such as open and mixed conifer. Areas of stand disturbance can safely be burned in fall when the possibility of a serious drought buildup no longer exists.

In using the fuel type map, fire hazard ratings and related information as aids in the short and long-term fire management planning and operations of the Park, the following additional considerations may prove helpful. Provided an ignition (man or lightning) source is present, most fuels are likely to ignite readily when the rate of spread rating is High or Extreme. Given similar ISI values, ignition probability is lower in summer than in spring and fall owing mainly to the abundance of green minor vegetation under most stand canopies. Detection intensity should be increased during High rate of spread conditions whereas travel restrictions and cancellations of any fire permits may have to be imposed when both rate of spread and resistance to control ratings are Extreme. Up-to-date roadside signs at one or two strategic locations are helpful to inform the travelling public of prevailing fire hazard and special travel restrictions while in the Park. More detailed guidelines for fire management planning and fire control operations can be prepared following familiarization by Parks personnel with the hazard classification scheme.

## REFERENCES

Anon. 1970 - Canadian Forest Fire Weather Index, Canadian Forestry Service, Dept. of Fisheries and Forestry.

Lopoukhine, N. 1970 - Forest types and related vegetation of Waterton Lakes National Park, Alberta, 1968. Canadian Forestry Service, Forest Management Institute, Inf. Rpt. FMR-X 28, including Appendix 1 - 5.

MacKay, B. R. 1952 - Geology of the National Parks of Canada in the Rockies and Selkirks. Can. Dept. Resources and Develop.

Weir, T. R. and G. Matthews, 1971 - Atlas of the Prairie Provinces. Oxford University Press, Toronto.

## APPENDIX I

Definition of abbreviations and stand descriptors used to describe stands and subtypes (after Lopoukhine, 1970)

### FOREST COVER TYPES

Species

| | |
|---|---|
| P | Lodgepole Pine |
| WHP | Whitebark Pine |
| S | Spruce (Engelmann X white) |
| F | Alpine Fir |
| D | Douglas Fir |
| AL | Alpine Larch |
| Po | Poplar |

In mixed species stands the predominant species is shown first (SPo). Species that are estimated to comprise less than 25% of the total volume of the stand are not shown in the symbol.

Height and Density

| Height in feet | Code | Canopy Density in Per Cent |
|---|---|---|
| 1-20 | 1 | 1-20 |
| 21-40 | 3 | 21-40 |
| 41-60 | 5 | 41-60 |
| 61-80 | 7 | 61-80 |
| 81-100 | 10 | 81-100 |

### NON-FORESTED AREAS

| Upland | Lowland |
|---|---|
| U - 1 Herbs | M - 2 Emergent vegetation |
| U - 2 Shrubs, deciduous | M - 3 Sedges and grasses |
| U - 3 Shrubs, coniferous | M - 4 Shrubs, herbs and sedges |

Stream flood plain phase

P - 0 Dried stream bed
P - 1 Emergent vegetation
P - 2 Herbs
P - 3 Shrubs

## APPENDIX II

Guidelines for Fuel Type Mapping

| | | |
|---|---|---|
| (1) | Grassland - all stand types U - 1, M - 2, M - 3, P - 1 and P - 2 | Yellow |
| (2) | Shrubs, deciduous - Stand types U - 2, P - 3, M - 4, all 1 POX (all 20' height class in Po), and all height class 1 mixed-wood with Po dominant, e.g. 1PoS1 | Light Green |
| (3) | Shrubs, coniferous - All stand types U-- 3, and all height class 1 conifers and mixedwood with conifer dominant, e.g. 1PPo1, 1LSPo1 Includes all height and density class 1 conifer stands. | Dark Green |
| (4) | Deciduous - 3 Po1 and 3Po3 and higher, e.g. 3Po5, 3Po7, 5Po5 | Red |
| (5) | Mixedwood - all mixedwood stands with height and density classes 3 and higher, e.g. 3SPo3, 3SPo5, 3PoP3, 5PPo5 | Blue |
| (6) | Lodgepole pine - All pure lodgepole pine stands 3P3 and higher, Douglas fir (D) and combination of DP on south, south-west, west and north-west slopes, or where designated on map. | Pink |
| (7) | Open conifer - all pure and mixed conifer stands in any height class 3 and higher and density class 1, e.g. 3P1, 5F1. | Orange |
| (8) | Mixed conifer - All mixed conifer stands with height class 3 and higher, including isolated pockets of pure lodgepole pine, e.g. 3P3. Any Douglas fir (D) pure or mixed in height and density classes 3 or higher on north, north-east, east and south-east facing slopes or where designated on map. | Rust |
| (9) | Disturbance - (natural or artificial) - refers to blowdown and salvage operation. | Purple |

## APPENDIX III

Guidelines for Fire Hazard Rating

| | | |
|---|---|---|
| (1) | Low - Fire spread possible in open but ignition unlikely in stands. Fuel consumption minimal. | Green |
| (2) | Moderate - Fire spread high in open but very slow in forests.<br><br>Fuel consumption low but smouldering may be persistant when ADMC exceeds 40. | Yellow |
| (3) | High - Fire spread rapid in open and may be fast in forest for short periods of time. All litter and part of duff layer may be consumed. Crowning likely to be spotty. | Orange |
| (4) | Extreme - Ignition can occur from sparks, rate of spread extreme through dry and continuous fuels. Duff consumption complete in shallow duff stands with persistent smouldering in deep duff sites. Crowning may be extensive. | Red |

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1972. Fire hazard classification for Waterton Lakes National Park.

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