FIRE ECOLOGY IN RESOURCE MANAGEMENT

WORKSHOP PROCEEDINGS

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INTRODUCTION

Fire management has been defined as "the integration of interdisciplinary efforts to support resource management goals defined in land use planning."

The objectives of the workshop were to provide a forum for exchanging information and ideas regarding fire management needs and priorities and to discuss opportunities for integrating fire management, including ecological considerations, into resource management.

Many resource organizations and agencies, including several federal and provincial government departments, universities and technical schools, industry and other groups are concerned with some aspects of fire management. Although the term "fire management" is in common usage, as defined it has not been fully implemented.

By gathering together many individuals and agencies with different objectives and perspectives in fire management we hope to stimulate the needed interchange that will encourage integration of planning based on common land-use goals and objectives.

Until this occurs, conflicts between resource agencies will intensify as greater private and public demands are made on the resources themselves. Communication is the key, and toward that end these proceedings are distributed.

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ANNUAL BURNING AND VEGETATION IN THE ASPEN PARKLAND OF EAST CENTRAL ALBERTA

by

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ABSTRACT

Fire has been instrumental in checking the encroachment of woody vegetation into grasslands. This study was undertaken to document some of the vegetational changes associated with burning in the Wainwright area of Alberta.

Repeated annual burning over the past 25 years has markedly altered the physiognomy and composition of the parkland vegetation. Forest cover declined from 68 to 15% while grass cover increased from 8 to 61%. The number of grass and sedge species was more than doubled by burning while the number of forb species increased 1.6 times. The number of shrub species was slightly reduced. Thus species diversity (no. species per unit area) was increased by burning.

Major increasers in cover were *Calamovilfa longifolia* (0.7% on unburned to 41% on burn), *Carex obtusata* (1.1 to 18%), *C. heliophila* (0.1 to 14%) and *Solidago missouriensis* (1.7 to 27%). Major decreasers were *Symphoricarpos occidentalis* (31 to 2%), *Festuca scabrella* (36 to 18%) and *Stipa spartea* var. *curtiseta* (15 to 11%). Increasers consisted of one shrub, six grasses and sedges, and twelve forbs, while decreasers consisted of six shrubs, ten grasses and sedges, and six forbs. Shrub density on *Flaeagnus commutata* (1.2 to 6.4 stems/m^2), *Amelanchier alnifolia* (1.2 to 6.2) and *Prunus virginiaua* (1.0 to 4.2) increased, while that of *Symphoricarpos occidentalis* (25.0 to 17.8) decreased.

Average maximum leaf blade lengths of *Festuca, Stipa, Agropyron subsecundum, Calamoyilfa* and *Carex siccata* on the burn were 41 to 82% of the lengths found on the unburned areas. *Calamovilfa*, the most abundant species on burned areas, showed the least reduction in blade lengths.

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Presence of seed heads of *Muhlenbergia richardsonis*, *Calamovilfa*, *Bouteloua gracilis* and *Koeleria cristata* was increased by burning, whereas that of *Stipa* and *Festuca* was decreased. Seed head densities for the latter three species were reduced by burning.

Total standing crop on the burned area in August 1976 (a dry year) was 1499 kg/ha compared to 9244 kg/ha on the unburned areas. Unburned grass- and shrub-dominant communities consisted primarly of litter (49%) and shrub (35%) components, whereas on the burned areas grass (50%) and forb (20%) components were dominant.

RECONSTRUCTING THE FIRE HISTORY OF PUKASKWA NATIONAL PARK

by

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INTRODUCTION

Pukaskwa National Park (PNP) is a 186 000 ha component of the National Parks System located in Ontario on the northeastern shore of Lake Superior (Fig. 1). The creation of PNP was agreed upon in July 1971 through a "memorandum of intent" signed by federal and provincial authorities. PNP is expected to be officially transfered to the federal government on Feb. 6, 1978.

The patternization of vegetation and age-class mosaics attests to the fact that PNP has been influenced to a large degree by periodic, random wildfires. The need for fire management inventories and anlysis was expressed to the Canadian Forestry Service (CFS) by Parks Canada in May 1976. Baseline information to guide fire and vegetation management planning, and for landscape interpretation was obviously a must. A co-operative, jointly financed investigation between the CFS and Parks Canada was initiated in April 1977 to assess the historical, ecological, and managerial role of fire in PNP (Alexander 1977). The primary objectives of this venture are: (1) reconstruction of fire history, (2) forest vegetation development following fire, (3) fire environment analysis, and (4) evaluation of future fire management needs. This paper represents a synopsis of the methodology for and a progress report on objective #1.

PARK SETTING

PNP is located in the Superior Forest Section (B.9) on the southern edge of the Boreal Forest Region of eastern Canada (Rowe 1972). Principal conifers are jack pine, black spruce (upland and lowland sites), white spruce, balsam fir, and to a lesser extent eastern white pine,

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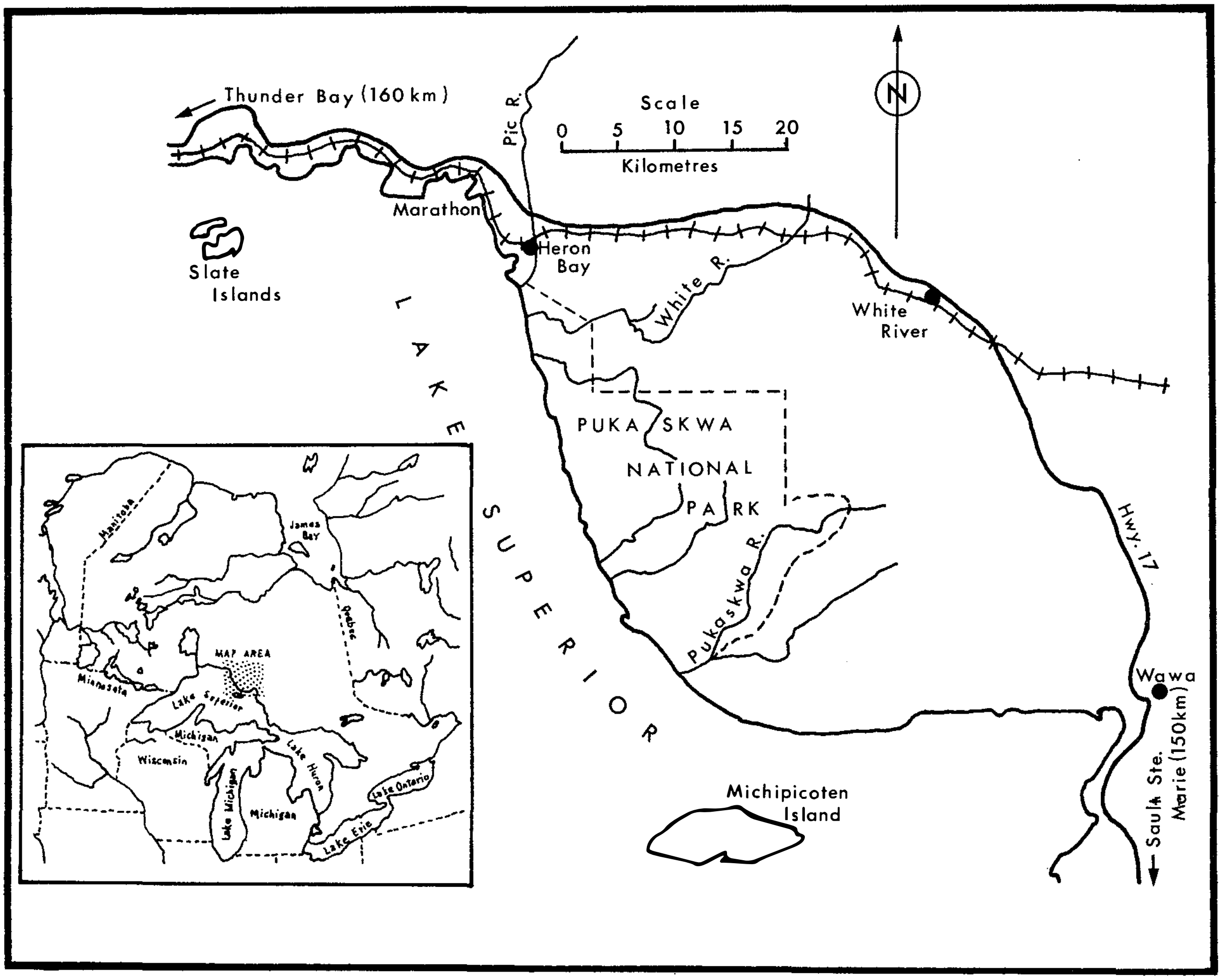

tamarack, eastern white cedar, and red pine. The broadleaf associates are chiefly white birch and trembling aspen. The topographic features are complex--the coastline is rough and rugged terrain, broken by slopes and depressions. This condition extends inland for some distance, gradually grading into a rolling landscape. Extensive areas of level terrain occur principally at the north and south ends of the Park. Elevation ranges from approximately 180 (Lake Superior coastline) to 640 m. The climate may be classified as modified continental, characterized by long, cold winters and short cool summers. Mean annual temperature is 2.2°C. Mean annual precipitation along the coast is about 76 cm (40% as snow) and increases slightly inland (Findlay 1976).

APPROACH

In terms of the roles played by each agency, both parties contribute fully to the field sampling. CFS staff are primarily responsible for data analysis (office and laboratory) because of available equipment (i.e., Map-O-Graph). PNP personnel play a major role in coordinating logistical arrangements and providing vital support to the field program through their first-hand familiarity with the Park area.

Our basic methodology is very simple and certainly not unique. A review of available fire history techniques (Alexander 1978) and the Park's forest vegetation is followed by a field reconnaissance and then assembly of all available resources. This base of information and experience allows for necessary modifications in sampling techniques and emphasis and provides the best possible approach to designing a systematic sampling network that hopefully will provide adequate coverage for the time allocated. A preliminary fire chronology can also be constructed.

Our aim is to determine the temporal and spatial characteristics of past fires as far back as the field evidence and historical references will allow. Two major historical plant geography techniques are being used to establish past fire dates and thus a master chronology: (1) dendrochronology--the tree ring record, and (2) written and oral accounts. The tree-ring evidence encompasses a variety of materials. These include (1) increment borings (min. 4/area based on size, appearance, etc., corrected for ht. of boring) from suspected (charcoal checked for in the soil) fire-origin (vs. insect, disease, or blowdown) stands, (2) wedges and cross-sections of basal fire scars from live and dead stems, (3) cross-sections from fire-killed standing and downed snags of known fire dates. Age counts are made in the field and returned to the lab for sanding, shaving, pith projections (if necessary), and final dating using an addo-x tree ring counter or variable power binocular microscope. All sampling points are noted on a 1:50 000 topographic map and field notes taken (i.e., core ht., fire scar direction). Another application of tree-ring evidence is in dendroclimatology, which involves the use of tree-ring widths and density chronologies (i.e., Parker 1976) to assist in identifying and/or verifying fire dates, relative climatic regime prior to and during past fires, and in determining the periodicity of climatic patterns (i.e., drought) in the area before weather stations were established and records kept. Assembling the written record from historical sources to establish and verify fire dates involves searching several possible published and unpublished sources and media--provincial fire reports and maps, newspaper articles, journals, diaries, file documents, government reports, historical reviews, land survey notes, etc. These items may also be of assistance in determining relative location, size,cause (role of lightning- vs. man-caused fires), behavior, and effects of past fires as well. Interviewing living pioneers (i.e., loggers, timber cruisers) from the area is yet another valuable tool. Previous fire history studies in the Great Lakes region may also help in identifying major fire years (i.e., those associated with a regional or subcontinental drought). In delineating the areal extent and boundaries of past fires, emphasis is being placed on: (1) aerial photographs, (2) forest and stand type maps, (3) physiographic features,(4) sampling locations, and (5) ground and aerial reconnaissance.

From the data gathered, we should have sufficient information to construct *Stand Origin* and *Fire History* maps (Heinselman 1973), determine the periodicity of various levels (size) of fires, estimate frequency by forest cover type, drainage, etc., and calculate the fire rotation or cycle by cultural periods. Inferences about the general behavior of past fires (from the beginning of fire suppression to present) will rely on information extracted from provincial fire reports, weather records, and interviews with fire personnel involved. Prior to this, stand structure, historical accounts, and the dendroclimatological results will have to be utilized.

AVAILABLE RESOURCES

Black and white aerial photos of the Park area were taken in 1928, 1937, 1949, 1963, and 1974. Stereoscopic interpretation of the 1949 photos was completed (spp., 7 age-classes) by the Abitibi Pulp & Paper Co. (Anon. 1953). The 1963 photos were interpreted as part of the Ontario Ministry of Natural Resources (OMNR) Forest Resources Inventory program (Dixon 1960) in 1964 (spp., est. age) and again in 1973 by the CFS Forest Management Institute (Ottawa) as part of the Biophysical mapping (Gimbarzevsky 1976) efforts for the Park (spp., 5 age-classes). Climatic data for the immediate Park area is available from the Atmospheric Environment Service for 1886-1975 at White River, 1887-1901 and 1913-19 at Heron Bay, and 1950 to present at Marathon (Anon. 1976). Data is also available for other regional stations back to the 1890's. The majority of logging activity was completed between 1917-30 in the southern portion of the Park. Logging maps and related facts have been obtained in order to separate the cutting vs. fire history (Heinselman 1969). A preliminary study to compile a bibliography and summarize the human history of the PNP area has been completed by Marsh (1976). Several potentially useful references have been turned up. A half dozen individuals with first-hand experience and information on the Park area have been located for interviews.

PROGRESS--PROBLEMS--PLANS

Three and half weeks of reconnaissance and sampling work was completed during the 1977 field season in which all forest community types were visited. Some 25 wood sections and 90 increment cores were colleted and are presently being prepared and dated. A coastal red pine stand (ca. 250 yrs old) and interior one (ca. 170 yrs old; outside the Park) have been located for the dendroclimatological work. As expected, jack pine stands were the most prolific source of information. Charcoal evidence in the soil was almost universally found in the areas examined. Preliminary results from a search of OMNR fire records revealed that since 1923, 55 fires have occurred (70% LC) with 14 (13% LC) greater than 40 ha. Area burned by LC fires has been approximately 36 000 ha while MC area burned has amounted to less than 160 ha.

The building of the railroad (1883-85) in the area appears not to have increased fire occurrence (preliminary results indicate fires of 1830, 1869, and 1910 in the northern end of the Park) as it did in the rest of the north shore of Superior, because of PNP's location in relation to the railroad; see Fig. 1. Fires as a result of logging activities have had minimal impact. Other aspects of whites and natives as ignition sources as described by Lutz (1959) and their total impact remain to be evaluated. A historian on contract with Parks Canada noted in his report on PNP that "Perhaps no region of comparable size in Ontario has been, on the whole, as devoid of human interaction...." Despite the lack of written record, several excellent references have been found. A sample is in order. In a journal kept by John Swanston of the Hudson Bay Company Trading Establishment at the mouth of the Pic River (north side) we find on July 21, 1830, "... fire on the opposite side of the [Pic] river...sparks are flying in all directions." Reverend Thomas Hurlburt, while at the Michipicoten River (Jesuit) Mission, remarked on August 6, 1862, "This region is now being ravished by fire. The season has been so dry...." Ontario Provincial Land Surveyor Hugh Wilson noted in his 1873 field survey report of Pic Township (which includes the northern extremity of the Park) that "The last fire occurred, I am told in 1869...." Our rather painstaking search of historical references is continuing.

The study is not without its obstacles. Access is perhaps our biggest problem. There are very few trails in the area as of yet, and the country is indeed rugged. A large portion of the coastal area can be worked from a boat. For most of the interior, we'll have to resort to a combination of canoe, helicopter (Hughes 500C w7 floats), fixed-winged aircraft, and foot in the summer and fall, and snowshoes and snowmobiles in the winter time. There is a large contiguous tract of spruce-fir-aspen-birch in the central portion of the Park with few intermingled jack pine stands. We expect this to give us some problems in accurately dating and mapping past fire years and boundaries. A large percentage of the white pine examined this past summer exhibited a high degree of rot. Only one stand of red pine has been recognized in the Park--this has resulted in a lack of long-term fire scar material. We expect to experience other limitations in fire history reconstruction technology such as interpreting two fires as one, not detecting small acreage fires, locating *actual* fire boundaries, etc. Realistically, we believe that we can quite accurately reconstruct the fire history for most of the Park back to 1825-50. Before that we are faced with reaching the longevity of most tree species and stands, and loss of material through fungal decay (quite accelerated in the area compared to western Canada), carpenter ants, and successive fires. Expected completion date for the entire investigation is 1980. A minimum of 60 days will be spent sampling over the 1978 and 1979 field seasons.

It is a pleasure to acknowledge the assistance of co-investigator W.R. Wyett (PNP Chief Naturalist), PNP patrolman L.T. Star, and CFS fire research technician J.A. Mason. The administrative support of GLFRC Director J.H. Cayford and PNP Superintendent A.N. Fisk is greatly appreciated.

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FIRE AND CARIBOU IN NORTHERN CANADA

by

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The devastation of the winter habitat by forest fires has been suggested as a possible cause of the decline of barren-ground caribou. Four areas in northern Canada were selected for studying the effects of fire on lichen rangelands. A literature review, forest cover maps, fire control records, and examination of the forests themselves indicate that fire is a natural phenomenon and not a new factor in the ecology of the region. During a period that extended from 1961 through 1964, there were 1,250 known forest fires that burned-over 5 005 872 acres of potential winter range. The cover-map data on forest age classes suggested that the amount of destruction in recent years has increased.

The standing crop of usable forage and high-value lichens was determined for six forest age classes. Destruction of the extremely slow-growing arboreal lichens by fire must be considered a serious loss of caribou winter forage.

Burning did not affect all game populations alike,as shown by the densities per acre of barren-ground caribou and moose pellet groups. In forests over 120 years old, 722 caribou pellet groups per acre were found compared with only 18 per acre on the 1- to 10-year age class. There were 49 moose pellet groups per acre in the 11- to 30-year age class and only three per acre in forests over 120 years old. Moose apparently preferred habitats in early stages of succession, but barren-ground caribou favored those in later stages of succession.

For more complete details the reader is referred to the following references:

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FIRE BEHAVIOR IN NATURAL FOREST STANDS

by

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In 1970 the Canadian Forest Fire Weather Index Tables were issued nationally to fire management agencies, providing a uniform danger rating scale across Canada. The Fire Weather Index (FWI) is the introductory phase of the overall Canadian Fire Danger Rating System and as such is limited to numerically rating relative wildland fire potential (1,2). The FWI is weather-dependent only, and regional studies are in progress to provide Fire Behavior Indices for local fuel complexes. Specific fire behavior parameters will be related to the appropriate FWI component, i.e., Initial Spread Index (ISI), Buildup Index (BUI), Fire Weather Index (FWI), Fine Fuel Moisture Code (FFMC), and Drought Code (DC).

In the region serviced by the Northern Forest Research Centre, fire behavior has been studied in relation to natural variation of weather and fuels through rigorous experimental burning designs. Regional fire management agencies have generously supported the operational aspects of this series of experimental burns. Prescribed burning studies facilitate accurate pre- and postfire measurement of the physical fuel attributes that determine rate of spread and fire intensity. Historical weather is documented onsite; component codes and indices of the FWI are calculated well ahead of the burn. A sufficient number of plots is delineated in a given fuel complex to sample the range of weather conditions necessary to observe behavior of low to extreme vigor fires.

The initial Fire Behavior Index in the NFRC region was determined for lodgepole pine (*Pinus contorta* var. *latifolia*) slash (3). Twenty 0.4-ha plots were experimentally burned during the summers of 1969, 1970, and 1971. Rate of spread was related to the ISI in the form

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of a simple linear regression RS = a + b(ISI). Minimum and maximum spread rates were 2.4 and 19.8 m/min., respectively. Depth of burn into the duff layer was best predicted by the DMC, again in the form of a simple linear regression DB = a + b(DMC). The range of depth of burn was 0.25 and 5.61 cm.

Thirteen 0.1-ha plots were experimentally burned in May of 1972 to define the fire spread and intensity range of aspen (*Populus tremuloides*) during the leafless stage. Rate of spread was best predicted by the equation $RS = a(ISI)^b$, and minimum and maximum spread rates were 0.1 and 2.5 m/min., respectively. Fires of low vigor had minor impact on understory vegetation and the aspen stand. Moderate and high vigor fires killed 25 and 60% of the aspen understory. Alder (*Alnus crispa*) and hazel (*Corylus cornuta*) suckered prolifically following the above burns; however, aspen suckering was less than 10%. A second series of burns in the aspen stand is scheduled; however, spring weather conditions to date have been unacceptable. Additional control plots and reburns of high intensity plots are planned to further investigate aspen and shrub response.

Fire behavior was also studied in upland jack pine (*Pinus banksiana*) stands in northeastern Alberta during the summer of 1974 (4). This was a cooperative project involving fire researchers from across Canada. A series of seven burns progressing from low to extreme hazard was conducted in mature jack pine stands. A relationship of rate of spread was established in the form of $RS = a(ISI)^b$, and fire intensity was calculated for each burn. A two-week drying period allowed observations of significant fire behavior changes as fuel moisture steadily decreased. Initial fires were at low hazard and spread at 0.6 m/min.; fires burned at extreme hazard (with full crown involvement) spread at 6.1 m/min.

Empirical fire behavior relations based on accurate weather, fuel moisture, and fuel loading data are accumulating. Future studies in the Slave Lake forest will relate high intensity fire behavior to retardant effectiveness. Observed fire spread will also be compared with the U.S. Forest Service fire spread model.

In summary,the mechanisms of fire behavior and fire effects are being related to fuel complexes through systematic prescribed burning in cooperation with regional fire management agencies.

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MANAGEMENT IMPLICATIONS OF HISTORIC FIRE PERIODICITY IN RELATION TO CHANGING CLIMATE

by

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Specific causal factors leading up to historic fires are not known, although a combination of weather and climatic factors may induce drought which increases the probability of fire. Implications of the relationship between fire and climate thus have potential significance for ecologists and land managers. Forest fire history of the Athabasca River valley around Jasper townsite, Jasper National Park was used as a basis for discussing some management implications of fire periodicity in relation to changing climate.

Fire scars were used to establish a fire chronology for the period 1665 - 1975. The mean fire return interval (MFRI) for the 43 200 ha study area was 4.4 yrs and 5.5 yrs from 1665 - 1907. Major fires (500 ha) occurred every 8.4 yrs. Fires covering more than 50% of the area (1889, 1847, 1758) had a MFRI of 65.5 yrs.

Comparisons with other fire history studies in the Canadian Rockies indicated that frequency and areal extent of forest fires were similar throughout the region, in spite of the fact that the areas did not experience similar human-use patterns. The area burned per year in the study area fluctuated erratically and was not well correlated with human-use patterns.

The size of fires increased exponentially with time, terminating with very large fires such as those in 1889, 1847 and 1758. These irregular exponential curves were attributed to climatic oscillations and variations of fuel buildup with time. A dendroclimatology record was used to assess major drought years or potential fire years.

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About 70% of the fires and 92% of the total area burned from 1700 - 1913 occurred during below-mean precipitation periods. The 1758, 1847 and 1758 fires occurred during severe droughts. This and other studies showed many fire years in common, suggesting major atmospheric circulation anomalies associated with subcontinental drought. It was therefore concluded that climate was the principal factor that controlled the frequency and extent of past fires.

Climate may vary on a short- (years to decades) and long-term (hundreds of years) basis between cool-moist and warm-dry periods. In the study area, climate was relatively warm and dry between 1700 - 1950 with the exception of three short-term cool-moist periods of ten years or less. Long-term climates which were cooler and moister prevailed before and after this period. Most of the investigation period therefore fell within the relatively short warm-dry period, thus potentially obscuring the long-term variability of fire periodicity.

Individual fire years may be associated with either short-term or long-term climatic cycles, but a higher fire frequency *must* be associated with the long-term dry periods. Whether or not a fire history investigation period such as this one overlaps or falls within longer-term climatic oscillations is a problem that has not been seriously considered by fire ecologists and land managers.

Most foresters and ecologists have used MFRI to characterize fire periodicity in the vegetation type or ecosystem investigated. These values have been used for interpretive or management purposes, as if they were representative of a vegetation type or ecosystem through time. However, the existence of a readily combustible community depends largely upon the changing relationship between past climate and present weather. Once a community type is established in an area it changes very slowly in response to long-term climatic changes. Short-term fluctuations on the order of a few decades will generally not be reflected in radical changes in community physiognomy or species composition, and consequently in rates and amounts of fuel accumulation. In contrast, long-term changes are likely to have a measurable and important effect on all of these community attributes, affecting the quantity and flammability of the available organic material, and consequently the frequency, intensity and extent of fires. Thus the fire regime for a given vegetation type or ecosystem is not constant but varies with major climatic changes.

It was therefore postulated that the periodicity of fire for any given study area is valid only for the period of record investigated,and extrapolation of such information to the present or further into the past must be undertaken with extreme caution. Although past climates have been shown to be cyclic in nature, the periodicity of warming and drying trends has varied greatly and therefore is essentially unpredictable.

PRESCRIBED FIRE ON HENRY HOUSE PRAIRIE, JASPER NATIONAL PARK

by

D.E. Dubé

Fire history studies in the Athabasca Valley of Jasper National Park have confirmed that fire has played an important role in the development and maintenance of the plant and animal life in the park. This information has encouraged park officials to seriously consider new approaches, alternatives and strategies to complement present fire suppression policies. Prescribed fire is one useful management tool that may provide a means of simulating the natural fire regime in the valley without the high risks associated with wildfires. Obviously, wildfires cannot be tolerated in the more heavily developed valley corridors.

In the summer of 1976, Parks Canada and the Northern Forest Research Centre embarked on a prescribed fire program at Henry House Prairie, 13 km (8 miles) north of Jasper townsite. The objectives of the program are to examine the role of fire as an effective management tool in perpetuating natural systems in the valley corridors of Jasper National Park; to assess the effects of fire on vegetation, wildlife habitat and other physical factors; to provide a basis for developing and formulating fire management plans; and to inform the public about the role of fire in the environment, including the development of interpretive programs. The Northern Forest Research Centre is responsible for all research functions; National Parks will supervise the operational aspects of the experimental program.

Approximately 14 ha (35 acres) of forest and grassland were selected and divided into two contiguous units of 3 ha (7 acres) and 11 ha (28 acres). The site is dry and well drained, resulting in sparse vegetation cover and fuel loading. June grass is a major

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component of the grassland; the forest is dominated by lodgepole pine, with buffalo berry and ground juniper the common understory shrubs.

A standard fire weather station was maintained on site several weeks prior to burning. Weather was monitored throughout the summer months, and the Canadian Forest Fire Weather Index (FWI) was calculated at 1:00 P.M. daily.

Grassland fuels weighed 5.3 t/ha while forest surface fuels weighed 31.9t/ha.(Fuels measured in grassland and forest were herbs and shrubs, duff and dead woody surface material.) Moisture content of grassland herbs was 92% and 160% for herbs under the forest stand.

At 1:00 P.M. on 23 September 1976, the temperature was 17°C, relative humidity was 43% and wind speed was 8 km/h. The FWI was 14 (moderate). Throughout the afternoon, temperatures increased to 22°C and relative humidity dropped to approximately 34%, thereby improving burning conditions.

A water curtain with sprinklers spaced every 30 m (100 ft) was established on the east and south boundaries of both units. This system, operating 2-3 hours before ignition and during the actual fire, provided a continuous overlapping wall of water. The flanks opposite the water curtain ran parallel to an existing trail that served as an effective fire guard. Conventional firelines, such as bulldozer and handlines, were not employed because of the extreme sensitivity of the site to mechanical damage.

Unit 1 was burned at 2:30 P.M. on 23 September 1976. Headfire ignition proceeded along the south edge of the unit in the open grassland. Sparse fuels and low wind speed hindered fire spread and prevented a uniform burning pattern. As the fire moved under the forest canopy where ground fuels were heavier, fire intensity and rate of spread increased considerably. Juniper shrubs burned vigorously and sometimes acted as a ladder fuel, resulting in candling of individual pine trees. The burn pattern was uniform under the forest canopy, with depth of burn being greater at the base of trees where litter accumulations were heaviest.

The eastern half of Unit 2 was ignited at 3:40 P.M. on the south boundary. Although more wind was evident during the second burn, the lodgepole pine stand prevented wind from having a marked effect on fire spread. Also, herbaceous fuels under the protecting canopy were not fully cured, resulting in spotty fire spread. When the fire moved out onto the open grassland at the north end of Unit 2, the influence of the wind was more pronounced, resulting in fairly rapid spread rate of about 10 m/min (35 ft /min) even though fuels were much lighter here than under the forest canopy.

Prescribed fire was safely and economically introduced into Jasper National Park by park personnel, who benefited from the field exposure to prescribed burning principles and procedures. Research and operational information obtained from this fire, together with that which will be collected in subsequent burnings, will assist park managers in developing a fire management plan consistent with resource management objectives.

FIRE RESEARCH AT THE PETAWAWA FOREST EXPERIMENT STATION: THE INTEGRATION OF FIRE BEHAVIOUR AND FOREST ECOLOGY FOR MANAGEMENT PURPOSES

by

Ian R. Methven[1]

Fire is a variable; it is not an absolute, a fact that is either ignored or given very superficial acknowledgment in the ecological literature. Unfortunately this reduces considerably the value of a great deal of work that has been done on fire effects, and probably goes a long way towards explaining the dearth of literature on fire prescriptions to attain specific ecological ends.

Fire variability is best broken down into three aspects: (1) fire intensity, (2) depth of burn, and (3) fire interval. Fire intensity refers to the frontal energy output rate, which is compounded of the quantity of fuel consumed in the flaming front, the rate of movement of the front, and the heat of combustion of the fuel. Intensity can vary enormously from approximately 70 kW/m for a surface backfire to 150 000 kW/m for an active crown fire, and is very much a function of the moisture content of fine exposed fuels and the wind, or in other words the short term and current weather. Effects can vary from the minor and ephemeral at the lower end of the scale, to a complete recycling of the age class and change of the cover type at the upper end of the intensity scale.

Depth of burn involves consumption of the duff or deeper organic layers, which occurs largely by smouldering behind the front. While this consumption also is dependent on moisture content, it is a function of longer term weather. Its biological effect is twofold, since it influences both the quantitative and qualitative aspects of regeneration through the amount of seedbed exposed, and the differential consumption of regenerative organs, depending on the depth at which they occur in the organic or mineral soil.

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Fire interval is simply the time between two consecutive fires at a point location, and the average fire interval for a large number of fires is theoretically equal to the more abstract fire cycle. Since plants vary in the time required to attain maturity and in the capacity of their regenerative organs to withstand repeated fire, fire interval can exert a selective influence on the vegetation.

The guiding principle of fire research should be the integration of fire behaviour and biological effects so that the consequences of specific fires can be predicted. This ability of course has a dual pay-off: (1) it allows the forest manager to predict the consequences of a wildfire, thereby providing him with an ecologic-economic input into the fire management decision-making process, and (2) it provides a prescription ability for the application of prescribed fire to manipulate vegetation, and of course its dependent wildlife, toward specified management objectives.

To illustrate the way this principle can be put into practice, I will discuss part of our work in the Great Lakes-St. Lawrence and the Boreal forest regions.

In the former we are faced with the continuing liquidation of the natural red and white pine as a result of demand pressures, modern logging techniques, and the exclusion of fire. Since fire is recognized as an integral component in the ecology of these species, it is only logical to assume that fire could offer a solution to the problem. Given the management objective of timber production, the problem was formulated as follows: What kind of fire regime would satisfy the constraint of minimal damage to the overstory trees?

Solution of the above problem was subdivided into a sequence of three logical steps:

(1) The development or adaptation of a system by which fire behaviour could be predicted.

(2) Correlation of this system with fire variables and ecological effects.

(3) Formulation of fire prescriptions that would result in the desired objectives.

A reasonably good and universally available predictive system is provided by the Canadian Fire Danger Rating System (FDRS), a system currently based on past and current weather, and devised to predict current fuel moisture conditions and expected fire behaviour in the form of three codes and three indexes. Of these,one code and the three indexes were chosen as being most useful in the prediction of fire behaviour in the red and white pine cover types. These are the Fine Fuel Moisture Code (FFMC), a numerical rating of the moisture content of litter and an indicator of relative ease of ignition and flammability; the Initial Spread Index (ISI), a numerical rating of expected rate of spread based on wind and the FFMC; the Buildup Index (BUI), a numerical rating of total available fuel; and the Forest Fire Weather Index (FWI), a numerical rating of fire intensity based on a combination of the ISI and the BUI.

There are three main biological effects of fire that are of concern in pine management and that need to be correlated with the fire variables. The first is that of crown scorch which, if severe enough, can result in tree mortality and destruction of the necessary live seed source. Experimental and theoretical work has yielded a number of equations relating crown or scorch height, fire intensity, the FWI, percent crown scorch, and the probability of mortality.

The second effect of importance is that associated with duff consumption and seedbed preparation. From the point of view of seedbed, the greater the duff consumption or depth of burn and exposure of mineral soil the better, but there are a number of constraints associated with fire behaviour, the economics of postfire mop-up, damage to roots on shallow soils, and nutrient pools and exchange capacity that have to be considered. The index most closely correlated with depth of burn and duff consumption is the BUI, and the required practical data to calibrate the relationship are now on hand.

The third and final effect of direct concern is that on the understory vegetation, which often constitutes lethal competition for the pine seedlings. In the case of coniferous competition such as that provided by balsam fir (*Abies balsamea* (L.) Mill.), there is no problem since the species is not adapted to fire and is easily eliminated by light surface fire. Many of the shrub and hardwood species, however, such as beaked hazel (*Corylus cornuta* Marsh) and red maple (*Acer rubrum* L.), are adapted to fire through the possession of rhizomes or the ability to sprout from the root collar. However, the sprouting vigour of these species can be considerably reduced by exhaustion of root and rhizome reserves through repeated fires, i.e., very short fire intervals.

Besides biological effects there are ignition and economic fire spread rate considerations, and these can be expressed in terms of the FFMC and the ISI.

Formulation of the fire prescription can now be achieved in terms of the FFMC (ignition success), the ISI (economic rate of spread), the BUI (depth of burn and seedbed preparation), and the FWI (fire intensity and crown scorch), and fire interval (control of competition).

Our work in the Boreal forest has as its basic purpose the provision of a fire effects input into forest management planning and fire management decision-making. Whether the management plan is for industrial forest lands, non-designated crown lands, parks, or wilderness areas, and whether it calls for total fire exclusion, prescribed fire, or letting wildfires burn, fires will always occur, and rational management must take this into account and be able to predict the biological consequences.

Two examples from this work will suffice to demonstrate the variability in fire behaviour and occurrence, and its importance to a proper interpretation of fire effects, which in turn must be the basis for rational forest management planning and optimal fire management decision-making.

The most striking feature of fire on a landscape scale is variability in fire intensity. This is most apparent from the air immediately after fire, when the ground appears as a mosiac of green, brown, and black, corresponding to unburned or light surface fire, intense surface fire, and crown fire. Sometimes brown and green are interspersed, indicating moderate surface intensity. For all practical purposes three kinds of effect can be identified: total tree kill, partial tree kill, and no tree kill. The relative amounts of these three categories are dependent on weather and fuel conditions at the time of the fire (which can be described by the FDRS), the relative proportions of upland and lowland, and possibly topographic roughness.

Failure of coniferous vegetation after fire can be a common problem throughout the boreal forest, but the reason for this failure may not be common. For example, in the Northern Coniferous (B.22a) section it appears to be largely a problem of short fire intervals, i.e., reburning of immature conifer stands, while in the Chibougamau-Natashquan (B.1b) section it appears to be largely a problem of inadequate depth of burn and duff composition.

Thus, in the B.22a section poor regeneration is a problem that arises from short fire intervals, whereas in the B.1b section it is a problem resulting from inadequate depth of burn. If coniferous fibre production is the management objective therefore, efforts in the former should emphasize increasing fire cycle through preventing the reburning of immature conifer stands, while in the latter it should emphasize decreasing the area burned under low drought conditions (low BUI and Drought Code), and be less concerned about fires that occur under high drought conditions (high BUI and DC).

This demonstrates once more that rational management policy can only be developed if the biological consequences of fire are interpreted in terms of the fire variables.

In conclusion I would like to emphasize that the use to which fire ecology work is to be put must be kept in mind, namely to predict postfire vegetation development for an ecologic-economic input into fire and land management decision-making. This cannot be done without taking the variability of fire behaviour into account, and integrating or correlating this with the biological effects.

Now whether the management function involves planning of prescribed fire or responding to wildfire, rational decisions can be made only if three conditions are satisfied:

(1) Specification of land use objectives.
(2) Characterization of fires as to their expected behaviour and occurrence in terms of fire intensity, depth of burn, and fire interval.
(3) Prediction of the response of the vegetation, i.e., the biological effect, according to the expected fire behaviour.

POTENTIAL FIRE MANAGEMENT ON BRITISH COLUMBIA NATIONAL WILDLIFE AREAS

by

John Hatfield[1]

In British Columbia there are eight National Wildlife Areas owned or leased and managed by the Canadian Wildlife Service of the Federal Department of Fisheries & the Environment.

Located along the east of Vancouver Island are Nanoose Estuary (29.5 ha), Marshall-Stevenson (29.7 ha) and Rosewall Creek 13 ha. They are 24, 57 and 71 km north of Nanaimo respectively. Prescribed fire on these estuary marshes may be tried if the need arises.

Three other National Wildlife Areas are located in the lower mainland: Alaksen (270 ha) on Westham Island in Delta, Steveston (1.5 ha) in Richmond and Wigeon Creek (124 ha) about 9.6 km north of Port Coquitlam. Prescribed fire may also be used on the marshes of these wildlife areas as the need arises.

The Wilmer National Wildlife Area of 471 ha in the east Kootenays, 32 km north of Invermere, offers good potential for fire management on the Columbia marshes and upland. Prescribed fires are planned on a small scale over a period of time in co-operation with the British Columbia Fish & Wildlife Branch. There are numerous tangles of dead willows (*Salix* sp.) on the marshes. Fire would enhance the marshes for wildlife and allow new willow growth for winter browsing by elk (*Cervus canadensis*) and whitetail deer (*Odocoileus virginianus*).

The best potential for prescribed burning on any of the British Columbia Wildlife Areas is on the 789-ha Vaseux-Bighorn National Wildlife Area. Vaseux-Bighorn is located 3.3 km south of Okanagan Falls in the Okanagan Valley. This wildlife area is a critical wintering area for California bighorn sheep (*Ovis canadensis california*) and the deer (*Odocoileus hemionus* and *O. virginianus*). As a result of the

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B.C. Forest Service policy of complete fire control over the past 40 years, ponderosa pines *(Pinus ponderosa)* and fir *(Pseudotsuga menziesii)* are encroaching over the range lands. Small-scale prescribed fire and physical removal of the trees are planned over the next few years. Also some burning of the lowland marshes will be tried to check the encroachment of willows *(Salix* sp.) and rose *(Rosa* sp.).

USE OF LAKE SEDIMENTS FOR RECONSTRUCTING PREHISTORIC FIRE RECORDS

by

Charles Schweger[1]

Recent trends in ecology have resulted in acknowledging the significance of natural wildfire in plant communities (1). Attention has shifted from the short term effects of fire, and the subsequent succession, to the role of fire in providing the long term stability needed to maintain certain types of communities (2,3).

Historical and even tree records of past fire are limited to the recent centuries. In order to fully appreciate the role of fire in the environment still longer term records are needed. The pollen-analytic method may be useful in that it documents the long term changes in vegetation composition.

Pollen shed from the plant community is trapped in the sediments of bogs and lakes in proportions roughly similar to the taxa in the community. Sediments cores provide a record of the history of vegetation change as well as organic material for radiocarbon dating. Analysis of the fossil pollen content yields percentage data that can be plotted to produce a pollen diagram. Pollen diagram records demonstrate the range of ecological changes, but they pose a series of interpretive problems since ecological changes can come about through a variety of factors.

For example, during the past glacial, a spruce dominated forest extended across large regions of the Great Plains. But between 12 000 and 10 000 years ago spruce was rapidly replaced by grasslands. Although climatic change is frequently given as the reason for this change, increased fire frequencies could have also played an important role. In the Great Lakes Region the late glacial spruce forest was very rapidly replaced by jack pine communities. Since this replacement was so very rapid one wonders

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if climate was the only controlling agent,or could fire have promoted the growth of pine at the expense of spruce?

These examples and others suggest that fire may have had an important role in bringing about important vegetation changes as well as maintaining certain types of communities. But how can the relationships between vegetation change and fire be established?

As one counts fossil pollen on a microscope slide it is not uncommon to come across opaque fragments of charcoal. Presumably this charcoal is released during natural fires and is deposited in lake sediments along with pollen. The question to be answered is whether the charcoal fragments can be counted along with pollen to reveal a record of fire history and fire frequency? And next, can the pollen/ charcoal record be related to ecological changes and climatic periods? These questions have directed much of the research not only at the Paleoenvironmental Studies Laboratory of the University of Alberta, but at other laboratories as well.

Pollen/charcoal records from bog cores in the Mackenzie Valley, N.W.T. show as many as eight charcoal peaks over 8000 years (4). If these peaks represent local burns then this record suggests one fire per 1000 years, a fire frequency much too low by most observations. But this record clearly shows the dilemma of sample bias. Pollen samples are collected at intervals along the sediment core; the length of the sample interval will determine the fire frequency as recorded by the charcoal frequencies. As the sample interval decreases the fire frequency should increase. Even though smaller intervals mean better resolution of the fire frequency record they also mean considerably more work for the analyst.

Many of the Mackenzie Valley pollen records show higher frequencies of charcoal nearer the base of the peat profiles (4). A sediment description revealed that the fresh surface peat was increasingly humified with depth. Since charcoal is inert to the humification process it was being concentrated in the lower portions of the bogs due to the loss of the organic sediment.

In counting opaque charcoal fragments it was noted that frequently the charcoal would appear as irregular fragments as well as spherules. Further observation demonstrated that the spherules could be found inside pollen grains, in chains or grape-like masses. It now appears that these charcoal spherules may be opaque iron-pyrites precipitated by bacterial action in the sediments. This raises a word of caution: not all black opaque material is charcoal, and misidentifications can greatly skew the results.

Sediment in shallow lakes is frequently reworked due to wave activity, the result being that charcoal layers perhaps representing a single fire are mixed,resulting in a blurred record. Shallow lakes also maintain an active benthic fauna of worms, larvae and mollusca. These burrowing animals completely rework and mix the bottom sediments, disturbing the sediment record of discrete events.

Research should be directed toward the deep, meromictic lakes where the effects of wave activity and burrowing bottom fauna are eliminated. Under the best conditions the sediments may be varved, displaying annual laminations. Lake of the Clouds, a meromictic lake in northern Minnesota, has been examined for the pollen/charcoal content of the varved sediments (5). This study provided one of the best records of the relationships between fire history, charcoal deposition and vegetation change. Although the vegetation over the past 1000 years has remained relatively stable, fire has been an important ecological factor.

Another avenue of research follows from the hypothesis that different size categories of the charcoal fragments will reveal information about the distance of the fire from the lake or even the type of fuel (prairie or timber). Pollen/charcoal studies from Lost Trail Pass Bog, Bitterroot Mountains, Montana (6) classified charcoal fragments into different size classes. There was a strong correlation throughout the sediment core between the size classes. It was concluded that this was not due to the proximity of the fire or the type of fuel but to the breakup of larger charcoal fragments during the processing of the sediment sample. Further research into the significance of different charcoal size classes is being done at the University of Alberta. Hopefully these results will prove to be more inspiring and conclusive.

Returning to our second major question--can charcoal fragment frequencies be correlated with vegetation types or climatic periods?--seem to have more positive results. In fact, the answer is yes.

The Hypsithermal, a mid-Holocene (7000 to 4000 years ago) period of hotter and/or drier climate, is evidenced by higher charcoal frequencies at Lost Trial Pass Bog (6). But twice as much pollen was deposited during the past 2000 years, a period often called the Neoglacial, noted for its generally cooler and more moist climate. Because explanations involving natural agencies seem inadaquate,it was suggested that aboriginal hunting patterns may have been responsible. Pollen studies done in central Alberta (7) also demonstrate greater fire frequencies during the mid-Holocene when grasslands spread northward into the parkland and boreal forest.

This review was intended to present the state of the art in regards to long term pollen/charcoal records. Since so much of this research is just now being undertaken one should not be unduly pessimistic. Yet our optimism must be tempered by the realities of the numerous problems.

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PERSPECTIVES FOR FIRE MANAGEMENT IN ALBERTA PROVINCIAL PARKS AND WILDERNESS AREAS

by

Melanie Miller[1]

A mandate for ecological land management in Alberta Provincial Parks and Wilderness Areas exists in both legislation and policy. The Provincial Park System is expanding, and resource management policies and guidelines are being developed.

The most successful resource management techniques are those which "duplicate or approximate natural processes." Fire is an appropriate resource management tool because it is a naturally occurring process which is often essential to ecosystem viability. Provincial Parks should thus plan for fire management rather than fire control. Fire management planning applies to all aspects of wildland fire-related activities, with a dual objective of allowing the maintenance of natural systems and minimizing damage caused by fire suppression activities. Fire management considerations should be integrated into resource and operational planning, utilizing principles of fire prevention, facility design and location, pre-attack planning and fuels management. Modified fire suppression techniques should be used in all Parks, and a policy of rehabilitation after fire suppression activities established. Fire management plans should also consider fire use, both prescribed natural fires and prescribed burning, if fire can be used to obtain resource management objectives. Management agencies for recreational land in the U.S. have been developing plans which incorporate all of these aspects of fire management. Their approach is directly applicable to our park system and will therefore be reviewed.

U.S. National Park Service policy requires that fire management plans "be developed for all areas of the system with resources capable of burning." A fire management plan is based upon a careful evaluation

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of the ecological role and characteristics of fire in ecosystems present in a particular land area. Natural and historic fire frequency and size are determined. Fire effects on vegetation, soils, water, air quality, and wildlife are evaluated for fires of different intensity and season of the year, as well as fire effects on historic and archaeologic resources. Fire behavior is predicted with respect to topography, weather, vegetation type, season of the year, and time of day. Information on natural fire frequency and intensity is integrated with fire effects and fuels to determine whether fire exclusion has caused a departure from "natural conditions." The Park is then divided into fire management zones, areas with similar fuels, vegetation and topographic features which can be expected to have similar fire behavior and fire effects.

Prescribed natural fires may be allowed within fire management zones, naturally ignited fires which are allowed to burn if prescribed conditions are met. Prescriptions are based upon human safety, facilities, cultural features, fire potential, existing and predicted weather and fire danger, the effects of past fire exclusion, and the possibility of fire spreading outside the zone or Park. If a fire exceeds a prescription, or is man-caused, it is suppressed. As of February 1976, 4.7 million U.S. National Park Service acres were managed according to the prescribed natural fire concept. Their goal is to "have natural fire zones cover as much area as possible."

The U.S. Forest Service has implemented natural fire plans in several Wilderness Areas. A similar concept can be applied to other lands within the U.S. National Forests, based upon an evaluation of economic and resource values, social needs, and the natural role of fire. Additionally, an increased emphasis will be placed upon prescribed burning for fuels and vegetation management. Prescribed burning for vegetation, wildlife and fuels management is used in many U.S. National Parks where natural fires cannot presently be allowed to run their course because of size, fuel continuity and amount, presence of facilities, or heavy visitor use.

How can the natural fire concept be applied to Alberta Provincial Parks and Wilderness Areas? A policy should be developed which recognizes that fire use is a viable management option in these lands. Guidelines for fire use should be formulated for each park class and zone, as defined within the draft classification and zoning document.

Prescribed burning would have limited use in Recreation or Preservation Parks, because of their small size, or the sensitivity of preservation features. However, prescribed burning could be used in Natural Environment Parks for vegetation and fuels management and natural fires allowed in backcountry areas if vegetation and fuels lend themselves to the containment of fires within Park areas.

In Wildland Parks, prescribed natural fires should be the preferred method of achieving management objectives. Prescribed burning could be used in facility zones and along park borders for fuels and vegetation management, and within primitive zones if fuels modification is necessary before implementation of a prescribed natural fire program.

Natural fires should be allowed in Wilderness Areas. However, prescribed burning is not compatible with the wilderness philosophy because it is a direct human intervention with ecosystem processes, and would set a precedent for other types of manipulation.

Individual Park areas should be evaluated within this framework to determine whether permissible fire uses could achieve specific management objectives. Consideration should be given to the role of fire in the various park habitats, and park characteristics such as size, topography, fuels, and the type and degree of recreational use.

A close relationship with the Alberta Forest Service is necessary thoughout plan development and execution, since it is responsible for fire control within the Green Zone and has considerable planning expertise. Cooperation with other agencies is necessary for planning and implementation because of existing institutional arrangement within Alberta.

A fire management program for Provincial Parks requires policy commitment, and a considerable amount of time and money. However, if we, as resource managers, believe in this concept, the damaging impacts of fire can be minimized, and its beneficial aspects maximized. The thoughtful application of fire management will promote the best management of the wildland resource.

SILVICULTURAL USES OF FIRE IN MIDWESTERN CANADA

by

Z. Chrosciewicz[1]

Many conifers reproduce themselves readily after a stand fire, but they often fail to do so when the timber is harvested. This is primarily because the harvest cuts usually leave behind most of the loose, surface forest-floor materials in their undisturbed state. The surface materials, consisting mainly of feather moss (*Pleurozium schreberi* (Brid.) Mitt. occasionally with some *Hylocomium splendens* (Hedw.) B.S.G. and *Ptilium crista-castrensis* (Hedw.) De Not.)[2] and foliar litter that merge downward either into an upland mor[3] or into a lowland peat[4], are subject to rapid losses of moisture. This alone makes them extremely poor media for seed germination and seedling survival. Moreover, the overshading created by logging slash, and the often severe competition from deciduous vegetation can still further hinder the re-establishment of conifers after cutting.

The use of controlled burning is proving to be of considerable silvicultural value, particularly as a means of rectifying the postcut conditions on productive sites. A controlled fire usually burns the slash, aerial parts of vegetation, surface moss and litter, and, depending on site and weather, varying quantities of the underlying mor or peat. The organic materials remaining after the fire normally include charred stumps and other large pieces of wood, partially burned mor or peat, and unburned plant roots in such mor or peat. These conditions are usually adequate for planting conifers, and if the fire burns deep enough into the mor or peat, they can be favorable also for the reproduction of conifers by seeding.

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2 Species' nomenclature follows Crum *et al.* (1973) for mosses and Hosie (1969) for trees.

3 Synonymous with the terms "raw humus" and "duff".

4 Predominantly "brown peat" of feather-moss origin. For further information on this type of peat, and also on the "green peat" of *Sphagnum* origin, see Chrosciewicz (1976).

Here, however, it is important to remember that a complete exposure of mineral soil whether by burning or by other means is seldom, if ever, required. This type of exposure can be even harmful to conifers and to plant growth in general, if the soil is nutritionally poor, drains very rapidly, has a low water-holding capacity, and frost-heaves when exposed. Elevated, pure or almost pure, uniformly sorted gravels and sands belong to this category. A complete exposure can be also harmful if the soil contains much clay, because then its surface structure breaks down into extremely compacted fractional aggregates that interfere with normal plant rooting. Moreover, large quantities of insoluble nutrient compounds are stored in the mor and peat materials, and although some disturbance is usually required to make the nutrients more readily available to the plants, a complete destruction of such materials either by burning or by other means is extremely wasteful and must be avoided. This is particularly critical on dry and otherwise nutritionally poor soils. Therefore, the object of most silvicultural uses of fire is not the total destruction of mor or peat materials present, but rather their reduction to a degree sufficient for prompt re-establishment of favorably stocked stands either by planting or by seeding.

Some conifers, notably jack pine (*Pinus banksiana* Lamb.), lodgepole pine (*Pinus contorta* Dougl. var. *latifolia* Engelm.), and to a degree black spruce (*Picea mariana* (Mill.) B.S.P.), develop and store large quantities of seed in their tightly closed cones. When fire burns underneath, the heat triggers cone opening and thus aids in seed dispersal. Other species, such as white spruce (*Picea glauca* (Moench) Voss) for example, do not possess this capacity, but instead they develop and freely disperse their seed at irregular intervals. This differentiation in both production and storage of seed must be considered when the use of seed-tree systems is contemplated. Moreover, one should know that postcut burning is not a suitable means of releasing seed from cones in slash, because the fire either destroys the seed or drastically reduces its viability. Therefore, if fire is used specifically for the improvement of seedbeds, a dependable natural seed source must be provided, or alternatively a direct seeding must follow the burning operation.

When properly planned and expertly executed, the use of fire as a basic postcut treatment can be much less expensive than mechanical scarification or plowing. Added benefits at no extra cost normally include an abatement of slash-fire hazard on all treated sites and a high degree of sanitation on pest-infested sites, neither of which can be effectively realized by mechanical means.

With this background information, let me now briefly review some of the relevant research findings to date, starting in Ontario and then following the investigative progress in the Prairie Provinces of midwestern Canada.

Initial experiments (1949-1956) in central Ontario demonstrated that the success of regenerating jack pine on dry to fresh sandy cutovers, either by burning and seeding or by burning with seed trees, depended primarily on the production of favorable seedbeds. However, the burning operations were carried out in spring and autumn when the moisture content of mor seldom allowed the fire to burn much below the dry surface moss and litter. This type of burning was satisfactory for the production of favorable seedbeds and pine regeneration, but only on those few sites that had an exceptionally shallow mor to start with. On all other sites, particularly where the average depth of mor exceeded 3.8 cm, the light surface burns were totally inadequate for the intended improvements. Cured logging slash burned well under all conditions tested, but periods of intensive summer drying were required for adequate burning of the deeper mor materials (Chrosciewicz 1959).

Subsequently (1960-1963), several summer-burning and spring-seeding treatments were experimentally tested in central Ontario following jack pine clear-cutting on moderately dry and fresh sandy sites. Deliberately, the burns covered a range of drought conditions, and the postburn seeding intensity was kept constant. The resulting jack pine regeneration was highly successful, and the experiment provided much useful information on the main interrelationships involved. Slash, ground vegetation, and surface litter burned uniformly well. Complete burning of the mor materials was not required, and the best fire-produced seedbeds occurred where exposed mineral soil and thin residual mor alternated and both had uniform areal distribution. Otherwise, the reduction of mor depth as well as the exposure of mineral soil varied directly with the drought conditions at the time of ignition. Jack pine regeneration showed predominantly consistent patterns of numerical variation that were inverse with the depth of residual mor and direct with the exposure of mineral soil. An increase in the silt-plus-clay content of the otherwise sandy soil materials had a distinctively positive effect on both the germination and survival of jack pine. In general, however, there were two basic requirements for successful application of the burning and seeding treatments. The first was the selection of a suitable drought condition for the desired reduction of mor depth by burning, and the second was the regulation of seeding intensity in relation to the quality of fire-produced seedbeds and the type of mineral soil materials present. Various evaluation and prediction curves, together with data tabulations and other practical guidelines, were then presented to assist in meeting both these requirements in future operations (Chrosciewicz 1967, 1968, 1969, 1970, 1974).

Soon after (1964-1968), burning and various supplementary treatments, including mechanical scarification, seed-tree systems, direct seeding and planting, were tried on dry to fresh, sandy, jack pine cutovers in southeastern Manitoba, and evaluations are continuing. The slash fires were intensive, and much of the originally very shallow mor was burned. However, jack pine regeneration was highly variable; overall, the results were discouraging (Adams 1966; Cayford 1966; Walker, unpublished reports). According to a later study (Sims 1976), the high-hazard burns used created seedbed conditions that were subject to temperature and moisture extremes that were most probably too harsh for the young pine.

In the meantime (1966), burning has been tried on a fresh to moist, clay loam, white spruce-trembling aspen (*Populus tremuloides* (Michx.)) cutover in southwestern Manitoba. The fire burned well in the dry slash, but the relatively deep mor underneath was too moist to burn satisfactorily, if at all. Consequently, the resulting seedbeds were thought to be unsuitable for the natural reproduction of white spruce, and aspen suckering was expected (Tucker and Jarvis 1967).

Back in southeastern Manitoba (1967), two experimental burns were tested on a peaty, very moist, lowland site to produce adequate black spruce regeneration after harvest cutting. Unmerchantable trees that were left standing at the time of cutting constituted the main seed source on each of the burns. The operations were conducted under different degrees of desiccation in the upper peat materials so that light and moderate burns were obtained. By consuming slash, feather moss, surface litter, and some of the underlying peat, the fire produced favorable seedbeds and simultaneously activated a gradual seed dispersal from the residual trees. The ultimate outcome of these operations was a good to excellent black spruce regeneration, generally improving with the depth of burn into the peat. Other beneficial effects included favorable plant succession and a rotation-long improvement of site productivity from the original oligotrophic (nutritionally poor) condition to the new mesotrophic (nutritionally intermediate) condition. The available information provided guidelines on how to conduct future operations of a similar nature (Chrosciewicz 1976).

With the hope of improving jack pine regeneration over the earlier results, additional burning and seeding treatments (1968-1970) were experimentally tested on dry, fresh and moist, sandy, clear-cut sites in southeastern Manitoba. Burning covered a range of drought conditions and, by groups of sites, seeding intensity was inversely adjusted in relation to the actual postburn exposure of mineral soil that was, in fact, much greater on the dry and fresh sites than on the moist sites. From the results of burning, straight-line regressions were calculated for predicting the mor reductions in future operations (Chrosciewicz 1978a). However, again the final results were highly variable: jack pine regeneration was consistently very successful on the moist sites, but it completely failed on both the dry and the fresh sites. The latter failures were attributable to severe moisture deficiencies that undoubtedly resulted from both the apparently excessive exposure and the extremely low colloidal content of the sand materials themselves. It would be now worthwhile to ascertain whether or not, under similar site conditions, this particular difficulty could be resolved by a much less intensive postcut burning of the slash and the mor present. I am now preparing a final report on this experiment.

Various burning and seeding treatments (1970-1972) were then experimentally tested on a number of fresh, moderately moist and moist, loamy till, jack pine clear-cut sites in central Saskatchewan. By sites, burning covered a range of drought conditions, and two intensities of seeding were tested on each of the burns. As a result, straight-line regressions were calculated for predicting the mor reductions in furture burning operations (Chrosciewicz 1978b). The overall jack pine regeneration, however, ranged from poor to excellent, varying inversely by groups of sites with the size of clear-cut areas, and varying directly with the intensity of seeding. Numerically, the regeneration was best on the moderately moist sites, with the fresh sites and the moist sites taking second and third positions, respectively. Otherwise, both the exposure of mineral soil and the depth of residual mor had little, if any, additional effect on the existing numerical variability in jack pine regeneration. I am now preparing a final report on this experiment.

Complementing this development, several large-scale operational burns (1971) were carried out on fresh to moderately moist, loamy till, jack pine clear-cut sites in central Saskatchewan. The burns provided a wealth of information on the basic requirements for the safe, effective, and economic use of fire in future operations that resulted in the formulation of a series of practical guidelines (Chrosciewicz 1978c). By conducting the burns precisely where and when wanted, the slash fire hazard was eliminated, and the areas became suitable for supplementary treatments. The latter (1971-1973) included operational autumn and spring seeding of jack pine, operational autumn and spring planting of nursery-grown jack pine, and some experimental autumn, spring and summer outplantings of several native and exotic container-grown pine and spruce species. Although final results were not yet available, an inspection of the areas revealed that jack pine regeneration following the operational treatments was highly successful, very much so after planting and to a somewhat lesser degree after seeding. Spring seeding was more successful than autumn seeding, and the results were usually better on the moderately moist sites than on the fresh sites. This differentiation was not evident in the plantations. As for the container-grown stock, high survival rates were observed. I hope to finally assess and report the results in the near future.

The last, so far, large-scale operational burn (1972) in central Saskatchewan was carried out following a special harvest cutting during which uniformly spaced jack pine seed trees were left standing. The site was fresh to moderately moist, with loamy till soil materials. The operation was conducted under a preselected drought condition so that, by burning slash, ground vegetation, surface litter, and some of the underlying mor, favorable seedbeds (below) and adequate seed dispersal (from above) were produced. The resulting jack pine regeneration was highly successful, and the young stand developed very well. I am now preparing a final report on this operation.

In west-central Alberta (1968-1970), burning followed by planting and seeding lodgepole pine and white spruce has been tried on moderately moist and very moist, glacial till, white spruce-alpine fir (*Abies lasiocarpa* (Hook.) Nutt.) clear-cut sites. The burns were conducted under different drought conditions, and most of the slash, ground vegetation, and surface litter and varying quantities of mor were destroyed (Kiil 1971). The survival of planted stock ranged from moderate to good; it was generally better for lodgepole pine than for white spruce. For both these species, the planting of container-grown stock produced somewhat better results than the planting of nursery-grown stock. The postburn seeding resulted in a satisfactory lodgepole pine regeneration in all but the few situations where the burn was very light. However, the regeneration of seeded white spruce was considerably more successful on the very moist site than on the moderately moist site (Endean and Johnstone 1974b).

Meanwhile (1969-1970), burning and various planting and seeding treatments were experimentally tested on a moderately dry, silty loam, lodgepole pine cutover site in southwestern Alberta. Burning over a range of drought conditions was successful in both slash disposal and variable mor reduction. As a result, a straight-line regression was calculated for predicting the depth of burn into the mor in future operations (Quintilio 1972). All postburn treatments, such as planting nursery-grown stock, planting container-grown stock, spot scarification and seeding, and broadcast seeding, produced satisfactory lodgepole pine regeneration that generally increased with the intensity of burning, the associated mor reduction in depth, and the consequent mineral soil exposure. Otherwise, both the survival and the stocking of pine varied little with the treatment (Endean and Johnstone 1974a).

In all of the experiments described, most of the unburned cutover controls, whether regular research plots or just untreated extensions of the original areas, had very poor conifer regeneration, and the need for proper remedial action was self-evident. However, there was one notable exception to this general rule. In the initial (1970-1972) series of burning and seeding tests in central Saskatchewan, jack pine regeneration on the controls was numerically similar to, or better than, that on the treated plots. This resulted from a locally rare conjuncture of the normally prolonged seed dispersal from cones in slash with cone opening triggered by solar heat near the ground, and the abnormally wet postcut second and third summers that made even the feather-moss and the litter seedbeds quite favorable for jack pine regeneration.

In conclusion, this review shows that considerable progress had been already made in elucidating the site-specific drought conditions under which controlled burning can be effectively used to produce favorable environments for the postcut reproduction of conifers either by planting or by seeding, including seed-tree systems. However, it is difficult to say right now how much of this information may become widely applicable, particularly in view of the existing diversity in postcut conditions throughout Canada. Because of differences in ecoclimate, vegetation, logging residue, landform, topographic position, type of mor or peat, soil texture, soil moisture regime, etc., one would be inclined to think that this is a problem of adaptation rather than of some indiscriminate application. Therefore, much more research is needed to precisely formulate the objective-oriented burning prescriptions for each important site and fuel combination by major climatic regions.

It is hoped that, as in the past, the various provincial forest agencies and the local wood-using industries will continue their splendid cooperation with the Canadian Forestry Service in further development and implementation of this vital research program.

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THE ROLE OF FIRE IN THE JACK PINE-LICHEN WOODLANDS OF THE ATHABASCA PLAINS REGION OF CANADA

by

Steve Carroll[1]

During the summer of 1977, the jack pine-lichen woodlands of the Athabasca Plains Region of northeastern Alberta and northern Saskatchewan were studied with the following objectives: (1) to determine the structure and species composition of these woodlands, (2) to document the frequency and role of fire in the region, and (3) to document the post-fire recovery of the vegetation. This summary will deal with the latter two objectives.

The widespread occurrence of fire margins, even-aged stands, fire-scarred trees, charred wood and charcoal in the soil attests to the importance of fire in this region. Analysis of fire-scar dates indicates mean fire return intervals (MFRI) of 17.2-29.0 yr at six widely scattered sites. When the MFRI was calculated for individual stands (that is, did not include intervals between fires occurring in different stands), the values ranged from 27.7 to 53.8 at the six sites. This interval averaged 45.0 yr when data from all six sites were combined.

Floristically, these woodlands are very simple. Sampled species totalled only 4 trees, 6 shrubs, 27 herbs, 5 dwarf shrubs, 2 Pteridophytes, 8 Bryophytes and 31 lichens. Despite this simplicity, species do replace each other over time (since burning).

One of the first species to colonize is jack pine, since a nearby seed source is almost always present in the form of remnant trees or patches of forest. Other colonizers include *Polytrichum piliferum*, *P. juniperinum*, *Ceratodon purpureus*, *Cladonia coccifera*, *Cladonia gracilis*, *Vaccinium myrtilloides*, *V. vitis-idaea*, *Ledum groenlandicum*, *Hudsonia tomentosa*, *Arctostaphylos uva-ursi*, *Carex foenea*, *Agrostis scabra* and *Epilobium angustifolium*. The species which colonize a particular site depend on many factors, and vary geographically.

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After initial establishment of vegetative cover, the species composition continues to change. *Cladonia coccifera* is soon replaced by *Cladina mitis* as the dominant lichen. Other lichens, including *Cladonia uncialis, Cetraria nivalis* and *Cladina stellaris*,increase in importance. *Cladonia gracilis* is less predictable, but is often codominant at this point, as are the two *Vacciniums*. Bryophytes such as *Pleurozium schreberi, Dicranum polysetum* and *Ptilidium ciliare* begin to appear. At this point (30-60 years after burning), a stand will likely burn, beginning the cyclical succession once again. If a stand remains free from fire,however, succession is likely to proceed in one of two directions, although variations are possible.

In most instances, the canopy will continue to thin, allowing more solar radiation to reach the ground. This maintains a warm, dry microclimate at ground level which favors the maintenance of the *Cladina mitis* dominated mat, although species such as *Cladonia uncialtis, C. gracilis, Cladina stellaris* and *Cetraria nivalis* may continue to increase in cover. These park-like woodlands are among the most beautiful of Canada's forests.

Despite continued changes in the relative importance of species, the lichen mat totally recovers (in terms of thickness and total cover) in approximately 45 years. This contrasts sharply with regeneration times farther north on the Canadian Shield.

In more mesic areas, and especially on north-facing slopes, *Picea mariana* may begin to seed in, or may form a subcanopy equal in age to the higher pine canopy. Through regeneration and layering, radiation levels on the ground are reduced. The increased moisture available under such conditions allows the Bryophytes to gain in importance. Given sufficient time, a mixed pine-spruce canopy forms, with a lichen-bryophyte understory. The modified microclimate can be expected to modify the fire regime by increasing fire-free intervals.

Under the mesic successional regime, the thickness of the lichen-bryophyte mat does continue to increase, and the species composition continues to change. The lichen species *Cladina rangiferina, C. stellaris, C. arbuscula* and *Cetraria nivalis* may eventually attain greater cover than *Cladina mitis*. Only under these conditions do *Cladina stellaris* woodlands form in this region. The *Stereocaulon paschale* woodlands reported from farther north are totally absent from this region.

FIRE HISTORY AND FUEL APPRAISAL OF KANANASKIS PROVINCIAL PARK

by

Brad C. Hawkes[1]

P.J. Murphy and I were contracted by Alberta Provincial Parks to do a fire history and fuel appraisal study of Kananaskis Provincial Park. Our proposal to Provincial Parks emphasized that detailed knowledge of fire history, fuel loading, and flammability is essential in preparing a fire management plan.

The objectives of this study are to (1) document the fire history of Kananaskis Provincial Park and (2) determine fuel loading, flammability, and resistance to control with handtools for selected vegetative types. Suggestions will be made for goals and methods for fire and fuel management in the park, based on the information obtained through the fire history, fuel loading, and hazard investigations.

Analysis of fuels data has not been completed; however, we have learned something about the fire history of the park using fire scars, age class data, and Alberta Forest Service records. A total of 133 fire scars and 705 increment cores was taken on 217 fire history plots. Fire scars and increment cores were aged in the field and again at the Department of Forest Science in the fall. Lodgepole pine (*Pinus contorta* Dougl.) fire scars were mainly used, although some Engelmann spruce (*Picea engelmannii* Parry) and alpine larch (*Larix lyallii* Parl.) scars were collected.

Preliminary fire dates in Kananaskis Provincial Park are 1973 (AFS records), 1967 (AFS records), 1920[2] (scar)[3], 1904[2] (scar), 1890 (scar), 1886 (scar), 1880 (scar), 1858[2] (scar), 1852 (scar), 1840 (scar), 1838

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[1] Graduate student, Department of Forest Science, University of Alberta, Edmonton, Alberta.
[2] Large fires (1000 acres plus).
[3] Fire scar data available along with lodgepole pine regeneration data.

(scar), 1832 (scar), 1804[2] (Pl Regen)[4], 1765 (Pl Regen), 1712[2] (scar), 1688 (Pl Regen), 1655 (Pl Regen), 1586 (Pl Regen), 1526 (Sw Regen)[5], and 1426 (Sw Regen).

The mean fire return interval (average number of years between fire years) for the whole study area for all fires between 1426 and 1920 is 29 years. For the period 1804-1920 it is 12 years. The M.F.R.I. for large fires only from 1712-1920 is 40 years with a range of 14 to 92 years. The M.F.R.I. as calculated above will be dependent on the size of the study area. More fires will be included as the size of the study area is increased. Mean fire return intervals have not yet been calculated on the basis of elevation, habitat type, watershed, or aspect.

Fire dates were compared to a dendrochronological record available for the Banff area. Five of the six large fires shown occurred during low-graph periods. This indicates that climate is an important factor in the occurrence of fires in the Kananaskis Provincial Park.

Kananaskis Provincial Park has medium to large fires of medium to high intensity. Some stands are left after large fires occur. By relating the fire history to the present fuel types, we hope to answer the question "Why did some stands escape fire?" The answer to this question will help in future fuels management in Kananaskis Provincial Park.

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[4] Lodgepole pine regeneration data only available.

[5] Engelmann spruce regeneration data only available.

ACTIVITIES OF THE ALBERTA FISH AND WILDLIFE DIVISION IN THE USE OF FIRE FOR HABITAT MANAGEMENT

by

B.J. Markham

The Fish and Wildlife Division of Alberta Recreation, Parks and Wildlife has had an active habitat management program only since 1970. This program has evolved from one of mainly habitat protection to a more complete program of habitat maintenance and improvement. We view fire as a potentially significant and often essential tool in the management of wildlife habitat in Alberta.

Fire is an ecosystem process, that is,a natural phenomenon (Mutch, 1976), and as such is largely beneficial to most species of wildlife. As Kelsall, Telfer and Wright (1977) state in their recent publication regarding the effects of fire on the ecology of the Boreal Forest, "With some possible exceptions, a mosaic of varied successional stages in the Boreal Forest provides a richer habitat for a more varied and abundant fauna than does the monotypic spruce forest characteristic of unburned areas". The key to good wildlife habitat is variety.

The experience of the Fish and Wildlife Division in the use of fire as a habitat management tool is quite limited. This experience relates to basically two controlled burning efforts with two quite different objectives in mind.

Our first experience with controlled burning was in 1972 on the Kvass Flats in the Smoky River valley in Willmore Wilderness Provincial Park in west central Alberta. The Smoky River valley in this area has traditionally been an important ungulate winter range, in particular for elk, sheep, and moose. The valley floor is at an approximate elevation of 3500 feet. Much of the lower valley slopes is dominated by stands of mature aspen.

The main target species in this case was elk. It was felt that the carrying capacity of the elk winter range could be increased by

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[1]Section Head, Wildlife Habitat, Fish and Wildlife Division, Alberta Parks, Recreation and Wildlife

returning some of the mature aspen stands, which offered little browse under the closed canopy, to an earlier successional stage.

In the winters of 1970-71 and 1971-72 a bulldozer was used to "walk-down" approximately 75 ha of aspen. The aspen was left standing in areas of locally severe topography. The necessary fire guards were provided at the time of clearing. In May of 1972, the felled aspen was burned with three main objectives in mind:

1) to experiment with controlled burning techniques;
2) to remove the slash; and
3) to promote suckering of aspen

Much of the fuel was consumed with the exception of the larger tree trunks. Suckering of aspen was extensive during the summer following the burn and even by the first fall a considerable amount of browse was available. In the following summer, 1974, large amounts of herbaceous vegetation and browse species dominated by aspen were produced on the burn.

Vegetation transects run in July, 1974 using the point-intercept method indicated that aspen *(Populus tremuloides)* made up 33% of the vegetation and averaged 6 feet in height. Other important species were wild Vetch *(Vicia americana)* 11%, Pea Vine *(Lathyrus ochroleucus)* 9%, Grasses *(Gramineae)* 7%, and Fireweed *(Epilobium angustifolium)* 7%. Thirty species of plants in all were recorded.

Elk, as well as moose, are using the area but much of the use appears to be during the summer months rather than winter.

Chip Lake, a large shallow lake approximately 100 km west of Edmonton, was the site of our second controlled burning effort. One of the major objectives of the habitat management project for this lake was to establish a resident Canada goose population through transplanting geese and by providing suitable nesting habitat.

Chip Lake contains a number of islands and since Canada geese prefer island nesting sites, it was decided to manipulate the habitat of several islands to provide suitable nesting habitat for geese. The islands were characterized by grassy margins with woody deciduous cover dominated by aspen and balsam poplar on the uplands. Clearing, followed by controlled burning, was decided on to provide a more desirable open cover for nesting geese and other upland nesting waterfowl.

Four islands cleared between 1969 and 1974 had significant regrowth develop. It was felt that several successive burns should be carried out in an attempt to reduce woody regrowth on the islands.

In late April, 1976, controlled burns were carried out on Hat and Little Islands. Fuel on Little Island consisted of the heavy grass cover along the margins dominated by Manna Grass *(Glyceria* sp.), Slough Grass *(Beckmania syzigachne)*, Reed Grass *(Calamagrostis* spp.) and Sedge *(Carex* sp.) as well as considerable slash from clearing the previous winter. A good burn was obtained.

Hat Island was almost completely in grassy cover. The fire carried well through this dry combustible vegetation and a virtually complete burn was obtained. One month later (late May) a lush regrowth had begun and was being grazed by geese as well as offering brooding cover. In mid-June, a month and half after the burn, regrowth was now 2 to 3 feet in height and several active duck nests were found.

A basic problem encountered in this project was when to burn, spring or fall. Planned burns in 1976 had to be curtailed due to goose nesting already in progress on the island in late April. However, fall weather seems to be characteristically wet in this area,making burning difficult. Our present intention is to carry out the burning as early as possible in the spring of the year in an attempt to avoid the majority of the nesting season.

The Fish and Wildlife Division anticipates the management of fire will gain increased importance in the management of wildlife habitat in Alberta. We see this happening in two ways.

Firstly, we see an increase in the use of controlled burning to manipulate habitat for a variety of purposes. Depending on the objective, a prescription for the burn will have be predetermined. Exchange of information through participation in workshops such as this will aid in developing the proper prescription.

Secondly, and probably more important, we see the need to influence fire suppression policy within the province. One only needs to take a quick look at the size of the Green Area in Alberta, over which fire suppression operates, to appreciate the tremendous influence this policy can exert on wildlife habitat and wildlife populations. We cannot ignore this influence on the resource for which we have management responsibility. As Kelsall et al. (1977) state , "Forests that are protected with optimum efficiency will proceed to a relatively sterile and homogeneous climax of conifers...". While this may be quite satisfactory from the timber management aspect, it is completely unacceptable to wildlife managers.

We, therefore, see the need for the establishment of management priorities within the Green Area so that total resource management objectives can govern the basic policies and nature of fire management. As suggested by Mutch (1976) fire management considerations must be integrated into the land use planning process. By zoning forest lands in terms of various uses, the type of fire management in each zone can be decided. The recent land use policy established for the Eastern Slopes in Alberta provides an obvious framework within which to discuss various fire management strategies.

Of course, one major factor we cannot forget in these discussions is public opinion. The basic notion in the mind of the public, that fire in any form is bad, must be addressed. Rather than in the traditional ways, the only way to properly inform the public is through conscienious and objective publication of not only the dangers of fire but also the benefits of objective fire management.

BRUSH AND REGROWTH CONTROL ON PASTURE ON CROWN LANDS IN ALBERTA

by

C.J. Richardson[1]

Lands Division of Energy and Natural Resources is charged with the management of Public Lands in Alberta. Some 7000 grazing leases, 90 grazing association leases and 20 Provincial Grazing Reserves in operation (with several others in the development stage) encompass a land area of more than 6 000 000 acres of Crown land grazing.

In line with increasing demands for additional grazing, brush encroachment, lowered grazing capacities and loss of the forage beds, economics and tightening management restrictions, the livestock industry dependent upon these lands is looking more towards improvement and better utilization of Crown grazing lands. This, by public pressure and economic necessity,is shifting the emphasis of the industry away from larger holdings and into intensified production in the form of pasture development and range improvement.

This has been exemplified in the North or "forested" region, where thousands of acres have been cleared and seeded to tame forages. Government assistance in the form of the 1975 Winter Works Clearing Grants, Provincial Grazing Reserve development, and Range Improvement Assistance has created not only pasture, but also heavy reinvasion and infestation of brush regrowth.

This situation is not specific to the forested regions of the North, but is increasingly becoming evident in the Parkland fringe areas and even the southern grasslands and prairie. Although the situation of climatic successional "reforestation" in the North, brush "encroachment" in the parkland, and invasion in the South differ, the problem is the same--"how to control it?".

[1] Lands Division, Northern and Central Range Management, Department of Energy and Natural Resources, Province of Alberta, Edmonton.

Early methods of control by herbicides and mechanical treatments still yield questionable results with regard to effectiveness, environmental acceptability, and high costs. Increasing public pressure and economics have directed our attention towards the use of alternative and "natural" methods of control--"prescribed burning."

At present, the greatest potential for prescribed burning on Crown land is in conjunction with range improvement and pasture development following clearing and forage establishment.

This is particularly true on areas such as Provincial Grazing Reserves where livestock use is minimal or non-existent for 3-4 years following development. High initial forage production of 3-4000 lb per acre annually leads itself to an ideal fuel situation at a time when regrowth is not only at a maximum density, but also at a most susceptible state. Also at this stage, the construction and maintenance of fireguards is most economically and effectively feasible.

Where Range Improvement (on leases) is similar in effect, management differs considerably. Here the livestock producer's aim is to obtain an immediate return on his investment. Consequently, forage utilization restricts the use of fire as a management tool to control regrowth. Hence we are confined by the lack of "fuel management" as a result of "livestock management". This situation also occurs to some degree on operating Grazing Reserves which are presently fully subscribed, and maximum forage production is utilized.

However, it is anticipated that by 1979, a "fuel management" program will be incorporated in operational planning, and a large scale "burning" program initiated by 1980.

Current prescribed burning for brush control is restricted as much by climatic (moisture, R.H.), ecological (nesting waterfowl, spring "greenup", etc.) and environmental (smoke density, burning index, etc.) factors as it is by human ("too dangerous," inadequate fuel load, "may need the forage," nonaesthetic, etc.) factors.

In implementing a burning program incorporating these and other factors, the results become quite variable. It can probably be stated that the "effectiveness of control is a measure of the degree of fit that burning conditions meet the burning prescription."

At the current "state of the art", I would consider an overall kill of 50% successful. While this may amaze researchers as a "low level of acceptance", on a practical basis impatience for resources and short-term economics tend to dictate fitting the prescription to the conditions rather than the reverse.

Our experience under these conditions is that we can obtain an 80-100% kill on one- to three-year regrowth less than four feet high and one inch in diameter. On older regrowth four to twelve feet high with diameters greater than one inch, our results become quite variable. Unfortunately, the largest proportion of our pastures fall into the latter category, and must be a "close fit" with the prescription to be effective. Even when successful, pasture in this state has already established a strong root system,and resprouting readily occurs, thus necessitating a further burn or alternate methods of control.

When used in conjunction with chemical and/or mechanical treatments, prescribed burning can be very effective. My preference is to spring burn two years after a given treatment. We have effectively reduced the incidence of woody stemmed resprouting to less than 5% of previous levels by these means. However, this is generally a "one shot deal", and the prescription "fit" must be close.

In general, the following conditions serve as our guidelines for effective pasture burning:

	RH - (%)	WIND (MPH)	TEMP (F°)
1.	50 - 65	0 - 3	30 - 45
		- used for burning out fireguards, brush piles and potential trouble spots.	
2.	45 - 55	0 - 3	40 - 50
		- used to back-fire particularly when perimeter firing technique is used, and in widening effective fire guarding.	
3.	35 - 45	3 - 5	40+
		- perimeter line fire ignition.	
4.	30 - 40	3 - 8	45+
		- head fire ignition and general burning.	

Although pasture burning is relatively safe (particularly so with the conditions we burn under), safety and fire control cannot be minimized. A burning plan should stress precautions as heavily as (if not more so than) its requirements. Generally the lack of volatile fuels when burning pasture precludes non-hazardous conditions. "1600+ lb /acre of prevention is worth $1-2 /acre of cure". The minds of the masses are full of memories of devastation and "the fire that got away!" While this may be the result of an oversold success story, personal experience, human error, indiscriminate burning, etc., the results are the same: the "fear of fire" syndrome. This puts the onus on those of us that use it to not only demonstrate its proper use as a management tool, but also its proper control *when* used.

In assessing an area to be burned, we examine four basic factors:

1. Problem identification and site delineation.
2. Assessment of the purpose of burning, objective obtained, alternatives available, and burning or treatment requirements.
3. An evaluation of the measures required for its control.
4. Follow-up management planning to ensure the success of meeting the objectives.

While our "control" is probably over-indulgent and dependent upon fire behaviour expertise, future expanded burning will emphasize control planning and safeguards deemed "more than adequate."

In conjunction with a future "burning program", a "fire control and fuel management program" will be incorporated. Presently used fireguards such as waterbodies, plowed fields, roadways, and disced guards, etc. will be continued, but with an "expanded perimeter" control system involved. This may involve a major fire guarding effort surrounding as much as a township (36 square miles) in size. Within this framework, minimal and natural fireguards will be constructed and utilized to a greater extent in site-specific and selection burning.

Personnel deemed adequate for basic ignition and control will be utilized, with "on-hand" back-up resources available and aware of the safety, control and danger potentials involved.

The use of fire as a major acceptable "management tool" for brush and regrowth control is great, and we intend to use it! The economics of burning (($2-$2.50/acre) under our present conditions as compared to

$11-$15 per acre by chemical and $7-$25 (depending on treatment) by mechanical, are evident. If associated pasture-production loss is included, the difference would probably be greater. I personally feel that our future program will effectively lower the cost per acre of burning to $1-$1.50. This alone, without an environmentally acceptable discourse, would seem to provide us the impetus to proceed as envisioned with prescribed burning.

TRADITIONAL INDIAN USES OF FIRE IN NORTHERN ALBERTA.

by

H.T. Lewis[1]

The *Fires of Spring* is a film being jointly produced by myself and Professor Peter Murphy, Department of Forest Science, at the University of Alberta. This film outlines the technology of controlled burning as it was recently used by the Slavey Indians of northern Alberta. Like other North American Indians, the Slavey used fires to influence the relative abundance and regional distribution of plant and animal resources. Filmed statements made by band elders giving details of the reasons for and the consequence of burning are shown against the background of activities and the kinds of areas that were once influenced by Slavey uses of controlled, man-made fires.

The narration introduces the subject of traditional Indian burning and notes the fact that there are close parallels between these practices and both the conclusions of fire ecologists and the controlled burning programs of environmental agencies. Whereas the role of natural fires is noted, it is emphasized that Indians did not simply follow the more disruptive and potentially destructive cycles of summer lightning fires but, rather, that they burned at times, under conditions, and in places of their own choosing. The multiple reasons for burning were all directly related to being able to plan and predict the annual round of hunting and trapping activities in the northern boreal forest.

The most frequently mentioned and regularly burned areas were meadows and small prairies. Originally important for the many small herds of woodland bison once found there, in more recent times meadows and northern parklands were maintained for domestic stock, particularly horses. The cover of grasses and brush found along sloughs and streams was kept

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[1] Department of Anthropology, University of Alberta.

open to maintain desired habitats for both large and small herbivores, all of these the prey of various fur-bearing predators. Settlement areas were fire-proofed in order to keep brush and tree stands from encroaching and presenting greater dangers during the natural fire season. The provisioning of firewood was an important by-product of burning, and campsites were selected with this consideration in mind. These and complementary reasons for burning are noted by the Indian elders.

Fires were controlled by employing the same natural safeguards used in contemporary forestry management practices of prescribed burning. The fundamental one was that of seasonality, most significantly early spring burning. Controls additionally included an understanding of differences in relative humidity between fuel types, winds to increase or reduce fire intensities, the time of day involved, the use of slope, the size of areas burned, the frequency with which areas were burned, natural and man-made fire breaks, backfires, and people to knock down small fires with wetted spruce boughs.

Indians were able to set up reasonably predictable sequences of plant growth and related animal associations, while at the same time helping to avoid the worst features of summer lightning fires. The film begins with spring burning and ends with winter trapline scenes while noting the fact that the consequences of spring burning were important throughout the year. The film is being produced in conjunction with a monograph which presents all of this in much greater detail.

Produced by the Motion Picture Services, University of Alberta, and due for release later this year, it is aimed for use in first year university level courses as an introduction to the history of fire uses by North American Indians. The film is 16 mm, sound-colour, with a planned running time of 25 minutes.

A LIGHTNING DETECTION SYSTEM FOR RAPID DETECTION OF LIGHTNING-CAUSED FIRES

by

Dale L. Vance[1]

In 1974, the U.S. Department of the Interior, Bureau of Land Management (BLM) formed a group called the Office of Scientific Systems Development (SSD). The purpose of this group is to bring technology to bear in solving specific land management problems. Some of the programs assigned to SSD include:

1. Monitoring of Hawks and Eagles using radio-controlled cameras.
2. Satellite classification of vegetation using the Landsat multispectral scanner.
3. Automatic weather station development.
4. Development of a lightning detection system to assist in detection of lightning-caused fires.

This paper specifically deals with lightning detection. The other programs were mentioned because of the interest shown in these other programs at the fire ecology workshop.

BLM Alaska Fire Management asked SSD in early 1975 to investigate the state-of-the-art in lightning detection and to come up with recommendations for detecting lightning ground discharges.

Research indicated that no effective lightning detection equipment existed that could pinpoint lightning ground discharges (± 1 mile at 100 miles) and could be implemented in the field at reasonable cost.

The next step taken by SSD was to investigate current research in hopes that technological spin-off from current work might provide assistance in solving this problem. At the University of Arizona just such a breakthrough was occurring.

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[1] Electronics System Engineer, Bureau of Land Management, U.S. Dept. of Interior.

Dr. E.P. Krider and Carl Noggle (University of Arizona) and Dr. Martin Uman (University of Florida) had discovered that accurate azimuths to ground discharges could be determined using a crossed magnetic loop technique. BLM then funded an experiment in Alaska during the 1975 fire season using two laboratory prototype systems that proved the validity of the original findings. This does not imply that the systems were ready for operational use. At this stage, only highly skilled operators could differentiate noise from lightning discharges. Armed with Alaska lightning signature information and a feeling for the amplitude and type of noise encountered in the field, we developed the system further. For the 1976 fire season, six operational prototype systems were implemented in Alaska. Detection stations were established at McGrath, Galena, Bettles, Fairbanks and Tanacross. Before this system was implemented, approximately 40% of the lightning-caused fires were detected by the primary detection aircraft. After implementation of the six-station network in 1976, this figure went to greater than 60%. This system yielded the advantage of detecting fires at a small size for control by initial attack forces. In 1977, a different situation existed. After multiple fire occurences for four days, the whole attack force was overrun and some of the fires escaped. Thus, there were few detection failures; the major problem was too many fire starts in too short a time.

The system cost is approximately $10,000. This does not include spares and maintenance.

Future systems will include automatic event correction processing. Uses other than fire could include severe storm warnings for use by civil defense, aviation and electrical utilities.

SPRING FUEL HAZARD REDUCTION IN NORTHWESTERN ALBERTA

by

A.H. Edgecombe[1]

INTRODUCTION

The year of 1961 was a disastrous fire season for northwestern Alberta. Light snowfall during the winter combined with a dry summer resulted in a high to extreme fire hazard for most of the fire season.

Due to an early spring with high temperatures, spring fire hazard started early in 1961. By the first week in May the Alberta Forest Service had taken action on a number of large grass fires in new homestead areas east of High Level. More fires were to come later in the La Create, Hay Lakes, and Meander River areas as a result of spring burning in extreme fine fuel hazard.

At the annual fire control meeting of the Peace River Forest the following winter, it was decided to carry out an extensive grass hazard reduction burning program each spring to reduce hold-over fires from spring burning carried out at the wrong time.

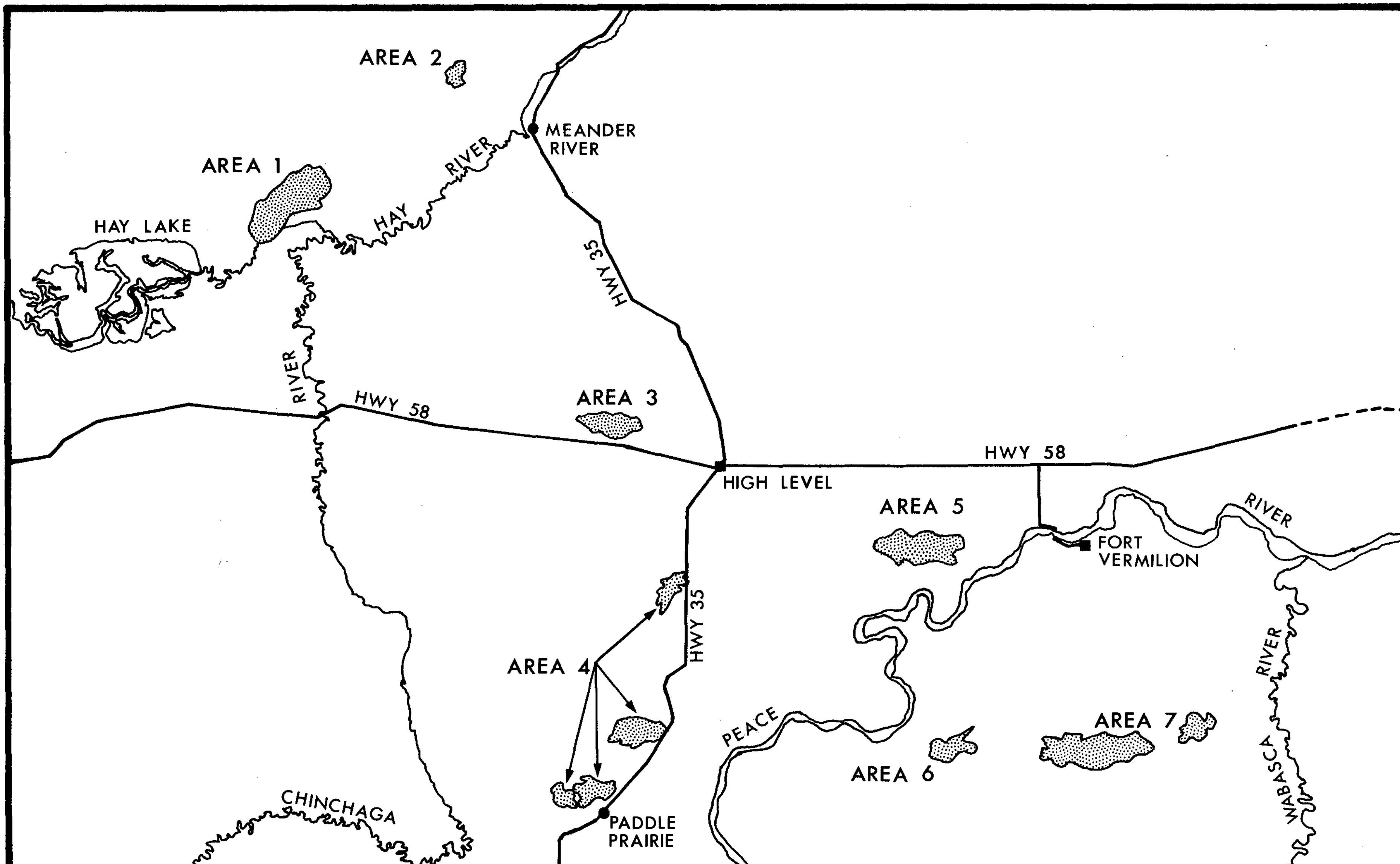
The year of 1962 was wet throughout the fire season, so only a limited amount of spring burning was carried out.

Light snowfall during the winter combined with a quick runoff resulted in an early fire season in 1963. A heavy grass growth on the large grasslands of northwestern Alberta presented a hazardous situation similar to the one in 1961.

One of the largest hazard reduction programs of the 1960's then got underway. The objective was to burn off the large open grasslands that created an extreme fire hazard and high risk factor as a result of homestead land-clearing range improvement fires.

The areas involved are marked on the accompanying map:

[1] Forest Technology School, Hinton, Alberta.



AREA 2
MEANDER RIVER
AREA 1
HAY RIVER
HAY LAKE
HWY 35
RIVER
HWY 58
AREA 3
HWY 58
HIGH LEVEL
AREA 5
RIVER
FORT VERMILION
HWY 35
AREA 4
RIVER
PEACE
AREA 7
AREA 6
WABASCA
CHINCHAGA
PADDLE PRAIRIE

Area #1--Hay Lake flats

Area #2--Meander River hay meadows

Area #3--Moose Prairie west of High Level

Area #4--Paddle Prairie hay meadows

Area #5--Devil's Lake hay flats

Area #6--Savage Prairie and east

Area #7--Tall Cree's Prairie

IGNITION PATTERN

PERIMETER IGNITION

Method--The small areas, 600 acres or less, were burned by hand crews using drip torches or pressurized flame throwers. Areas over 600 acres were ignited by helicopter and utilization of the diesel torch. The Devil's Lake area was ignited by men on horseback and diesel torches pulled along the west end of the flats so that the fire would burn with the wind.

SUPPORT CREWS

Local crews were hired to mop-up and extinguish after the burn.

ADVANTAGES OF THE BURN

1. The one obvious benefit of burning was the on-the-job training that the local firefighters received while employed to carry out the burn.
2. Fire behaviour studies on forward advance and fire growth were carried out.
3. As a result of mop-up and extinguishing by the crews, hold-over fires were reduced on the large land area that had been affected by burning.
4. The burning program effectively set the stage for fire suppression in the Peace River Forest for the coming fire season.
5. Hazard reduction burning gave Forest personnel the opportunity to assess the detection system.
6. The early spring burning improved the grazing lands by enhancing the grass growth by pre-heating the lowlands as a result of the black mantle that was laid over the landscape.

7. The hay crops of wild grass in the Hay Lakes and Meander River areas were found to be of better quality after the burn due to the reduction of the amount of dead grasses carried over from the previous year.

CONCLUSION

When we considered the logistics of transporting crews to burn sites and the relatively small percentage of total area involved compared to the protected zone, it soon became obvious that spring burning could not be justified on such a large scale. Furthermore, the fire prevention program that was implemented about this time was starting to show results; it was therefore decided to discontinue this program.

Some spring hazard reduction burning is still being carried out, but not to the extent that it was in 1963.

FOREST PROTECTION IN ALBERTA, 1977

by

H.M. Ryhanen[1]

The Forest Protection Branch of the Alberta Forest Service is responsible for provision of protection services over approximately 60% of Alberta or about 95 million acres. The forest land base is considered to be approximately 82 million acres.

Provincial headquarters for the Branch is Edmonton. The administrative structure is three-tiered: provincial, forest and district. The provincial and forest levels are manned with line and staff personnel. The District level is responsible for implementation of the planned programs and they carry out most of the field work.

Permanent Forest Service administrative and operational staff number about 660 people. During the summer this total increases substantially with the addition of seasonals, who are hired to perform forest protection duties or assist in other resource management field work. During fire emergencies majority of total staffing may be utilized to cope with the situation.

In Alberta, the main objective is "to manage Alberta's forest lands in a manner ensuring perpetual supply of benefits and products while maintaining an environment of high quality". The goal of the Forest Protection organization is to minimize the loss of forest areas to fire and to control any major insect and disease infestation that may develop. Specifically, Alberta's aim to hold the annual burn from wildfire to one-tenth of one percent of the forest land area.

Prevention - over the next three years (1977-1979) reduce land clearing fires 35%; incendiary fires 20%; hold recreation fires at the current level and lessen miscellaneous known fires,i.e.,children playing with matches, by 20%.

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[1]Director of Forest Protection, Dept. of Energy & Natural Resources, Alberta Forest Service, Edmonton.

Detection - discover all wildfires at 1/4 acre in size or smaller.

Pre-suppression - maintain a pre-season state of readiness (based on historical fire load) of:

- fireline and fire camp equipment
- heavy equipment
- ground transport
- air tankers (land based and skimmer)
- air transport
- supervisory and firefighting personnel
- training (maintenance and up-grading)

Suppression - the aim in suppression is to attack all wildfires within 1 hour of notification and to contain them at 3 acres or less in size. The "10 o'clock Rule" is also observed except in a special zone located in the extreme northern portion of the province.

Legislation for the protection of Alberta's forests takes the form of the Forest and Prairie Protection Act and two sets of Regulations issued pursuant thereto. Legislative application belongs totally to the province excepting hamlets, villages, towns, new towns or cities and land owned by the Government of Canada (in the absence of an Agreement in the latter instance). Protection responsibility in Counties and Municipalities lies with these administrative bodies. Action and cost of wildfire suppression within Counties and Municipalities is their responsibility.

In 1956 an intensive program of tower construction was commenced. This has resulted in a present network density of 140 lookouts. These lookouts provide the nucleus of our detection system. Most of these installations are in high value areas such as forest management agreement areas, timber licenses, recreation areas and valuable watersheds.

The lookout system provides valuable secondary benefits such as a comprehensive fire weather and fire sampling network, lightning storm reporting, and an intensive forest level communications system.

In 1962 the Alberta Forest Service embarked on a training program to upgrade the performance of firefighters, straw bosses and crew bosses. To date, we have in excess of 3,700 personnel consisting mostly of native and metis people of Alberta who are trained and welcome the challenge of firefighting on an "as needed basis." This complement of manpower allows us to field a force of 1,500 - 2,000 trained firefighters at any one time.

The Alberta Forest Service has an inventory of firefighting and camp equipment capable of supplying 6,800 men. In providing aircraft services throughout the 1977-78 operating year, the Forest Service utilized the following aircraft types and numbers.

Government Owned Aircraft

Executive Aircraft:	1 Beechcraft King Air 200,
	1 Beechcraft King Air 100 and
	1 Beechcraft Queen Air 90.
Utility and Patrol Aircraft:	1 Douglas DC-3 and 2 Dornier DO-28B's.
Helicopters:	4 Bell 206-B's (Jet Ranger) and
	2 Bell 47-AJs's.

Contracted Aircraft

Air Tankers and Bird Dogs:	6 Douglas B-26's (Invader), 4 Consolidated PBY-5A's (Canso)
	2 Cessna 310's (Riley Rocket) and
	2 Cessna 337P's (Skymaster).
Utility and Patrol Aircraft:	1 Britten-Norman Islander and 1 Cessna 180.
Helicopters:	2 Bell 204B's, 3 Bell 206B's (Jet Ranger) and 1Bell 47-AJ2.

According to the current inventory, Alberta's forests could sustain an annual allowable cut in coniferous stands of 517 million cubic feet and 478 million cubic feet of deciduous timber.

At the present time, Alberta's wood industry harvests only a portion of the allowable cut. In 1973-74 production reached a peak of 200 million cubic feet of marketable timber. The present merchantable stands could support a doubling of the annual cut in the soft woods and a major increase in the harvesting of hardwoods.

During the 1930's and 40's, large fires occurred throughout the northern part of the province. These burns, estimated at about 24 million acres, have restocked to established young growth. This established young growth, because of its small size at the time, was not included in the existing forest inventory.

When the new inventory establishes the amount of this young growth, it is expected that the existing annual allowable cuts for softwoods and hardwoods may be almost doubled during the next rotation (in approximately 40 to 50 years).

THE CAMERON-CARIBOU FIRE CONTROL PLAN

by

J.M. Skrenek[1]

INTRODUCTION

The Cameron-Caribou area is located in the extreme northwest portion of Albera. The area is characterized by a high percentage of muskeg. Cover generally consists of black spruce, Labrador tea, *Cladonia* and *Sphagnum* moss. Organic soils are reported frozen at depths ranging from 12 to 30" below the surface.

Fires that occur in this fuel complex spread extremely rapidly. Large fires are uncontrollable when fire hazards are critical. The problem was that suppression costs were too high for the land values involved. The Cameron-Caribou fire control plan was adopted to serve in controlling fires without employing unreasonable forces, at minimum suppression costs. It is designed for fires that have escaped initial attack.

ANALYSIS

In our analysis of the problem we looked at:

1. Suppression costs
2. Weather
3. Fire hazards
4. Past history

1. Suppression Costs

   Statistics compiled for an 11-year period 1961-1971 indicate a total of 252 fires, all of which were caused by lightning. Initial action or immediate follow-up was successful on 94% of the total number of fires. The remaining 6%, however, accounted for 84% of the total suppression costs.

[1] Head, Air Administration, Forest Protection Branch, Alberta Forest Service, Edmonton.

2. Weather

Temperature maximums were highest in June and July, when temperatures of 27-37°C were reported. The critical Relative Humidity factor is believed to be 40%, at which point *Cladonia* moss is susceptible to maximum fire spread. Again, June and July were the critical months. Precipitation records indicated that this area had 14-26 rain-free days during June and July. An important consideration in developing the fire control plan was the time since the last rain, because it is a significant factor in determining *Cladonia* fire hazard.

3. Fire Hazards

Cladonia Fire Hazard records showed that during June and July, hazard ratings were High-Extreme for 14-22 days in each month.

4. Past History

Comments from past fire reports indicated how important a factor weather was. "A slight change in weather to our favour and the fire will stop all movement." This change in weather could be in the form of cooler temperatures, a rise in Relative Humidity, a rain shower, cloudy weather, etc.

FIRE CONTROL PLAN

1. Policy

Suppression expenditures must be commensurate with value endangered.

2. Standard for Initial Attack

Any wildfire will be reported and suppressed with speed and the strength of resource needed to effect control or to accomplish specifically defined purposes as directed by existing and predicted burning conditions.

This policy calls for aggressive action when needed, but recognizes that there are circumstances which at times make it appropriate to delay initial action when fires are expected to be uncontrollable due to existing fire behaviour, or when resources are required in or committed to high-value areas.

3. Standard for Fire Escaping Initial Attack

Any fire for which initial or subsequent action fails will be controlled according to the following alternatives:

a. If safe, and if adequate suppression forces are available, direct attack of sufficient strength will be employed to effect control before 7 o'clock the next morning.

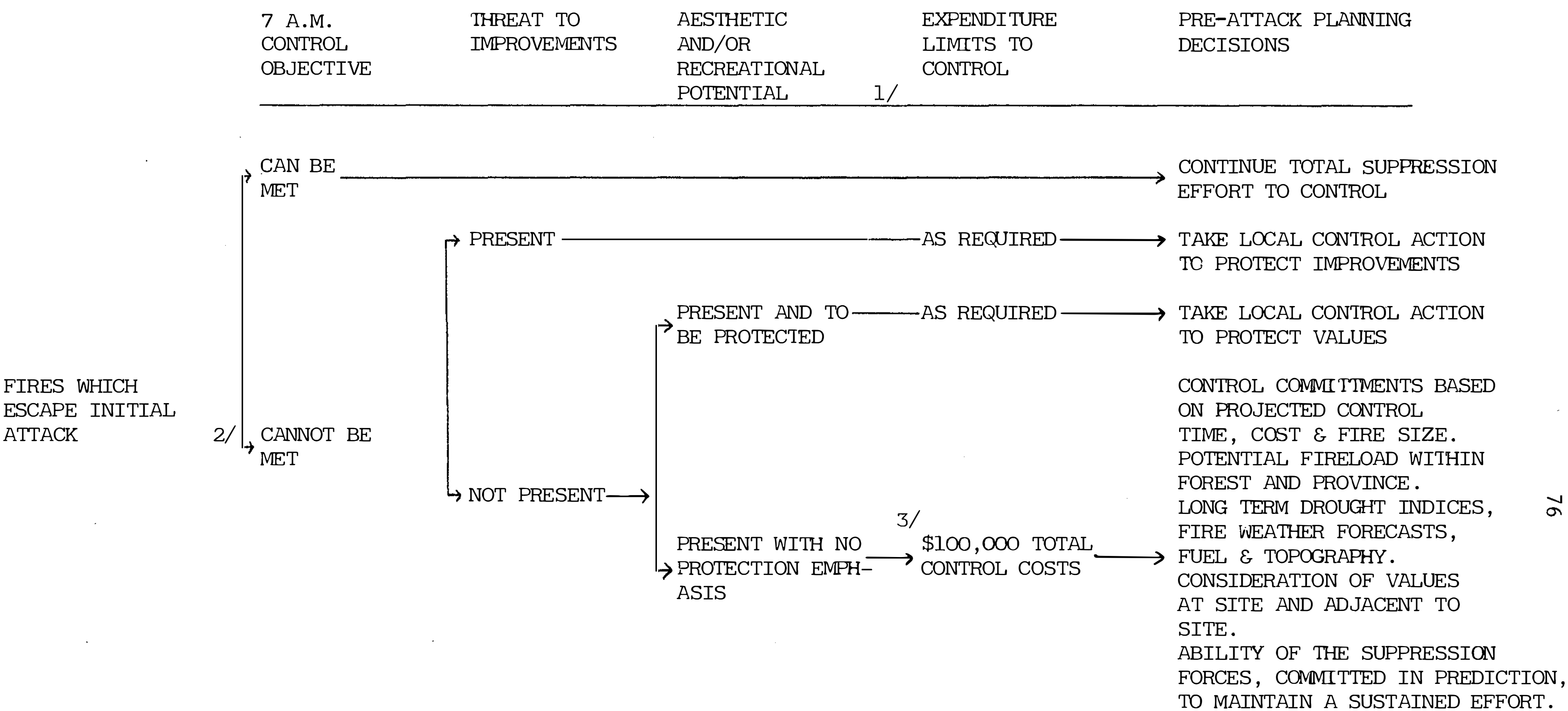
b. If not safe for direct attack or 7 o'clock objective cannot be met, indirect attack of sufficient strength will be employed to meet as closely as possible the pre-attack planning as outlined in the Decision Chart. Decisions will be subject to Forest Superintendent's or Fire Control Officer's approval.

Expenditures on fires within the same zone will be limited to $100 000.

4. Discussion

We feel that by establishing a figure of $100 000 based on past costs, we are not only establishing ground rules but forcing our staff to become more cost-conscious, resulting in realistic projections of expected fire behaviour and generally more efficient fire management. The key to success of this proposal lies in fully qualified overhead on the fire and close supervision from H.Q. Fire Control Staff. In discussing this proposal we certainly foresee problems; however, we feel that it is a starting point in reducing costs and worthy of a trial fire season under close supervision by our Fire Control staff.

DECISION CHART - FIRES ESCAPING INITIAL ATTACK - CAMERON-CARIBOU AREA



1/ TIMBER VALUES NOT CONSIDERED AS NONE ARE PRESENT IN COMMERCIAL QUANTITY.

2/ FIRE CONTROL OFFICER ADVISED.

3/ FIRE CONTROL OFFICER AND/OR FOREST SUPERINTENDENT DECISION.

FIRES NORTH OF 60°

by

J.S. Rowe[1]

Fire management implies land use goals. The "out by ten a.m." policy aims to safeguard standing timber, communities, engineering works. The "let burn" or prescribed burn policies aim to regenerate vegetation, maintain habitat diversity or reduce hazard.

Wherever land use goals are vague, fire policies are difficult to frame. In Canada north of 60°, it is not easy to decide what ought to be done in the way of fire suppression. Although there are communities and corridors to be protected and local patches of merchantable timber to be preserved, such areas make up a relatively small part of the north.

In recognition of these facts, the Department of Indian Affairs and Northern Development has instituted a reasonable system of priority zones for fire suppression. Nevertheless the question is still asked if more attention ought not to be paid to fighting fires in the hinterland, in zones 3 and 4. The tendency to accept what is done in the south as the norm is strong.

In the absence of sharp objectives, perhaps a general management goal for the northland as well as for major national parks and large wildlife reserves should be set, namely maintenance of the biological variety and diversity that existed in the pre-industrial landscape. This can be justified as guaranteeing at least the level of productivity and stability that Europeans found on their arrival. A diversified landscape will keep options open. Variety is more than the spice of life, it is a means of providing for choices in the future.

How shall we get and maintain diversity in the landscape? The northern scene provides a baseline, presenting as it does a patchwork pattern largely attributable to fire. Variety exists in the mosaic of landscapes. Fire continually renews between-site diversity, creating a range of vegetation age classes, fragmenting large monodominant stands,

[1]Department of Plant Ecology, University of Saskatchewan, Saskatoon.

maintaining productive early successional stages.

There is ample evidence that large fires have been a normal part of the northern environment, creating a spacious mosaic. The larger animals are travellers, finding the variety they need for food and shelter by moving from place to place, from patch to patch. Their mobility reflects the fact of low primary productivity. Aboriginal man too was nomadic in this environment as is the modern recreationist.

Examination of fire statistics for the Northwest Territories shows that lightning fires have been the major agent of vegetation renewal in the past. In recent times such fires have accounted for more than 95% of the area burned annually. A fire rotation age of about 100 years seems to be average for forested parts of the Shield.

Many lightning fires are associated with frontal activity as air masses of different temperatures and humidities meet. More,however, seem to result from "stalled" air masses within which convective instability develops from earth surface heating.

Some examples of weather conditions conducive to fires can be found in ALUR reports 73-74-61 and 74-75-61 (DIAND, Ottawa) on which this paper is based.

AN APPLICATION OF LANDSAT DIGITAL TECHNOLOGY TO FOREST FIRE FUEL TYPE MAPPING

by

P.H. Kourtz[1]

Economic limitations prevent the mapping over large areas of forest fire fuel types using conventional forestry methods. The information contained in such maps would be a valuable tool for assisting in initial attack planning, presuppression planning and fire growth modeling. During the past several years, the Forest Fire Research Institute,with assistance from the Canadian Centre for Remote Sensing, has examined the role of digital classification and enhancement methods for producing general forest cover classifications suitable as fuel maps.

Supervised and unsupervised classification methods were tried on a forested test area in the Province of Quebec. Of these two methods, unsupervised classification appears to be more appropriate for the forests of eastern Canada. It was found that coniferous, deciduous and general mixed stands, plus new clearcut logging, recently burned and regeneration areas, large new woods roads, water and muskeg swamp could be classified over large areas with a degree consistency suitable for fire control purposes.

The search for improved methods led to the use of Taylor's digital image enhancement program (Dr. M.M. Taylor, Defence and Civil Institute of Environmental Medicine, Department of National Defence, Downsview, Ontario). Excellent results were obtained in the test area and based on these, an 8-million-ha forest fire fuel map was prepared for the Outaouais forest protection region of Quebec, using enhanced summer data. The color allocation scheme of the enhancement program was such that the output resembled a classification of the major cover types listed previously. In addition, adequate geometric

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[1]Research Scientist, Forest Fire Research Institute, Canadian Forestry Service, Ottawa, Ontario

correction of output, coupled with a greatly improved display of roads, regeneration and forest transition areas, made it preferred by fire control field personnel over classification output.

Field experience with the 120 8" x 10" Outaouais enhancement photographs during the 1976 and 1977 fire seasons immediately showed their value. One particular example stands out. A fire was reported and a conventional dispatch of ground personnel ordinarily would have followed. A check with the fuel map showed a large and very dangerous logging slash situation downwind from the fire. An immediate dispatch of air tankers and helicopters stopped the fire at the edge of the slash area. The savings were estimated to be between 20,000 to 50,000 dollars. The cost of LANDSAT maps was less than 3,000 dollars.

Preliminary studies have shown that it is feasible to use LANDSAT imagery for constructing forest fire fuel maps in digital form. The data contained in the maps is to be used as input to a computer forest fire spread model and for "real-time" initial attack decision making. Given auxiliary information such as location of the fire, weather conditions and fuel moisture, the computer model computes the future perimeter location. This in turn may be used by the field personnel to determine the most effective disposition of fire control resources. The computer maps must supply up-to-date information on fuel type, as well as information on water resources, roads and slash areas. The digital fuel map is initially to cover an 8,000,000-ha forest area, down to a resolution of approximately 0.5 ha, and is designed to be used and updated on a PDP11/T34 minicomputer at the Forest Fire Research Institute. The imagery is to be supplied by the Canada Centre for Remote Sensing, where both the initial reformatting of the imagery and the visual verification of the results on a colour display device are to be performed. From previous studies, it has been found that there is a significant variability in classifications accuracies, both within an image and between successive images. In order to build up a reliable map for a given area, it is, therefore, necessary to use a number of images from different dates. The procedure proposed is to first realign all images to a standard grid, such as the UTM coordinates, so that comparison between different images can be made. An unsupervised classification is then carried on and a reliability measure is calculated for each pixel. The new classification is subsequently compared with the previous classifications which are stored in a database. A decision is then made whether to change or retain the previous classification. Test sites will be used to monitor the results both by visual and statistical methods.

THE USE OF PRESCRIBED FIRE IN THE MANAGEMENT OF LODGEPOLE PINE

by

S.J. Muraro[1]

The lodgepole pine (*Pinus contorta* var. *latifolia* Engelm.) stands of the Chilcotin Plateau present a multi-age, level, and density mosaic interspersed with small areas of generally dense, even-aged stands. This heterogeneous mosaic is the result of a fire history of generally low-intensity fires that covered extensive areas at 20- to 40-year intervals. The even-aged areas are the result of occasional periods of higher fire intensities of these same fires, rather than isolated high-intensity fires superimposed on the mosaic.

These stands are markedly different from the extensive areas of even-aged lodgepole that occur in wetter and mountainous terrain where fires are generally of higher intensity but at longer intervals, and residuals of the former stand occur only in areas of distinctly different moisture and fuel regimes, i.e., creek bottoms and ridge tops.

The unique characteristics of the Chilcotin pine stands are accompanied by insect, disease, and economic fibre production problems that if not different, are amplified from those encountered in other areas of British Columbia. One of the more obvious differences is the decreased density of mountain pine beetle infestations due to the multi-age structure of the stand.

The basic principle of fire management--the application of fire-related knowledge to achieve land management objectives--is eminently applicable to the management of these stands in particular and in some instances to the more common even-aged stands.

A series of studies to examine the potential for using fire for lodgepole pine management is currently in progress. They involve:

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[1] Research Scientist, Pacific Forest Research Centre, Canadian Forestry Service, Victoria, B.C.

1. using fire to control mountain pine beetle, *Dendroctonus ponderosae* Hopkins
2. using fire for either sanitation or stand rehabilitiation in areas of dwarf mistletoe, *Arceuthobium americanum* Nutt. infection
3. using fire as a means of precommercial thinning

All of these applications take advantage of the perpetual seed supply available in lodgepole pine stands and the ability to release varying amounts of this seed through fire manipulation. This characteristic of lodgepole pine provides the possiblity of economic stand replacement to desired stocking through the judicious use of fire, Determining the operational feasibility of utilizing this supply of seed whether on standing trees or on slash may remove one objection to the use of fire where natural regeneration in lieu of planting was the management objective for allowing logging.

For the control of mountain pine beetle the most obvious use of fire was to reintroduce the 1930 technique of standing tree burning. Adaptation of the technique for winter use with modern all-terrain vehicles and pumping equipment has proved to be an economical and practical control technique where the height of infestations is not beyond the pumping capability of the equipment. Mortality is achieved with a fire residence time of 3 minutes.

The use of broadcast fire for treating large areas of infestation was also demonstrated. This procedure involves concentrating a limited logging capability towards felling and removal of perimeter timber and construction of an access road to serve as a guard and/or for future timber removal. Prior to flight time the standing timber within the control line is broadcast burned to achieve:

1. mortality of broods due to underbark temperature greater than 46°C
2. an area of fire-stressed trees attractive to beetles to establish a holding area for emerging beetles in and adjacent to the burn area

In the case of merchantable stands where product degrade due to scorch has to be minimal, a low- to moderate-intensity broadcast burn is desirable to maximize the attractant effect. Beetle mortality is accomplished by subsequent logging. Where product degrade is not important,or in nonmerchantable stands in remote or recreational areas, a high-intensity fire is desirable to maximize immediate brood mortality. In either case, the high moisture content of the underbark habitat in fire-damaged trees and especially crown-scorched trees is undesirable for overwintering populations. In both cases,seedbed preparation, seed release from serotinous cones,and sanitation of advanced regeneration are extra benefits achieved by burning. Lack of anticipated wind precludes fire spread through the demonstration area. Brood mortality was not achieved; however,postburn assessment of the inner perimeter trees resulted in a ratio of 10 scorched trees to 1 unscorched being attacked.

This technique has the best chance of success where there are sufficient forest floor fuels to carry fire with a minimum of drying. Favorable topography, high probability of favorable weather prior to flight time,and good perimeter layout and supervision to ensure adequate perimeter fuels with adequate curing time are other requirements for success.

The presence of dwarf mistletoe in lodgepole pine is strongly associated with the occurrence of low-intensity fires; mistletoe is the major forest pest in the Chilcotin Plateau. Study areas to assess and three approaches to using fire for mistletoe control were therefore established. In order of priority, based in order of lowest to highest direct cost and difficulty of implementation they are

1. sanitation of areas following logging in commercial stands
2. minimum cost sanitation and restocking of marginally commercial stands
3. rehabilitation of uneconomic stands

Sanitation of areas to be logged can be accomplished with proper fuel management practices at extremely low direct costs. The treatment of residual slash and advanced regeneration with fire may,however,incur the need to plant if the slash-borne cones are destroyed by fire. There exists,however,the possiblity of providing hot fast fires that do not result in complete seed mortality. Whether this is an operationally feasible practice (that is, is there sufficient latitude in fire behavior between complete seed mortality and adequate stocking), remains as one of the questions to be answered by these studies. The key to successful use of fire for sanitation of these logged areas is fuel management. Traditional full-tree logging methods wherein the entire tree is forwarded to a landing for delimbing and topping result in huge waste piles at landings and a scarcity of fine fuels over the remainder of the area. In older areas of logging this is exacerbated by summertime use by cattle. Areas logged in this manner are extremely difficult to burn; even under the most severe burning conditions fire coverage is poor and there are difficult control problems on the perimeters. Only conditions of prolonged drying, high sun, and winds greater than 20 km/h will result in adequate coverage. Both control and ignition costs in these fuel complexes are excessive unless very large areas are treated. In addition, winter-logged areas are generally slow to regeneration due to the lack of exposed mineral soil and thick sod encouraged by stock cropping.

Where logging slash is concerned fuel management practices must be accomplished at the time of logging. In order to manipulate the resultant fuel complex the land manager must know if treatment is required prior to disposal of the timber. In the Chilcotin, openly stocked stands clearly evident on aerial photographs are an almost sure indicator of infection at some level of the stand. Treatment will probably be justified if, upon ground examination, mistletoe is obvious in the overstory and if advanced regeneration, obviously infected or not, is present. If these conditions are present, logging practices that will enhance the fuel complex for burning must be included in the contract. In most cases favorable fuel complexes can be created by enforcing a practice of topping and limbing prior to forwarding to the landing. In favorable terrain a saving on landing treatment will result. The resulting fuel complex of continuous freshly cured slash permits good fire spread and excellent fire coverage with ISI's* of 3 or less and on summer nights when surrounding timber stands will not support fire spread. This allows the land manager

* The initials ISI, BUI, FWI, AND, FFMC, DMC and DC refer to indices and moisture codes of the Canadian Forest Fire Weather Index.

a wide degree of latitude as to seasonal timing and BUI levels in response to the particular needs for removal of woody material and organic layer. Sanitation treatment of these stands should receive the highest priority and should be routinely conducted where infected advanced regeneration or infection of the overstory is present. If the cost of planting is a deterrent and utilization of slash-borne seed proves to be operationally impractical,then the possiblity of a seed tree cut remains an alternative.

A combined sanitation and restocking treatment may be the most economic treatment of marginally commercial stands where some inducement may be required to achieve harvest. These stands should receive second priority for treatment and return to production at the lowest possible cost. Two treatments are proposed for these stands,depending on the ultimate use of the product and the condition of the stand. If the stand is decadent,with a large proportion of butt rot,or if chipping of manufacturing waste is not envisaged, underburning the stand prior to logging is suggested. If chipping of manufacturing waste is contemplated and butt rot is not present,then product degrade due to scorching can be minimized by a seed tree cut preceding a broadcast burn. In this treatment only the seed trees would be scorched, this volume may either be recovered and or left on the site. In both cases,however,stocking control is exercised by manipulation of flame heights relative to the serotinous seed source. In the case of seed tree cut, seed trees not killed by the fire are hand-felled following seed dissemination. If the seed tree technique is followed,20 to 30 evenly distributed full crowned trees selected for their quantity of serotinous cones should be left on each hectare.

The third priority for mistletoe control involves extensive areas of small-diameter stands that offer little chance of being merchantable in the foreseeable future. This decision alone requires research effort,and indeed these stands may be put into one of the previous stand categories if a manufacturer of special products such as fence fire posts or corral rails can be interested in them.
In any event,whether some portion of the stand is utilized or not, broadcast burning will provide the most economical sanitation and reforestation treatment. For success of this treatment two conditions are necessary.

The BUI must be sufficiently high, generally in excess of 70, to obtain about 60% exposure of mineral soil. The ISI, adjusted for state of fuel curing,must be sufficiently high, between 5 and 10, to permit good coverage for complete sanitation and manipulation of flame height relative to crown height, i.e., cone location. Of necessity, treatments in these types of stands will require follow-up hand felling to remove surviving trees that are capable of passing on the infection.

All of these proposed treatments are designed to provide minimal cost of sanitation with the added benefit of using the available seed for controlled stocking. In general,they apply where fire use is permitted and where there are no value conflicts between overstory and understory species that may be of higher value.

Contrary to general opinion, wildfires in lodgepole pine, especially in fuel-sparse areas, do not necessarily result in complete stand mortality. Smaller areas of pine that have been thinned by ground fires during periods of low fire intensity are evident even in areas of normal fuel loading. The potential for manipulating fuel consumption and fire intensity with underburning ignition techniques provides the forest manager an economic tool for precommercial thinning of a variety of forest species. In the relatively low-value lodgepole that is especially prone to overstocking, the economics of thinning with fire are especially appealing. Plots established in an 18-year-old and a 68-year-old stand have demonstrated the feasibility and also emphasized some important considerations. In the case of the 18-year-old stand,the absence of surface fuel prevented a continuous fire and resulted in a spotty type of burn that killed all stems in areas of log fuel or none where there were no log fuels. In these types of stands,where there is an absence of surface fuel to carry a continuous low-intensity fire,the decision to burn under such conditions to achieve a 100% kill might be best. Openly stocked stands resulting from reburns of overstocked young stands having relatively few cones are commonly encountered in nature. Normal stocking and faster growth are exchanged for stagnated or even locked slow-growing stands for the price of the difference in age. This phenomonen has been documented by

Clements in 1910 and by Smithers in 1961, who cites the following stand characteristics of an 80-year-old stand compared with a portion that reburned at age 15 (all values were converted to SI units by author).

	Age yr	Height m	Av dbh cm	Stems/ha	Volume m^3/ha	Basal Area m^2/ha
Original stand	75	10.3	4.5	22,230	123	36.9
reburned portion	60	17.7	15.0	2,124	310	38.2

Where areas of sufficient fine surface fuel occur, the option for thinning rather than wiping out remains.

In older stands, preferably between 25 and 40 years, there are generally adequate surface fuels to achieve well-controlled, low-intensity surface fires required to selectively kill a portion of the stand. Mean annual increments also approach maximum at these ages. Although mortality is definitely greater in the smaller diameter classes, due to differences in bark thickness, fuel characteristics near the base of the tree determine if the tree lives or dies, regardless of diameter. In stands where the larger trees exceed 6 cm, postfire *Ips* attack should be anticipated, invariably against those trees that are only slightly fire stressed; i.e., it will selectively attack the larger surviving trees. The resultant stand after direct fire mortality and subsequent *Ips* attack tends to be composed of trees near the average diameter of the original stand. The effect of *Ips* can be minimized by fall burning after *Ips* activities have ceased for the year and by treating stands that offer a minimum of desirable stems for *Ips*. In general, the most stagnated stands have the least variance in diameter. Dominant trees in stands that are starting to release will be the most susceptible to subsequent *Ips* attack. In any event, the fire prescription should not be designed to achieve the final stocking. Allowance for mortality due to *Ips* should be considered to achieve the final objective. Mortality may continue for a number of years following the fire, depending on local climate, other food supplies, and local populations. In this treatment flame length must be rigidly controlled to avoid seed release from serotinous cones. For these treatments, dependent on fuel curing and the amount of log debris, BUI's of 40-50 with ISI's of 10-15 with moderate winds of consistent direction and the use of strip headfires or backing fires will achieve objectives of precommercial thinning.

It is anticipated that well-planned operational underburning for precommercial thinning can be accomplished for less than $40/ha.

Operational costs of underburning must be expected to be less than other precommercial thinning techniques, adverse environmental impact resulting from fuel hazard will be less, and, most appealing, fire can be used with the least difficulty on steep ground where mechanical techniques are not usable and the only other options are the high-cost hand felling methods.

The main disadvantage of using fire is the extent of injury to the surviving stems, although maintaining minimum flame height will minimize the height of damage on the boles. Local constraints of favorable burning periods must also be considered in implementing an operational program.

All of these studies have had a combined research and demonstration emphasis, with greatly appreciated strong involvement by the B.C. Forest Service. The intent of these demonstration areas is to establish prescribed fire along with, not in lieu of, other approved tools available to treat the multiplicity of problems confronting the land manager.

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FIRE RESEARCH AT THE UNIVERSITY OF ALBERTA

by

P.J. Murphy[1]

The Edmonton region can be described as a stimulating mileu within which to work in the field of forest fire management, and the University of Alberta is fortuitiously located for fire-related studies within a variety of disciplines.

In the fire management field generally, staff and graduate students in the Departments of Forest Science, Botany, Plant Science, Anthropology, Geography, and Agricultural Engineering have all been involved to some degree with the broad complexity of forest fire. In addition, fire research and fire management are conducted by staff in the Canadian Forestry Service, Canadian Wildlife Service, and Parks Canada on the federal level, and Alberta Forest Service, Lands Division, Parks Alberta, and Fish and Wildlife Division on the provincial level.

In 1950 a forest fire came out of the Fort St. John, B.C. area and moved northeasterly into Alberta. At that time those areas of both British Columbia and Alberta were in nonprotected zones, so the fire was in effect an early-day "let burn." What distinguishes this fire from so many of the others of that day is that it burned approximately 2 million acres, had a long axis of about 160 miles, a width of 60 miles at the widest point and appeared to be moving with a front about 30-40 miles wide during its peak activity.

This fire is believed to have started 1 June northeast of Fort St. John. It was burning in old logging slash and was believed to have been started by a careless traveller. By the time the Ranger arrived on 2 June the size was estimated at 200 acres. It was decided that no action was to be taken on the fire since there was little chance of control at that time, the area would likely be developed for agriculture, and it was

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in a nonprotected zone. This fire may have later joined additional fires to the north believed to have escaped from smudge fires left by seismic crews working north of Fort St. John.

The reports suggest that the fire, although it burned June, July, and August, did not really move with a high intensity until mid-September when gale-force winds caused it to blow up.

Weather records from the Ministry of Transport suggest that peak burning activity took place on 19, 20, 21, and 22 September, when winds reached speeds of over 34 mph and relative humidity dropped to 29%. The resulting intensity of the fire, which may have moved as much as 60 miles in one run, can be seen in the postfire vegetative recovery, and in the *Reader's Digest* reference to the moon turning blue from an Alberta 1950 forest fire.

Investigations are continuing on the circumstances surrounding this fire to try to determine the conditions that prevailed before and during the fire, and what effects those conditions had on the fire behaviour. There are undoubtedly some lessons to be learned from an analysis of this phenomenon.

SLASH HAZARD ASSESSMENTS IN ALBERTA

by

H. Gray[1]

INTRODUCTION

In 1971 and 72, a task force was formed to review the slash hazard in Alberta. Field checks were made throughout the province; using the line intersect method, slash was sampled in a variety of timber types.

In conjunction with the slash evaluation, the CFS carried out actual weighing of various tree components from several species which were used to develop a slash weight table by timber type.

These field checks and sampling indicated that Alberta had from 5 to 25 tons per acre of logging debris less than 4" in diameter covering the 50 000 acres of forested land cut annually. This material, along with varying amounts of heavier logs, duff, lesser vegetation and standing dead trees,represented a potentially hazardous fuel complex. This fuel complex could have important implications in terms of fire control planning, hazard reduction and suppression activities.

The task force then developed a systematic method of evaluating this logging slash hazard and developed the procedure into the *Logging Slash Hazard Evaluation and Prescribed Burning Manual*.

PURPOSE OF THE MANUAL

The purpose of the manual was twofold. Firstly, it was designed to provide a systematic and consistent approach to assessment of the slash hazard throughout the province. Secondly, it established a prescribed burning feasibility rating system to be used when burning was being considered either for hazard reduction or silvicultural purposes.

The manual was designed to be used in the field for assessing all potential slash hazard and for conducting all prescribed burning in Alberta.

[1] Fire Control Officer, Alberta Forest Service, Slave Lake, Alberta

COMPONENTS OF MANUAL

The manual is divided into two parts: Part one deals with a slash fire hazard rating. This part of the manual evaluates the slash hazard to determine if a given block is unacceptable and therefore requires some form of hazard reduction or if it is acceptable and no work is required.

The slash hazard rating system considers three main components: the risk of ignition, rate of spread and resistance to control. Each of these componenets was divided into the individual factors affecting the component and a point weighting was assigned to each.

Risk was classed into two categories--lightning and humans. In lightning risk, a map of Alberta was prepared which indicated the historical lightning risk by three classes: high, moderate, and low. Man-caused risk was a subjective rating of continuous, intermittent or very infrequent. Points were then assigned each category.

Rate of spread considered slash weight in tons per acre, slash arrangement, fuel continuity, slash condition, forest floor fuels, standing snags, aspect and slope.

Resistance to control considered depth of duff, log weight (material over 4" diameter), slope and condition of terrain.

After totalling all points for each factor, a chart is provided which indicates the acceptability of the cut block in terms of slash hazard.

If the block being assessed is unacceptable, then any type of treatment which reduces the point rating can be used and tested to determine if it will bring the block to an acceptable standard.

Part two is a rating system to evaluate slash burning to be used when consideration is being given to reduce the slash hazard by prescribed burning.

The prescribed burning feasibility rating considers and places a point rating on block layout, snags per acre, slash weight per acre, mop-up, adjacent areas, prevailing weather and estimated cost per acre. Points are totalled for the block to determine if burning is feasible. With a total point rating of 15 or less, burning is recommended. For a total between 16 and 25, burning is recommended only if no other economical method is applicable.

IMPLEMENTATION

The manual was slanted towards the use of prescribed fire and tends to set the ratings in such a manner that the majority of cut blocks in the province will not require any hazard abatement. It also is arranged so that very little short of prescribed burning can be done to reduce the hazard on those blocks which are unacceptable.

Several reasons for the delay in implementing the manual have just been eliminated. One problem was the reliability of the slash weight table. In 1976, intensive field sampling using line intersect was undertaken to assess the reliability of the table. The results indicated the table was unacceptable in its present form. This has now been corrected and a new table has been devised using permanent sample plot and cruise data. Some further testing in 1977 indicates the new table is within acceptable limits.

Another unknown factor was the validity of the point weighting used for the rating systems. This was field checked in 1976-77 and appears to be workable and acceptable.

The manual is presently under review by the other branches of the AFS and should be forest service policy by the early part of this winter.

Once the manual is implemented fully throughout the province, it will ease the old problem of individual interpretation of the disposal regulations and provide for a provincial standard in slash hazard assessment.

Another favourable aspect is that the approach can be used to assess slash hazard potential prior to cutting. This will bring fire control and timber management concerns together at the annual operating plan approval stage. This will allow for fire control concerns to be considered prior to cutting. Certain adjustments in cut block layout, cutting sequence, road layout, landing locations, etc. may allow for an adequate reduction in potential hazard and/or provide for a better prescribed burning show.

The future holds several refinements of this approach which will make the system more workable with time. The first step already proposed is to place the components of this system directly into the

Timber Management computer program so printouts will contain the slash hazard automatically for each block or type.

CONCLUSION

This approach to evaluating slash hazard replaces a very unfavourable method in which the forest industry is not always treated in a consistent manner from forest to forest due to present individual interpretations of existing regulations.

This method allows for a consistent approach which should come up with similar results in all areas.

Further work will be necessary as the system is used in order to refine and upgrade the approach.

N.W.T. PRIORITY ZONES FOR FOREST FIRE SUPPRESSION

by

John McQueen[1]

The Mackenzie region of the N.W.T., mainly within the treeline, is considered to be the fire area. The fire area is approximately 700 miles north-south by 550 miles in an east-west direction.

Development of specific fire management objectives is made within the context of the following considerations:

1. The total land area of the Northwest Territories (limited to the Mackenzie District for purposes of fire management) is approximately 493 000 square miles. The population amounts to about 43 000. Almost one-half of the population of the Territories is concentrated in a few main centres: Yellowknife (8000), Fort Smith (2500), Hay River (2500), Inuvik (4100). A total of about 30 native settlements is scattered throughout the Territories.
2. Canada's north is a natural lightning-fire environment and forest fires have been primarily responsible for the types, composition, and distribution of vegetation. In addition to lightning fires, a number of fire starts can no doubt be attributed to the indigenous Indian and Eskimo peoples. Since the 1890's, increases in the number of man-caused fires have occurred as a result of explorations, mining, and the activities of various casual agencies including hunters, fishermen, and children playing outdoors. Each year, Northwest Lands and Forest Service is required to take suppressive action on approximately 125 man-caused and lightning fires.
3. Relatively low resource values in parts of the Territories, the apparent effects of wildfires on these resources, and the size and operational capability of the Lands and Forest Services preclude the implementation of a uniformly intensive fire suppression policy in all parts of the

[1] Regional Manager of Forest Resources, Northwest Lands and Forest Service, Ft. Smith, N.W.T.

Territories. In remote areas, where protection of life and property is not required, the general aim will be to limit fire damage to a level believed to have existed for thousands of years.

4. Resource values, including human life and property, are the basis for determining the intensity of fire control effort justified to achieve policy aims and objectives. In recognition of different resource values in various parts of the Territories as well as to allow for the systematic growth in intensity and extent of fire management in the future, the priority zone concept was developed and will serve as the basic aid for effective implementation of policy. This concept rates resource values and includes specific fire management objectives to provide an adequate level of fire control capability in the normal fire year. The fire management objectives for each priority zone are, therefore, the main determinants of the intensity of the fire control effort.

The area is divided into four zones, with zones I and II receiving protection and zones III and IV receiving no protection from an operational point of view.

ADMINISTRATION

Administratively the area is divided into four district and four sub-districts.

District Inuvik (EV) - Sub-District Normal Wells (VQ)
District Ft. Simpson (FS) - Sub-District Ft. Liard (JF)
District Ft. Smith (SM) - Sub-District Hay River (HY)
- Sub-District Caribou Range (CR)
District Yellowknife (ZF)

PRIORITY ZONE DESCRIPTIONS

PRIORITY ZONE I

Comprises an irregular or circular area around cities, towns and settlements according to the following criteria.

Population	Approximate Size of Area
over 500	1256 square miles
25 to 500	314 square miles

Priority Zone I covers 30 settlements and a total of 18 500 square miles.

Policy Guidelines

1. District Protection Officer (District Fire Centre)
   a. takes initial and follow-up action on fires to a limit of $8000.
   b. reports the situation to Regional Fire Centre before the cost exceeds $8000, and requests further direction.
2. Regional Fire Centre (Head, Fire Control), on behalf of Regional Manager:
   a. reviews the situation on any fire approaching a cost of $8000, and advises on or directs further action and tactics.
   b. may authorize further expenditures to $50 000.
   c. reports to the Regional Manager any fire in zone I approaching a cost of $50 000.
3. Regional Manager reviews and analyses the operation and tactics and advises Director on further action.
4. Director may authorize further expenditures within funds available to him.

Operational Considerations or Options

1. "10 A.M. concept" applicable--extinguishment.
2. If extremely limited spread (island)--no action.

PRIORITY ZONE II

Includes the following:

1. Regular or irregular strip of land averaging approximately 10 miles wide on both sides of numbered highways.
2. Regular or irregular strip of land on both sides of transmission and communication lines.
3. Regular or circular land area containing approximately 13 square miles around producing mines, lodges, and scattered population groups, or settlements of fewer than 25 people.

4. National parks which are covered by co-operative fire control agreements or memoranda to the same effect. N.W.T. provides fire control for Nahanni Park, but not for Wood Buffalo Park. Parks pay all costs.
5. Timber stands presently part of a cutting cycle; accessible stands of merchantable timber within 20 miles of existing and passable roads; and young stands on highly productive sites.

Priority zone covers 46 000 square miles.

Policy Guidelines

1. The District Protection Officer (District Fire Centre)
   a. *may* take initial and follow up action on fires in PZ 2 to a limit of $8000.
   b. reports situation to Regional Fire Centre (Head, Fire Control) before expenditures exceed $8000 and requests further direction.
2. Head, Fire Control (Regional Fire Centre) on behalf of the Regional Manager:
   a. reviews the situation on any fire approaching a cost of $8000 and advises on or directs further action and tactics.
   b. may authorize further expenditures to $50 000.
   c. reports to Regional Manager--who reports to Director, etc.

Operational Considerations of Options

1. Normally "10 A.M. concept" applicable to extinguish.
2. If relatively confined area, no action may be taken--usually larger islands.
3. If initial attack fails, abandon entirely or pull off and wait for suitable conditions.

PRIORITY ZONE III

Includes the following:

1. High value habitats or sanctuaries for Wildlife, Game and Fur Bearers, critical habitats for the survival of a species and important trapping areas where trapping is an integral part of life patterns of population.

2. Unique recreation areas which have or will have a significant aesthetic value in the forseeable future.
3. Areas with high erosion potential.
4. High quality sites with merchantable or potentially merchantable timber which are not part of zone I or II.
5. Valuable watersheds which are part of, or which possess considerable potential as domestic watersheds.

Priority zone III covers 22 000 square miles.

Policy Guidelines

1. District Fire Centre (District Protection Officer)
    a. *may* take initial and follow-up action on any fire within zone III *that in his opinion* threatens life or property or to invade a PZ I or II, to a limit of $8000.
    b. subject to the approval of Regional Fire Centre (Head, Fire Control) may initiate action in other areas of zone III to a limit of $8000 and must request approval to exceed the $8000 limit.
2. The Regional Fire Centre (Head, Fire Control), on behalf of the Regional Manager:
    a. reviews the situation on any fire approaching a cost of $8000 and advises on or directs further action and tactics.
    b. may authorize further expenditures to a cost limit of $30 000.
    c. reports to Regional Manager any fire in zone III approaching the $30 000 limit.
3. Regional Manager reviews and analyses the operation and tactics and advises Director on further action.
4. Director may authorize further expenditures within the funds available to him.

Operational Considerations or Options

1. a. If initial attack instituted by district under Policy guideline 1-a, 10 A.M. concept normally applies to extinguishment.

b. If initial attack fails and it is only private property threatened then action would probably be to protect the property only.

2. If not a threat as per above then following options exist.
   a. no action of any kind.
   b. limited action to strengthen natural barriers and leave to burn itself out.
   c. limited action to protect private property.
   d. if current and expected fire business is low, using pre-suppression resources only, campaign fire training has been done with good results.

PRIORITY ZONE IV

Comprises all of the remaining forest land not covered by National Parks in zones I, II, and III. Zone IV exceeds the total area of zones of man-caused fires and does not justify intensive fire protection. This area may be sub-divided into: (1) the area inside the tree line, and (2) the area beyond the tree line to satisfy forest service requirements.

Policy Guidelines

1. The District Fire Centre (District Protection Officer)
   a. *may* take initial and follow-up action only on such fires *which in his opinion* threaten life or property or to invade a Priority Zone I or II, to a limit of $5000.
   b. will abide by the expenditure limitations specified in co-operative fire control agreements with other agencies.
2. Regional Fire Centre (Head, Fire Control) on behalf of Regional Manager may authorize action anywhere in zone IV to a limit of $15 000.
3. Regional Manager reports to Director.
4. Director may authorize more.

Operational Considerations or Options

1. If initial attack instituted by district under Policy Guideline 1-a, then 10 A.M. concept applies. Usual procedure field consults with Region prior to initiating action--depending on circumstances. If

initial attack is not successful, Head, Fire Control usually goes to the fire for a further assessment of potential.

2. Action to protect property or halt movement of fire in one direction.
3. No action--frequent observation to ensure fire remains no threat. May be used to train inexperienced staff on fire behaviour.
4. No action--no checking--final mapping near end of season.

Some obvious advantages are the reduction of costs on many fires to limited action or mapping and observation costs only, better resource availability for higher priority fires and excellent training grounds and opportunities to test new methods and equipment. There is also the aspect that lightning fires, particularly in remote areas, are natural and perhaps should be allowed to run their course naturally.

Obvious disadvantages: non-actioned fires can cause a smoke problem for detection and actioning other fires. Public pressure can become very demanding. Biggest problem is not what the fire is doing now or next week, but next month and later. Some non-actioned fires burn in the N.W.T. for more than 3 months; however, relatively few exceed 100 000 acres.

Example:

Carribou Range--CR #II Priority Zone (PZ) IV

61°30' N 111°15' W

Reported June 18--size 12 acres

Next report August 6--size 16 000 acres

Last report September 19--size 60 000 acres and still burning.

Public pressure will increase for more protection of forested land. Pressure will be mainly from the trapper and the tourist with lesser pressure from other businesses such as airline companies and exploration companies. It appears at this time more protection will be given in future years.

PRESCRIBED BURNING FOR WILDLIFE HABITAT MANAGEMENT IN BRITISH COLUMBIA

by

D. Eastman[1]

Ladies and gentlemen, in the next few minutes I would like to describe how prescribed fire is being used as a tool of habitat management in British Columbia. Since I am unable to come to the conference and also because I haven't written out my talk, I thought I would do the next best thing, and that is to send you this tape. This is the first time I have tried it so I am a little bit hesitant and hopefully the experiment will be a successful one.

The basic outline of my presentation will be first to describe the rationale, or in other words why are we using prescribed fire in British Columbia, discuss briefly the historical use of prescribed fire, outline some of the reasons why we are using prescribed fire, discuss the extent of its application in the province and some of the common features of our burning programs in B.C., and then finish with a brief statement of what I think are some of the future roles of fire, some of the needs and problems that we face in making prescribed fire an acceptable and respectable tool of wildlife management.

This province is fortunate in having a wide variety of wildlife species. This of course is a natural and inevitable consequence of the inherent ecological diversity found within the province. Although many people acknowledge the variety of wildlife species, the greatest public interest is in those that we typically call big game species, and in particular the large ungulates. Similar to most provinces and states, wildlife management in B.C. has concentrated upon these big game species. Also similar to most states and provinces, wildlife management is faced with a difficult challenge in the future. On the one hand we face

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increasing demands for the wildlife resource. This demand traditionally has been by hunters, but more recently and just as importantly, is the demand by what we typically call nonconsumptive users. In other words, those people who want to see, photograph, and study wildlife species in natural surroundings. While the demand is increasing, the resource base that produces wildlife is decreasing. In British Columbia, we are losing very productive lands to such diverse and widespread activities as settlement, utility corridors, impoundments, coal exploration and development. Unfortunately, most of these types of activities occur on the critical winter ranges upon which the numbers of big game depend. Not only are we losing the land base from which to produce wildlife,but the vegetation on this land base is changing. Although it is too difficult to generalize throughout the province, I think it is safe to say that the change in vegetation has been to reduce the production of wildlife. Thus the wildlife manager is faced with increasing demand and at the same time a decreasing productive land base. In this situation, wildlife managers look to ways of increasing the production of wildlife on existing lands. This is what we could call wildlife enhancement.

Now there are many ways of producing or improving the production of wildlife on suitable lands, but of course faced with restrictive budgets we are looking at the most economical ways of enhancing habitat. Also, I think it is generally true that we are looking at ways that mimic the natural forces at work in these particular areas. For these reasons, prescribed fire holds great promise. We believe that prescribed fire, if properly used, has significant ecological, economic,and social benefits.

Before going any further, I think it is important to make several distinctions regarding the causes of fire. On one hand we have naturally caused fires and on the other we have man-caused fires. The category of man-caused fires can be subdivided into two subclasses. First, those that are accidentally set by man, and those that are delibertately set by man. I would consider that those that are deliberately set by man to be prescribed fires. In other words they are fires used for constructive purpose and according to a management plan. This last phrase is a definition of prescribed burning proposed by Biswell.

It is a well established fact that natural fire played a significant and integral part in the development of vegetation over much of North America. Although we have little evidence, I believe it is also true that prescribed fire was used to a significant extent by the native Indians before the arrival of white man. There are few data to relate the effects of wild fire and those fires caused by Indians to the abundance of big game. Most early travellers in British Columbia remark upon the apparent absence or at least scarcity of big game species in the province. Although this is very fragmentary evidence, it does suggest that wildlife, in particular big game species, was not very abundant under the regime of natural fire. With the arrival of white man and the development and settlement of many areas in the province, the incidence and extent of burning probably increased quite dramatically. In association with this increase in fire, there was an increase in the abundance of big game species. For example, we have the remarkable extension of moose from northeastern British Columbia through to the coast and into southern British Columbia over the period from about 1900 to 1945. Although it is circumstantial there seems to be good correlation between the southward spread of the species and the abundance and spread of fire.

In the east Kootenay region, there seems to be a good correlation between the widespread fires of the 1930's and the subsequent abundance of mule deer, white-tailed deer, elk and big horn sheep in the 1940's and early 1950's. Man-caused fires in the twentieth century have been both accidental and prescribed but perhaps the most ironic factor or feature of these fires from the point of view of a wildlife manager is that their effects on the wildlife were largely accidental. Thus for most of this century the large numbers of ungulates in this province have been fortunate although completely accidental spinoffs of fires set for other purposes.

With the increasing efficiency of fire detection and suppression the extent and role of fire in affecting wildlife populations has changed considerably in the last ten to thirty years. The productive seral winter ranges have been gradually filled in with coniferous regeneration. This change in the mosaic of vegetative cover has been relatively slow and for the most part quite deceptive in the sense that many people do not appreciate that what is now a young stand of Douglas fir, lodgepole pine or yellow pine was once a seral shrub/grassland range. The effects of efficient fire suppression have been large with respect to ungulates.

But is is also true that complete suppression or exclusion of fire from forest systems in this province is having and will have tremendous impact upon the forest themselves. With the exclusion of fire in many parts of the province, the forests are accumulating litter and dead material that probably increases their flammability and predisposes them to some very large fires. I believe both from the point of view of forest management and wildlife management, we should be doing a lot more towards integrating fire or reintroducing fire as a natural factor in our forests. While most wildlife managers have accepted and recognized the importance of fire in the management of big game ranges, the prevailing government policy of complete fire suppression has prevented its application except in the past few years.

Now I would like to take a few minutes to describe where we are burning presently in British Columbia, what wildlife species we hope to benefit, and the results we have so far. To date we have done no prescribed burning either on Vancouver Island or the coastal mainland. All of the burning has been east of the coast range. Beginning in the southern interior we have been burning in the Okanagan region south of Keremeos. The target species is California big horn sheep and we are burning grassland areas that overlie chernozemic soils. The objective of this burning program is to improve the food supply on wintering areas by inducing early grazing on grasslands adjacent to their critical winter ranges. In other words we are trying to decoy the big horn sheep off these critical areas as soon as we can. To do this we are burning small patches in the spring. These patches are planned to create a mosaic effect on the grassland areas. This work has been underway since 1975 and is planned to continue for at least a couple of more years. The results to date indicate a successful program. The winter range vegetation is improving in condition and there is a remarkable shift of the big horn sheep off the winter ranges on to these burned-over areas in the early spring.

We are also beginning a small burning program in the Okanagan to benefit mule deer. This burning is occurring primarily in the Ponderosa pine/bunchgrass zone. The area is a critical mule deer winter range and the project objectives include a reduction in forest cover, an increase in forbs and shrubs, an increase in nutritive quality of preferred foods, and a reversal of the trend of pine to fir so that we can maintain a pine/bunchgrass type. Again for this area we are conducting rotational burning and we have planned assessments to monitor changes in the vegetation in its use by wildlife and also changes in the soils.

In the east Kootenay region of southeastern British Columbia we have an ambitious prescribed burning program. The burning program is coordinated and integrated with grazing systems associated with coordinated range use plans. This burning program began in 1975 with a 600 acre burn on one critical big game winter range. In 1976 two areas were burned. This year a total of about 6 acres was burned and we plant to burn many more areas in 1978. We hope that prescribed fire becomes a routine habitat management tool in these coordinated land use plan areas. The target species for these burns are primarily elk, secondarily mule deer and also big horn sheep and white-tailed deer. The areas being burned are mostly seral shrub/grasslands developed after the extensive fires of the late 1930's. The vegetation is quite variable,as is the parent material.

In general the management goal of the prescribed burning program is to enhance the wildlife resource, but in particular we want to recondition and rejuvenate the big game winter ranges. Important objectives for other users of these areas is to fire-proof and thin the regenerating forest and also to improve range for cattle. All burns are spring surface fires and are done in cooperation with the B.C. Forest Service and with local users. We have not conducted detailed monitoring of the effects of these fires but there was an obvious basal resprouting of willows, saskatoon, and even bitter brush. Grass species such as *Festuca idahoensis* and *Festuca scabrella* all show a remarkable response to fire. Our observations suggest that animal use is increased on these burned areas.

We have also conducted several small burns in the west Kootenay region,but in general the main thrust in southeastern British Columbia has been on the critical big game winter ranges lying in the Rocky Mountain trench.

It is in the southcentral part of British Columbia that prescribed fire for wildlife management had its origins. The first recorded use of fire in British Columbia for wildlife occurred in the mid-1950's in Wells Gray Park. These early attempts were generally unsuccessful because they were too cautious. But two things were evident. First, it was very difficult to burn mixed or deciduous stands on flat topography except in the most favourable conditions. Secondly, the regrowth of suckers from the roots of burned willows and aspens was immediate and vigorous after burning.

All remained quiet in the southcentral interior until 1966 when a six year burning program was undertaken, again in Wells Gray Park. This burning program was primarily to improve the habitat for moose. But a secondary objective was to maintain early seral stages of forests at low elevations to add to the diversity of the Park landscape.

During the period of 1966 to 1971 a total of 4200 acres was burned over ten locations. All these burned-over areas are producing more available forage than previous to the fire. All are used either moderately or heavily, primarily by moose and mule deer. These burns have been conducted either in May or June. While we were successful in burning 4200 acres of moose winter range,it appears at least tentatively that much of the area is unsuitable for economical burning and it has been suggested that mechanical treatment should be considered as an alternative method of habitat improvement in these areas that are unsuited to fire.

We are also conducting prescribed fires in southcentral B.C. on some Douglas-fir/pine grass and Ponderosa pine/bunch grass ranges. These are being conducted on low elevation mule deer winter ranges. The objectives of these other burns are to promote resprouting of browse species that have grown beyond the reach of ungulates and also to reduce Douglas-fir regeneration and remove the duff layer of yellow pine needles.

In central British Columbia we have a prescribed fire program for the Junction Wildlife Management Area, an area that is used by California big horn sheep. We are conducting burns on a shrub-grassland area where the major species are big sage brush and blue bunch wheat grass. The target species for this burning are California big horn sheep and mule deer. The objectives of this fire are:

1. to increase the quality of forage
2. to increase the production of forage
3. to retard or eliminate the growth of undesirable species
4. to alter the species composition of the plant community.

We are monitoring the effects of this fire in terms of the vegetation species' composition abundance, its productivity, and its nutritive value. We are also measuring the animal response through pellet group surveys and measuring the soil response through sampling of soil horizons. We had some preliminary results one year after the burn. First there was an increase in the forage quality primarily in group protein. This increase was large but short-lived. There also has been an increase in forage production that has been maintained over the two years since the burn. The big sage brush has been completely eliminated by the fire and this was the prime species that we wanted to get rid of. Primarily because of small sample sizes we have not been able to detect any significant change in the use of burn areas by mule deer or big horn sheep.

The last area where we have been conducting prescribed fire is in the northeastern part of the province. The target species are Rocky Mountain elk, stone sheep and moose. The areas being burned are the alpine spruce ecotone, aspen stands and seral shrub-grasslands. The management goal is similar to many of the other burns elsewhere in the province, that is, to increase the production of wildlife and so offset losses due to other factors. The main objective of the burning in the northeastern part of B.C. is to alter the successional stage of the vegetation to a form that is more usable by the target species. This program began in 1976 when about 25 000 acres were burned for elk. In 1977 about 75 000 acres were burned again primarily for elk. This burning occurred in about four major river drainages. We have been successful in burning much larger acreages in this area than elsewhere in the province primarily through the coooperation of the B.C. Forest Service, the guides, and the fact that timber values in this area are generally quite low while the wildlife values are quite high.

From this brief perspective you can see that prescribed fire is a fairly recent phenomenon in B.C., that it is widely distributed geographically, and widely distributed ecologically in terms of the types of biogeoclimatic zones in which the burning is conducted. In almost all cases, we are conducting spring surface fires in nonforested or early forest successional stages. The burning is in almost all cases cooperative with the B.C. Forest Service. It is primarily oriented around benefiting big game. While most burning in southern British Columbia is in habitat types similar to those in the United States where we have a sufficient research background to allow prediction about the fire's effect, the burning in the northeast is in areas that have not been studied previously. For this reason we are particularly interested in the effects of fire in these areas.

Now I would just like to comment briefly on some of the future problems and needs I see facing prescribed fire in B.C. For sure we look to an expanding role of prescribed fire but we have two major obstacles to overcome. These obstacles relate to public attitudes and government policy. The Smoky the Bear campaign was effective but too simplistic and overemphasized all the bad aspects of fire at the expense of some of the very valuable benefits of fire. We now have a very important and difficult problem facing us and that is to educate the public into accepting fire as an integral and potentially useful tool in wildlife and forest management. This won't be an easy change to effect,I think,because people have some innate fear of fire and also because there will be some resistance in government to promoting a more tolerant attitude towards fire. The other major problem is in the area of policy. The fire protection divisions of our governments have to change to fire management divisions. This change has to be more than in name only and must reflect a genuine attempt to use fire sensibly in management. Without these two broad areas of change, that is, changes in public opinion and changes in government policy, we face many difficulties in instituting prescribed fire in wildlife management programs.

On a more specific level, I think there is a need for us to improve the type and level of documentation of our fires. Ideally we need a practical and standard way of assessing the effects of fires, not only from the point of view of routine monitoring but also from the point of view of trying to understand the behaviour of fire more clearly and to predict the effects of fire more reliably. Thus our efforts in wildlife management in B.C. go along three major lines. First, we are attempting to modify policy and public attitudes in a variety of ways. Secondly, we are striving to incorporate prescribed fire more as a routine technique into habitat management. Thirdly, in the area of research we are trying to establish ways of monitoring the effects of fires so that we can understand them more clearly and are able to use fire more effectively.

I will be writing up a paper on the use of prescribed fire in wildlife management in this province. It will cover much of the same ground that I have given to you already but will have some more specific details regarding the location, area and extent of fires.