FIRE MANAGEMENT IN WILDERNESS AREAS, PARKS AND OTHER NATURE RESERVES[†]

by

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Martin E. Alexander[1] and Dennis E. Dubé[2]

Abstract

Boreal forests are fire-dependent systems that would lose their character, vigor, and faunal and floral diversity in the absence of fire. The objectives of natural area preservation implies maintaining the original character of the land and perpetuation of those plant and animal communities dependent on fire for their continued existence. This paper focuses on the status and assessment of fire programs in nature reserves of northern circumpolar countries, principally Alaska, Canada, north-central U.S.A., and Fennoscandia.

The necessity for considering fire in natural area management is now widely recognized, particularily in North America. A considerable body of supporting research on fire as a historical-ecological factor exists. The trend toward active fire management programs is strong but the employment of fire by prescription in nature reserves is still very much in its infancy. Conflicts between ecological processes and social concerns hinders widespread application of "wilderness" fire management concepts and principles. Concern for human safety and adjacent lands severely tests the ability to mange fire on the scale required. Public understanding of fire's role and acceptance of management practices is needed. A gradual and conservative approach, education programs designed to inform and involve, and application of existing technology will work towards effective fire management planning and implementation. The ingenuity and collaboration of managers, specialists and scientists is needed to develop and bring progressive management strategies prescribing recurrent fire to an operational stage.

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Introduction

Throughout northern circumpolar countries, representative samples of major biomes and other areas of unique biological and environmental interest have been set aside or are being proposed for their educational, scientific and cultural values (Harroy, 1971). Observation and subsequent documentation has substantiated the historical significance of fire and its importance as an ecological factor in northern ecosystems (Lutz, 1956, 1959, 1960; Ahlgren and Ahlgren, 1960; Kayll, 1968; Heinselman, 1970b, 1973a, 1980; Scotter, 1972; Rowe and Scotter, 1973; Swain, 1973; Viereck, 1973; Wright and Heinselman, 1973; Uggla, 1974, Vakurov, 1975; Kelsall et al., 1977; Zackrisson, 1977, 1979; Tolonen, 1978; E.A. Johnson, 1979; Rowe, 1979; Viereck and Schandelmeier 1980; *these conference proceedings*).

Because fire has long played an integral role in the evolution of natural landscapes, molding maintaining the diverse flora and fauna of northern circumpolar forest habitats, any wilderness area, park or other nature reserve established here must consider fire in the development of resource management plans. If a major objective of such areas is to perpetuate, not only the diversity of biological entities, but also the diversity of biological processes, then these areas should be managed in accordance with ecological principles that relate to the objectives that have led to their establishment, including the management of fire (Stone, 1965; Haapanen, 1965, 1973; Heinselman, 1965, 1970a, 1978; Hendrickson, 1971; Van Wagner, 1973; Wright and Heinselman, 1973; Wright, 1974; McClelland 1977; Van Wagner and Methven, 1980).

Fire management suggests that fire, in an ecological sense as well as a protection sense, should be considered in developing land and resource management objectives and that, once these objectives have been set, fire-related activities should be designed to support their accomplishment (Barney, 1975). Fire management in wilderness areas, parks and other nature reserves generally favors a biocentric focus--allowing for the natural role of fire to the maximum extent possible consistent with public safety and adjacent lands. This approach favors using "random" (or "chance") ignitions prescribed fires (those fires of unplanned origin that are allowed to burn, based on predetermined criteria, because they are expected to achieve a specific objective(s)). Where such an approach cannot be tolerated or a specific situation/benefit(s) are desired, traditional planned ignition prescribed fires or even complete fire exclusion may offer the only viable alternatives. Fire management alternatives and their consequences are covered in greater detail by Agee (1974, 1979) and Heinselman (1970a, b, 1971, 1973a, b, 1978).

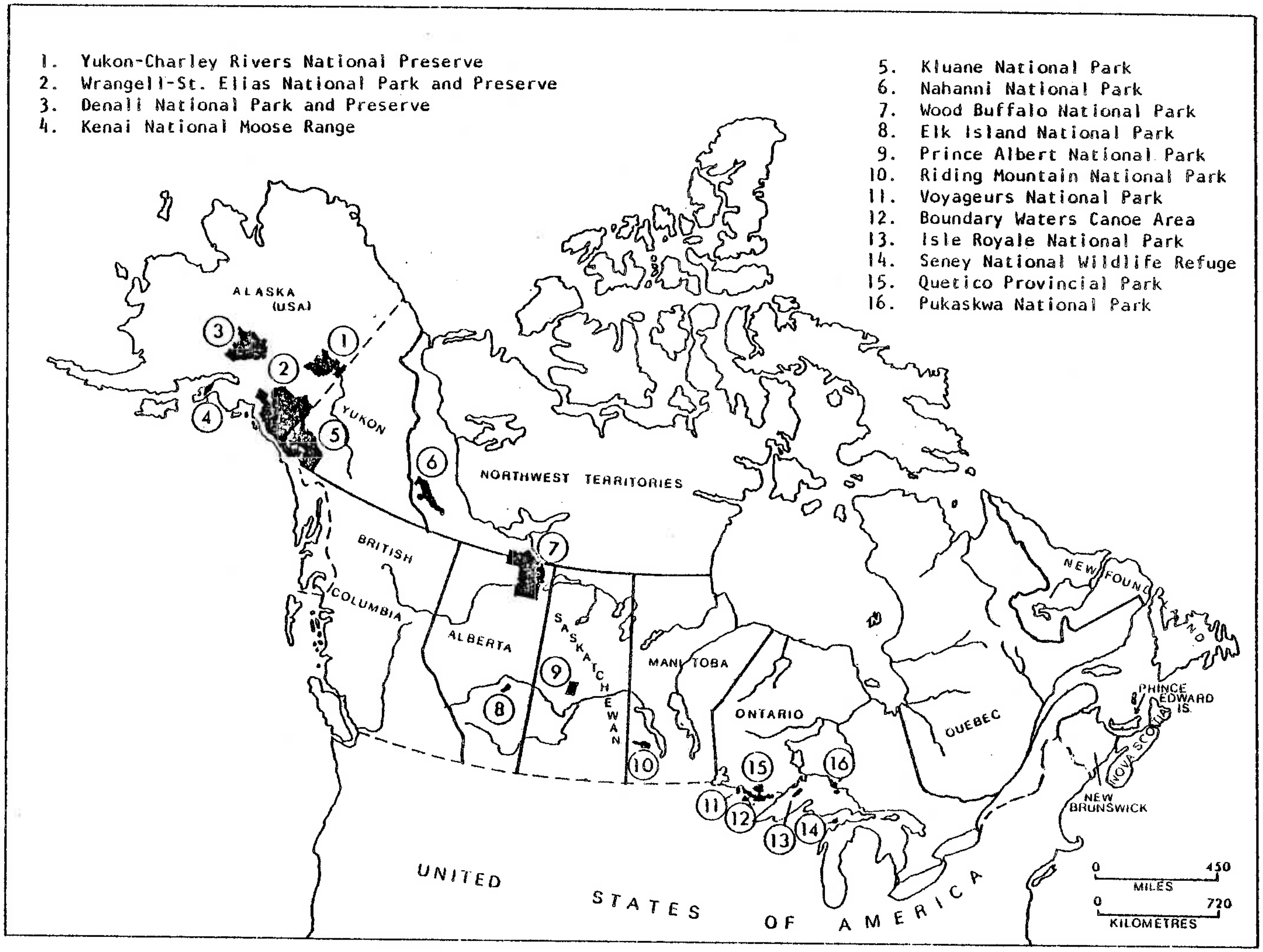
On federally owned lands in the continental United States and Alaska, the Forest Service and National Park Service have had for some time now fire management policies that allow for planned and random ignition prescribed fires (Agee, 1977; Davis, 1979; Nelson, 1979; USDI National Park Service, 1979). Parks Canada (1979) recently released a more definitive policy on fire management including prescribed fire use (Burles, 1980), for the Canadian National Park System than was previously stated (Flanagan, 1972). In Canadian provincial parks and wilderness areas, fire management, for the most part, is in a fire suppression mode although their resource management policies generally recognize the importance of fire (e.g., Miller, 1979). Similarly, the management of Ecological Reserves in Canada addresses the importance and foreseen use of fire (Weetman and Cayford, 1972; Maini and Carlisle, 1974).

Fire management programs in wilderness areas, parks and other nature reserves of northern circumpolar countries are not nearly as developed as those of western U.S.A. national forest Wilderness areas, national parks and national monuments (*see* Kilgore, 1976; Heinselman, 1978). It is our purpose here to review past and current fire research and survey the status of fire management planning and programs in the boreal forest and adjacent transitional zone nature reserves of northern circumpolar countries based on the readily available literature and personal contacts. Finally, problem areas are highlighted and possible solutions suggested.

Alaska

The future jurisdiction and classification of thousands of square kilometres of land in Alaska was until recently uncertain (Hendee et al., 1978; Vale, 1979). This has made it difficult to completely assess the status of fire management planning in the vast northern boreal forest or taiga region of interior Alaska. In 1978, the Alaska Land Managers' Co-operative Task Force was formed with a fire management subcommittee having representatives from several state and federal agencies. A pilot area of 56,650 km^2 was selected in east-central Alaska to test new fire management concepts. Two broad objectives were agreed upon: (1) to reduce fire suppression costs commensurate with actual values threatened, and (2) to accommodate the various resource management objectives of the participating agencies (Kelleyhouse, 1979). As a result of this effort, the Fortymile Interim Fire Management Plan was completed (Anonymous, 1979) for operational implementation during the 1980 fire season. The prescriptions for random ignition prescribed fires are considered conservative but annual revisions to the plan are expected. Within the Fortymile fire management area are portions of two recent additions to the U.S. National Park Service system of

Figure 1. Geographical location of wilderness areas, parks and other nature reserves in North America referred to in the text.



natural areas. This includes about 5,670 km^2 of the Yukon-Charley Rivers National Preserve (6,933 km^2 total) and 4,000 km^2 of the Wrangell-St. Elias National Park and Preserve (49,850 km^2 total) (Fig. 1). Approximately seventy and thirty percent of those portions of Yukon-Charley Rivers and Wrangell-St. Elias, respectively, that lie within the Fortymile planning unit are forested (Paleck, pers. comm.). Fire suppression tactics on National Park Service lands have been designed with natural ecosystem values in mind.

The new Denali National Park and Preserve in central Alaska encompasses the former 7,850 km^2 Mount McKinley National Park plus 15,223 km^2 of northerly and southerly extensions (Fig. 1). The highest point (6194 m) in North America, Mount McKinley, lies within the Denali reserve. Many tourists visiting Alaska plan trips specifically to see scenic values of the Mount McKinley area. During the summer of 1969, extensive fires in the local and general area created widespread smoke palls which obscured much of the scenic attractions of the area but apparently did not greatly affect visitor use (Miller, 1971). At least 68 fires are known to have covered more than 40,000 km^2 in Denali with the majority of area burned due to lightning fires.[3] An interagency fire planning effort patterned after the Fortymile endeavor will involve 121,400 km^2 north of the Alaska Range. The Tanana-Minchumina fire management area will include approximately seventy percent of Denali and the plan is expected to be ready for implementation during the 1981 fire season (Dalle-mole, pers. comm.).

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[3]Buskirk, S. 1976. A history of wildfires in Mount McKinley National Park and adjacent lands. Unpublished report on file with USDI National Park Service, Denali National Park and Preserve, McKinley Park, Alaska. 16 p. + maps.

The Kenai National Moose Range, located in northwestern portion of the Kenai Peninsula in south-central Alaska (Fig. 1), is a 7,000 km^2 unit of the U.S. National Wildlife Refuge System. It was established in 1941 primarily to ensure the perpetuation of the giant Kenai moose (*Alces alces gigas* Miller). Past wildfires, responsible for creating favorable moose habitat, have tended to cause great fluctuations in the Kenai moose population in recent times. The unpredicatble nature of wildfires has been a deterent to long-term moose management on the refuge. Other resource and economic considerations also preclude the "use" of wildfires. Planned prescribed fires have been conducted but have been difficult to arrange due to weather conditions (Spencer and Hakala, 1964; Johnson, 1975). U.S. Fish and Wild-life Service refuge staff have favored the mechanical manipulation of vegetation and fuels to simulate fire effects. Moose populations peaked between 13-22 years after a 125,455 ha fire in 1947. Current surveys indicate a declining population. The primary cause of the decline appears to be the loss of quality winter range associated with forest vegetational development and over utilization of browse (LeResche et al., 1974; Oldemeyer et al. 1977; Bailey, 1978). To assist in stabilizing the herd, habitat improvement work consisting of mechanical crushing areas of advanced plant growth with a complimentary assessment program (Bailey, 1978; Sigman, 1979). Between 1974-8, 2,800 ha of the 1947 burn were treated (Johnson, pers. comm.). A limited amount (140 ha) of commercial logging took place during that same time (Johnson, pers. comm.). An additional 35,480 ha was burned over by the 1969 Swanson River fire. Mechanical "tree-crushers" were used to knock down and crush fire-killed stems in cirtical areas (4,000 ha in total) in order to reduce the possibility of a reburn, aid wildlife access to browse species, and for asethetic reasons (Hakala et al., 1971).

Effects of the fire on wildlife were apparently light although spruce grouse (*Canachites canadensis franklinnii* Douglas) densities, measured on a previously established study area, one-year after the fire were reduced (Ellison, 1975). A fire management plan covering the entire Kenai Peninsula, similar to the Fortymile endeavor, is currently being prepared for operational implementation during the 1982 fire season (Johnson, pers. comm.). The creation and/or enhancement of moose range by burning is presently not perceived as detrimental to the resident Stone caribou (*Rangifer arcticus stonei* Allen) population (Davis and Franzmann, 1979).

Northwestern Canada

Kluane National Park was set aside as a park reserve in 1972 and formally established in 1976. Located in the southwestern corner of the Yukon Territory it borders the Wrangell-St. Elias reserve on its western boundary (Fig. 1). Kluane is a recent addition to the UNESCO list of World Heritage Sites (Downie, 1978). Much of the park is non-vegetated, consisting of valley glaciers and barren mountains, including Mount Logan, Canada's highest peak. Approximately seven percent of Kluane's gross land area of 22,015 km^2 is forested. Douglas (1974) examined the montane plant communities of the park area and attributed the extraordinarily rich vegetation diversity and complex forest landscape pattern to climatic (micro and macro) variability and the frequency of fire and geomorphological processes. Through field reconnaissance and with the aid of aerial photos, Therberge[4] estimated that about half of the forest zones in the park area showed evidence of fire within the past 80 years. The forest zones of Kluane, dominated by white spruce (*Picea glauca* [Moench] Voss), are characterized by a mosaic of stands ranging from 100 to 250 years old (exclusive of recent forest fires < 80 yrs. old). The relatively wide distribution of age-classes and moderately

[4]Therberge, J.B. 1972. Considerations for fire management in Kluane National Park. Unpublished report on file with Canadian Wildlife Service, Western Region, Edmonton, Alberta. 23 p. + maps.

low maximum ages is indicative of recurring fire and geomorphologic events (Douglas, 1974). In 1972, Theberge[4] made a cursuroy survey of vegetation and wildlife use on eight recognizable burn areas (18-70 yrs. old). Regeneration following fire was found to be quite variable. Moose and snowshoe hare (*Lepus americanus* [Erxleben]) utilized recent burned areas heavily. Therberge (1976) also examined the avifauna populations with respect to fire-induced secondary succession and found very little change in number of species or density and only minor changes in species composition. The extent to which man has altered the natural fire regime of Kluane has not been ascertained. The forested portion of Kluane is concentrated in eastern half of the park adjacent to the Haines Road which joins the Alaska Highway. This situation presents a number of potentially limiting criteria in terms of fire use. At the request of Parks Canada, the Canadian Forestry Service has undertaken an investigation to elucidate fire's role and evaluate fire management strategies in Kluane National Park (Hawkes, pers. comm.).

Nahanni National Park, located in the southwestern corner of the Northwest Territories (Fig. 1) is a recently established (1971), remote, mountainous, wilderness park of approximately 4,800 km^2. The park was recently been declared a World Hetitage Site by UNESCO, the first such site in Canada to be so designated. Access to the park is difficult, limiting visitor use to about 200 people per year (July and August), mainly canoeists on the two principal rivers. Fire history and fuel assessment along with climatic and vegetation interpretation studies have been conducted by the Canadian Forestry Service on behalf of Parks Canada. Field work was undertaken in 1977 and 1978 with a final report due to be completed in mid-1980. The results of the study are meant to provide the basis and rationale for developing a workable fire management plan within the framework of park planning (Dubé, 1979).

On-site observations and preliminary results attest to the prevalence of fire within Nahanni National Park. Large fires have repeatedly swept the broad glacial-scoured U-shaped valleys of the Flat and South Nahanni rivers in the northwestern reaches of the park. Towards the southeast, in the more topographically rugged and often unglaciated portions of the park, fires, though common, have been generally smaller in size, restricted by numerous natural barriers.

A similar study with nearly identical objectives is being pursued in Wood Buffalo National Park with completion scheduled for mid-1980 as well (Dubé, 1979). As Canada's largest national park (44,807 km^2), Wood Buffalo spans both Alberta and the Northwest Territories (Fig. 1). Much of the park is virtually inaccessible, however an all-weather road transects the northern boundary. The park was established in 1922 to protect a herd of free-roaming wood bison (*Bison bison athabascae* Rhoads) that were soon interbreeding with introduced plains bison (*B. bison* [L.]) from the south. The park also provides habitat for the few remaining whooping cranes (*Grus americana* L.). Commercial logging operations persist within the park along the Peace River. Hydro-electric activities outside the park have altered water regimes within and other developments along the Slave River, the park's eastern boundary, are being considered. Trapping and some hunting occurs throughout the park. Native people are negotiating treaty land settlements within the park, with some success. Private recreational lease holdings (cabins, etc.) are held within the park. Park headquarters are located in the town of Fort Smith which borders the northeastern corner of the park. All of these factors make fire management planning and implementation relatively complex. The park has for several years, maintained an effective fire control organization, the only national park in Canada to do so. As a result, fire reports on cause, size, location, etc., are available for the past 20-30 years. Similarly, fire weather station records from several strategically located lookout towers throughout the park have been maintained. The necessary nucleus is thus in place to facilitate a smooth but gradual transition from fire control to fire management.

Western and Central Canada

Elk Island National Park is located in the northern section of Alberta's Beaver Hills (Fig. 1). It is considered an elevated island area (194 km^2), of the boreal mixedwood forest to the north. Trembling aspen (*Populus tremuloides* Michx.) is the dominant tree species within the park. White spruce is often present under the aspen canopy and is codominant on the major islands that have escaped past fires. There is little doubt that fire, either lightning or man-caused, has significantly influenced the vegetation of the park[5]. Historically, the park had been hunted by indigenous peoples and more recently much of the Beaver Hills was cleared, logged and burned by settlers prior to becoming a national park. The present vegetation mosaic of aspen forest and open grassland or shrubland meadows is a reflection of past cultural activities (indigenous peoples and European man) and natural factors (including lightning and man-caused fires) as well as present management practices.

The size (relatively small), location (adjacent to agricultural lands; 20 km from a large city; bisected by a major highway), presence of large ungulates (bison, moose, and elk [*Cervus canadensis* Erxleben]) confined to the park by a retaining fence, the absence of effective natural predation, as well as recreation uses and other developments in the park requires that active resource management programs be conducted to meet management objectives. Currently, grassland meadows are being invaded by several woody plant species and although this is a natural process, the loss of these grasslands will

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[5]Thomas, G. 1976. Fire in the Beaver Hills. Unpublished report on file with Parks Canada, Prairie Region, Winnipeg, Manitoba. 15 p.

mean a decrease in plant community diversity and loss of a major food source for bison and elk. Because of the factors listed above park managers recognize that random ignition prescribed fires are not a viable option for management purposes so to ensure the maintenance of the grassland meadows, a planned ignition prescribed fire program is underway to meet management objectives. A 30-40 ha area was burned in May 1979. A preburn site evaluation was undertaken (including species composition, fuel moisture, etc.), fire weather was documented and fire behavior data was collected. Postburn monitoring is continuing. Additional prescribed fires are planned on the basis of information gained from these initial trials.

Prince Albert National Park lies in the boreal mixedwood forest section of central Saskatchewan (Fig. 1). Wildfire has strongly influenced the vegetation complex here as in other areas of the boreal forest of western Canada. Kiil et al. (1973) report that about one-third of the total 3,874 km^2 park area has burned since 1930. In the southerly portions of the park, exists some remnants of rough fescue (*Festuca scabrella* Torr.) grassland, which have been described in some detail by Cameron[6]. He determined the importance of fire in the evolution and maintenance of these particular grassland communities. Cameron recognized that presently these grasslands are being encroached upon by aspen forest and shrubs. The potential loss of these grasslands has led to a cooperative study between Parks Canada, the Canadian Wildlife Service and the Canadian Forestry Service, whose purpose is to examine the role of prescribed fire as a management tool in maintaining the grassland communities and to make recommendations as to the future use of prescribed burning as a management tool (Gunn et al. 1976; Samoil et al. 1977). The study is being conducted over a five-year period, 1975-1980, with final results to be reported by early 1981. The first burns took place

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[6]Cameron, J.F. 1975. Fescue grasslands and associated communities of Prince Albert National Park, Saskatchewan. Unpublished report on file with Parks Canada, Prairie Region, Winnipeg, Manitoba. 190 p. + appendices.

in the fall of 1975. Subsequent burns have taken place but other planned ignitions have been cancelled due either to unsatisfactory burning conditions or management problems. Nevertheless, this prescribed burning information along with a completed fuel type map and fire hazard classification scheme of the entire park completed by Kiil et al. (1973) will greatly assist park managers in their fire-resource management planning.

Riding Mountain National Park is situated in southwestern Manitoba on a rolling plateau that forms part of the Manitoba escarpment (Fig. 1). The 2,976 km^2 park embraces three major ecosystems; the northern boreal forest, the central grasslands and the eastern deciduous forest. Together, these life zones produce a rich and complex mix of vegetation. Early settlers, farming on the surrounding fertile plains, used Riding Mountain as a source of timber for buildings and firewood. Up until 1970, the native grasslands within the park were used for domestic grazing and hay production. Though the past fire history is complex and not easily deciphered, early historical records indicate that fires started by settlers were common. Briscol et al.[7] have compiled the recent fire history of the park for the period 1930-1978. Prescribed fire has been used on an *ad hoc* basis within bison enclosures for several years. Currently an attempt is being made to formalize fire management planning as a part of overall resource management planning and it is expected that fire ecology/history studies will commence shortly to provide some of the necessary background information (Lee, pers. comm.).

[7]Briscol, B.W., Lee, B.S., Allan, C., and Tempany, I. (1979). Riding Mountain National Park resource description and analysis. Unpublished report on file with Parks Canada, Prairie Region, Winnipeg, Manitoba. n.p.

North Central U.S.A.

Voyageurs National Park, situated in the forested lake country along Minnesota's northern border (Fig. 1), is a relatively new addition to the U.S. National Park Service's natural area system. Approximately a third of the Park's 887 km^2 is water. Forest fires have historically been instrumental in altering vegetation in the park. Logging operations for sawtimber and pulpwood have drastically altered forest composition in certain areas. Roughly two-thirds of the land area shows evidence of being logged and/or burned in modern times. Two studies currently in progress are designed to furnish basic information to guide fire management direction. A paleoecological analysis of charcoal and pollen found in lake sediments, due to be completed by August 1980, seeks to establish the postglacial vegetation and fire history record (Swain, pers. comm.). The second study involves documenting the original vegetation, historic and modern fire patterns, logging activities, and assessing the influence of fire and logging as factors affecting forest succession and patterns of vegetational development (Rakestraw et al., 1980). This two-year study, involving a combination of field work and historical documents research, was completed in July 1980. Results indicate a dramatic shift in species composition from predominately pine or spruce-fir forests in the past to predominately aspen forests today due to a combination of logging, post-logging fires, and 40 years of fire suppression (Ferris, 1980). These changes in the original forest vegetation are not considered a problem because plant succession and natural influences (e.g., fire) can be relied upon to reestablish a natural vegetation (Cole, pers. comm.). Current policy is to suppress all fires. Potential constraints arising from the use of fire as a resources management tool relate to visitor safety, leased properties within the park and fires extending outside park boundaries (Cole, pers. comm.).

To the east of Voyageurs National Park lies the Boundary Waters Canoe Area (BWCA), a 4170 km^2 unit of the U.S. National Wilderness Preservation System within the Superior National Forest (Fig. 1). Probably more is known about the fire history and ecology of the BWCA than any other area in the northern circumpolar environment. Charcoal stratigraphy in annually laminated lake sediments indicates that periodic fires have occurred in the area for at least 9,300 years (Swain, 1973, 1980; Wright, 1974). Heinselman's (1969, 1971, 1973 a, b) dendrochronological dating and mapping of forest fire patterns for nearly the last four hundred years is of course legendary. The Quetico-Superior Wilderness Research Centre has since 1952 established more than 2,000 permanent plots in the BWCA (and Quetico Provincial Park) as part of a long-term study of ecological processes in the region (Ahlgren, 1966, 1974, 1976). Phytosociological studies of the upland plant communities indicate that present forest structure and composition is closely related to the length of time since last fire and the character of that fire, and the age and composition of the former stand (Ohmann and Ream, 1969, 1971a, b; Grigal and Ohmann, 1973, 1975; Ohmann et al., 1973). A program of fire effects studies was undertaken by U.S. Forest Service and university scientists (*see* Rudd, 1971; Books, 1972; Peek, 1972) following a 6,000 ha fire in 1971 (Sando and Haines, 1972) has yielded a considerable amount of knowledge (e.g., Ohmann and Grigal, 1979). A much smaller scale program involving a 1,368 ha fire in 1976 has also been initiated (Ahlgren, 1976; Buech et al., 1977).

In 1976, planning commenced on introducing random ignition prescribed fires on a pilot basis within a contiguous 400 km^2 area of the BWCA (Gibson, 1976). The remoteness, light visitor use and lack of developments allows BWCA fire managers to focus on the potential for uncontrollable fire growth outside the area as a criterion for initiating suppression action. Detailed fuel inventories were conduced in the study area during the summer of 1976 and the data related to potential fire behavior (i.e., spread, intensity, crowning, spotting) utilizing mathematical models (Roussopoulos, 1978a, b). Predicted fire behavior compared favorable with actual conditions on three 1976 wildfires in or near the study area suggesting that the modelling results, coupled with experience and judgement, could be used in writing fire management prescriptions and operationally for assessing escape potential. A fire-related information base for the area has been assembled including the preparation of a vegetation/fuel type map (Roussopoulos, 1978b) and a draft environmental analysis report prepared. Preattack planning for the area has been completed and accommodations made for ensuring visitor safety. The pilot study area project has not been implemented. Completion of the land management planning process on the Superior National Forest is a necessary prerequisite to implementation and the final outcome of this effort may indicate other alternatives to reintroducing fire into the BWCA ecosystems (Tomascak, pers. comm.).

In the western portion of Lake Superior lies its largest island, Isle Royale, a 544 km^2 archipelago managed by the U.S. National Park Service as a National Park (Fig. 1). In 1909-10, the late W.S. Cooper carried out his classical study of Isle Royale vegetation successions, concluding that "It is nearly certain that fire has played a part in the vegetational history of almost all if not the entire forested areas of the island" (Cooper, 1913). Charcoal analysis of sediment cores from inland lakes indicates that fire has been an important ecological factor in the island's forest history for at least a thousand years (Raymond, 1975). Fire ecology studies, particularly those regarding fire-moose-wolf (*Canis lupus* L.) relationships associated with a 10,000 ha fire in 1936 (Krefting, 1974; Allen, 1974, 1979), has clearly shown the significant role of fire in the island's ecology (Hansen et al., 1973; Janke et al., 1978; Janke, 1979, Janke and Lowther, 1980). Approval for allowing random ignition prescribed fires (only of lightning origin) to run their course provided they met predetermined management criteria (USDI National Park Service, 1977) was granted in 1976, pending final acceptance of a fire management plan. Six fires have been classed and monitored as random ignition prescribed fires between 1976-79 (Morehead, pers. comm.). The largest of these, the 1976 Card Point Fire, burned 2 ha over an eighty day period (Miller, 1978). Postfire monitoring of vegetation response to these fires has been initiated (Janke, pers. comm.). Although no planned ignition prescribed fires have been conducted to date, it is still considered an option available to park managers. A vegetation/fuel type map of the island was recently prepared (Steigerwaldt and Meyer, 1979) to interface with a fuel inventory data collected in August 1977 (Roussopoulos, pers. comm.).

The Seney National Wildlife Refuge, located in Michigan's Upper Peninsula (Fig. 1), is a 386 km^2 component of the federal Fish and Wildlife Service refuge system. It includes 102 km^2 of designated "wilderness" under the U.S. National Wilderness Preservation System. Seney is generally thought to be the southern limit of patterned bogs on the North American continent (Heinselman, 1965b). As of July 1976, its fire plan had not been updated since part of the Refuge received wilderness status, refuge personnel had no system of monitoring fire-danger conditions, and there was a lack of experienced fire personnel on the refuge. On July 30, 1976, a thunderstorm passed over the wilderness portion of the refuge, igniting what is now known as the Walsh Ditch Fire. Because of the refuge's fire policy and financial considerations the fire was not suppressed upon detection. The fire was allowed to burn freely until August 11 when it was estimated to be around 4,900 ha in size. Suppression action was initiated on August 11. Aided by worsening drought conditions (Johnson, 1976), the fire spread to a final size of 29,000 ha including 7,000 ha of state and private lands, until containment on September 21. Suppression costs amounted to approximately $8 million dollars. Further details regarding the fire can be found in Popovitch (1977), Miller (1978), V.J. Johnson (1979), and Anderson (1980). The lack of information on fuel and weather conditions, coupled with a fire management plan that did not cover the refuge's wilderness lands, resulted in severe criticism of the agency's decision to allow the fire to burn.[8] We cite this example, not to draw undo attention to this one particular situation and the people or agency involved, but rather to emphasize the importance of a technically sound management plans and staff capable of carrying them out. Failure to do so might result in the loss of public and pollitical acceptance of fire use as a tool in natural area management.

The research arm of the U.S. Fish and Wildlife Service established a monitoring program to evaluate the initial impact of the fire on wildlife, soils and water chemistry (Anderson, 1978, 1979, 1980). Preliminary results indicate that the fire impact on wildlife has been minimal. Remote sensing techniques have been used to prepare a post-fire vegetation map of the burn area (Sugarbaker, 1979). A small pamphlet describing the effects of the fire on wildlife and wildlife habitat has been prepared for public distribution at the Refuge's visitor center (Anderson 1980). A final report

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[8]*See* American Forests 82(11):41, 83(2):2,4, 83(6):48; Journal of Forestry 75(7):377, 419, 75(8):541-544.

detailing the effects of the fire on wildlife and wildlife habitat is to be released in 1982 (Anderson, pers. comm.).

Eastern Canada

Queitco Provincial Park is, like the BWCA to the south of it, a 4,655 km^2 wilderness-lake ecosystem in northwestern Ontario (Fig. 2). The park master plan recognized the role and need of fire in ecosystem management. As a prerequisite to the implementation of a fire management versus fire exclusion program in Quetico, a two and a half year fire ecology study of the park was undertaken between 1975-77 (Woods and Day, 1977d). The species composition and stand structure of Quetico's forests were examined photogrammetrically (Woods and Day, 1976) and a fire history map was prepared showing recent fires and as many older burns as possible (Woods and Day, 1977a). Stand case histories and analysis of relevant literature were used to determine the specific ecological role of fire in four of the Park's major forest communities (Day and Woods, 1977; Woods and Day, 1977b, c)--jack pine (*Pinus banksiana* Lamb.), red pine (*P. resinosa* Ait.), poplar (*Populus* spp.), black spruce (*Picea mariana* [Mill.] B.S.P.). An "ecological burn zone" (Woods and Day, 1977d) map was reconstructed showing three zone classes based on a forest stand's life cycle where fire use should not (regenerative phase), could (immature-mature phase), and should (overmature phase) be employed. In 1978, a 250 km^2 pilot fire management study area was proposed by the Ontario Ministry of Natural Resources (OMNR) that would involve the use of planned and random ignition prescribed fires to allow for the application of fire to be tested on an operational basis over a two-year period. The proposed pilot study area, oriented in a southwest-northeast direction, has been subdivided into "start" and "spread" zones to account for typical fire spread due to topographic features and prevailing winds in an effort to limit potential for escapes. Approval for the project has not been granted, pending clarification of OMNR fire policy and funding for the project (Cockerline, pers. comm.). Although logging operations have been discontinued in Quetico since 1973, the local forest industry is likely to oppose the program. An appropriate public education program is recognized as an essential ingredient to successful implementation of the project. An analysis of Quetico's fire weather and fire danger climatological characteristics is in progress (Alexander and Woods, 1977).

On the northeastern shore of Lake Superior lies the Province of Ontario's largest National Park, Pukaskwa (Fig. 1), a 1,860 km^2 parcel of rugged Canadian Shield country (Gimbarzevsky et al., 1978). Pukaskwa is the most recent addition to Canada's National Park System. Baseline information to guide fire management direction and for landscape interpretation was recognized early in park's planning activities. This need was expressed to the Canadian Forestry Service by Parks Canada. Commencing in 1977, a three-year investigation into the historical, ecological and managerial role of fire was undertaken (Alexander, 1978). From a fire history standpoint, emphasis is being placed on construction of Stand Origin and fire history maps through field sampling and existing vegetation maps. Elucidation of the area's fire ecology centers on the review and synthesis of applicable literature and photo (aerial and ground) comparisons. An assessment of the Park's "fire environment" in terms of fuel types, climatic and meteorological characteristics and terrain features is being undertaken (e.g., Street and Alexander, 1980). From the knowledge gained and information assembled, recommendations will be made regarding an appropriate fire management strategy for the Park. The Ontario Ministry of Natural Resources is currently responsible for fire detection and suppression in Pukaskwa under an existing ten year agreement (until 1988) between provincial and federal governments. All fires are to be suppressed within a five mile buffer zone between the boundary and interior of the Park. Pukaskwa's woodland and caribou (*Rangifer tarandus caribou* Gmelin) population of 30-35 animals, represents the southern limit of this species in Ontario. The local economy depends heavily on forest products for livelihood. Caribou habitat within the Park and commercial timberlands adjacent to the Park are two such examples of real concern to implementing a more liberal fire management program in Pukaskwa.

Fennoscandia and U.S.S.R.

Geographically, Fennoscandia comprises Norway, Sweden and Finland and represents a total land area of 1,110,535 km^2. Nature reserves are generally smaller than their North American counterparts. Forest fires are generally not recognized by the general public or politicians as an important or positive historical-ecological factor in the management of national parks and reserves in Fennoscandia and Russia (Ȧbrahamsen and Zackrisson, pers. comm). although the Finnish legislation on nature conservation is at the present time being revised, including considerations of fire in the management of parks and reserves (Haapenen, pers. comm.).

Norway has 13 national parks with a gross area of 5,000 km^2 and approximately two hundred smaller reserves (Holt-Jensen, 1978). Very little local information is available on the natural role of fire in Norwegian nature reserves. Management agencies are relying on results from other nordic countries where Scots pine (*Pinus silvestris* L.) and Norway spruce (*Picea abies* [L.] Karst.) are dominant speices for basic knowledge and potential future use of fire in reserve management (Abrahamsen, pers. comm.).

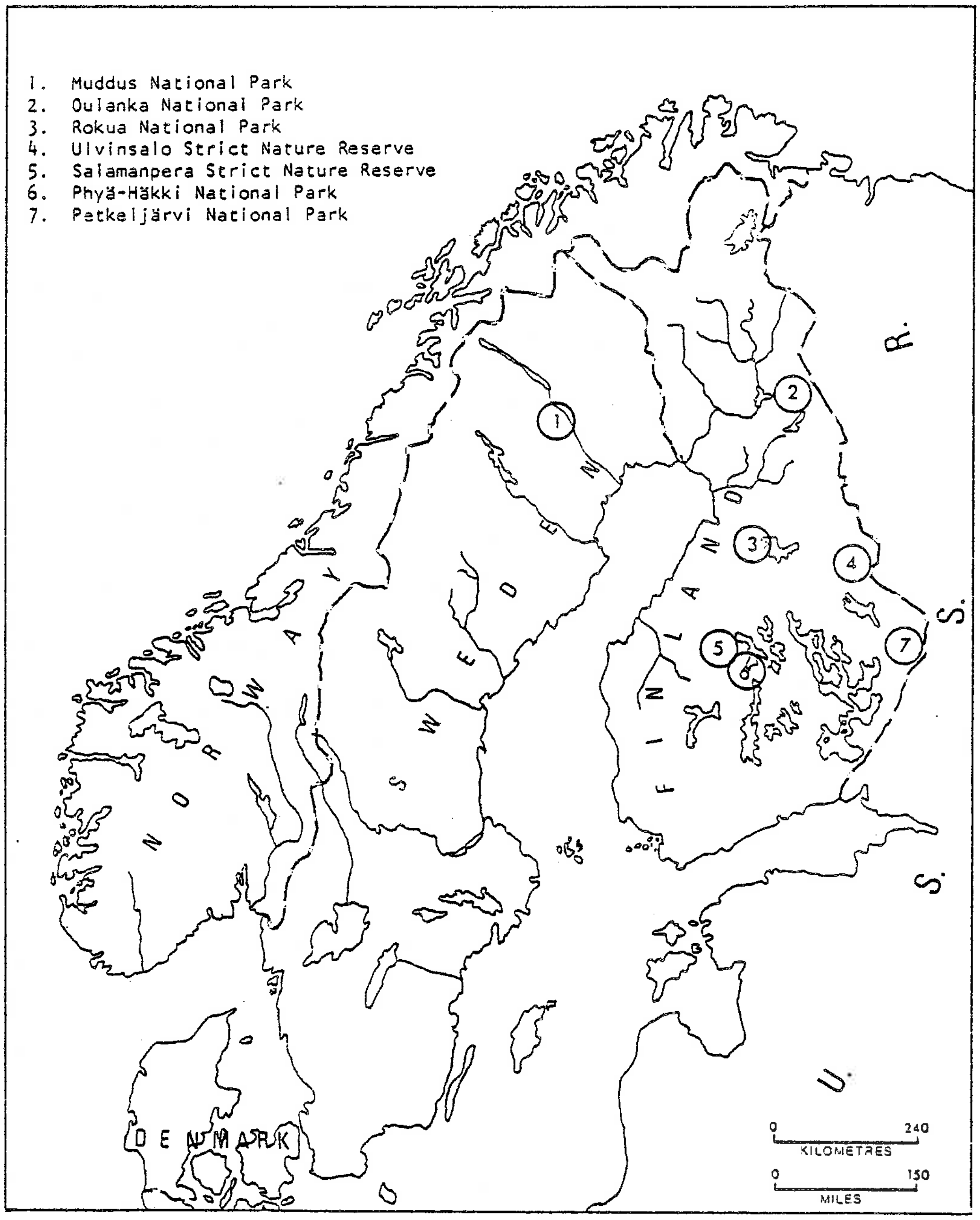
Sweden's sixteen national parks and some 500 nature reserves have a total area of approximately 9,600 km^2 and 1,750 km^2, respectively (Esping, 1972). Forest fire history investigations in northern Sweden by Zackrisson (1976, 1977) has led him to conclude that:

> The over-representation of the later stages of forest successions in our forest reserves and national parks, due to the fire suppression measures introduced during the past century, presents quite a problem from a nature conservation point of view. If this suppression of fire as a natural ecological factor in such forest is continued, then we shall create a forest structure in our reserves that has scarcely existed, at least during the past 600 years. There is therefore some justification for the suggestion that fire should be re-introduced...in some of the larger forest reserves and national parks of northern Sweden...(Zackrisson, 1979).

A project to assess fire management needs in Swedish parks and reserves was formalized in July, 1979 by Zackrisson (pers. comm.). This investigation, supported by Sweden's National Environmental Protection Board, represents the first attempt to review the introduction of fire restoration programs in the country's nature conservation areas. Initial efforts are directed at reconstructing the fire history of Muddus National Park (Fig. 2), one of the largest virgin forest areas in northern Sweden (492 km^2). The historical data on fire incidence coupled with Uggla's (1949, 1958, 1974) studies of postfire regeneration of trees and understory flora on wildfire sites in the park will assist in clarifying the specific role(s) of fire in Muddus.

Finland's nine national parks anf fifteen "strict" nature reserves have a combined total area of 3,247 km^2 (Kalliola, 1970; Anon., 1975). The first step in considering fire in the management of Finnish parks and reserves was the initiation of a project in 1972 by the Department of Environmental Conservation at the University of Helsinki to investigate the fire ecology and history of six selected study areas (Haapenen, pers. comm.). Four parks and two reserves were selected as being representative

Figure 2. Geographical location of parks and nature reserves in Fennoscandia referred to in the text.



of the Finnish boreal forest from the standpoint of predominate forest cover and soil types (Fig. 2): Oulanka National Park (107 km^2), Rokua National Park (4.2 km^2), Phyä-Häkki National Park (10 km^2), Petkeljärvi National Park (6.3 km^2), Salamanperä Strict Nature Reserve (12.7 km^2), and Ulvinsalo Strict Nature Reserve (25 km^2). Field surveys for the project have been completed and the first report, on the Ulvinsalo Strict Nature Reserve, issued (Haapanen and Siitonen, 1978). The Ulvinsalo landscape is a mosaic of upland and lowland sites. These effective fuel discontinuities may assist the application of prescribed fire planning by serving as natural barriers to surface fire spread. A phytosociological analysis and distribution map of the vegetation types in Oulanka National Park has been completed (Söyrinki et al., 1977).

The main type of nature reserve in the Soviet Union is termed a zapovednik or State natural preserve (Pryde, 1972, 1978) although a variety of protected areas do exist. The number of preserves flucuates considerably from year to year and the largest ones exceed 1,000 km^2. These areas are specified as being "forever withdrawn from economic utilization for scientific-research and cultural-education purposes." Each preserve has its own scientific staff and supporting research facilities. A large portion of the research carried out in the preserves has direct application to the national economy. The importance of zapovedniki as outdoor laboratories for biological and ecological research represents one of the main justifications for withdrawing such areas from econimic development although biosphere preservation cannot be understated. Fire does indeed have a historical-ecological role in the northern forest ecosystems of the Soviet Union, for example, in northern European Russia (Vakurov, 1975). However, the Soviet attitude to fire in the zapovedniki is perhaps best illustrated by the case of the Mari zapovednik. Much of the preserve was swept by fire in 1972. As a result, in 1973, a decision was made to abolish Mari. Although the study of fire effects could have been conducted whether the area was officially designated as a zapovednik or not, lacking this status it was easier to place it in some economic activity (Pryde, 1978).

Discussion

A number of broad generalizations can be made regarding the survey. The crusade for fire management in North American wilderness areas, parks and other nature reserves is largely over. Policies have been formulated that give a legal basis for more than just fire control. In Fennoscandia, the "battle" is only just beginning. Area specific historical research and assessment of plant and animal communities in relation to fire is available or is underway for many reserves in support of fire management policies and practices. In some instances, the detail is considerable. There has been some experimentation with planned ignition prescribed fires but no long-term programs as of yet. Experience with random ignition prescribed fires is limited. Pilot study areas have been proposed for the use of random and planned ignitions. In only a couple of instances are there operational programs and these have not been critically tested. By and large, fire suppression is the only aspect of fire management that is being practiced in nature reserves although the outlook is promising.

Fire suppression has traditionally been the cornerstone of conservation so it is not surprising that the exclusion of fire is still the policy for most nature reserves, and, to the extent it succeeds, it is a management practice as well (and it does have its advocates). The stated objectives of nature reserves, namely the preservation of natural conditions is clearly not being accomplished under a policy of nearly total fire suppression.

Fire exclusion carries two major risks if pursued indefinitely: (1) fuel accumulation to the point that widespread, high-intensity fires will result in spite of protective measures and (2) loss of floral and faunal diversity. Attempted fire exclusion is at the very least a defensible "holding action" until the necessary expertise can be developed to use prescribed fire (suggested only as an interim measure). Some would argue that it is the preferred alternative.

Heinselman (1978) felt that fire management programs are really only needed if there is concern: (1) about public safety or (2) about unnatural ecosystem effects due to prior fire exclusion. Unfortunately, one or both concerns are often justified. The guiding principle in choosing between random ignition prescribed fires, planned ignition prescribed fires or some combination--should be this--if not precluded by safety or ecological concerns, random ignitions are preferred (Heinselman, 1978). Safety concerns might dictate that only planned ignitions be used near boundaries, near structures, in very small reserves, and in high visitor use areas. Prescribed fire, especially random ignitions, carries the risk of potential danger to human safety. As noted earlier, fire exclusion policies carry the same or greater risks. Forest fires are dangerous. The intelligent manager will never allow his enthusiasm for initiating or restoring fire to the ecosystem to override safety considerations. We cannot endanger human lives either inside or outside nature reserves, and we cannot risk damage to adjacent commercial forests and man-made structures. Fire management programs that jeopardize the lives or porperty of people not involved in the use of management of a nature reserve will not be tolerated by society and rightfully so. Visitors can be given pre-entry instructions, directed away from fire areas and evacuated if necessary, closures to fire areas can be initiated, and announcements issued or messages dropped from aircraft to backcountry users.

However, the responsibility of preventing uncontrollable fire growth outside a reserve is paramount and tests our *ability to manage fire on the scale required.*

Some say the public would never accept the idea of prescribed fire management programs in nature reserves. Some reserves have only recently come under some sort of program of organized fire protection in the last 10-20 years while fire suppression has been practiced in others for 60-80 years or more. As Stankey (1976) notes, "The fear of fire is deep and not easily lost. Shifting from a policy where fire was attacked and suppressed quickly, and virtually without regard to cost, to one in which fire is not only tolerated but viewed as necessary has not been without resistance from the public." Managers must seek to improve the *public's awareness of fire's role and gain acceptance of fire management policies and practices.*

The problems of prescribed fire capability and public support are real and immediate concerns that will and are hampering the implementation of more liberal fire management programs. We would be remiss in our responsibility if we did not attempt to at least suggest partial solutions to them and identify specific research and management needs. They are certainly not unique to northern ecosystems but certain aspects of each problem are more complex while others are simpler. For example, the smoke question from the standpoint of health concerns and aesthetics, is generally not a problem because of the sparsely populated areas involved.

The need to develop public (and agency staff) understanding and support for ecologically sound prescribed fire programs is not an insurmountable problem but requires careful and thoughtful planning. The public needs the unvarnished facts about "natural" ecosystems, and about the measures that will be needed to maintain and/or restore these systems. Efforts to gain public support, in the absence of concomitant programs to educate, inform, and involve the public, seemed doomed to failure. Stankey (1976) notes that "To the extent that public opinion is strongly counter to a proposed program, it is unlikely that a program can be successfully implemented. Several students of natural resource policy making have concluded that failure to incorporate attitudes into resource decisions reduces the probability of successful implementation of programs that were otherwise technically sound..."

There may be a problem with understanding the need for reintroducing fire--a legacy of intensive fire prevention campaigns. To overcome this legacy (posters, slogans, etc.) that told an incomplete story, new and innovative educational work with the media, public schools, clubs, etc. is needed. Careful distinctions must be made between unwanted fires, which still must be suppressed in all cases, and wanted fires (Barrows, 1977). To make these distinctions the public must have accurate knowledge.

Garnering support for fire management policies and programs is closely linked to educating the public to the role of fire in forest ecosystems and equally as important--the consequences of continued fire exclusion. Persons who understand little about fire are more likely to endorse stringent suppression statements than those that are better informed. The findings of Stankey (1976) and Rauw (1980) suggest that the public will respond positively as the factual knowledge of fire's natural role increases.

Management actions that would enhance public support for fire management programs have been outlined by Stankey (1976): (1) <u>educate and involve all segments of the public</u> and (2) <u>avoid sudden changes in policy implementation</u>. Rauw (1980) has shown that a slide/tape presentation can be an effective means of increasing and assessing visitor knowledge of fire's natural role and attitudes towards fire management policies and practices.

It seems reasonable that fire prevention posters and literature are an important influence on public attitude, and therefore we should carefully consider the messages they communicate. Fire management policies and practices should be publicized and interpreted so that the public will relate them to the specific management objectives of the nature reserve and not be led to believe that similar practices and policies would automatically apply to land managed by other agencies for different management objectives. It is vital that the public understand that, rather than abandoning the area to the vagaries of wildfire, the agency has an effective fire control program.

There are legitimate concerns about our ability to implement fire management plans that consider random and/or planned ignition prescribed fires. Such programs involve unavoidable risks, not the least of which is public safety and damage to adjacent lands (Flanagan, 1972). Barrows (1977) provides an appropriate cautionary message:

> ...in our enthusiasm and confidence about bold new approaches to forest fire problems we cannot overlook the fact that under some conditions man is still incapable of coping with wildfires. Thus there is one overriding challenge to fire management: that of maintaining full respect for the power of fire and the effects of this power on both wildland environments and the people who live and work in these environments.

Although risks cannot be entirely eliminated, they can be minimized to within acceptable limits through management plans that are professionally prepared, technically sound and expertly executed. Moore (1976) very aptly puts it:

> ...to say we shall never fail is like telling a doctor to go practice medicine but never lose a patient. Even if a patient crosses the big saddle now and then the doctor has performed no malpractice so long as he adheres diligently to his professional code. As it is in medicine so it is in fire management. We know that to continue all out fire control in all places would be as much malpractice as allowing fire to roam without expertly applied scientific prescriptions and control plans. A thorough, visible, professional rationale must underline each

> major fire management plan and responsible managers must stand accountable for the results. If the rationale is sound, the prescription scientific, the implementation thorough, then errors will be minimal and an occasional error, or lost patient, acceptable.

Two problems unique to using random ignitions in northern ecosystems are: (1) lack of defensible boundaries and (2) typical fire behavior. Northern ecosystems are characterized by generally flat terrain with continuous fuels. Low-lying areas (e.g., swamps) and water-bodies (i.e., lakes rivers) inhibit fire spread but short- and long-range spotting is common. Fires of any real ecological significance (size, intensity, effects) in the boreal forest, at least in North America and Siberia, are most often stand replacing high-intensity surface fires, passive crown fires or active crown fires, most often associated with high rates of spread. In Fennoscandia and northern European Russia, low- to medium-intensity surface are more prevalent. Managers are understandably apprehensive of high-intensity fires, not only because of the fire-killed stems that remain in its path, but because of the very real potential for escape beyond the limits of an area. In many northern forests such fires were the natural agents of periodic stand renewal and must somehow be provided for if the natural system is to survive. Expertise must be developed to meet these ecological requirements without losing control of such fires. We have had very little experience with the deliberate use of such fires on a large scale. We lack the prescribed fire "know how" and confidence at present. Planned ignitions generally present far fewer problems (i.e., less unknowns). Much of our experience and knowledge in the application of prescribed fire in other ecosystems is only partially applicable (including western U.S.A. programs in nature reserves). A manager must make use and take full advantage of existing and new technology (e.g., aerial ignition). Must avoid mistakes which are caused not by lack of knowledge but poor application of widely known and proven practices (Moore, 1976). Addressing the "ability to manage fire" problem encompasses the full realm of fire management planning and decision making. Only the pertinent highlights can be considered here.

The major problem encountered with random ignition prescribed fires is that they inevitably occur during and/or experience periods of extreme fire weather (low fuel moisture, high velocity winds, etc.). Severe wildfire situations generally coincide with these conditions and fire suppression resources are then committed. Once such fires become large, control is difficult and wind shifts could threaten lives or property in and/or outside a reserve. Thus, the fire manager is faced with decisions at ignition and detection (delcaration phase) and during the active period (monitoring phase).

One of the first considerations is current fire suppression capability. The extensive experience in fire fighting technology that has been acquired over the decades must now be applied to an objective that in the long run is just as important to the health of the ecosystem as is fire suppression. For even when managers rely on random ignitions, they must have the option of suppressing certain perimenters, or even the entire fire, if they anticipate unacceptable safety problems, etc. There is a "fine" line between a wildfire or unwanted fire and a random ignition prescribed fire. The prescription for a random ignition may call for partial containment or suppression and a wildfire might be "herded". The distinction is the declaration decision which requires considerable thought and analysis in developing the prescription criteria. An assessment of fire potential (e.g., fire growth) and a knowledge of the threshold conditions for severe fire behavior (crowning, high rate-of-fire spread, spotting) is absolutely essential.

Assessing potential fire behavior encompasses at least four interrelated facets: (1) an adequate fire weather and climatic station network; (2) a system to integrate past and present weather effects on fire danger conditions; (3) fire behavior prediction scheme(s) with appropriate fuel and terrain map data; (4) short- and long-term fire weather forecasting. Much of the thought and analysis that goes into evaluating fire potential can be incorporated and organized into decision making flow charts (e.g., Devet, 1976; Chapman, 1977; Fischer, 1980) such as found in the Fortymile Interim Fire Management Plan (Anonymous, 1979). Remote weather stations offer a solution to the problems of manned observation units and vast, remote areas (e.g., Harrington, 1978). Sophisticated fire danger-rating systems have been developed, at least in North American (Deeming et al., 1977; Turner and Lawson, 1978).

Quantitative fire behavior prediction is still pretty crude, fragmented and often incomplete, although useful schemes are slowly becoming available (*see* Van Wagner, *these preceedings*). The situation is not likely to improve in the very near future. Thus, the fire manager must rely on: (1) case studies and analyses of past fires (e.g., Street and Alexander, 1980); (2) maximize the knowledge documented for wildfires (e.g., Sando and Haines, 1972) and experimental prescribed fires; (3) mathematical modeling (e.g., Roussopoulos, 1978a, b); and (4) experienced judgement. Perhaps we can learn about the management of high-intensity fires by observation of free spreading fires. In North America there are many such opportunities where for economic reasons suppression action is deterred.

In spite of the fact that empirical techniques and mathematical models for predicting fire behavior are slowly becoming available, they have their limitations and require considerable interpretation to properly apply.

Thus, there is still the need for professional judgement and practical experience. Fire management is complex and demanding work. (e.g., day-to-day decision making during active random ignition prescribed fires). The degree of confidence required by a fire manager to develop practical and meaningful management plans can only be derived from extensive fire suppression and use experience. Moore (1976) put it well: "... there is no substitute in fire management for the capable specialist intimately familiar with his chunk of earth and master of the state of the art in fire." In Fennoscandia, attrition through retirements is taking its toll on personnel involved with prescribed fire during the 1950s and 60s (Zackrisson, pers. comm.). The necessary expertise to fill this void might be acquired through an international exchange program of short-term visits by: (1) North American specialists to Fennoscandia and (2) Fennoscandia managers to North America.

The development of a close working relationship between the fire manager and area fire weather forecaster is absolutely essential. The forecaster must be aware and appreciate the manager's objectives, needs, etc. and the manager should be sympathetic and understand the forecaster's limitations. The uncertainty associated with the variability in synoptic weather patterns challenges our abilities to make adequate long-term fire weather forecasts. In fact, the state-of-technology doesn't permit a reliable weather forecast much beyond three days. Another source of future weather information must be used--fire weather and danger climatology, provided sufficient data is available. Historic weather records reveal patterns which can be used by fire managers in developing intelligent fire management prescriptions (e.g., number of days suitable for planned ignition prescribed fires and when they might occur). Climatology substitutes weather hindsight for weather foresight by assuming climate in the near future will be similar to the climate of the recent past, say in the last two or three decades. We cannot determine which specific weather occurrences from the past will be repeated at any given time in the future. Instead, we examine all of the past occurrences and assume they will occur with the same frequency in the future (Furman, 1979). Heinselman (1978) states that "We need to learn more about the probability of quiescent periods during intense fires when further enlargement of the burn could easily be restricted by suppression along key perimeters." Statistical climatological analysis might be of assistance in this regard and in determining the probability of below-normal precipitation or meteorological drought (Furman, 1978).

Concluding Remarks

The basic objective of fire management programs in nature reserves is to restore or maintain fire's natural role as an environmental factor. If we were to let nature choose the time, the place and fuels (i.e., allow all lightning fires to burn regardless), then supposedly a natural system should result. This is unrealistic because of socio-economic-political factors, plant and animal communities in some reserves have been altered by fire exclusion and/or prior land use, and many reserves are really only a fragment of the primeval system. What managers really desire, presumably, is not the natural fire regime *per se*, but rather the vegetation complex that the natural fire regime would have created (Van Wagner and Methven, 1980). The objective would be to emulate the long-term historic pattern as nearly as possible considering safety and ecosystem size. There are a number of reasons for critically examining active versus custodial fire management for even when we make decisions about unwanted and wanted fires we are unknowingly practicing vegetation management on a landscape scale. This is a management problem that is seldom addressed because of the problem complexity and long time periods involved.

Fire managers for nature reserves should have clear, specific, and of biologically attainable objectives. Action plans or statements must spell out the philosophy of ecosystem management and the biological nature of the ecosystem to be maintained or restored (e.g., vegetation types and successional stages to be encouraged, the approximate proportions of the area that might be occupied by each type and stage at any one time, the native fauna to be encouraged, etc.). Historical research and inventory will allow judgements about the degree to which present ecosystems should be managed. The proportion of area to be occupied by various successional stages is a key issue and should be based on the forest age-class structure. The negative exponential age-class distribution form (Van Wagner, 1978) may be appropriate for large reserves since only in this way could the entire ecological age-range of a forest type be represented. The area burned per decade and timing of repeated burns should be based on the actual fire history. Only a small percentage of a reserve would be burned at any one time. The aim would be to maintain or slowly re-establish the primeval distribution of forest age-classes and vegetation types.

Care must be taken in using fire history alone as a basis for developing fire-vegetation management strategies (Franklin, 1978; Tande, 1978; Van Wagner, 1978). Rather, the ecology and longevity of the main vegetation species should be considered jointly with present age-class distribution and known fire history (Van Wagner and Methven, 1980).

If planned ignition prescribed fires are used exclusively, then the ignition patterns, the size of areas to be burned, timing, frequency of burning, etc. are crucial (Heinselman, 1973a). It can be argued that since man would control the times and places of ignition, and the size of the burns, the system would be "unnatural" (the same could be said for lightning fires used as random ignition prescribed fires). But there would be no direct control over local fire behavior or effects, or over other variables that determine vegetative or animal responses. Philosophically man would have some control, but only through the deliberate use of the very environmental factor that shaped the primeval vegetation. To the extent fire frequencing, intensity and timing mimic the natural regime, the resulting fire effects should be natural (Heinselman, 1978).

As a fire management alternative, the mechanical manipulation of fuels and vegetation (including commercial timber harvesting) as a substitute for nature fire seems inconsistent with the basic philosophy and objectives of most nature reserves (Heinselman, 1978). Forest industry points out that the loss of timber induced by burning could be avoided if this alternative was used exclusively. However, we shouldn't have to meet our wood demands by logging in nature reserves if adjacent lands our properly managed. It is technically feasible to simulate many of the effects of fire by mechanical manipulation (e.g., Peck et al., 1976; Noble et al., 1977) but in doing so we sacrifice many of the intrinsic values associated with nature reserves. How would the ecological and aesthetic effects of snags be simulated?

If we are serious about maintaining the natural character of wilderness areas, parks and other nature reserves, then clearly the elemental forces of the past must prevail. We must face up to the ultimate question of natural area preservation in its full-blown meaning. A quote from Heinselman (1970b) is perhaps appropriate in closing:

> ...fire was part of nature for eons; and mankind has lived with fire on the landscape since his earliest days as a primitive hunter. The need to retain some examples of the earth's primeval ecosystems is real urgent. The educational, scientific, and cultural values of such areas will be immeasurable in the man-dominated world we shall soon find ourselves living in. Those of us pursuing careers in fire management, fire behavior research, fire control research, prescribed burning research, or fire ecology have a special opportunity--and a special obligation.

As stewards of the earth it is our responsibility to leave the unborn some semblance of natural ecosystems. Or will we leave the task to the next generation of managers and scientists?

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