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Risk Assessment of Fire Management Alternatives

- Final Report -

MOUNTAIN PARKS

March 1996

RISK ASSESSMENT
of
FIRE MANAGEMENT ALTERNATIVES

Mountain Parks
Parks Canada

-Final Report-

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Table of Contents

Table of Contents (cont.)

List of Figures

Executive Summary

In support of current efforts to adopt a Vegetation Management Strategy for Canadian National Parks in the Rocky Mountains, the Western Fire Management Center initiated a risk assessment of viable alternatives. This assessment reports the current observations within the five mountain parks of the Alberta Region: Banff, Jasper, Kootenay, Yoho, and Waterton Lakes. In addition, the scope of review includes two parks from the Pacific & Yukon Region: Mt. Revelstoke and Glacier National Parks.

Available evidence points to four threats.

First, scientific monitoring demonstrates a significant decline in the biodiversity within some areas of the mountain park ecosystems. Observations include a decrease in area devoted to key vegetation communities, such as aspen, open conifer, and young pine. Grasslands are also disappearing at an unnatural rate in some areas. Such habitat loss also results in loss of wildlife populations.

Second, more older vegetation is evident in all seven parks than would naturally be expected. Where young trees would normally comprise more than 50 percent of the vegetation communities, they now make up less than 5 percent of some total stand areas. Older vegetation is prone to attack by disease and insects, such as the mountain pine beetle infestation in Waterton Lakes National Park in the late 1970s.

Third, some forested areas are overgrown, with a significant degree of canopy cover. In many areas, open space has declined considerably, resulting in more continuous vegetation. This inhibits some natural processes, such as the production of buffaloberries and other foods of bear and other wildlife.

Fourth, observers note an unnatural and threatening amount of vegetation fuels available for wildfire, called the *fuel load* of an area. The more fuel available to a wildfire, the more intensely and the longer it will burn.

These observations are attributed to a common fact. There has been a significant reduction in burned area within the mountain parks within the last five to seven decades. Many vegetation species and communities depend on wildfire to remove competition, recycle nutrients, open the forest canopy, and control pests. Some species, like the lodgepole pine, require fire to reproduce. In the absence of fire, these communities and park ecological integrity will inevitably decline.

A likely future, if trends continue, would see decreasing forest health, severe reduction in wildlife habitat, and infestations by insects and disease, at least within the montane eco-regions. In addition, the continued accumulation of both fine and heavy vegetation fuels mane future wildfires will be hotter, more extensive, and more difficult to control.

Uncontrollable wildfires are on the rise in many different North American jurisdictions, largely for the same reasons: Decades of fire prevention and effective suppression have allowed fuels to accumulate.

The principal ingredients required for a large, hot fire are evident for most parks. These include high hazard levels of mature wood, marked by fine fuels and heavy timber, periods of extremely dry weather, and an abundance of ignition sources, particularly of human origin.

Intense wildfires tend to remove nutrients, enhance erosion, and destroy trees. Where frequent low-intensity fires were once the norm, as in the valley bottoms (montane eco-regions) of the Rocky Mountains, large and hot fires would return the ecosystem to an early successional stage. The prospect of uncontrollable wildfires also threaten park facilities and infrastructure, cultural resources, employees, concessionaires, and visitors.

The Risk Assessment summarizes the risks and benefits of four principal tools available through a vegetation management program: 1) *Fire suppression* attempts to prevent the spread of wildfire as soon as possible in order to minimize short-term damage. 2) *Fuel reduction burns* are planned and intentional fires (called prescribed fires) that reduce the fuels available for a catastrophic fire, 3) *Lightning burns* take advantage of natural processes to burn in prescribed areas while being closely monitored, and 4) *Ecological burns* represent controlled burns that benefit the environment within large areas.

This report evaluates each of five alternative strategies that utilize these tools in various combinations. The evaluation employs the key criteria of ecological integrity, service clients, efficient economic operations, safety and freedom from liability.

We conclude that a short-term policy of fire exclusion presents greater overall risks to the environment, stakeholders, and the public purse than a long-term strategy of reintroducing fire to the natural landscape. Said another way, the risk of declining ecological integrity and catastrophic fire outweigh the risk of liability losses from escapes of planned ignition prescribed burns.

Escapes will inevitably occur, even without negligence. These events, while few, could erode public support and diminish agency support for restoring fire to the natural landscape. There are considerable uncertainties surrounding prescribed burns that nevertheless may be mitigated through experience and careful implementation. Any prescribed burn program, if approved, must adopt an operational risk management framework that identifies the high risk factors associated with adverse smoke effects and escaped prescribed burns.

The risks of reintroducing fire can be minimized through a phased approach that allows for monitoring and feedback: 1) Protect park facilities and infrastructure using mechanical fuel reduction, 2) Reduce fuels using low-risk prescribed burns at park boundaries and other critical locations, 3) Expand prescribed burning for fuel reduction and ecological benefit, and 4) Consider lightning prescribed burns only when containment is highly likely. In implementing the strategy, managers should prepare a targeted Fire Management Plan for every zone within each park.

Section 1.0 - Introduction

Visitors from around the world come to Canada's national parks to enjoy the variety of wildlife, vegetation, and terrain. The Mountain District parks and the Revelstoke and Glacier National Parks in the Pacific & Yukon Region, in particular, preserve ecosystems representative of the Rocky Mountain and Columbia Mountain natural regions.

Historically, the management of wildfire risks within Canadian National Parks has parallelled broader management policies within the Parks organization. The original policies of "protection" and "preservation" encouraged exclusion of wildfire whenever possible to preserve natural wilderness. Fire suppression gradually became more effective due to increased park resources and technologies.

Parks Canada is now adopting the principles of "ecosystem management." Ecosystem management takes a broader view of the natural environment that extends beyond park boundaries and recognizes the complex and dynamic nature of park ecosystems. The health of the environment and the preservation of biodiversity, rather than naturalness, have become predominant concepts. The manipulation of naturally occurring processes such as fire is contemplated as part of the overall goal of ecosystem management. This new management approach leads to questions regarding the proper role of wildfire in preserving and protecting ecosystem health and biodiversity.

Apart from ecosystem management concerns, however, other values and considerations may be affected by fire management activities in parks. Park managers must balance public safety, tourism, fire suppression costs, and other relevant issues with the park's ecological mandate to determine a suitable fire management alternative for the mountain parks. To assist in designing an appropriate strategy, this report identifies the potential risks associated with broad alternative strategies for vegetation management.

1.1 Background

Since 1979, Parks Canada has recognized and addressed wildfire management as part of the broader issue of vegetation management. The term "fire management" is defined as:

> *The deliberate integration of knowledge on fire control, effects and behaviour into the decision making process pertaining to natural resource management.*

Fire management typically comprises a "fire control" phase (which may consist of less than full-force control) and a "fire use" phase (Directive 2.4.4, 1986). Recently, however, progress on these issues has been stalled by the lack of a comprehensive regional strategy.

In an effort to ensure consistent application of policy, control costs, and avoid duplication of effort, Parks Canada has drafted a single Vegetation Management Strategy for the mountain national parks.

Within the context of this draft Vegetation Management Strategy, regional staff presented three fire management alternatives to the Regional Policy Committee:

- Full Suppression
- Let Burn (Suppression + Prescribed Lightning Burns)
- Mixed Fire Restoration

The presentation addressed the economic, social, safety, and ecological risks associated with each of the three options and recommended Mixed Fire Restoration as the preferred alternative. The Regional Policy Committee requested a more detailed assessment of the risk factors associated with each of the alternatives and suggested a fourth alternative, Suppression + Fuel Reduction Burns, be considered. Accordingly, this study was commissioned to examine the risks of the four fire management alternatives.

Regional staff subsequently hosted an introductory workshop for representatives from each of the mountain parks and the British Columbia and Alberta Forest Services to assess the risks associated with each of the four fire management alternatives. In the course of the workshop a fifth alternative was developed, Planned Prescribed Burn, to cover the full spectrum of fire management options.

1.2 Study Needs and Expected Results

Our report to the Regional Policy Committee examines the pros and cons of competing fire management alternatives in the mountain parks. The aim of our report is to summarize the principal risks of each alternative and to discuss the effectiveness of various measures for controlling these risks. This report uses principles drawn from risk management and the decision sciences to evaluate these fire management options and to recommend a preferred course of action.

Our challenge was to highlight the risks in a clear and concise written manner. We have endeavoured to distinguish among the various options in a way that allows Committee members to assess trade-offs, benefits, and potential losses from each approach.

Concern for both the ecological integrity and vegetation fuel buildup is not new. Evidence of such consequences have been linked to full fire suppression within Canada's National Parks for more than a decade (Van Wagner and Metvin, 1980; CPS, 1986). Likewise, the management options addressed in this risk assessment have been under consideration for many years.

We note that the CPS Natural Resources Branch contracted an independent consultant review of the fire management status within Parks Canada in 1988. Key recommendations accepted by the Regional Director General level for the Western Region included specific provisions to integrate fire control and fire management (CPS, 1989).

1.3 Scope of Study

The purpose of the study is to assess the risks of various fire management alternatives. Our review of the risk factors comprises one part of a number of considerations that will influence the committee's final decision. Other factors the committee must consider include the policy context of fire management, internal and external communications, and scientific evidence. Background information on these aspects is being provided in separate studies.

While focusing on the mountain parks, we consider similar operations within Alberta, B.C., Canada, and the U.S. to draw upon collective experiences. We also consider other jurisdictions in order to compare Parks Canada practices with those of the broader fire management community. We do not attempt to evaluate specific plans for implementation.

The following five parks comprise the Mountain District:

1. Banff
2. Jasper
3. Kootenay
4. Waterton Lakes
5. Yoho

In addition, the scope includes two parks from the Pacific & Yukon Region:

6. Mt. Revelstoke
7. Glacier

Fire management practices at Elk Island National Park have evolved parallel to those within the mountain parks in many respects. However, Elk Island is not included within the scope of this study due to its different vegetation and terrain. The risk assessment methodology outlined in this report can be applied to other national parks, such as Elk Island, after considering the nature of the particular values at risk in that jurisdiction.

1.4 Methods and Limitations

This risk assessment predicts the relative probability and consequences associated with five options. Because legal liability is an important issue, we consider relevant case law principles that might offer specific insight. We also include a limited review of other organizations to ascertain the current standard of care and applied rules of reasonableness to assist in recommending an appropriate strategy.

We relied upon a facilitated workshop of experts, existing data, text, and research findings provided by others. Our report provides an analysis of the comparative risks in a qualitative manner, highlighting findings from similar studies around the world.

The members of our study team have previous experience working both with Parks Canada and other fire management agencies. The Project Manager, Jim LaMorte, has assisted in the development of the Parks Canada Visitor Risk Management Program and has prepared Public Safety Plans for several parks and historic sites, including Banff. Mr. LaMorte has also worked extensively with the B.C. Forest Service in developing their in-house risk management program and on a range of projects including a comprehensive review of wildland / urban interface issues within B.C.

Robin Gregory has worked on a variety of forestry policy issues in both Canada and the U.S., including a recent examination of divergent public attitudes toward forest vegetation management options for the Ontario Ministry of Natural Resources. Mr. Gregory is currently developing expert systems to assist U.S. Forest Service managers in fire prevention and control.

Shannon Craig has assisted in the development of Public Safety Plans for Pacific Rim National Park and Fort Rodd Hill National Historic Site, and in the preparation of a targeted risk assessment for the Parks Canada Hot Springs Enterprise Unit. Ms. Craig also performed all research requirements for the wildland / urban interface report for the B.C. Forest Service.

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Section 2.0 - Situation Report

A reasonable starting point for any risk assessment documents the threats to an organization and its objectives. This section offers an overview of the current situation within the mountain parks and defines the hazards related to vegetation and fire management.

Within this section, we report the results of our literature review among other similar jurisdictions in North America, and speculate on the causes and likely outcome of current trends.

2.1 Threat to Ecological Integrity

Preserving and protecting ecological integrity is a paramount principle of Parks Canada programs. Ecological integrity is defined as:

> *The condition of an ecosystem where the structure and function of the system are unimpaired by stresses induced by human activity and are likely to persist* (Parks Canada, 1994).

Maintaining ecological integrity includes managing the diversity of vegetation and wildlife within an ecosystem. Biodiversity is commonly considered to be related to the number of species occurring in a given area. More precisely, biodiversity represents:

> *The richness of biological variation, ranging from within-species genetic variation, through subspecies and species, to communities, and the pattern and dynamics of all on the landscape* (Freedman, et al., 1994).

Four distinct observations within the mountain parks suggest the ecological integrity is being threatened in some locations.

Decline in Biodiversity

First, scientific monitoring over the last decade suggests a significant decline in the biodiversity within some mountain park ecosystems (Achuff, et al., 1996; Duchesne, 1994; Kay, et al., 1994; Van Wagner, 1995). Parks Canada staff members have consistently reported reductions in vegetation types and habitat that are vital to park ecosystems.

As an example of these observations, Figure 2-1 notes the historic and projected loss of three representative vegetation communities within the Bow Valley in Banff National Park.

	(sq km)			
Habitat	1950	1995	2020	2045
Aspen	7.9	0.2	0	0
Open conifer	95.9	34.0	5.7	1.6
Young pine	323.8	62.0	4.8	0

Figure 2-1. Decline of Indicator Vegetation in Banff Bow Valley (Achuff, et al., 1996)

As reflected in Figure 2-1, young conifer, herb and low shrub communities, and aspen forest types in the Bow Valley have decreased over time. Grasslands are also disappearing at an unnatural rate in some areas. If this trend continues, the vegetation patterns within the valley will virtually exclude aspen, young pine, and open conifer within the next 50 years (Achuff, et al., 1996).

In addition to the intrinsic value of these vegetation communities, they provide important habitat for wildlife. Stands of aspen trees, for example, provide food elements for ungulates and many bird species.

The production of buffaloberry, an important crop for bear grazing, has declined in areas with significant increase in canopy cover (Hamer, 1994). Researchers have linked such habitat loss to a decline in wildlife populations, such as the grizzly bear in Banff National Park (Herrero, 1996).

Aging Vegetation

Second, researchers report that vegetation within all seven parks is aging unnaturally (Barrett, in press; Masters, 1990; Rougeau & Gilbride, 1994; Tande, 1979; Tymstra 1991).

In natural ecosystems, the majority of trees in the stand are young, diminishing in number to older trees, as illustrated in Figure 2-2.

In some regions of Alberta, however, this typical age distribution has changed dramatically. Trees of ten years or younger comprise less than five percent of the total stand area. Older vegetation dominates with trees of 40-to-80 years of age forming the majority of forest stands (Murphy, 1996).

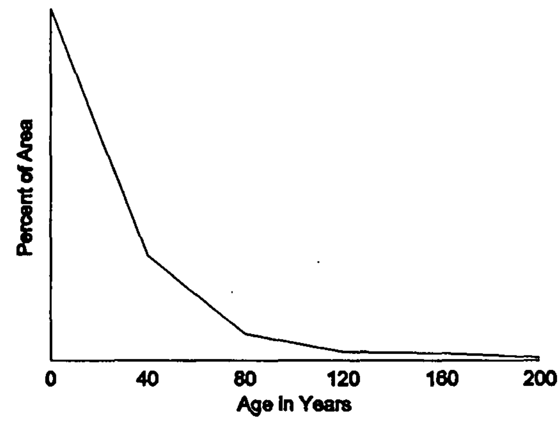

Figure 2-2 Typical Age Class Distribution for Area with Regular Fire Regime (Adapted from Murphy, 1996)

Older, woody vegetation is prone to attack by disease and insects. Trees in all mountain parks are susceptible to infestations of mountain pine beetle, spruce beetle, spruce budworm, root fungus, and stem decay.

Examples of this threat have already been noted within the mountain parks. In the late 1970s, the 70-to-100 year old lodgepole pine stands in Waterton Lakes National Park suffered a substantial infestation of mountain pine beetle. More than 50 percent of these pines were killed (CPS, 1989).

Overgrowth and Continuous Cover

Third, vegetation within the mountain parks has changed over the last few decades to create a more enclosed forest, with a significant degree of canopy cover. Observers note more continuous vegetation throughout many areas of the parks, indicating a substantial decline in open space.

Examples of the problems with this vegetation overgrowth abound elsewhere. One part of south-central Idaho that held about 70 large ponderosa pines per hectare in the mid-19th century contains 1,300 trees per hectare today. About 60 percent of these trees are dead (Knudsen, 1994).

Vegetation overgrowth can also lead to some of the threats noted earlier. In a dense forest, more vegetation competes for limited nutrients and water. When trees weaken, they fall prey to drought, disease, and insects. Buffaloberry production, for example, drops off rapidly when canopy cover exceeds 45 percent in an area (Hamer, 1995).

Increasing Fuel Load

Fourth and finally, scientific and empirical observations within each of the seven parks point to a gradual increase in the *fuel load*, the amount of vegetation available for wildfire.

Fuel load is typically measured using the units of tonnes per hectare. Fuel load has a direct relationship to fire intensity and duration; the more fuel available to a fire, the more intensely and the longer it will burn.

White (1985) measured fuel load levels in Banff's closed forests and found values ranging from 200 to 400 tonnes per hectare for several different vegetation types. White concluded that similar levels probably would not have occurred in the era before 1900 because of a regular fire regime, especially in the montane or valley regions of the park.

In other areas, Parks Canada researchers estimated in 1989 that fuel loads have reached one million metric tonnes in the southern national parks of Canada, representing "explosive levels of fuel for future fires" (CPS, 1989).

2.2 Likely Causes

These empirical observations within the mountain parks - a decline in biodiversity, aging vegetation, overgrowth, and increasing fuel loads - are linked by most researchers to a reduction in the number and extent of wildfires over the last 75 years.

Reduction in Area Burned

There has been a significant reduction in burned area within mountain parks within the past five to seven decades.

Most parks have experienced no fire for 60 to 70 years. At no time in the past 540 years of park fire history has there been a period with so little fire.

Figure 2-3 illustrates the decline in burned area for four mountain parks: Jasper, Banff, Kootenay, and Yoho. In the past 500 years, the area burned by wildfire in each park has dropped dramatically. Research shows, for example, that 1,647 square kms burned in Jasper National Park in the three decades between 1880 and 1909. In the 25 years between 1970 and 1995, the burned area totalled less than 8 square kms. Similar observations are noted for Banff, Kootenay, and Yoho.

Area Burned (sq km)	JNP	BNP	KNP	YNP	AVG	TOTAL
1880-1909	1,647	*612	*77	NA	-	*2,336+
1910-1939	310	297	200	48	25	855
1940-1969	26	27	18	11	3	82
1970-1995	8	1	5	48	2	62
Veg. Area (sq km)	6,500	3,800	1,000	650	-	11,950

* Underestimated due to reburning by more recent fires.

Figure 2-3. Area Burned by Wildfire in the Mountain National Parks, 1880-1995 (Sources: Van Wagner, 1995; Tymstra, 1991; park unpublished data)

Fire Dependent Ecosystems

The decline of biodiversity noted in the Banff's Bow Valley involves many vegetation species that depend on major disturbances, particularly fire (Achuff, et al., 1996). To appreciate the importance of this observation, we considered the frequency of fire within specific park ecosystems.

Historic fire regimes vary within parks according to major eco-regions, as illustrated in the example for Banff and Jasper in Figure 2-4 and discussed below.

Montane. The montane region covers less than 10 percent of the total area within the mountain parks and consists primarily of low elevation valley bottoms. This area is characterized by frequent low intensity ground fires, returning every 5 to 30 years.

Lower / Upper Sub-Alpine. Found at higher elevations, this region comprises the largest proportion of vegetated park lands at approximately 65 percent. Lower subalpine pine forests burn once every 50 to 125 years, while upper subalpine spruce / fir and larch forests burn on a cycle that exceeds 300 years. Fires in these eco-regions are typically intense crown fires.

Alpine / Unvegetated. The remainder of the parks, roughly 25 percent, consists of the alpine eco-region that rarely burns, if ever.

It is clear from the vegetation communities within these eco-regions that the mountain parks depend on regular exposure to fire, particularly in the montane regions. In the relatively cool and dry environment of the Northern Rockies, biological matter accumulates faster than it decomposes. Fire is the major agent that processes this accumulation (Risbrudt, 1995).

Fire-adapted species, such as lodgepole pine and aspen, also require fire to reproduce. Recycling of nutrients is essential to a healthy ecosystem, and it proceeds either through biological agents such as insects, disease and decomposition, or through fire (Harvey, 1994).

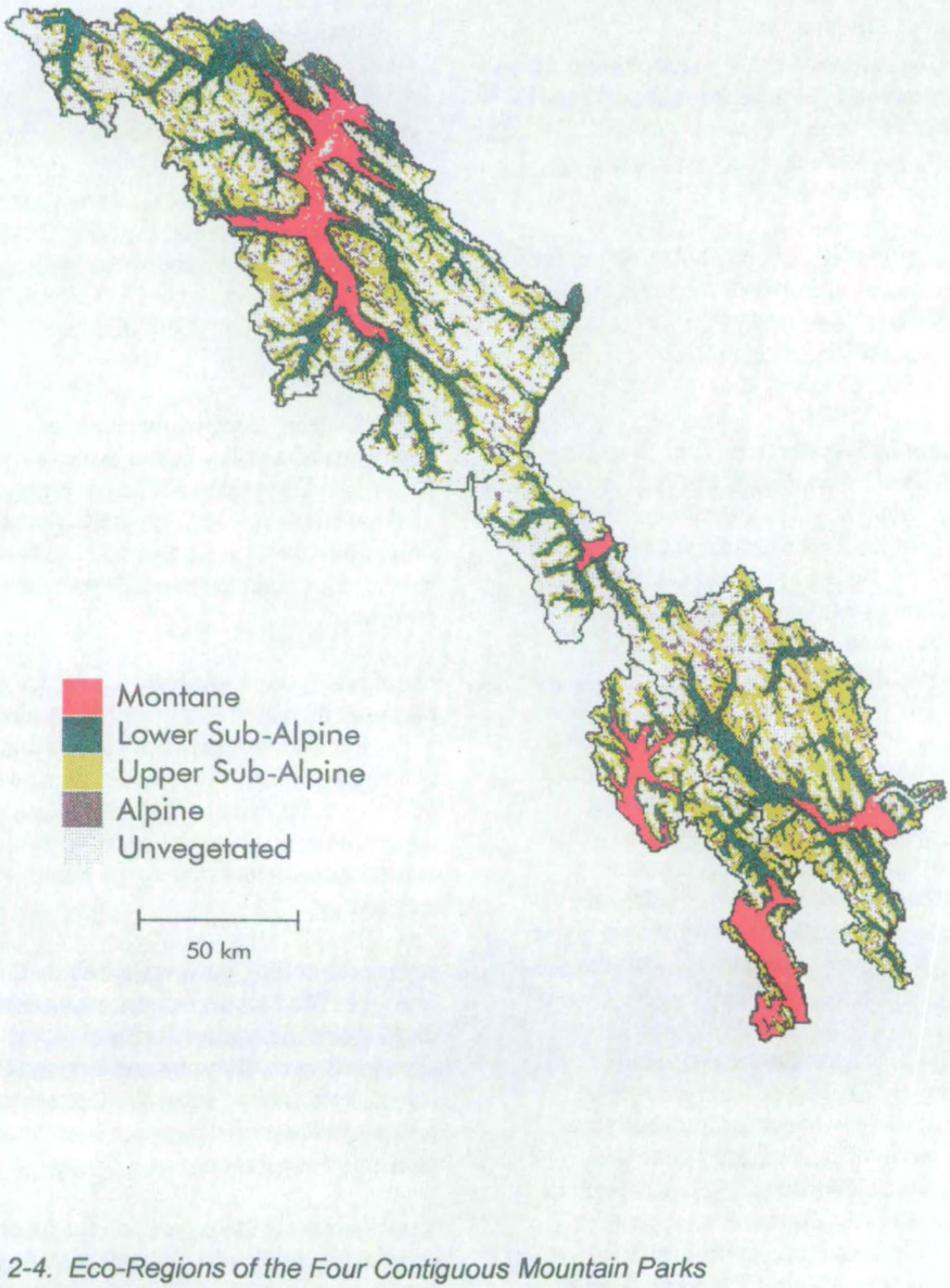

Figure 2-4. Eco-Regions of the Four Contiguous Mountain Parks

Fire reduces tree disease and insect populations, converts dead organic matter into useful soil nutrients, and exposes mineral soil to allow pioneer species to germinate.

In addition, wildlife habitat and food sources are rejuvenated by fire. The mosaic of stand ages of varied composition and structure essential to wildlife diversity are created primarily by wildfire.

Prevailing theories currently hold that the fire-dependent species in North America developed over the last 10,000 years through the widespread influence of Native burning practices (MacCleery, 1994).

Significant U.S. research on fire use by the American Indian concludes that Native peoples everywhere in the Americas set fire to hundreds of millions of hectares on a regular basis to improve game habitat, facilitate travel, reduce insect pests, enhance conditions for berries, and control undergrowth (MacCleery, 1994; Pyne, 1995).

Natives typically set fires in spring or late fall, when burning was not severe, to modify lands for the production of plants or to create grazing areas for game. According to many fire historians, Native burning produced a higher frequency of low-intensity fires and structured entire ecosystems for thousands of years before Europeans arrived in North America.

Parks Canada researchers are currently collecting evidence to confirm the role of aboriginal burning in prehistoric vegetation regimes in Banff, Jasper, and Kootenay National Parks (Walker, 1995). Research to date suggests that the montane vegetation mosaic within mountain parks is primarily a result of historic aboriginal burning (Barrett, in press; Kay and White, 1995).

In conclusion, significant evidence suggests that the observed changes in biodiversity and accumulation of combustible vegetation is related to the decline in the number and extent of wildfire events.

Wildfire Prevention and Suppression

A number of forest ecologists have concluded that success in fire prevention and fighting has contributed to the decline in biodiversity in the Northern Rocky Mountains (Duchesne, 1994; Kay, 1995; Risbrudt, 1995; Tande, 1979; Van Wagner, 1995).

For more than 75 years, the mountain parks have pursued a policy of fire exclusion. Records indicate that with few exceptions, this goal has been achieved. Over 90 percent of all fires within the mountain parks have been suppressed within the first 24 hours of being reported.

During this period, the level of wildfire detection increased enormously in direct correlation to the number of visitors and park overflights. Most parks have maintained effective fire prevention campaigns and deployed highly efficient and mobile fire control forces supported by the latest technology.

Some researchers, however, attribute the change of fire regime, current ecosystem decline, and fuel accumulation to global climate changes. Johnson and Larsen (1991), for example, maintain that fire regimes are driven by climate and have not been altered by human fire suppression.

Van Wagner (1995) argues, on the other hand, that the recent decades of nearly fire-free conditions can hardly be explained by weather changes because there is no evidence that weather during the recent decades has been so cool and wet as to prevent burning. Kay (1995) specifically points to the elimination of native burning and rejects the notion of climatic factors.

1994 Fire Statistics for the Mountain Parks

Total Number Wildfires	**86**
Caused by Lightning	65
Caused by Humans	21
Five Largest Fires	**149 ha**
Kootenay NP, Shoebox Fire	100 ha
Glacier NP, Casualty Creek Fire	26 ha
Waterton NP, Rock Fire	11 ha
Glacier NP, Mountain Creek Fire	6 ha
Waterton NP, Avian Ridge Fire	6 ha
Remaining Fires (81)	**17 ha**
All Controlled upon Initial Attack	

Theories of significant aboriginal burning that resulted in fire-dependent ecosystems are not unique to the Canadian Rockies. Many other research studies throughout North America and around the world conclude that declining biodiversity and fuel accumulation are likely due to the absence of fire in an aboriginal regime that depends on it (Duchesne, 1994). None of these studies have attributed their observations to climate, even in part.

In conclusion, it seems reasonable to assume that humans have shaped the ecosystems of the Rocky Mountains through the use of fire over the last 10,000 years. Within the last several decades, it appears that fire suppression and prevention are chiefly responsible for the observed changes in biodiversity and the buildup of fuels. The latter two conditions have significant bearing on fire-related risks and risk management over the short and long terms.

2.3 The Likely Future

Given the current observations and contributing factors, we can speculate on probable consequences if trends continue unchecked. In essence, these are the risks of continuing a practice that excludes wildfire from the mountain park landscapes.

Decline in Ecosystem Health

Several researchers propose the following consequences of the current course of vegetation management within Banff National Park (Duchesne, 1994; Kay, 1995; Risbrudt, 1995; Tande, 1979; Van Wagner, 1995):

1. Biodiversity will continue to decline as vegetation communities age and replace grasslands in the absence of frequent low-intensity fires.

2. Open areas and early successional species such as aspen will eventually be eliminated from most valleys.

Aspen support an array of species. If aspen stands are lost, many bird and small mammals will decline, some rapidly.

In addition, the potential for epidemic of forest insects and disease will increase. Many researchers have documented that fire helps control the amount of disease and insect infestation (Washington State, 1994).

Large, Intense Wildfires

The observed changes in park vegetation have disturbing implications for future wildfires within the mountain parks. Present and future fuel conditions within forested communities suggest wildfires will be more extensive, hotter, and more difficult to control.

Large, hot wildfires present three primary challenges:

1. Extensive Tree Mortality
2. Large Scale Ecosystem Damage
3. Difficulty in Control

Each of these concerns is discussed in the paragraphs that follow.

Extensive Tree Mortality

In the montane eco-region, where recent fire has affected a vegetation community, grass and shrubs in the understorey tend to burn at relatively low intensities without killing the overstorey trees.

Overgrown montane forests, however, with large trees and layers of small and intermediate trees in the understorey, burn intensely due to the accumulation of fine fuels, such as small diameter branches and shrubs. "Ladder fuels" allow ground fire to climb to the tree crown, where leaves are completely consumed and trees are destroyed (Risbrudt, 1995).

These crown wildfires present dire consequences for old growth forests. The 1992 Foothills Fire in Boise National Forest, for example, claimed the largest ponderosa pine in Idaho, a tree that had survived dozens of fires over centuries (Knudsen, 1994).

Large Scale Ecosystem Damage

Continuous fuels both vertically and horizontally can lead to extensive burned areas. Whereas breaks in the vegetation continuity can lead to small patches where total destruction takes place, aged communities have lost these natural fire breaks.

Large fires could delay natural regeneration from 2 - 4 years to 15 - 25 years. This also greatly enhances the opportunity for erosion, and significant damage to the ecosystem. In addition, the larger the burned patches, the more difficult to reseed.

Intensely hot wildfires do much more damage than low-intensity burns over the same area. The presence of heavier ground fuel loads (downed wood and duff layers) often leads to fires of longer duration, driving heat deeper into the soil and increasing damage to soil and root systems.

Hot fires volatilize nitrogen, remove nutrients, and kill the necessary fungi material in the soil that supports nutrient for tree roots (Heilpern, 1996). The 1992 Foothills Fire in Boise National Forest burned so intensely that even mats of lichen covering canyon rocks burned. The destroyed area was reseeded but, for reasons still unknown, the seedlings failed to grow. Much of the area remains barren and vulnerable to erosion today (Knudsen, 1994).

Intense fires tend to seal the soil and make it impermeable to rainwater (Stevens, 1994). In parts of Idaho during 1994, wildfire burned so hot that an impermeable wax-like layer formed on the surface of the forest floor. Because water could not penetrate, topsoil that took 1,500 years to accumulate blew away in days (Knudsen, 1994).

Similar effects have been observed elsewhere, such as the 1989 Tanner Gulch Fire in Oregon, and the 1992 Cleveland Fire east of Placerville, California.

The resulting heavy runoff may induce major erosion and permanently scar an area (Risbrudt, 1995). After the intensely hot Rabbit Creek Fire in Idaho in 1994, rivers draining the affected basin ran black with ash and soot for days, and deltas of mud formed in low-lying areas (Knudsen, 1994).

Intense wildfire in 1994 on Idaho's Rattlesnake Mountain created a "moonscape," according to John Thornton, a hydrologist for the Boise National Forest. Across more than 100 hectares, nothing grew even months after the fire, not even grass or brush. Hundreds and perhaps thousands of fish died, and creeks remained buried in mud (Knudsen, 1994).

Mountain park fire histories show that frequent low-intensity fires were the norm in montane areas, while large-scale high-intensity crown fires were rare (Kay, 1994; Rougeau and Gilbride, 1994; Tymstra, 1991; Van Wagner, 1995). Most fires within Jasper National Park, for example, between 1665 and 1913 were low to medium intensity, although some fires of higher intensity did occur (Tande, 1979).

More Difficult to Control

According to Kourtz, wildfires in Canada number about 9,500 annually and burn approximately one million hectares. About 95 percent of these fires are confined to 40 ha or less. The remaining 5 percent are large, uncontrolled fire events, responsible for 95 percent of the total burned area.

High temperature fires, especially in combination with significant wind speeds, are more difficult to control than low intensity wildfires. Many factors affect controllability of a fire:

- Fuel load
- Distribution of fine fuels
- Presence and extent of heavy timber
- Humidity
- Wind speed
- Access
- Terrain
- Rapid action
- Suppression resources

Some wildfires simply cannot be controlled, regardless of the resources available or experience of fire suppression crews. Under drought conditions, once a fire reaches a certain size and complexity, no amount of resources will contain it (Bate, 1993).

Even the use of aircraft to drop water and fire retardant can prove ineffective in intense fires. Aircraft are typically used to lay a retardant guard, support a guard constructed by ground crews, or to cool isolated hot spots. Air tankers and helicopters are ineffective in directly attacking large intense wildfires, especially when wind leads to fire spotting hundreds of metres beyond a fire front (B.C. Forest Service, 1995). In addition, aircraft are limited by steep mountain terrain and weather conditions that may endanger crew members.

Some fire managers advise that successful fire suppression of the past six decades has created hazards that increasingly exceed the capability of any response effort (U.S. Dept. of Agriculture, 1993). Researchers have consistently concluded that long term suppression of wildfires creates conditions that make occasional catastrophic conflagrations inevitable (Sierra Club, 1996; Medd, 1993).

Others note the direct relationship between fuel accumulation and fire intensity. Dr. Dennis H. Knight, Ecologist at the University of Wyoming at Laramie states the principle clearly, "The longer you let fuels accumulate, the worse the (future) fire is going to be and the higher the probability a fire will start and burn out of control" (Stevens, 1994).

Evidence of this concern is available through observation of the area burned each year in locations adjacent to the mountain parks.

Figure 2-5, for example, illustrates the long-term trends in the annual extent of wildfire within three jurisdictions: Alberta, Canada, and Western United States. Linear regressions are indicated for the Canadian and U.S. figures, with maximum and minimum trendlines to identify the extreme range of incidents. (Figure 2-5a is adapted from unpublished information provided by Dr. Peter Murphy, Fire Historian in Edmonton, Alberta. Figures 2-5b and c are adapted from Auclair and Carter, 1993; shading is ours.)

All three graphs highlight the declining trend in area burned since 1920 until about 1975. These jurisdictions also report a significant increase in burned area beginning around 1976 and continuing today.

The fact that the jump in area burned can be demonstrated for many jurisdictions within North America suggests they share some common factors. Fire agencies link these observations to highly unpredictable and uncontrollable wildfires.

A number of recent catastrophic events lend credence to forecasts of large and intense wildfires in the mountain parks.

Following decades of active fire exclusion, North American agencies have encountered many fires of intensities that exceed the natural range of variation and produce extraordinary problems of control and post fire environmental effects (Risbrudt, 1995).

U.S. firefighters have failed to gain control of some very large fires in the last few years, such as the Eastern Washington firestorms in 1991 that burned 15,000 hectares, damaged 114 homes and 40 buildings, and killed several people (Washington State, 1994).

Since 1986, more than one-fourth of the Boise National Forest has been destroyed by fire, accounting for more than 220,000 ha (Knudsen, 1994). In Montana's Flathead National Forest, forest officers experienced fire behaviour in 1994 that was far more intense than expected, partly due to the accumulation of fuels (Bunnell, 1994). Oregon's Blue Mountains have sustained severe wildfires associated with six years of drought conditions that began in 1987 (O'Laughlin, 1993).

British Columbia, Alberta, Manitoba, Idaho, Montana, and other Rocky Mountain jurisdictions have all recorded similar losses and for similar reasons.

After reviewing the evidence, we conclude that forest fuels have accumulated within the mountain parks to significant volumes over time. Current fuel loads and the abundance of fine vegetation indicate catastrophic fire is not only possible, it seems likely. The principal ingredients required for a large, hot fire are evident for most parks.

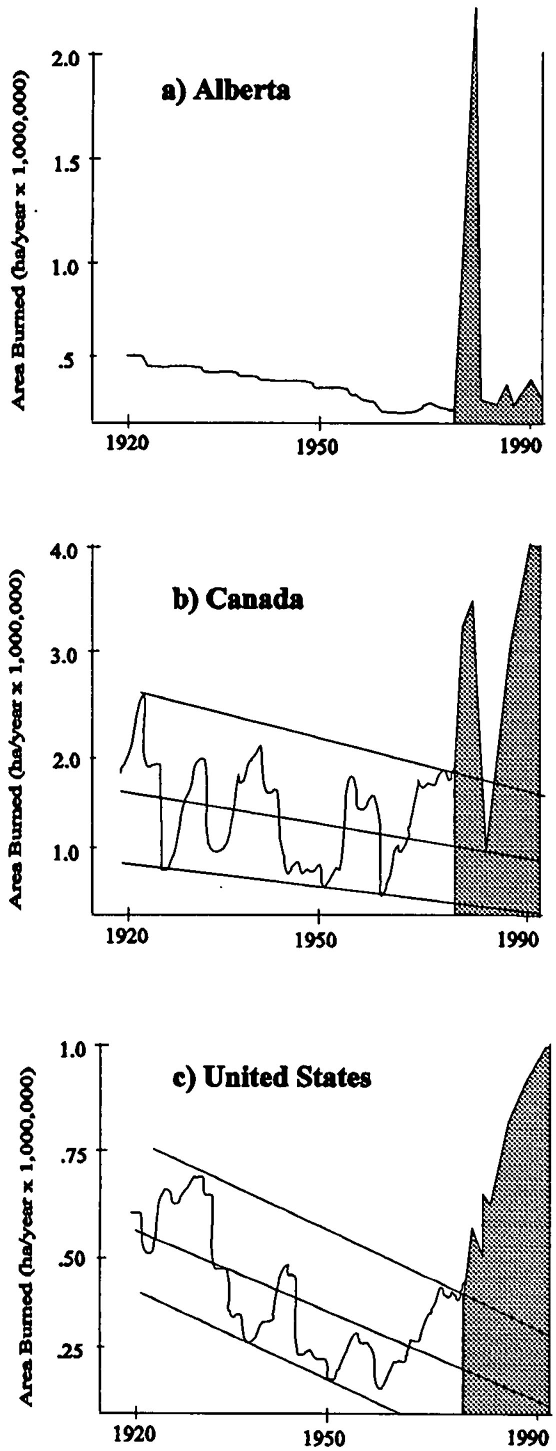

Figure 2-5. Yearly Area Burned for Alberta, Canada and U.S.

These ingredients include:

- *Fuel*. The current condition of forested areas within the boundaries of most parks represents high hazard levels of mature wood, marked by fine fuels and heavy timber. Vegetated patches have grown together throughout much of the landscape, providing large continuous areas with few breaks. This means greatly decreased opportunities for fire suppression.

- *Weather*. Short periods of extremely dry weather occur regularly throughout the mountain parks, bringing dangerous dry and windy conditions virtually every year. These conditions are favourable to fast moving fires, with size dependent upon the length of time they prevail. Large fires are obviously related to long sequences of days without appreciable precipitation. In Jasper, long sequences without rain are much more frequent in the spring and fall than in the summer. The number of consecutive rain-free days is highest in late April, May, and early October.

- *Ignition Sources*. Both natural and human-initiated events are known to cause fires among the mountain parks. Lightning occurs less frequently in some locations, such as Jasper and Banff National Parks. But the accessibility of most parks, particularly the heavily forested montane regions of the valleys, suggests that human ignition sources pose a significant threat.

Infrastructure Damage

In addition to the risk of significant harm to the natural environment from intense fires, severe damage could be inflicted on park infrastructure, buildings, campgrounds, roadways, and populated areas. Intense wildfires can also result in loss to cultural landscapes, such as historic buildings and archaeological sites. Parks should expect to lose vegetation and soil layers that protect and insulate some buried sites.

Expansion of concessionaire operations and park facilities over the last few decades has introduced more people and property to the chance of wildfire damage. Such attributes are typically located in the valleys, within the montane zones where biomass is accumulating at alarming rates. These areas are the most likely to experience catastrophic fire.

Increases in risk exposure from wildfire are evident in many areas of the mountain parks, such as Banff, Jasper, Field, Lake Louise, Waterton, and numerous roadside tourism operations.

The Town of Banff, for example, houses about 7,000 permanent residents and hosts more than 1 million visitors during the wildfire season (Arbor, 1991). Fire management wardens within the mountain parks have identified approximately 60 sites that pose a wildland / urban interface risk. These sites will be assessed and ranked by risk in the next year or two, according to current plans.

In summary, the seven mountain national parks are currently suffering declining biodiversity, aging vegetation, overgrowth, and increasing fuel loads. It seems clear these observations are linked to the documented decline in area burned by wildfire over the last several decades. This conclusion has at least been confirmed by dozens of studies conducted by other land management agencies in North America.

Although there is some debate, the decline in burned area seems attributable to changes in Native burning practices, and the parks' own fire prevention and suppression programs.

Given the ample experience of other jurisdictions, the current situation with the mountain parks indicates severe consequences for the natural environment. Even without catastrophic fire, the parks will likely experience decreasing forest health, severe reduction in wildlife habitat, infestations by insects and disease, at least within the montane eco-regions. Adding the risk of catastrophic fire only means effects of greater severity, not only to the natural environment, but to park infrastructure, concessionaires, and members of the visiting public.

The Wildland/Urban Interface

The interface is a line, area, or zone where combustible structures and other human development meets or inter-mingles with undeveloped wildland or vegetative fuels (BCFS Manual, 1996).

Wildland / urban interface fires are a worldwide problem that have likely caused destruction since early times. Interface fires have been reported on every continent, according to the U.S. Foreign Disaster Assistance Agency. The urgency of the problem has been brought to the forefront in the last few decades due to an ever expanding population and a tendency towards suburban and rural lifestyles. The scope of the interface fire problem first reached national attention in the U.S. in 1985 when wildland fires across the country damaged or destroyed 1,400 homes.

Section 3.0 - Management Alternatives

A wide range of options are available for managing the threats of biodiversity decline and catastrophic fire. The following primary risk control actions are contemplated by the Regional Policy Committee as part of a vegetation management program:

Risk Control Actions

1. Fire Suppression
2. Mechanical Fuel Reduction
3. Prescribed Burning

These activities are contemplated by Directive 2.4.4 of August 1986 and recommended by the 1989 report "Keepers of the Flame" in the overall Parks Canada strategy for implementation of the fire management program. Each of three risk control actions is examined in this section, with a discussion of the benefits and limitations of each tactic.

3.1 Fire Suppression

Fire suppression attempts to prevent the spread of wildfire as soon as possible, in order to minimize fire damage to vegetation, property, and lives. Fire suppression activities are supported by the once-popular notion that all fires are destructive and must be halted. Fire suppression has essentially been the goal of most fire control agencies throughout Canada and the U.S. during the 20th Century, including Parks Canada and the mountain parks.

The mountain national parks are currently able to provide initial attack action on fires within their boundaries. Interagency agreements and several memoranda of understanding with other agencies, such as the B.C. Forest Service and the Alberta Land and Forest Service allow for additional support when required.

Suppression personnel within the Mountain District include five initial attack crews, three helicopter-dispatched rappel trained crews, and two hover-exit crews. Additional trained crews may be available through park staff.

Incident command facilities are located within the Western Fire Management Centre in Calgary. A network of park weather stations provide daily fire weather reports to assist in suppression activities.

Costs for fire suppression activities range from $1,000 to $10,000 per hectare.

Parks Canada does not retain medium helicopters or water bombing fixed wing aircraft on standing contracts for fire suppression. Rather, Parks Canada periodically obtains the services of light to medium helicopters on short term contracts when weather dictates that an additional level of preparedness is required. Costs range from about $5,000 per hour for medium helicopters to more that $10,000 for a single drop from a large aircraft, given a one-hour flight time.

Parks Canada calls upon other agencies with aircraft capabilities through mutual aid agreements. The number of aircraft in Canada is limited due to the high costs of operation and maintenance. Most aircraft move throughout the country to maximize their use.

Response to emergency requests for large capacity aircraft is governed by a number of factors: Base location, readiness status of aircraft, and a balance of priorities if other fires call for aircraft resources. None of these factors is within control of Parks Canada.

Limited experience has shown that a two-to-three hour response time for Alberta provincial water bombers can be expected due to their requirements to position aircraft for timber protection. Shorter response times are the general rule for British Columbia, also due to the proximity of adjacent timber resources.

There are clear limitations to the effectiveness of large aircraft in relation to fire intensity and inability to manoeuvre in steep mountain terrain. For this reason, they are used primarily for initial attack on vigourous surface fires or the initial stages of crown fires that exceed the capability of ground fire crews, but remain small in size (i.e., when fire intensity measures less than 5,000 kW/meter. On more intense fires, heavy aircraft are used to support indirect attack or holding actions until a favourable weather change occurs. Aircraft are not effective on wildfires with intensities greater than about 10,000 kW/meter. Virtually all crown fires fall into this category.

3.2 Mechanical Fuel Reduction

Mechanical fuel reduction refers to the removal, reduction or replacement of potentially hazardous forest fuels by means other than fire. Methods can include:

- Thinning, pruning, or spacing of trees and branches
- Removal of undergrowth or surface fuels
- Replacement of flammable vegetation with more fire-resistant species.

Removing flammable fuels reduces the biomass energy per unit area, therefore reducing the intensity of fires occurring in these areas. In addition to limiting heat generated by a fire, mechanical fuel reduction restricts fire to ground cover rather than the crowns of trees, and improves the ability to control fires.

Mechanical fuel reduction is particularly appropriate for immediate areas surrounding park and private facilities. Reducing fuel in this context creates a defensible space that affords better protection to facilities and provide firefighters with a better opportunity to control fires.

Mechanical fuel reduction in these areas reduces the risk of wildland / urban interface fires and can be used in conjunction with other fuel reduction methods, such as prescribed burning.

Banff National Park currently performs some selective thinning where 50 percent or more of the smallest live standing trees are removed in addition to most of the dead wood present on the forest floor.

Most of the trees removed at Banff are not merchantable timber and are therefore provided to campgrounds as firewood.

Mechanical fuel reduction presents little risk to park visitors, residents, and structures. The practice presents several limitations, however, that make it an inappropriate strategy for large scale use.

First, programs of mechanical thinning are time consuming and costly. It typically costs from $3,000 to $8,000 per hectare to perform mechanical thinning. These costs cannot be fully recovered through timber sales. Where prescribed fire can treat hundreds of hectares in a matter of days, mechanical fuel reduction may take months to benefit the same area.

Second, mechanical fuel reduction provides none of the ecological benefits associated with fire. While logging removes wood, trees burned during a fire provide biomass and nutrients to the regenerating forest. Stumps left behind during logging may increase the danger of root rot. Logging removes mature trees that could become homes for wildlife or act as nurse logs.

Logging for hazard reduction represents another form of mechanical fuel reduction. Such practices, however, typically require the construction of roads, cat trails, and sorting areas that may damage or alter park ecosystems. These activities may not be consistent with Parks Canada's mandate. Furthermore, large clear cuts are not required for effective hazard reduction.

3.3 Prescribed Burning

Prescribed fire is defined in Directive 2.4.4 as:

> *A random or planned ignition fire contributing to the attainment of the management objectives of a park by adhering to predetermined criteria and prescriptions defined in detail in a resource management plan.*

Three categories of prescribed burns are discussed in this section:

1. Prescribed Lightning Burns

2. Prescribed Burns for Fuel Reduction

3. Prescribed Burns for Ecological Benefit

The common feature of all three types of burns is that they are carried out only under "prescription," referring to the conditions under which a burn is implemented. Fire managers consider a range of ecological, social, safety, and economic factors in determining prescribed fire zones and prescription conditions.

Prescribed burn programs have garnered much support from fire management agencies in recent years. Virtually all U.S. states and Canadian provinces are engaged in some prescribed burn programs.

Practitioners and Organizations that Actively Support Prescribed Burn Programs

- Alberta Lands and Forest Service
- Blood Indian Reserve
- British Columbia Ministry of Forests
- Calif. Dept. of Forestry and Fire Protection
- Canadian Forest Service
- Ecological Society of America
- Florida Dept. of Environmental Protection
- Florida Division of Forestry
- Florida Game and Fresh Water Fish Comm.
- Florida Water Management District
- Government of the Northwest Territories
- Montana Fish, Wildlife and Parks
- North Florida Prescribed Fire Council
- Ontario Ministry of Natural Resources
- Oregon Department of Forestry
- Rocky Mountain Elk Foundation
- Sierra Club
- Tall Timbers Research Station
- The Nature Conservancy
- U.S. Council on Environmental Quality
- U.S. Forest Service
- U.S. National Comm. on Wildfire Disasters
- U.S. National Weather Service
- U.S. Bureau of Indian Affairs
- U.S. Bureau of Land Management
- U.S. National Biological Service
- U.S. National Park Service
- U.S. Environmental Protection Agency
- U.S. Federal Emergency Management Agency
- U.S. Fire Administration
- U.S. Fish and Wildlife Service
- U.S. Forest Service
- U.S. National Wildlife Refuge
- Univ. of Alberta Range Sciences Department
- Washington State Dept. of Community Dvlp.
- Washington State Dept. of Natural Resources

Prescribed Lightning Burns

Prescribed lightning burns use a natural fire ignition to assist in maintaining biodiversity and ecosystem health. In the practice known also as random prescribed burns or natural burns, lightning-ignited fires are allowed to burn in designated areas, under certain prescribed conditions, while being closely monitored. Fires that do not meet prescription or occur in areas requiring protection are immediately suppressed.

Prescribed lightning burns may meet some park objectives in areas that would otherwise be expensive to carry out a planned ignition.

There are several disadvantages, however, with relying upon lightning-induced fires to maintain ecosystem health. Lightning-caused fires alone cannot be relied upon to reintroduce fire to Jasper ecosystems because they may be infrequent and only occur in certain locations (Heathcott, 1995).

A study of lightning-induced fires in Jasper National Park from 1929 to 1994 revealed that lightning fires accounted for only 18 percent of total fire starts. Lightning fires predominated in the summer months, from mid-June to early September, and rarely occurred outside the main drainage of the Athabasca Valley.

Banff experiences similar lightning conditions. However, lightning strikes in other parks, such as Kootenay, may be more prevalent.

Reliance on lightning-induced starts also fails to account for the possible role of native fire starts in shaping ecosystems. These native burns were often set in the spring or fall, resulting in lower intensity fires than those induced by lightning, often in the summer months.

High costs usually accompany the requirement for lengthy on-site monitoring and periods of resource commitment for fires that burn over a period of weeks or months. In addition, the period of exposure to risk is significant.

Prescribed Burns for Fuel Reduction

Wildfire intensity is directly related to available fine fuels. Reducing fuel amounts with a prescribed burn can reduce the likelihood of a disastrous wildfire.

The State of Florida is widely considered to have made prescribed burning a sophisticated and systematic science (Stevens, 1994). Studies of the long-term effects of prescribed burns in Florida indicate that a sustained program:

1. Reduces the average area burned per wildfire
2. Ameliorates the adverse effects of wildfire, principally burn intensity
3. Does not eliminate the threat of wildfire

Fire managers on one prescribed burn in Oregon reported that pre-burn fuel loads averaged 235 tonnes per hectare, including duff, logs, and branches. After the burn, the fuel load was estimated at 65 tonnes per hectare (Heilpern, 1996).

As early as 1978, California established a public code recognizing that prescribed burns "serve a public purpose and will benefit all the citizens of the State" (Calif., 1978). The California Act also recognizes that controlled burning of wildland fuels reduces the volume and continuity of such fuels and helps prevent high-intensity wildland fires (Calif., 1978).

Lessons from the Yellowstone Fires of 1988

A total of 248 separate fires devastated the Greater Yellowstone National Park Area in a 1988 fire season that was characterized by extreme fire behaviour and huge costs for fire suppression. Approximately one-fifth of these ignitions were natural lightning-caused ignitions.

Fire Management policy in the United States National Parks dictated that lightning caused ignitions could be allowed to burn under defined conditions in areas where the management objective was to maintain ecosystems unaffected by human influences and manipulation. Fires exceeding prescription due to changing weather conditions, movement into land not included in a fire management zone, or threatening life or property were to be suppressed.

A Fire Management Policy Review Team was formed subsequent to the fire season in response to public outcry and concerns among natural resource managers. It was found that the Yellowstone National Park fire management plan and actions were deficient in several respects:

- The plan contained no criteria or prescriptions under which fires were allowed to burn as a prescribed fire or when they should be re-classed as a wildfire and actioned accordingly
- No fuel management was performed in and around structures in wildland/urban areas
- No criteria were established to evaluate social and economic effects inside or outside park boundaries when determining whether a fire should be allowed to burn
- Information disseminated to the public was inadequate

In conclusion, the Review Team found that the fire policy allowing prescribed lightning burns was sound, but implementation in fire management plans at individual parks was not uniform or always acceptable.

(Source: Wakimoto, 1993)

Prescribed burns are used by the County of Los Angeles Fire Department where fuel accumulations threaten buildings. Since 1983, eleven major fires have occurred in areas under advanced fire prevention and planning. Fire officers report that, "These wildfires were stopped dead where (prescribed) burns had been completed" (Franklin, 1988).

An example of the fire intensity-reduction potential of prescribed burns was provided by a 1992 fire near Boise, Idaho. The Sampson Commission, struck following the fire, reported that the wildfire raced out of control, killing all vegetation, scorching and solidifying soil and obliterating entire wildlife populations. When the fire encountered a stand of ponderosa pine that had been thinned two years earlier and subjected to a prescribed ground fire to reduce fuels, the wildfire slowed and immediately allowed firefighters to move in and halt its advance (Stevens, 1994).

Prescribed burning offers economical advantages over straight fire suppression, as well. The U.S. Forest Service determined the economic benefits of prescribed burning in terms of suppression costs and damage in a review of wildfire statistics on federal land in the Southern U.S. in 1985. The Forest Service determined that $2.14 US were saved in suppression and damage costs for each dollar spent in fuels management (Florida Division of Forestry, 1996).

Extensive areas need not be treated to obtain the benefits of prescribed burns. Rather, prescribed burning can be used in conjunction with other tactics and tools to reduce wildfire risks. Prescribed burning for fuel reduction may be especially useful at park boundary areas to create "anchors." These anchors can guard against catastrophic fires spreading from or to park neighbours. Anchors are also valuable in containing future prescribed fires.

Prescribed Burns for Ecological Benefit

Jurisdictions where large-scale prescribed burning has occurred, notably in the Southeastern U.S. since the 1930's, have reported ecological health problems that are much less extensive when compared with those nationally (U.S. Dept. of Agriculture, 1993). In addition, ecological burns contribute to landscape variability and biodiversity while providing fuel reduction benefits as discussed above.

Scheduled prescribed burns provide the ecological benefits of fire, while allowing managers to choose the time, location, and fuel moisture conditions. Combined with the opportunity to arrange fire control resources in advance, these features allow burns to be substantially complete within 24 to 48 hours, therefore minimizing costs and risks.

Some researchers, such as E. Johnson at the University of Calgary, dispute the use of prescribed fire for ecological and fuel reduction purposes within the Rocky Mountain parks. An examination of their arguments is discussed fully in the scientific paper accompanying the Draft Vegetation Management Strategy.

Prescribed Burn Risk Controls

Two principal risks associated with prescribed burns include the generation of smoke and the chance that a burn will escape prescribed boundaries. A wealth of experience with prescribed burns among North American fire managers has lead to many techniques that control these risks.

Figure 3-1 illustrates the variety of risk control measures that are typically used to enhance the safety of a prescribed burn.

Potential Hazard	Risk Controls for Prescribed Burns
Fire may escape boundaries.	Predetermine ignition plans and holding strategies. Assign adequate personnel and equipment. Put contingency plans into place. Identify burn boundaries with barriers to fire spread, such as ridges, rivers, roadways, and past prescribed burn areas. Construct fire guards by hand where natural breaks are absent. In addition, widen hand guards through limited burns (blacklining).
Fire intensity may exceed spread rate predictions and ability to control.	Gain a thorough understanding of the vegetation in the burn area, including calculation of tonnes per hectare for ground fuels, surface fuels, and crown fuels. Detail the weather conditions that must occur for the burn to proceed, identifying such factors as season, number of days since rain, temperature, relative humidity, wind speed and direction, and weather forecasts. Burn when some moisture remains in the smaller combustible material like tree branches and small logs. Do not ignite if conditions are not met. Begin all prescribed burns with test burning to verify the forecasted rates of spread and other operational parameters.
Burn area may rekindle following departure of fire crews.	Follow each burn with mop up and monitoring until all hot spots are cold or area experiences rain or snow. Provide daily patrols by qualified crews until there is no threat of escape from boundaries.
Smoke may seriously impact adjacent activities or communities.	Conduct burns when forecasted winds will carry smoke away from sensitive areas, such as townsites. Spring time burns are preferred in some areas where night time weather inversions are less likely. Ignition can be halted or delayed if smoke becomes a problem. Time ignition pattern to induce convective drafts as a means of drawing fire upslope and away from nearby values.
Weather may change unexpectedly and can lead to adverse fire behaviour.	Establish a remote weather station at the site at least two week prior to the burn. Conduct a temperature profile by helicopter prior to ignition on burn day. Specialized weather forecasts are received as required. Place fire behaviour observers on site.
Visitors, guides, and concessionaires may be present in the burn area.	Close entire burn area to public on the day prior to the burn and until conditions are safe. Conduct pre-burn sweeps and patrols to ensure that no one is within the unit boundary.
Escaped fire may quickly overcome limited burn crew capabilities.	Backup all operations with hoseline, tanker trucks, neighbouring fire department equipment, pumps, water sources, radio communications, helicopter services, and first aid facilities. Select burn units for availability of second and third lines of defense (natural topography). Place trained staff on standby for response to escaped fire, including a regional overhead team. Have holding teams in place at the unit in case of fire escape.
Members of the public or media may not appreciate the benefits of prescribed burn programs.	Handle all pre- and post-fire press releases through executive. Keep other agencies informed. Initiate public consultation, communications, and collaboration programs. Prepare and distribute formal media releases, advertisements and roadway signs.
Unexpected fire behaviour may endanger fire crews.	Identify escape routes and procedures for all personnel, including backup plans. Prohibit personnel in steep slopes where rolling debris and rocks are possible. Conduct a pre-burn safety briefing for all personnel. Create a contingency plan for escaped fire, including provisions for excessive smoke.

Figure 3-1. Risk Control Measures for Prescribed Burns

All aspects of the prescribed burn are addressed throughout the preparation of a detailed prescribed burn plan. A typical burn plan includes such information as:

- Predicted Fire Behaviour
- Weather Prescription
- Smoke Management Considerations
- Preburn Preparations (including tree felling, handline construction)
- Public Closures
- Mop up Requirements
- Fire Crew Safety
- Escaped Fire Contingency Plan
- Public Information

Common measures to manage smoke generated by prescribed burns include (B.C. Ministry of Forests, 1990):

- Maximize combustion efficiency
- Ensure mop-up to reduce residence time and smouldering
- Burn only when winds will carry smoke away from sensitive areas
- Work with adjacent land managers

Mountain Parks Prescribed Burning

Controlled burning has been practiced in the mountain national parks since the 1970s. Figure 3-2 illustrates the hectares burned to date through the use of prescribed fire within the mountain parks.

Jasper has performed approximately ten prescribed burns since 1977. The prescribed burning program in Banff began in 1983 and has replaced an estimated one-third of the expected area burned over the period of the program. In addition, Waterton has performed some prescribed burns since 1987.

Elk Island has been involved in active fire restoration for almost 20 years. Over this period fire has been applied to more than 40 percent of the park. Statistics for Elk Island have been included to offer a broader picture of the prescribed burn program within the Alberta Region.

Burns have gradually grown in size and complexity as staff have gained experience.

	Banff (1983)	Jasper (1977)	Kootenay	Elk Island (1978)	Waterton Lakes (1994)	Yoho	Rev-Glacier	Total
Prescribed Burns (ha)	7,686	2,000	0	4,000	399	0	0	14,085
Deviations within Prescription	55	0	0	15	0	0	0	70
Escapes (ha)	0	3	0	5	0	0	0	8
Wildfires (ha)	0	64	481	0	17	69	352	983

Figure 3-2. Prescribed Fire in the Mountain Parks

Lightning prescribed burns have not been attempted recently, however. Suitable conditions to allow free burning of a lightning prescribed fire have not occurred in the past three years.

Burn plans prepared by mountain park fire managers are reviewed by the Regional Fire Management Officer and a District Fire Command Team. The Fire Command Team may then be placed on the prescribed fire as an added risk control measure.

In planning for prescribed fires, burn officers establish several logical lines of defence in case the first intended boundary is breached. Burns that exceed the first boundary are considered "allowable deviations" and are anticipated in the burn plan. Excursions or allowable deviations are inevitable and, at worst, lead to fire control expenses. "Escapes" are those burns that exceed the outermost lines of defence.

Within the mountain parks to date, fire managers have conducted prescribed burns on 14,025 hectares. Allowable deviations have involved 70 hectares, for a deviation rate of 0.5 percent. The largest deviation burned 30 hectares beyond the initial boundaries.

Escapes have totalled 8 hectares, for an escape rate of 0.02 percent. To compare, California reports an average escape rate of 0.5 percent, (Knudsen, 1994). No structural or facility losses have occurred from escaped burns.

The 1991 Mt. Norquay prescribed burn near the Town of Banff was one of the more visible programmed burns within the Mountain District. Members of the public expressed concern due to the visibility of the burn and the amount of smoke produced. The fire did not, however, exceed its prescribed boundaries. A review of the burn, involving other fire management agencies, supported the fire management approach at Banff.

Figure 3-3 summarizes the relative costs of the three risk control options within the mountain parks.

Comparative Costs of Risk Control Actions (1987 to 1994)

	Prescribed Burning	Fire Suppression	Mechanical Fuel Reduction
Area (ha)	7,460	650	43
Cost ($)	585,000	660,000	202,000
Range ($/ha)	18 - 625	500 - 10,000	2,700 - 7,700
$/ha	78	1,000	4,700

Figure 3-3. Costs of Risk Control Actions

Prescribed fire costs in Banff have averaged $200 per hectare (1996 dollars). Burn costs including these extra suppression costs were $31,000 or $172 per hectare based on a total burn size of 180 ha.

Other options for fuel reduction are under review throughout the fire management community. U.S. specialists recently examined logging techniques that mimic fire where prescribed burns may be too risky. Others are experimenting with a "biomass industry" where young trees and unwanted vegetation are cut from the forest, chipped, and burned locally to generate electricity (Knudsen, 1994).

3.4 Fire Management Alternatives

Various combinations of these basic actions form the basis of the five fire management alternatives currently under consideration within the proposed Vegetation Management Strategy. The five strategies are:

Fire Management Alternatives

1. Full Suppression
2. Suppression + Fuel Reduction Burns
3. Suppression + Prescribed Lightning Burns
4. Planned Prescribed Burns
5. Mixed Fire Restoration

A variety of risk control actions are assumed as part of all five alternatives. Actions common to each alternative include, but are not limited to the following:

- Public education and communication
- Training and equipment
- Mechanical fuel reduction to protect facilities
- Firefighter and public safety
- Protection of adjacent lands

The following two figures summarize the five fire management alternatives currently under consideration.

Figure 3-4 identifies the risk control actions contemplated under each alternative.

	RISK CONTROL ACTIONS			
	Suppression	Fuel Reduction Burns	Lightning Burns	Ecological Burns
Alt. 1 Full Suppression	√			
Alt. 2 Suppression + Fuel Reduction Burns	√	√		
Alt. 3 Suppression + Prescribed Lightning Burns	√		√	
Alt. 4 Planned Prescribed Burns	√	√		√
Alt. 5 Mixed Fire Restoration	√	√	√	√

Figure 3-4. Risk Control Actions Associated with each Fire Management Alternative

Figure 3-5 discusses the application of the identified risk control actions for each alternative.

The potential applications are discussed only in broad terms. The Vegetation Management Strategy represents overall policy decisions and does not provide detailed guidance for operational use within a particular park.

Within the context of these broad alternatives there are always three other levels of decision making and control: 1) Within a Park, 2) Within a Park Fire Management Zone, and 3) On individual applications.

Some possible alternatives have been dropped from consideration. Widespread mechanical fuel reduction, for example, is considered too costly for practical implementation.

In addition, the potential for ecological damage without corresponding ecological benefit precludes large-scale mechanical fuel reduction from being a viable option at this time.

To offer a clear concept of how each of the five alternative strategies may be implemented, we have included an example for Banff National Park. Figure 3-6 displays five panels, one showing the implications of each strategy at Banff.

The graphic illustration in Figure 3-6 has been prepared for demonstration purposes only. Details of implementation would require consultation with respective managers for each mountain park.

Alt. 1 Full Suppression

Action	Application	
Suppression	▸ All fires	The Full Suppression alternative involves the suppression of all wildland fires regardless of where they occur within a park. No prescribed fires will be allowed to burn under any circumstances.
Lightning Burns	▸ None	
Fuel Reduction Burns	▸ None	
Ecological Burns	▸ None	

Alt. 2 Suppression + Fuel Reduction Burns

Action	Application	
Suppression	▸ All unplanned fires	Suppression + Fuel Reduction Burns combines fire suppression and the use of prescribed burns for fuel reduction purposes. Prescribed burning in this option will essentially be limited to park boundary areas to reduce fuel loads in these critical zones and burning of slash piles from mechanical fuel treatments.
Lightning Burns	▸ None	
Fuel Reduction Burns	▸ Adjacent to Boundaries	
Ecological Burns	▸ None	

Alt. 3 Suppression + Prescribed Lightning Burns

Action	Application	
Suppression	▸ All unplanned fires	This alternative requires suppression of all fires except those fires which are lightning-induced and occur within "prescription". All human caused fires and lightning caused fires near infrastructure or park boundaries will be extinguished. Any lightning fires which are allowed to burn will be closely monitored to ensure they do not become a threat to developments or key park resources.
Lightning Burns	▸ In Prescribed Areas Only	
Fuel Reduction Burns	▸ None	
Ecological Burns	▸ None	

Alt. 4 Planned Prescribed Burns

Action	Application	
Suppression	▸ All unplanned fires	Planned Prescribed Fire allows the use of planned prescribed fire both as a method of fuel reduction and for ecosystem management purposes. All lightning caused ignitions will be suppressed.
Lightning Burns	▸ None	
Fuel Reduction Burns	▸ Anchors, Priority Areas	
Ecological Burns	▸ Priority Areas	

Alt. 5 Mixed Fire Restoration

Action	Application	
Suppression	▸ Some unplanned fires	Unplanned or random ignition wildfires would be evaluated and considered for less than full force suppression. Lightning fires within prescription will be allowed to burn under carefully monitored conditions. Fuel reduction and ecological planned prescribed burns will be allowed in designated areas and under prescribed conditions.
Lightning Burns	▸ In Prescribed Areas	
Fuel Reduction Burns	▸ Anchors, Priority Areas	
Ecological Burns	▸ Priority Areas	

Figure 3-5. Fire Management Alternatives

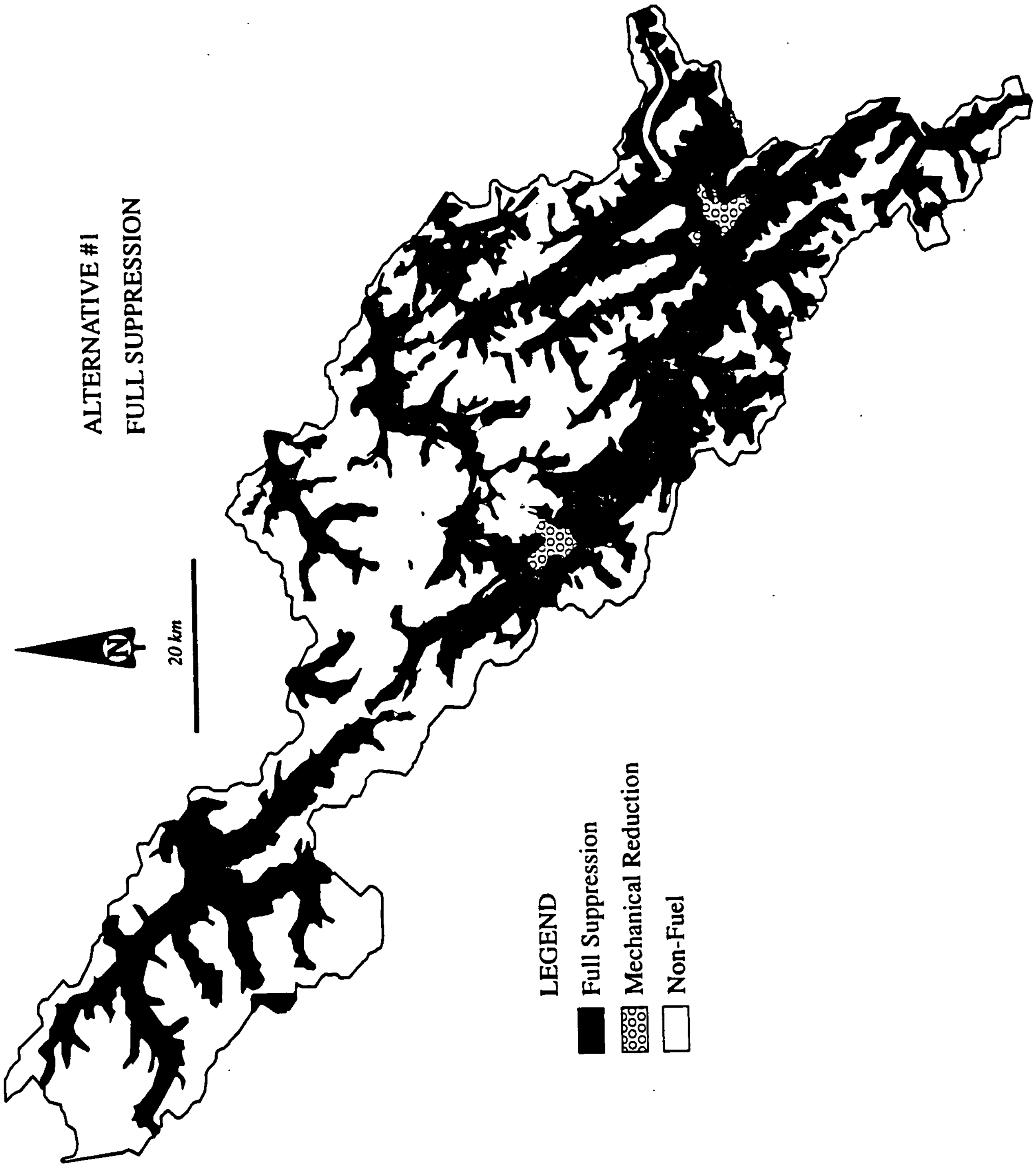

Figure 3-6. Comparison of Five Alternative Strategies at Banff National Park

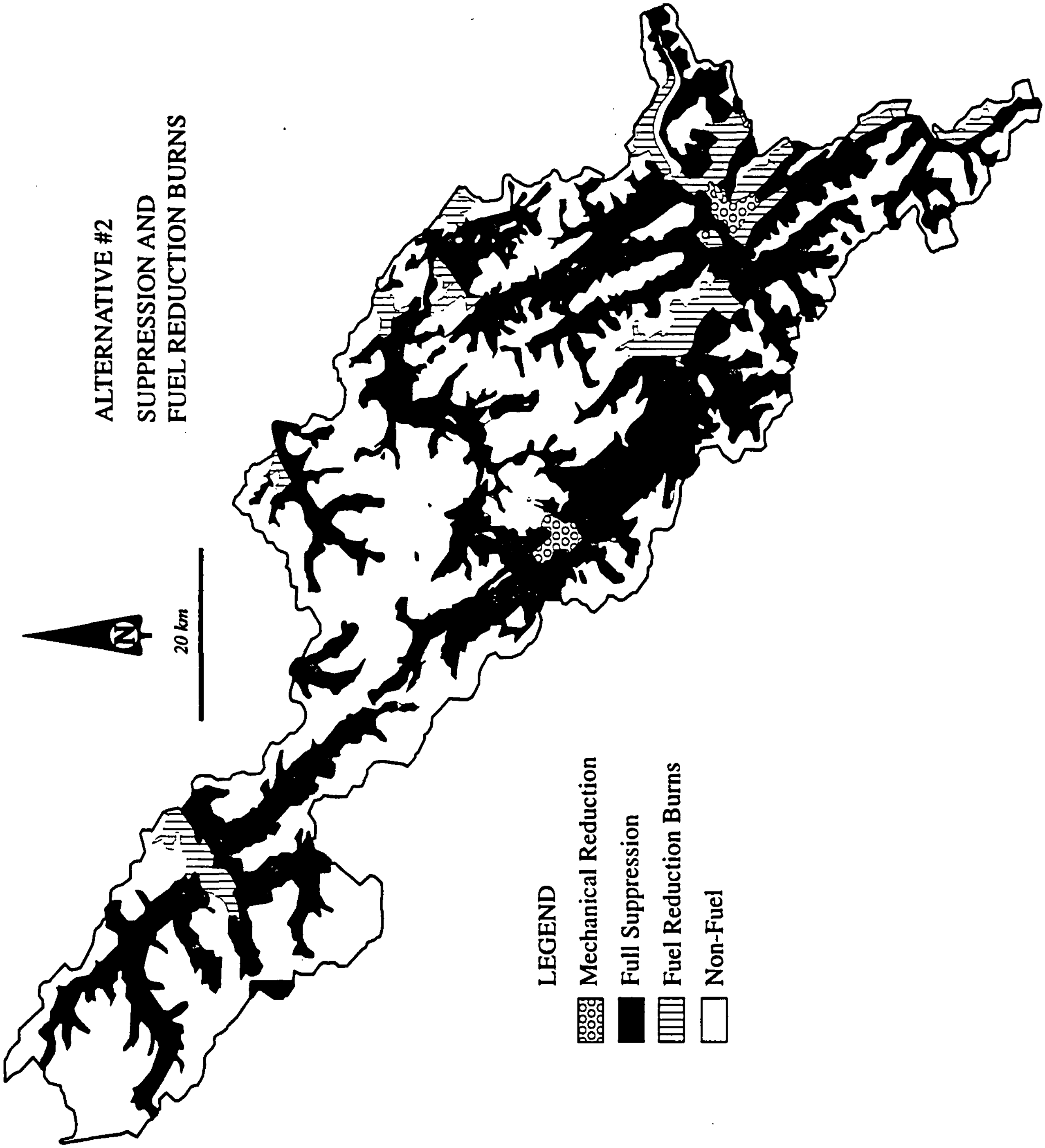

***Figure 3-6. Comparison of Five Alternative Strategies at Banff National Park** (cont.)*

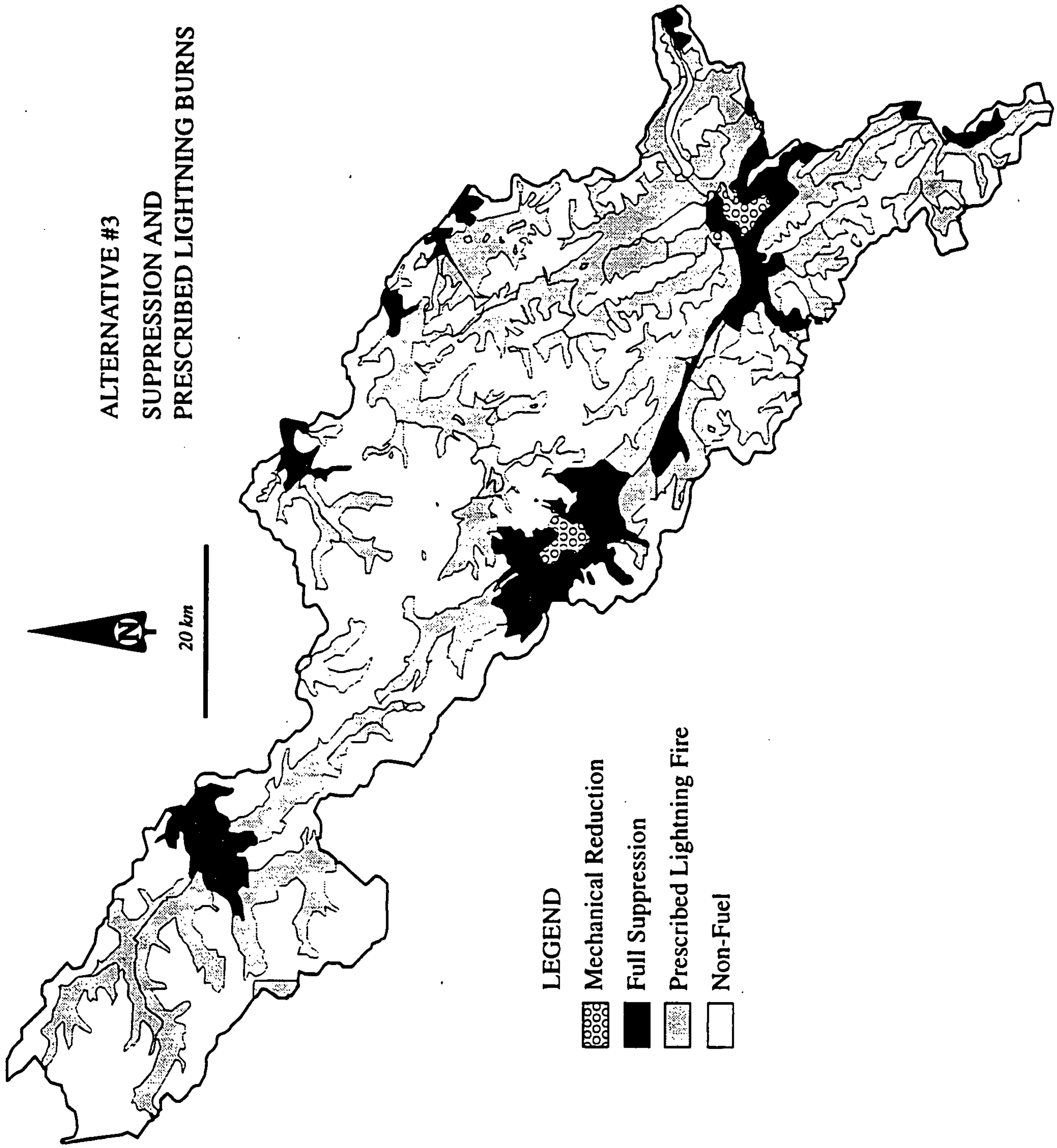

***Figure 3-6. Comparison of Five Alternative Strategies at Banff National Park** (cont.)*

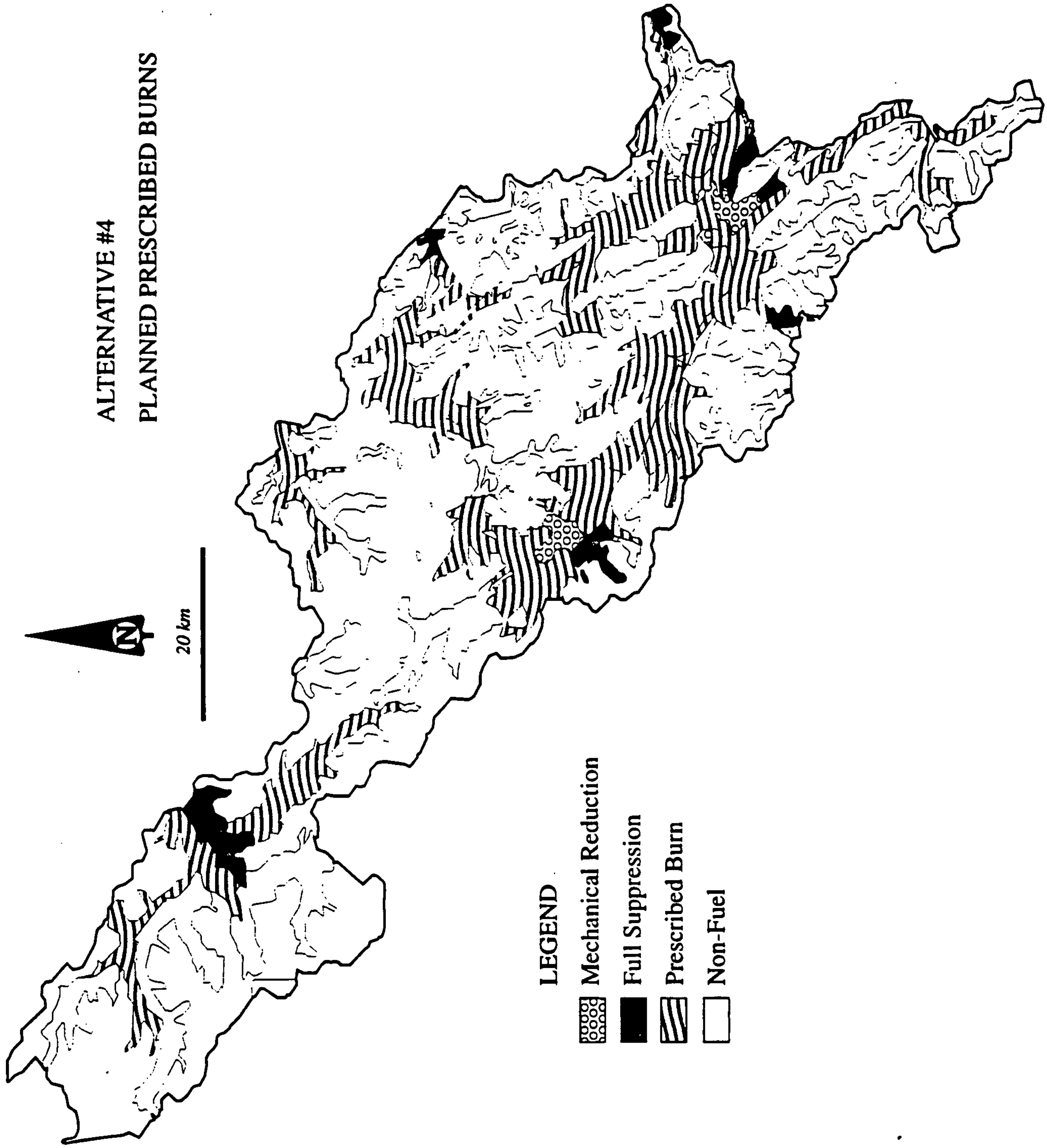

Figure 3-6. Comparison of Fivè Alternative Strategies at Banff National Park (cont.)

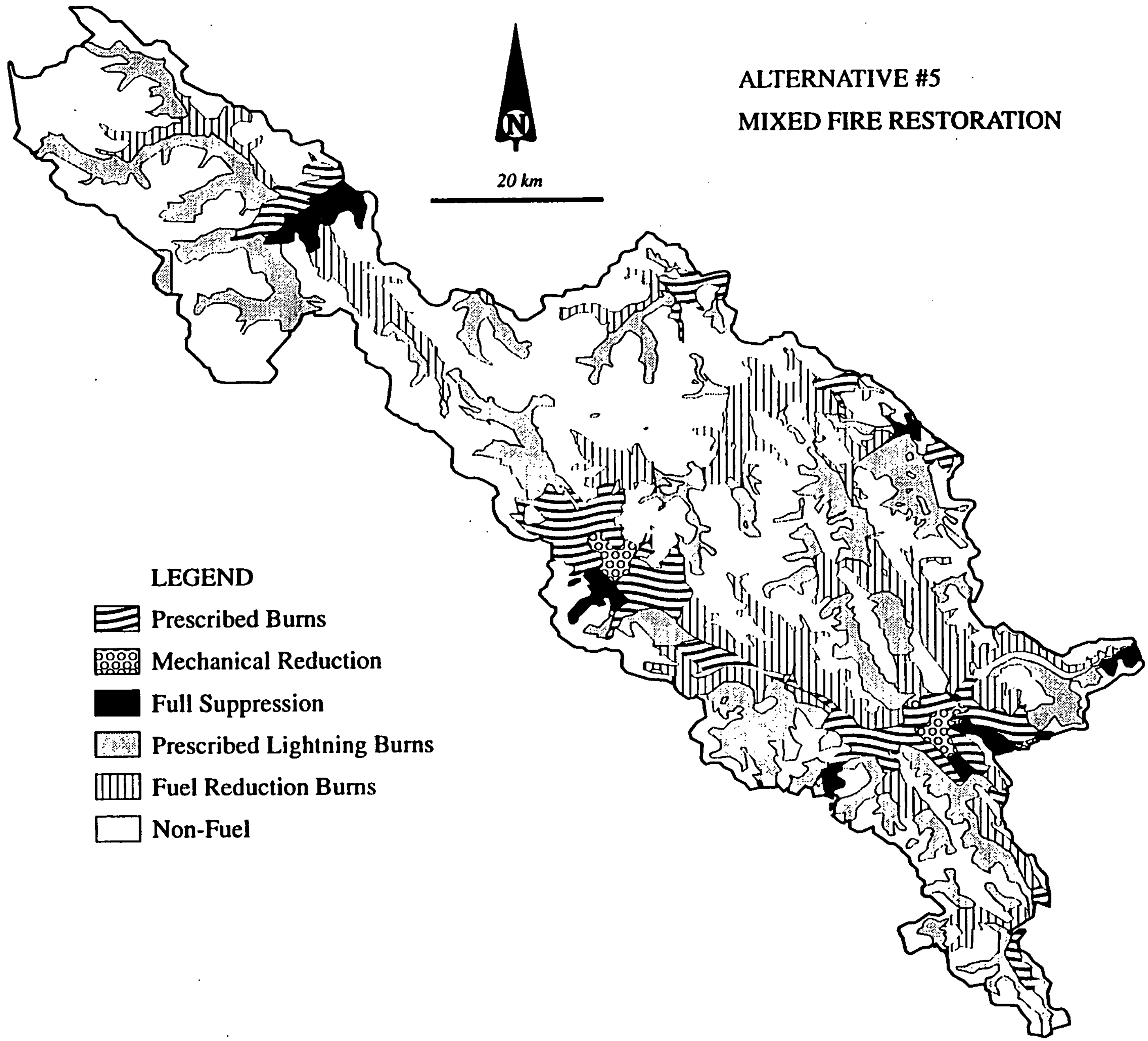

Figure 3-6. Comparison of Five Alternative Strategies at Banff National Park (cont.)

Section 4.0 - Decision Criteria

The selection of a preferred strategy from among the five policy alternatives introduced in Section 3.0 must be based on the consideration of important values that may be at risk. Values may be monetary in nature, such as revenues or property, or may not be easily equated with a dollar value, such as ecological diversity.

The nature of these values and the potential effects of fire management actions were discussed in a March 1996 workshop with representatives of the mountain national parks, other adjacent parks, the Western Fire Management Centre, the B.C. Ministry of Forests, and Alberta Department of Renewable Resources. Workshop participants identified five key values that are presumed to influence fire management decisions and encompass a wide variety of considerations:

- Ecological Integrity
- Service to Clients / Social Concerns
- Efficient Economic Operations
- Safety
- Freedom from Liability

The results of these discussions are presented here. However, without consultation with other key stakeholders, such as members of the public, adjacent landowners, park visitors, and concessionaires, quantification of values or a determination of their relative importance cannot be attempted at this time. Perceptions of decision criteria and their importance to certain segments of the population should be further analyzed to provide a sound basis for decision making.

4.1 Ecological Integrity

Several components of park ecosystems may be affected by fire management activities, as discussed in Section 2.0 and the scientific report accompanying the Draft Vegetation Management Strategy. These include vegetation, wildlife, special ecological or cultural resources, air, soil, and water.

4.2 Service to Clients / Social Concerns

Service to clients is another key aspect of the Parks Canada purpose. National Parks are to be "maintained and make use of so as to leave them unimpaired for the enjoyment of future generations" (National Parks Act).

National Parks Policy is to provide opportunities for public enjoyment, education, and appreciation of park lands (Parks Canada, 1994).

The Alberta Region Business Plan recognizes the importance of client service to the park organization and ranks client service as one of its primary goals.

Client services provided by the mountain national parks include:

- ❑ **Visitor Enjoyment** - Burn areas may temporarily affect clients wishing to view wildlife and scenery. In the long term, burns can enhance wildlife viewing by creating attractive habitat and opening vistas. Fires may inconvenience visitors due to poor visibility, poor air quality, evacuation, or restricted access.
- ❑ **Recreational Activities** - Burning may cause some areas or activities to be temporarily closed to park visitors for short periods.
- ❑ **Business Opportunities** - Fire may lead to the interruption of business opportunities or the loss of revenue for concessionaires, guides, and other stakeholders who rely upon the park.
- ❑ **Transportation/Utilities** - Fire may cause the interruption of the delivery of utilities or the use of transportation corridors through parks.

Other social concerns that may influence fire management decision making can include the following:

- ❑ **Community Disruption** - Damage or evacuations due to uncontrolled wildfires may disrupt communities within, or adjacent to, mountain parks.

4.3 Efficient Economic Operations

Efficient economic operation is a goal enunciated in the National and the Alberta Region Business Plans. As a government agency, Parks Canada is responsible for wisely using public funds for optimal benefit.

Economic considerations should include short-term benefits or losses as well as long-term economic effects of a particular strategy. While one strategy may prove cost-efficient in the short term, it may lead to higher suppression costs or fire losses over a longer period of time. Economic interests of mountain parks include:

- ❑ **Revenues** - Fire may cause a reduction in park revenues. Revenues from commercial operators and licensees may be affected if areas are closed due to fire.
- ❑ **Expenses** - Fire Prevention, preparedness and suppression costs can be affected by fire management activities. These expenses include personnel, training, monitoring and detection systems, and equipment.
- ❑ **Infrastructure/Facilities** - Fire and smoke are risks to park infrastructure and facilities.

4.4 Safety

All fire management strategies recognize the primary importance of personal safety during activities. While all fires pose a threat to public and firefighter safety, the size, intensity, and behaviour of any fire greatly affect its potential for injurious results.

Safety considerations include the following:

- **Public** - Residents living in communities adjacent to parks may be threatened by wildland / urban interface fires. Smoke may compromise visibility of motorists on park roadways. Members of the public may be injured during evacuations.

- **Guides** - Guides and visitors in backcountry areas may be trapped or injured by unplanned fire ignitions.

- **Staff** - There are inherent dangers associated with fighting fire that can compromise firefighter safety.

4.5 Freedom from Liability

Liability concerns necessarily factor into any decision on fire management strategies. Liability in this context refers to legal liability as well as potential damage to public relations due to fire management activities.

- **Public Relations** - Fire management activities can lead to public complaints or media attention if they do not accord with the public perception of Parks mandate.

- **Legal Claims** - Damage to private property through smoke, escaped prescribed fire, failure to extinguish a wildfire, or fire suppression activities are examples of situations where legal repercussions may ensue. Parks must ensure the capability to effectively perform a chosen fire management strategy once undertaken.

Liability in relation to fire usually arises under strict liability (the rule in Rylands v. Fletcher), negligence, or both. According to the court findings in Rylands v. Fletcher, if a landowner brings something onto or has something dangerous on his property and it escapes onto someone else's land and causes damage, the landowner will be liable for those damages caused to the other's property.

This cause of action is the one that could apply in the event that a prescribed burn in a park escapes from a park or burns private property (including leasehold) within a park.

Where a fire begins on park land, negligence may be found in the starting of the fire or in the attempts to control the fire. For example, if a member of the public started a fire either deliberately or accidentally, they may be held liable in negligence. If it could be shown that Parks Canada's suppression actions were in some way negligent (e.g., failure to respond in time, taking the fire too lightly, sloppy operations, etc.), Parks might also be liable to some extent for fire damages.

There is the potential in a park for a prescribed burn to cause sufficient smoke to deter tourists and thereby affect some business operations in the short term. In the absence of specific damage to property, this claim would be for straight economic loss. This is a developing area of the law that provides little evidence for concrete conclusions at this time.

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Section 5.0 - Risk Evaluation

The risk overview provided in this section forms the heart of the risk assessment. Alternatives and decision criteria have been presented in earlier sections. The intent of this chapter is to bring the key elements of the decision together, and to highlight the important risk factors.

The risk presented by each viable alternative is evaluated in light of each of the decision criteria. For the most part, this evaluation reflects discussions held among a range of vegetation and fire management experts in a one-day workshop in Calgary on March 21, 1996. Given the limited time and data available to these reviewers, the following risk determination is more qualitative than quantitative.

In general terms, this evaluation attempts to communicate assumptions underlying predictions of consequences and probabilities associated with each fire management alternative. One objective of the evaluation is to ensure all reviewers consider the available alternatives and decision criteria in the same way.

5.1 Evaluation Table

The table presented in Figure 5-1 on the following two pages summarizes the risk overview. The left-hand column lists the five alternatives currently under review (see Section 3.0 for a more complete description of each option). The headings denote the five key decision criteria considered relevant to selecting a fire management strategy (refer to Section 4.0 for details on these criteria).

We again note that these are policy level options, not operational. There are many opportunities for improving the favoured set of policy directions.

As the decision proceeds to finer resolution, it may be helpful to more closely define one or more of these five alternatives.

Some alternatives could be optimized by assuming specific risk control measures, such as enhanced monitoring or suppression capability in the event of escape of a planned ignition prescribed burn.

In summary, we note that the following evaluation does not distinguish the more detailed, but still important, available options.

ALTERNATIVES	ECOLOGICAL INTEGRITY	SERVICE TO CLIENTS / SOCIAL CONCERNS
ALT 1. FULL SUPPRESSION	▸ Declining biodiversity ▸ Larger, hotter fires mean more soil erosion, loss of nutrients ▸ Potential for epidemic of forest insects and diseases increased ▸ Widely fluctuating carbon dioxide outputs, air quality ▸ Loss of cultural landscapes ▸ Loss of ecosystem stability	▸ Increased risk of catastrophic fire (disaster, evacuation, etc.) ▸ Slow erosion of public confidence related to decrease in biodiversity ▸ Increased smoke control in short term, decreased in long term ▸ Wildlife viewing and aesthetics decline in the long term
ALT. 2 SUPPRESSION + FUEL REDUCTION BURNS	▸ Similar to Alt. 1	▸ Similar to Alt. 1 ▸ Lower risk of catastrophic fire on boundary areas but no change in developed areas
ALT. 3 SUPPRESSION + PRESCRIBED LIGHTNING BURNS	▸ Similar to Alt. 1 except biodiversity and ecological integrity marginally improved ▸ Restoration of fire will be beneficial to local areas but not on a landscape scale	▸ Similar to Alt. 1 ▸ High risk of smoke and prolonged smoke exposure ▸ Increased access restrictions ▸ Some temporary loss of recreation and business opportunities in remote areas
ALT. 4 PLANNED PRESCRIBED BURNS	▸ Increased protection of biodiversity and ecological integrity over Alt. 1, however impractical to apply in all park areas ▸ Reduced fuel loads means less potential for destructive wildfire intensity ▸ Better protection of cultural heritage sites, cultural landscapes ▸ Minimal air impact	▸ Smoke is managed ▸ Impact on visitor enjoyment can be managed (short term) and long term benefit ▸ Good long term protection of business and recreational opportunities ▸ Minimal interruption of transportation and utilities
ALT. 5 MIXED FIRE RESTORATION	▸ Similar to Alt. 4 ▸ Ecologically conservative and therefore preserves options for adaptive management	▸ Similar to Alt. 4 ▸ Increased access restrictions ▸ Good smoke management ▸ Maximum long term protection of business and recreational opportunities ▸ Fires less likely to interrupt transportation and utilities

Figure 5-1. Risk Evaluation Table

EFFICIENT ECONOMIC OPERATIONS	SAFETY	FREEDOM FROM LIABILITY
▸ Probability of catastrophic losses increases with time in developed areas ▸ High suppression and mop-up costs, increasing over time ▸ Very high rehabilitation costs ▸ Probability of extensive losses to Provincial timber leases ▸ Forest insect and disease losses likely both within and outside of parks	▸ High fuel load, therefore large uncontrollable fires possible ▸ Fires that threaten communities may put firefighters and residents at risk ▸ Visitors at greatest risk ▸ High risk of smoke when catastrophic fire occurs ▸ High risk of injury during evacuation	▸ Presently has high political and public acceptance ▸ Possible legal claims due to catastrophic fire loss
▸ Similar to Alt. 1 ▸ Reduced probability of catastrophic losses to commercial timber ▸ Fuel reduction (PB costs) added to suppression costs ▸ Rehabilitation costs marginally lower ▸ Reduced chance of forest insect and disease losses	▸ Similar to Alt. 1	▸ Moderate political and public acceptance ▸ Possible legal claims due to catastrophic fire loss but lower than Alt. 1 due to less chance of catastrophic fire crossing park boundaries ▸ Chance of legal claims due to prescribed burn escapes
▸ Reduced suppression costs in areas where prescribed lightning burns allowed but same as Alt. 1 elsewhere ▸ Lengthy monitoring, management and personnel costs for lightning burns ▸ Potential for loss of business due to smoke and area closures on long lightning burns of weeks or months ▸ Extra costs due to escapes possible	▸ Similar to Alt. 1 ▸ Highest risk of continuous smoke	▸ Low public and political acceptance ▸ Possible legal claims due to catastrophic fire loss ▸ Chance of legal claims due to prescribed burn escapes
▸ Reduced risk of catastrophic losses in developments and timber areas ▸ Same suppression costs as Alt. 1 but decreasing with time ▸ Lower probability of lost business ▸ Additional costs due to escapes possible ▸ Fires are of short duration, therefore personnel and monitoring costs lower than Alt. 3	▸ Least risk to personnel, visitors, motorists, and adjacent lands due to decreased chance of catastrophic fire	▸ Low political and public acceptance and support ▸ Low chance of legal claims due to catastrophic fire loss ▸ Highest chance of legal claims due to prescribed burn escapes ▸ Accords with current Parks mandate
▸ Reduced suppression costs in areas with lightning burns but same as Alt. 4 elsewhere ▸ Lengthy monitoring and personnel costs for lightning burns ▸ Low risk of catastrophic loss and lost business in and outside of parks ▸ Better interagency sharing opportunities may mean reduced costs overall	▸ Similar to Alt. 4	▸ Similar to Alt. 4

5.2 Summary

Following is a brief summary of the principal results emerging from the risk evaluation table above.

Alt. 1 - Full Suppression

While fire suppression may manage the short term risk of wildfire, it provides little in terms of a sustainable long term strategy.

The greatest risk of the full suppression approach is to the ecological integrity and biodiversity within the parks due to the exclusion of fire from park ecosystems. In this context, ecological integrity means an environmental structure that supports a healthy diversity of species, communities, and landscapes. With a full suppression option, researchers project an inevitable decline in key plant communities and habitat.

If the region's montane vegetation mosaic is primarily a result of aboriginal burning, preserving ecological integrity means maintaining the biological diversity representative of the last 10,000 years. If the multitude of scientists who attribute regional vegetation mosaics and biological diversity (at all levels) to an active regime of landscape fire are correct, then management efforts to exclude fire are ill advised.

The long-term decline of diverse landscapes will ultimately mean loss of some visitor services, such as wildlife viewing opportunities and heritage appreciation. Increasing stand density can make observation of wildlife more difficult. Ungulate and bear viewing opportunities are considered important elements of the services offered to park visitors.

In addition, there is a significant risk of catastrophic damage to large ecological areas. Intense and uncontrollable wildfires will likely affect the landscape unless lands are converted to other uses (e.g., agriculture) or fire is re-introduced in a managed way.

Research at Banff National Park, for example, suggests that following a policy of full fire suppression would inevitably allow forest fuels to continue to accumulate, setting the stage for high-intensity crown fires that could not only threaten park developments and human life, but that could also create burn patterns unlike any previously seen in Banff (Kay and White, 1995):

In a recent study of ecosystem management, the U.S. Department of Agriculture concluded that eliminating wildfire creates the following consequences (U.S. Dept. of Agriculture, 1993):

- Change from relatively low damage, stand-maintenance fires to more severe high damage, stand-replacement fires.
- Conversion from fire-resistant species to fire-intolerant species having less resilience to fire disturbances.
- Less controllable and more costly wildfires.
- Increasing danger to firefighters.
- Growing threat to wildland/urban interface values where development is occurring in fire prone types.
- Increasing potential for higher particulate matter emissions (smoke) as fuel loads and understorey biomass increase.

In the short term, park aesthetics and recreation activities will be maintained due to the exclusion of fire, fostering public acceptance and approval of fire suppression actions. A catastrophic fire event, however, could occur at any time, presenting a high risk to the safety of visitors and the potential for costly liability claims.

Suppression costs under this option will continue to increase over time as fuel accumulations lead to fires that are more difficult to control. Monitoring of fire suppression expenses in the U.S. show that costs have escalated exponentially in the Rocky Mountain area. Preparedness costs will likewise increase to ensure the capability for successful initial attack.

Fire suppression costs for a single high-profile, catastrophic fire could reach tens of millions of dollars. Yellowstone National Park spent $140 million and used 10,000 fire fighters in suppressing their series of blazes in 1988. B.C. spent $13 million suppressing the 1994 Garnet fire in Penticton. It has been well documented that suppression costs escalate where there is a perceived need to protect life and structures, regardless of the actual effect on wildfire suppression (Washington State, 1994).

The costs of rehabilitating sites subjected to large, hot fires are likely to mirror the experiences of other similar jurisdictions. Uncontrollable fires also have more potential to damage or destroy significant and valuable park facilities and infrastructure.

Safety concerns would increase for firefighters under a full-suppression strategy. Following the July 1994 deaths of 14 firefighters in the South Canyon Fire of Colorado, an interagency review team concluded that "the tremendous build-up of fuels in many parts of the country poses a significant risk to the safety of firefighters as well as to the well being of forests and other vegetation. Fire behaviour in such situations can be expected to be extreme" (Interagency Management Review Team, 1994).

In addition, significant fuel loads mean increased threat to public safety from catastrophic fires. Visitors will face elevated risks of evacuations, injury, death, property loss, and limited access during fire. Smoke conditions during some fires may impact views and personal health. In addition to visitors, similar impacts are forecast for park businesses, guides, and concessionaires.

The chance of liability losses increases with dangerous fires that may slip the boundaries of a national park. Figure 5-2 indicates the approximate percentage of park boundaries adjacent to commercial timber.

Yoho	50 %	
Kootenay	60 %	
Jasper	20 %	
Rev-Glacier	85 %	(much has been logged)
Banff	15 %	(K Country)

Figure 5-2. Percent of Park Boundaries Adjacent to Commercial Timber

Alt. 2 - Suppression + Fuel Reduction Burns

This fire management strategy presents the same risks to the ecological integrity of parks as Alt. 1, full suppression. The probability of catastrophic losses may be reduced somewhat due to fuel reduction at boundary areas through the use of prescribed fire.

Park aesthetics and recreational opportunities will be preserved in the short term due to the exclusion of fire in the majority of park areas. Costs for fuel reduction activities will be added to increasing suppression costs over time. The safety of adjacent lands will be increased. However, in the long term, risks to park visitors and potential legal liability will rise.

Prescribed fire operations fail from time to time, although less often as collective experience mounts. California State Forestry Department estimates that less than one-half of one percent of its controlled fires escape and destroy property (Knudsen, 1994).

Alt. 3 - Suppression + Prescribed Lightning Burns

This strategy alternative presents the same risks to park ecosystems as Alts. 1 and 2. Some ecological benefits may result from lightning-induced prescribed burns. However, experience suggests that lightning ignitions are infrequent within some parks, occur during hazardous times of year, and are generally localized in specific areas.

In areas where lightning fires are allowed, suppression costs will be reduced. However, the need for monitoring and management of lightning burns will lead to increased costs. Lengthy lightning burns prolong exposure to the potential for escaped fire.

The unpredictable timing of lightning burns presents the chance of area closures during high-use seasons and prolonged exposure to smoke. Backcountry visitors may be at risk due to random lightning ignitions. Lightning burns offer fewer opportunities for control when compared with planned control burns.

Alt. 4 - Planned Prescribed Burns

This option maximizes the benefit to park ecological integrity. Prescribed burning for ecological and fuel reduction purposes would reintroduce wildfire to fire-dependent ecosystems and reduce hazardous fuel loads that can lead to high intensity, catastrophic fires.

Although prescribed burn costs pose an additional expense in the short term, suppression costs are expected to decrease over time. Other organizations have calculated the investment potential of prescribed burns and concluded they make economic sense. In 1993, for example, the U.S. Congress awarded federal managers $ 1 million to thin national forests in California (Knudsen, 1994).

The potential for escaped fire and resulting legal liability increases in the short term. In the long term, however, legal liability is expected to decrease due to reduced fuel loads and less potential for catastrophic fire. In terms of safety, this option presents the least risk to visitors, motorists and adjacent lands. The chance of catastrophic fire is reduced. At the present time, this option seems to have low political and public appeal outside the community of environmental specialists and wildfire managers.

Smoke from prescribed fires can also decrease visibility, a point that is especially important along major highways.

Alt. 5 - Mixed Fire Restoration

The mixed fire restoration approach presents many of the same ecological benefits as Alt. 4. Reintroducting fire to park ecosystems would improve biodiversity and ecosystem health while reducing fuel loads.

Visitor enjoyment will be affected periodically by prescribed burns occurring within the park, with concurrent access restrictions to burn areas. Visitor enjoyment would increase in the long term, however, due to improved ecological integrity. Potential legal liability may increase in the short term due to the greater chance of escaped prescribed fire.

5.3 Conclusions

All five alternative strategies have their merits and provide some benefits and risks.

There are similarities among Alternatives 1, 2, and 3 as strategies offering insignificant or little benefit to the observed decline in ecological health or increase in forest fuels. In fact, these options would likely exacerbate current concerns. Although short-term risks of continuing a policy of full wildfire suppression are considered low, the spectre of a catastrophic fire suggests increasing likelihood and very severe consequences over the long term.

Alternatives 4 and 5, on the other hand, assume actions that reintroduce wildfire in significant proportions, thereby addressing the ecology and safety concerns of a fire exclusion policy.

Risk is an inherent part of prescribed burning. The two principal hazards associated with prescribed burn programs are the negative effects of smoke and the risk of escape.

The adverse effects and occasional damage that results from prescribed fire failures tend to be poorly tolerated by the public. The most important benefits of fire are often long-term, biologically complex, and largely inconspicuous. As a consequence, they are seldom valued by the general public.

Efforts to expand prescribed burning programs are frequently met with significant resistance, especially where human populations have increased near wildland setting. Without an effort to inform the public, short-term impacts of smoke and vegetation charring may be viewed as unnecessary.

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Section 6.0 - Recommendations

This study set out to assess the relative risks of several broad policy-level alternatives. The effort essentially weighs the risks of two futures. On one hand, continued full wildfire suppression alone may result in an unhealthy ecosystem and catastrophic fires. On the other hand, a program that adds prescribed burning to suppression efforts may result in smoke intrusion and fire escape. In this section, we offer our opinions from a risk management perspective. Based on a review of available information that can be correctly called cursory, we conclude with a few recommendations.

6.1 Preferred Strategy

To oversimplify a very complex set of interrelated issues, members of the Regional Policy Committee face two choices:

1. Watch the ecosystem age and deteriorate without renewal, eventually reaching an ecological dead end of one sort or another, whether by insect infestation, disease, gradual replacement by other vegetation, or major conflagration.

   With catastrophic fire, managers may expect widespread destruction of vegetated areas, loss of park facilities, elevated chance of injury to firefighters and others, high suppression costs, and significant exposure to liability. This option is characterized as Alternative 1, Full Suppression.

2. Reintroduce fire to park ecosystems, to renew them at a more-or-less pre-Columbian rate. Planned fire ignitions bring their own challenges, such as the inevitable losses associated with the escape of prescribed burns, the nuisance and hazards of smoke during spring and fall shoulder seasons, and the need to educate the public and media concerning fire management principles. Alternative 4, Planned Prescribed Burns and Alternative 5, Mixed Fire Restoration share significant efforts to reintroduce fire.

Our findings suggest the latter course holds greater promise for net benefit to the public interest over the long term. In drawing these conclusions, we considered the forecasts by scientists both inside and outside the organization for significant ecological deterioration if full wildfire suppression continues. Heeding these warnings seems a prudent course with ecological integrity as a principal objective of the Business Plan.

Even without the argument of ecological benefit, however, the accumulation of forest fuels and threat of intense, uncontrollable fire is enough to warrant preventive action.

Given the success of other organizations in using prescribed burns to reduce fuel loads and even halt, in some cases, the advance of dangerous wildfires, a long-term program of fire management seems reasonable.

In adopting alternative 4 or 5, the Regional Policy Committee would not be alone. The majority of other organizations with similar land management responsibilities in North America, including other regions of Parks Canada, have followed suit. In 1995, for example, the combined effect of rising costs, safety risks and ecological damage resulted in all U. S. Federal agencies adopting a new policy of recognizing suppression impacts and greater use of managed fire.

In addition to reducing the risks of conflagration and ecological decline, reintroducing fire under Alternatives 4 or 5 may reduce net exposure to liability.

Under Alternative 1, park managers may face some small potential for legal action from interested citizen groups, given a mandate to "preserve the integrity of park ecosystems as representative examples of the Rocky Mountain and Columbia Mountain Natural Regions" and the current threat to ecological integrity. Although some debate continues, the preponderance of evidence throughout North America emphasizes the ecological threat of excluding fire from the natural landscape. It could be argued that excluding fire violates the Parks Canada mandate.

We can foresee, however, the possibility of some legal claims associated with prescribed burns. Although no legal claims have been pursued as a result of fire management actions undertaken by the mountain parks to date, simply undertaking the activity means a few planned fires will escape and cause unintentional damage.

Given the purpose of the fire as a management tool, Parks Canada's policy, and the nature of parklands, the act of burning under prescribed conditions seems defensible.

Some jurisdictions, such as the States of Georgia, California, and Florida, see such value in prescribed burning that they have instituted regulations limiting the liability exposure for private landowners engaging in the practice.

Parks Canada has developed a small core of individuals who are recognized as experts by their peers in Canada and the United States. This fact alone helps to reduce the chance of liability claim. Parks may also consider conducting prescribed burns through contracts or with the assistance of an outside reputable organization, such as the B.C. Forest Service, to gain some additional liability protection.

Failure to institute an effective fuel reduction program and subsequent catastrophic fire, on the other hand, may be considered negligent in some courts in light of:

1. The standard of care adopted by many other similar organizations, principally through prescribed burn programs

2. The evidence that prescribed burns provide some measure of protection against uncontrolled fire

3. The specific acknowledgement of the benefits of fire management and prescribed burning in Parks Canada Directives. In fact, several other regions within Parks Canada are actively pursuing prescribed burning programs, namely the Quebec, Prairie, Atlantic and Ontario Regions.

Liability Protection under Florida's Prescribed Burning Act

The Legislature of the State of Florida has determined that...

The application of prescribed burning is a land management tool that benefits the safety of the public, the environment, and the economy of Florida. Pursuant thereto, the Legislature finds that prescribed burning reduces naturally occurring vegetative fuels within wildland areas. Reduction of the fuel load reduces the risk and severity of major catastrophic wildfire, thereby reducing the threat of loss of life and property, particularly in urbanizing areas.

Most of Florida's natural communities require periodic fire for maintenance of their ecological integrity. Prescribed burning is essential to the perpetuation, restoration, and management of many plant and animal communities. Significant loss of the state's biological diversity will occur if fire is excluded from fire-dependent systems. Pressures from liability issues and nuisance complaints inhibit the use of prescribed burning.

Prescribed burning conducted under the provisions of this section shall be considered a property right of the property owner... ***No property owner or his agent, conducting a prescribed burn pursuant to the requirements of this subsection, shall be liable for damage or injury caused by fire or resulting smoke, unless negligence is proven.*** (Florida, 1995).

Liability claims may therefore result from catastrophic fire losses associated with fire exclusion. Wildfires resulting in such claims may be few in number, but the collective dollar amount associated with each catastrophic fire could exceed millions or even tens of millions of dollars. Although we lack reliable information to assess the probability of catastrophic fire in the Mountain Parks, several vegetation and wildfire experts have expressed concern for such an event, and the likelihood grows with each passing year.

In summary, the role of wildfire in ecological integrity is perhaps one of the most important vegetation management issues confronting Parks Canada today. Despite public intolerance for smoke, program costs, and risk of escape, fire remains a fundamentally important ecological process that directly serves the mandate of ecological integrity.

The full suppression alternative goes counter to the best available scientific findings today. A large majority of scientists, resource managers, and fire control experts agree that planned ignition fires not only help achieve ecological objectives but also decrease the risk of catastrophic fires. A short-term policy of full suppression, in our opinion, presents greater overall risks to the environment, stakeholders, and the public purse than a long term strategy that reintroduces fire to the natural landscape.

We conclude that the risk of catastrophic fire and the extreme consequences outweigh the risk of liability losses from escapes of planned ignition prescribed burns under controlled conditions.

Selecting a strategy that reintroduces fire to the landscape does not dictate specific objectives for fire management within each park. There is, therefore, much room for additional risk management in the implementation phases.

6.2 Risk Controls

Given the growing wealth of experience in conducting prescribed fire programs, both within Parks Canada and among other similar agencies in North America, there are ample opportunities to manage risk.

Parks have been practicing elements of risk management in their fire program for a decade or more. Careful attention to training, equipment purchases, and gaining experience in prescribed burns are examples of the "due diligence" provisions expected under civil law.

Caution must also be exercised against a rushed reintroduction of fire where high fuel loadings and multistoried canopies have developed in the prolonged absence of fire. The number of prescribed burn escapes can be reduced by mechanically treating understorey fuels and constraining burn windows.

The risks of reintroducing fire can be further minimized through continuing to apply a phased approach that allows for monitoring and feedback, yet makes significant progress where it counts.

> **Step 1**. Support ongoing efforts to protect park facilities, campgrounds, roadways, and utilities with targeted and coordinated mechanical fuel reduction program. This effort makes sense regardless of the commitment to other strategies.
>
> **Step 2**. Implement a limited fuel reduction program using low-risk prescribed burns at key park boundaries and other critical locations deemed important for facility and public protection.
>
> **Step 3**. After gaining experience and with confidence in the outcome of such a program, prescribed burns should be expanded to include dual-objective burns for fuel reduction and ecological benefit at other key locations. Such burns will likely present less risk once the controlled burns in Step 2 are completed.
>
> **Step 4**. Lightning prescribed burns should be considered only when containment within the prescribed areas is highly likely. Again, the fuel reduction and ecology burns from previous steps could be used to identify low risk locations.

Each phase demands a targeted Fire Management Plan for each park and a specific fire management plan for each zone within each park.

Other agencies have highlighted the need to establish an ongoing dialogue that provides fire related information to the public and decision-makers, enabling them to make more informed judgements (U.S. Dept. of Agriculture, 1993). We suggest that the proposed strategy be accompanied by a concise, scientifically sound message about fire's ecological role and deliver it clearly, both within the Parks Canada organization and externally.

In addition to a phased approach, a number of other measures should be considered to manage the risks associated with the proposed strategy, as follows:

1. Prepare fire management plans for all park areas. These should include detailed proposals on exactly where programs of mechanical fuel reduction, prescribed burning, and lightning burns would be appropriate.

2. Alert all organization staff of the selected fire management strategy and rationale. Strengthen the concept of total fire management and reduce risks by increasing expertise in prescribed burns.

3. Identify high hazard wildland / urban interface areas within and immediately adjacent to all parks.

4. Implement an ongoing and permanent program of mechanical fuel reduction near park and private facilities. Each exposed facility should be evaluated to identify structural modification (e.g., roof materials) that can reduce risk.

5. Limit development in park areas where natural and prescribed fire can be applied. Every new development proposal must be evaluated in terms of impact on the vegetation management strategy.

6. Communicate need for concessionaires to reduce fuels near their facilities and to undertake other risk controls. Inform businesses, guides, and concessionaires within the park environment, especially where they own or operate facilities that could be affected by fire.

7. Work with adjacent land managers to develop a common approach to prescribed burning and fire cooperation plans for critical boundary areas. Fire and vegetation management should be integrated into the surrounding region.

8. Pursue a targeted public education and communication program in cooperation with adjacent land managers, particulary the provinces of Alberta and B.C.

9. Actively exchange information on prescribed burning practices and risk controls with other agencies and leaders in fire management.

10. Institute a data collection and a analysis system to track the success of the vegetation management strategy. Establish prescribed burn escape rates and high-risk factors, and develop specific tactics to mitigate risks.

6.3 Adaptive Management

We acknowledge that the members of the Regional Policy Committee face the decision of a fire management strategy amid some uncertainty. There is no single causal factor in the observed risks and no easy fix. Reintroducing fire may very well result in unexpected consequences, as might continuing with the current strategy of fire exclusion.

To optimize a fire management program within the Alberta Region for the long term, we suggest managers consider fire management as an ongoing, adaptive, and experimental process where applied work can lead to new insights and theories over time.

Other policy-makers have advised that successful vegetation management depends on constant feedback and change. Bernard Bormann wrote in the 1993 document entitled "A Broad Strategic Framework for Sustainable Ecosystem Management" that successful ecosystem management requires:

- Converting management into an experiment
- Elevating information to the status of a primary resource
- Defining objective measures of ecosystem sustainability so that people will know when it has been achieved
- Building a decision process and management system to facilitate ecosystem management

Such recommendations suggest a thorough and intricate ecosystem modelling effort for all parks. Banff National Park, for example, is currently developing an ecosystem management model that predicts the long-term effects of various management strategies, including use of prescribed fire (Gilbride, 1995). There may be opportunities, however, to gain additional benefits of such knowledge at little or no cost.

In conducting our research, we were struck by the similarities between the RPC's concerns and a large number of other organizations throughout North America. From the Yukon to Florida, Newfoundland to California, land owners and managers report remarkably similar effects from the exclusion of fire. In addition, many public agencies and private citizens alike are aware of the liability concerns that come with prescribed fire. With this widespread concern comes the opportunity to learn from the experiences of others.

Several other organizations are currently conducting the type of fire management monitoring and modelling of interest to Parks Canada. Some examples include the following:

- The Canadian Forest Service in Petawawa has developed an integrated terrestrial landscape model to study boreal forest fires.
- The Northern Region of the U.S. Forest Service has begun a region-wide analysis to assess the role of fire restoration in ecosystem management (Risbrudt, 1995).
- The Columbia River Basin Assessment Project is using a 800,000 sq km area of Idaho, Washington, Oregon, and Montana as a model for testing various fire management strategies (Keane, 1994).

Even though some risk factors are unique to the Alberta Region and to each individual park, information on risks of both fire exclusion and fire reintroduction generated through these other studies should prove useful.

6.4 Future Tasks

This section identifies steps required in the immediate future to continue the risk management process.

Parks Canada should uncover details regarding two critical pieces of the risk puzzle: Smoke and escape of prescribed burns.

Ideally, Parks would attempt to quantify the risks of these events, identify specific hazards, and assess alternative techniques for reducing the likelihood of adverse consequences.

Parks Canada should attempt to distinguish, for example, nuisance smoke releases from smoke that can be truly harmful to humans. They should investigate worldwide experimentation in reducing the amount of smoke generated by controlled burns.

Likewise, they should assemble available experience on escapes, collecting available documentation on the number and consequences of such events. Parks Canada should extract information on losses, successes, and lessons learned from the many public and private agencies that have been practising prescribed burning for several years.

They could use this research to identify further opportunities to reduce the risks of controlled burns and to predict the future financial risk such practices bear.

The RPC should also clearly document the process they follow in selecting an appropriate fire management alternative and Vegetation Management Strategy. Complete and accurate evidence of the decision-making process may enhance the capability of Parks Canada to defend itself against any legal claims resulting from chosen fire management activities. Assistance in this regard may be obtained through consultation with the Department of Justice.

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Appendices

APPENDIX A - GLOSSARY

Blow-Up
Sudden increase in fire intensity or rate of spread sufficient to overwhelm existing suppression action or plans.

Burnoff
To remove all unburned fuel within a fire guard by fire.

Crown
The upper portion of a tree, comprising the foliage, twigs, branches, and cones.

Crown Fire or Crowning
A fire that advances through the crown fuel layer, usually in conjunction with the surface fire. Crown fire can be classified according to the degree of dependence on the surface fire phase:

1. **Intermittent Crown Fire** -- A fire in which trees discontinuously torch, but the rate of spread is controlled by the surface fire phase.

2. **Active Crown Fire** -- A fire that advances with a well-defined wall of flame extending from the ground surface to above the crown fuel layer. Probably most crown fires are of this class. Development of an active crown fire requires a substantial surface fire, and thereafter the surface and crown phases spread as a linked unit.

3. **Independent Crown Fire** -- A fire that advances in the crown fuel layer only

Crown Fuels
The standing and supported forest combustibles not in direct contact with the ground that are generally only consumed in crown fires (e.g., foliage, twigs, branches, cones).

Fire Danger
A general term used to express an assessment of fixed and variable factors such as fire risk, fuels, weather and topography, which influence whether fires will start, spread, and do damage, and also the degree of difficulty of control to be expected.

Fire Guard
A strategically planned barrier, either manually or mechanically constructed, intended to stop or retard the rate of spread of a fire, and from which suppression action is carried out to control a fire.

Flashover	The sudden ignition of all fuels in an area after being preheated to the ignition point.
Fuel Break	An existing barrier or change in fuel type (to one that is less flammable than that surrounding it), or a wide strip of land on which the native vegetation has been modified or cleared, that act as a buffer to fire spread so that fires burning into them can be more readily controlled. Often selected or constructed to protect a high value areas from fire. In the event of fire, they may serve as a control line from which to carry out suppression operations.
Ground Fire	A fire that burns in the ground fuel layer.
Interface	The line, area, or zone where structures and other human development meets with undeveloped wildland or unmodified vegetative fuels.
Ladder Fuels	Fuels that provide vertical continuity between the surface fuels and crown fuels in a forest stand, thus contributing to the ease of torching and crowning (e.g., tall shrubs, small-sized trees, bark flakes, tree lichens).
Spotting	A fire producing firebrands carried by the surface wind, a fire whirl and / or convection column that fall beyond the main fire perimeter and result in spot fires.
Surface Fire	A fire that burns in the surface fuel layer, excluding the crowns of the trees, as either a head fire, flank fire, or backfire.
Surface Fuels	All combustible materials lying above the duff layer between the ground and ladder fuels that are responsible for propagating surface fires (e.g., litter, herbaceous vegetation, low and medium shrubs, tree seedlings, stumps, and downed-dead roundwood).
Torch or Torching	A single tree or small clump of trees is said to "torch" when its foliage ignites and flares up, usually from bottom to top.
Wildfire	An unplanned fire, as contrasted with a prescribed fire.

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