Wildland Fire Management and the Fire Regime in the Southern Canadian Rockies

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Prescribed fires (fire burning under specified fire behavior) have often been proposed as a means of re-introducing fires into wilderness or natural areas where natural wildfires are no longer tolerated (Fisher 1984). Planned or unplanned prescribed fires are commonly carried out when prescribed fire is required over the entire landscape. Planned, landscape prescribed fires are ignited in landscape units under specific prescriptions and with a predetermined frequency. Unplanned, landscape prescribed fires are allowed to burn under certain "prescribed" fire behavior conditions, but ignition is unplanned ("wildfires"). However, when unplanned fires occur outside the prescribed fire behavior conditions, they are suppressed. It is important to note that the fire frequency resulting from the use of unplanned prescribed fire is not necessarily the "natural" frequency or a prescribed frequency.

The re-introduction of fire into wilderness areas through prescribed burning practices has been widely implemented in open, high-canopied forest landscapes which have natural fire regimes characterized by frequent low-intensity (kW/m) surface fires e.g., ponderosa pine (*Pinus ponderosa* Laws.), long-leaf pine (*Pinus palustris* Mill.), slash pine (*Pinus elliottii* Engelm.), loblolly pine (*Pinus taeda* L.) and short-leaf pine (*Pinus echinata* Mill.) forests and sequoia (*Sequoia-dendron giganteum* Lindl.) and oak (*Quercus* spp.) savannas (Chapman 1947; Cooper 1960; Habeck and Mutch 1973; Kilgore and Taylor 1979; White 1983). In these systems it appears that fire frequency has been reduced by fire suppression activities because frontal attack of these low-intensity fires is often successful. Consequently, surface and intermediate height (ladder) fuels accumulate and allow for the development of infrequent, high-intensity, stand-replacing crown fires (Van Wagner 1977), a fire regime markedly different from the historic fire regime. In these landscapes, prescribed fire has been used to reduce the accumulated load of surface and intermediate height (ladder) fuels and then to reintroduce, in a controlled manner, a frequent, low-intensity fire regime (Biswell 1989).

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In closed-canopied coniferous forests (such as boreal and subalpine forests), the landscape use of prescribed fires to replace the natural fire regime has been proposed based on the following assumptions:

- Past fire suppression has reduced the area burned by wildfire and has therefore decreased the fire frequency from natural levels creating an "older" forested landscape
- "older" forests are often more fire prone than "younger" forests
- Prescribed fires can be used to recreate and maintain younger stands, which will reduce fire hazard (Habeck and Mutch 1973; Heinselman 1973; Loope and Gruell 1973; Romme 1982; Heinselman 1981; McCune 1983; White 1985; Knight 1987).

These assumptions are often accepted without empirical data, since they seem intuitively correct, and methods for testing them have not been widely used. This paper will examine the basis upon which the use of landscape prescribed fire is dependent. To do this, we will address three questions:

- Is there any evidence that fire frequency has been reduced by fire suppression so that fire must be re-introduced into this landscape?
- Why has fire suppression been ineffective in changing the fire frequency in this landscape despite the diligent efforts by fire suppression agencies?
- Can prescribed fires prevent large wildfires?

This paper is concerned with prescribed burning practices within intact wilderness forests, specifically the subalpine forests of the southern Canadian Rockies. It does not address prescribed burning practices specific to harvested forests which are designed to reduce the postharvest fuel hazard, such as slash burning, or to prepare a suitable seedbed for regeneration.

STUDY AREA

The study area includes Banff, Kootenay and Yoho National Parks and the Bow-Crow Forest Reserve. It is an area of approximately 20,500 km^2 and is situated within the southern Canadian Rockies (Figure 1). This region is largely forested with a minimum number of roads, few towns, and essentially no private dwellings. The Dominion Lands Act of 1879 set aside the region for watershed and timber protection, barring homesteading and most permanent settlement. Lumbering, hydroelectric development and some coal mining have been permitted; however, these

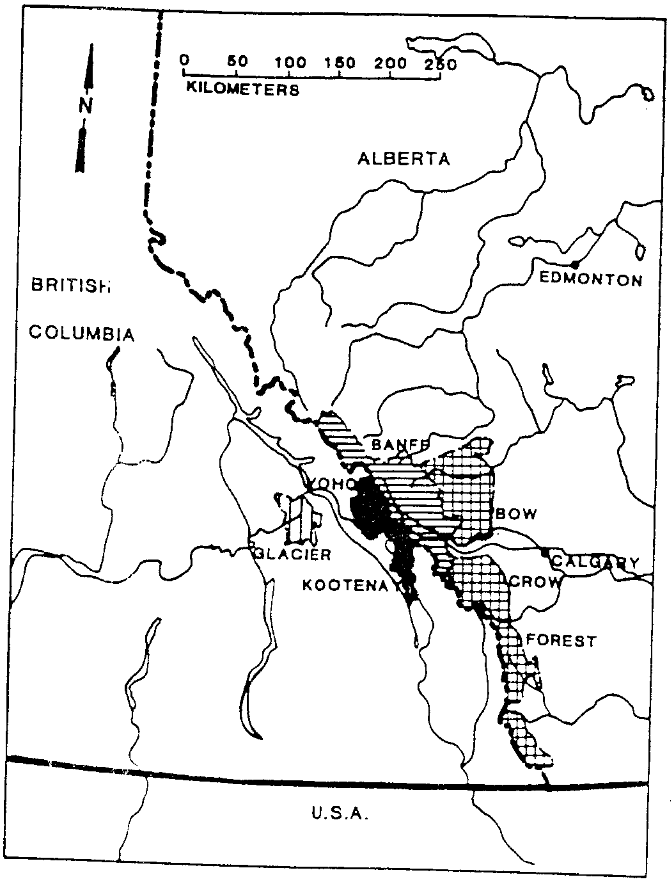

Figure 1—The study area, a 20,500-km² area of the southern Canadian Rockies comprised of Banff, Kootenay, and Yoho National Parks and the Bow Crow Forest Reserve.

developments have had only localized effects on the vegetation pattern (Johnson and Fryer 1987). Forest disease or insect outbreaks have also been of very limited importance in the past.

The subalpine forest of the front and main ranges of the southern Canadian Rockies consists of two zones. The lower subalpine zone extends from approximately 1,200 to 1,700 m and is forested by lodgepole pine (*Pinus contorta* var. *latifolia* Engelm.), Engelmann spruce (*Picea engelmannii* Parry ex Engel.), white spruce (*Picea glauca* (Moench) Voss), trembling aspen (*Populus tremuloides* Michx.) and Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco). The upper subalpine zone, extending from approximately 1,700 to 2,300 m, is dominated by Engelmann spruce and subalpine fir (*Abies lasiocarpa* (Hook.) Nutt.). Population dynamics of lodgepole pine and Engelmann spruce in the lower subalpine forest are given in Johnson and Fryer (1989).

The fire season extends from May to early October with most lightning fires occurring during July and August.

DISCUSSION

Has Fire Frequency Been Reduced by Fire Suppression, Requiring Fire to be Reintroduced?

This question is central to landscape fire management in natural areas and requires an understanding of fire frequency. Fire frequency is the average proportion of the study area which burns per year. To determine the fire frequency of a study area requires estimating its time-since-fire (survivorship) distribution. It is essential to keep in mind that fire frequency describes a distribution and that comparison of fire frequencies implies a comparison of distributions (see Johnson and Gutsell 1994).

Fire suppression in recent decades is believed to have reduced fire frequency, resulting in older forests and increased fuel accumulation (Habeck and Mutch 1973; Loope and Gruell 1973; Heinselman 1973; Tande 1979; Heinselman 1981; McCune 1983; White 1985). In order to determine the influence of fire suppression programs, time-since-fire distributions prior to and since the programs' implementation must be compared to determine if they are significantly different.

Time-since-fire distributions derived from stand origin maps (Figure 2) have been published for the Kananaskis Valley in the Bow Crow Forest Reserve, Yoho National Park and Kootenay National Park (Masters 1990; Johnson and Larsen 1991; Tymstra 1991). All of these survivorship distributions show a significant break in the fire frequency distribution in the mid-1700's indicating a change from more frequent fires to less frequent fires. The regional consistency in the timing of this change indicates its causal mechanism operates on a large scale. This observed change in fire frequency has been found to correspond closely to the onset in the early 1700's of a cool-moist period known as the Little Ice Age (Luckman 1986; Osborne and Luckman 1988). The occupation of this area by Europeans in the 1880's, the imposition of laws forbidding the landscape use of fire by native North Americans, and the initiation of concerted fire suppression activities within the last 50 years have produced no detectable change in fire frequency in the time-since-fire distributions for the Kananaskis Valley and Yoho National Park (see Figure 2).

The apparent change in fire frequency in the time-since-fire distribution for Kootenay National Park after 1930 is not statistically significant (Masters 1990). However, weather records for this area do indicate an increased average summer precipitation since 1930, which coincides with this apparent decrease in fire frequency.

It has been suggested that fire suppression is particularly effective at preventing "hold over" fires which start under moist fuel conditions and persist until drier fuel conditions allow them to spread. By extinguishing these fires before fuel moisture conditions change and allow larger burns, fire suppression is believed to reduce fire frequency. Such reduction should be apparent in the empirical time-since-fire distributions; however, no significant change has been detected.

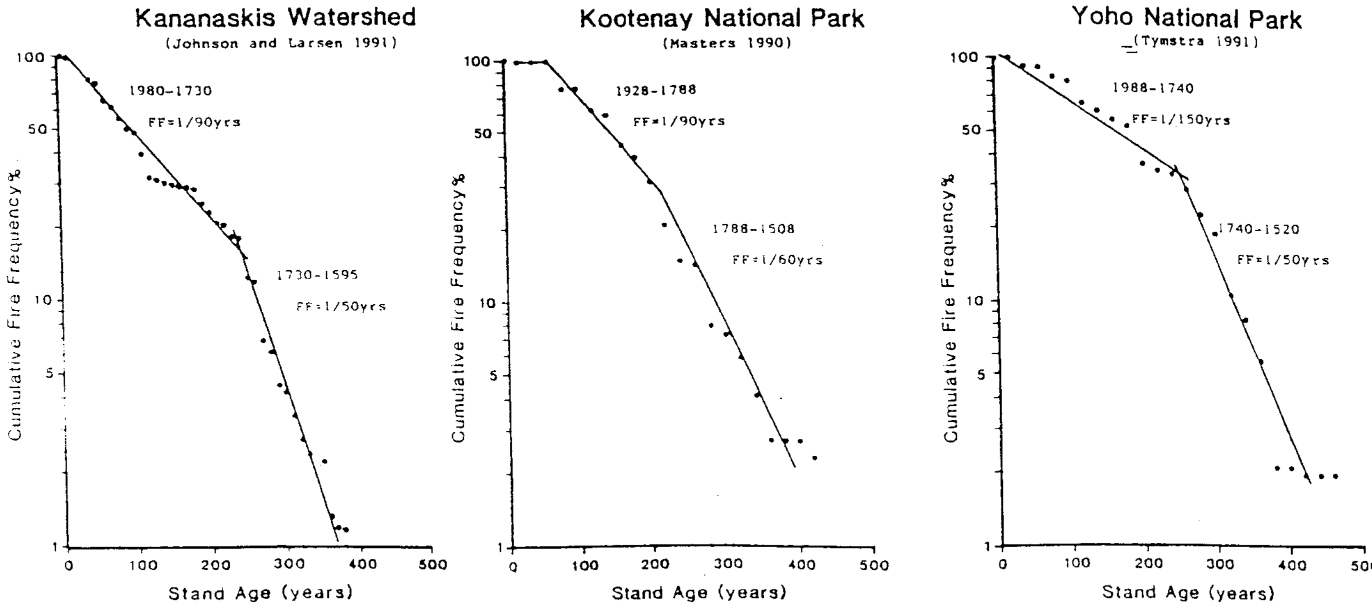

Figure 2—The time-since-fire distributions of closed-canopied coniferous forests within wilderness areas of the southern Canadian Rockies. Fire frequency (FF) is the average probability of an element burning per unit time (years) and is the inverse of the fire cycle.

Studies of fire frequency in closed-canopied coniferous forests within wilderness areas of the southern Canadian Rockies show no significant change in the past 100 years that can be explained by the influence of fire suppression. Since there is little evidence to support the belief that fire suppression has reduced fire frequency, wildland prescribed burning is not required to reintroduce fire into this landscape.

Why has Fire Frequency Been Unchanged by Fire Suppression?

In the closed-canopied coniferous forest of the southern Canadian Rockies, lightning-caused wildfires have accounted for 95% of the area burned in the last three decades (unpublished fire records, Alberta Forest Service and the Canadian Parks Service). Johnson and Wowchuk (1993) found that 3% of these lightning-caused wildfires account for 95% of the area burned. Most fires remain small, but a few occur under conditions which allow them to increase rapidly in size. Only this 3% of fires influence the area burned and fire frequency.

In years with a large area burned, fires in the Rocky Mountains (Anderson 1968; Alexander and others 1983; Fryer and Johnson 1988) characteristically have high intensities (>7,000 kW/m), high rates of spread (≥10 m/min) and high duff consumption (>3 kg/m^2). Under these conditions, extreme fire behavior is preceded by a persistent anomalous high pressure system which produces prolonged periods of above normal temperatures and below normal precipitation (Newark 1975; Harrington and Flannigan 1987), and leads to the severe drying of both medium and heavy fuels. This extreme fire behavior exhibits little difference between aspect, elevation and vegetation type (Anderson 1968; Alexander and others 1983; Nimchuk 1983; Janz and Nimchuk 1985; Street 1985; Flannigan and Harrington 1988; Fryer and Johnson 1988). In years with only a small area burned, differences in aspect, slope, elevation and vegetation composition can have a significant effect on the fire behavior (Alexander and McAlpine 1987); however, the area burned in these years is insignificant.

The extreme fire behavior associated with persistent high pressure systems results in large areas burned. During these years, it is unlikely that fire suppression can significantly influence the total area burned.

Can Prescribed Fires Prevent Large Wildfires?

In closed-canopied coniferous forests within wilderness areas of the southern Canadian Rockies prescribed burning has been proposed as a means of disrupting the continuity of forest fuels by changing the age mosaic of the landscape. This management action is based on the assumption that younger forests act as fire breaks on the landscape and consequently reduce the likelihood of large wildfires (White and Pengelly 1992).

This assumption stems from the belief that the probability of burning increases and fire behavior changes as forests age and fuels accumulate (Habeck and Mutch 1973; Loope and Gruell 1973; Heinselman 1973; Romme 1982; Knight 1987). Consequently, if the proportion or arrangement of younger to older forests in the landscape were managed, then the size and behavior of fires could be controlled.

The detailed argument is as follows: In closed-canopied coniferous forests the forest age-mosaic is managed to create adjacent stands of different age and therefore different flammability. The flammability-aging pattern postulates that very young stands have a high hazard of wildfire, exhibiting high rates of spread and high intensity. This potential hazard is high because surface fuels, in the form of dead, fire-killed trees, have fallen to the ground, and regenerating trees, shrubs and herbaceous plants accumulate on the forest floor. Young- to middle-aged stands have the lowest potential hazard of high-intensity and high-rate-of-spread fires since crown bases are elevated and understory vegetation has become sparse. In older stands, the forest canopy has become open due to the senescence of canopy trees, the forest floor is again littered with medium and large fuels, and advanced regeneration is increasingly abundant. Consequently, older forests have a higher hazard of crown fires, since they can support higher intensity ground fires and possess vertically continuous (ladder) fuels.

Clearly, this argument suggests that a definite aging pattern should be apparent in the time-since-fire distributions and in the spatial pattern of adjacent ages in the forest age-mosaic. The time-since-fire distributions for the southern Canadian Rockies (Figure 2), however, all exhibit a negative exponential distribution (Van Wagner 1978; Masters 1990; Johnson and Larsen 1991; Tymstra 1991), a model which indicates no age effect in the probability of burning (Johnson and Van Wagner 1985). Thus, past fires have not stopped when burning into younger or older stands except as would be expected by chance (Johnson and Larsen 1991; Johnson 1992). Clearly, a constant hazard of burning over stand age is consistent with the extremely dry fuel conditions under which large fires have been shown to occur.

Prescribed burning practices designed to prevent the development of large wildfires by creating fire barriers of young forest throughout the landscape are not supported by evidence obtained from fire frequency studies.

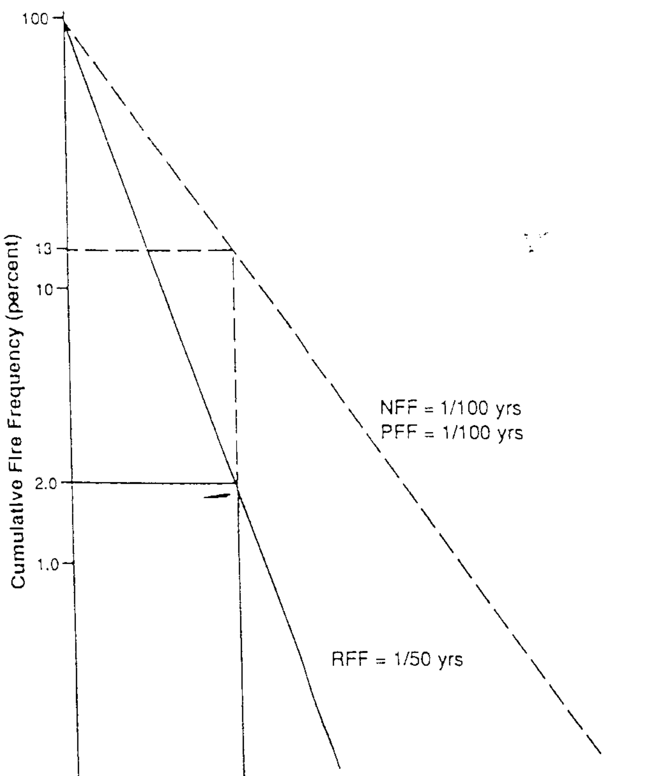

Figure 3—Both natural (NFF) and prescribed fire frequencies (PFF) are one for every 100 years. When they are added together, the resultant fire frequency (RFF) is one for every 50 years, assuming natural and prescribed fire frequencies are operating independently of each other.

What Could be the Consequence of Reintroducing Fire?

The impact of fire management actions on the landscape can be addressed by examining the time-since-fire distribution that would result. Fire managers would like to implement a prescribed burning program designed to completely replace the natural fire frequency. This management action assumes that wildfire suppression has completely removed natural fire from the landscape. In this case, the prescribed fire frequency, say for example one for every 100 years, would replace the wildfire frequency. However, if fire suppression has not effectively removed wildfire from the landscape, the natural and prescribed fire frequencies are simply additive.

Figure 3 shows that adding a prescribed burning frequency of one for every 100 years to a wildfire frequency of one for every 100 years would increase the fire frequency of the landscape to one for every 50 years. In other words, the increased fire frequency would result in the reduction of the average time-since-fire (fire cycle) of the forested landscape from 100 to 50 years. A consequence of this addition would be to reduce the percentage of the landscape older than 200 years from approximately 13 percent to 2 percent.

If fire was reintroduced on a landscape scale in order to replace the natural fire regime that was falsely thought to be nonexistent, due to fire suppression, the resultant disturbance frequency would increase, causing a reduction in the average age of the forested landscape.

CONCLUSIONS

What fire management strategy would be most appropriate in natural or wilderness areas of closed-canopied coniferous forests? Any fire management program must recognize that suppression of fires during the infrequent years of extremely dry fuel moisture may never be possible, but that suppression during low and moderately dry fuel years will be possible. Consequently, at least two strategies present themselves. The first strategy is to continue to attempt suppression of all fires but recognize that suppressible fires would probably have remained small even if they were not suppressed. The second strategy is to allow most wildfires to burn except where public safety, administrative boundaries, and facilities are threatened. Both strategies recognize that large fires will occur in extremely dry years and may be unsuppressible. Consequently, facilities and visitor use should be planned and managed with these large fires in mind. In preparation for these large fires, frequent, localized fuel management (fire breaks) around facilities, roads, trails and other priority areas should be performed to facilitate protection from fire. A prescribed fire plan like this has been suggested for Yellowstone National Park (Brown 1989). The result of this policy will allow the lightning fire regime to determine the vegetation age structure and pattern of the landscape; however, public safety, facilities, roads, and other priority areas will be protected. This is a policy based on the realities of the suppression capacities as they exist today and our current understanding of lightning fire frequency and behavior.

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