Mixed-Severity Fire Regimes in the Northern Rocky Mountains: Consequences of Fire Exclusion and Options for the Future

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Abstract—Findings from fire history studies have increasingly indicated that many forest ecosystems in the northern Rocky Mountains were shaped by mixed-severity fire regimes, characterized by fires of variable severities at intervals averaging between about 30 and 100 years. Perhaps because mixed-severity fire regimes and their resulting vegetational patterns are difficult to characterize, these regimes have received limited recognition in wilderness fire management. This paper presents examples of mixed-severity fire regimes in Glacier National Park, the Bob Marshall Wilderness Complex and the Selway-Bitterroot Wilderness and discusses how suppression and fire management policies have affected them. It suggests possible management actions to return a semblance of the historical mixed-severity fire regimes to these and other natural areas.

The ecological problems associated with removing frequent low-intensity fires from ponderosa pine ecosystems are well known to forest and wilderness managers, and restoration of fire is being planned or implemented in many of these ecosystems (Bailey and Losensky 1996; Covington and others 1997; Kilgore and Curtis 1987). In contrast, ecosystems historically characterized by infrequent stand-replacement fires may not have been greatly altered by 60 to 90 years of fire suppression, partially because it is often not possible to suppress high-intensity fires (Agee 1993; Johnson and Larsen 1991; Romme and Despain 1989). However, little recognition has been given to possible effects of fire exclusion in ecosystems historically shaped by mixed-severity fire regimes. Mixed-severity regimes produced highly diverse forest communities containing abundant seral, fire-dependent species, including multi-aged stands with large, old fire-resistant trees that are of great importance as wildlife habitat (McClelland 1979). These regimes also helped produce intricate mosaics of even-aged tree groups and contrasting forest communities at the landscape level. Effects of fire exclusion on ecosystems shaped by mixed-severity fire regimes should concern wilderness managers because these ecosystems are important components of national parks, wilderness and other natural areas of the northern Rocky Mountains (Fischer and Bradley 1987; Smith and Fischer 1997). A recent field inspection of areas historically characterized by mixed-severity fire regimes in the Bob Marshall Wilderness led us to this analysis of the situation.

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Defining "Mixed Severity"

Fire plays a complex role in wildland ecosystems, and individual fires can have highly variable effects in space and time. An individual fire's behavior can change dramatically as it moves across the landscape under the influence of daily and longer term changes in temperature, humidity and wind. The fire is also affected by changes in stand structures, fuels and topography. To facilitate communication, planning and management related to wildland fire, Brown (1995) presented a simplified classification of "fire regimes" to characterize the kinds of fires that have occurred over the past several hundred years in different regions or forest types.

The classification is based on fire severity, namely what happens to the dominant vegetation—in this case, trees. If most of the overstory trees die in most fires, that area is said to be characterized by a "stand-replacement fire regime." Conversely, if most trees survive most fires, it is called a "nonlethal fire regime." If severity is a mixture of the above—for example, frequent nonlethal fires and infrequent stand replacement fires—it is a "variable fire regime" (Arno and others 1995; Brown 1995). If severity is generally intermediate—many trees dying and many surviving—it is a mixed-severity fire regime. Variable and mixed-severity fire regimes probably intergrade and may be difficult to differentiate based on available evidence; thus, for this discussion, we will lump both into "mixed-severity fire regimes." Fire frequency is often inversely related to fire severity. Nonlethal fire regimes generally have frequent fires (commonly at intervals of 5 to 30 years), and stand-replacement regimes have infrequent fires (intervals of 100 to 400 years in the northern Rocky Mountains), while mixed-severity fire regimes have fires at intermediate frequencies, with average intervals ranging from about 30 to 100 years. Fire sizes and burning patterns are additional components of fire regimes not dealt with directly in the classification (Brown 1995).

Characteristically, a mixed-severity fire regime will have a number of individual fires that burn at mixed severities. It may also have some stand-replacement fires and some nonlethal fires. Individual mixed-severity fires typically leave a patchy, erratic pattern of mortality on the landscape, which fosters development of highly diverse communities (fig. 1). Overall, these fires kill a large proportion of the most fire-susceptible tree species, such as subalpine fir, which tend also to be the shade-tolerant species favored by fire exclusion (Minore 1979). Conversely, mixed-severity fires kill a smaller proportion of the fire-resistant species—including western larch, ponderosa pine, western white pine and whitebark pine, which are long-lived species that are replaced successionally by shade-tolerant species with fire exclusion (Arno and others 1997; Hartwell and others, in process; Keane and Arno 1993; O'Laughlin and others 1993).

Historical Conditions

In past centuries, mixed-severity fire regimes characterized large areas of forest ecosystems throughout the western United States (Arno, in process), and specifically in the northern Rocky Mountains (Arno 1980; Arno and others 1993; Barrett and others 1991; Brown and others 1994; Murray 1996; Zack and Morgan 1994). In Northern Rocky Mountain forests, mixed-severity regimes occupied about 50 percent of the area now in national forest lands, nonlethal regimes included about 30 percent of this area, and stand-replacement regimes covered about 20 percent (Quigley and others 1996). A Fire Regime Analysis being conducted by the USDA Forest Service has found similar proportions of these fire regimes nationwide (Hardy, personal communication).

The presence of appreciable quantities of old trees with scars from pre-1900 fires is prima facie evidence of historical mixed-severity or nonlethal fire regimes. In the northern Rockies, nonlethal regimes are primarily confined to forests where ponderosa pine was historically dominant. Mixed-severity regimes were found across a broad range of forest types, including some of those dominated by interior Douglas-fir and western larch, western white pine, lodgepole pine and whitebark pine, as well as some relatively moist ponderosa pine types. Other areas of these same forest types (except, possibly, ponderosa pine) were characterized by stand-replacement fire regimes. The kinds of fire occurring in a given forest type depended on fuel and vegetation development patterns, climatic factors, topography, and sometimes the history of Indian burning (Arno and others 1997; Barrett and Arno 1982). Mixed-severity fire regimes covered sizeable areas in the largest national parks and wilderness areas, including Glacier National Park (Barrett and others 1991), the Bob Marshall Wilderness complex (Davis 1977; Gabriel 1976; and observations presented later in this paper), the Selway-Bitterroot Wilderness (Brown and others 1994), the Frank Church-River of No Return Wilderness (Crane and Fischer 1986) and Yellowstone National Park's northern range (Barrett 1994; Houston 1973).

Forests associated with mixed-severity regimes were often dominated by the early seral, fire-dependent tree species, but also may have had a substantial component of late-successional trees. Individual stands were often uneven-aged and multi-layered. Moderately short fire intervals allowed important seral shrubs and hardwoods to remain

Figure 1—A stand on the Lolo National Forest, Montana, shaped by a mixed-severity fire regime. The tall trees (western larch) were established after various fires between the mid-1400s and the early 1800s. The older larch have survived 4 to 5 fires between the mid-1600s and 1904. A few of the lodgepole pines survived fires in 1889 and 1904, but most of the densely stocked smaller trees (lodgepole pine, subalpine fir, and Engelmann spruce) became established after these latest fires (S. Arno, unpublished data).

abundant (Fischer and Bradley 1987). These included aspen, Scouler willow, serviceberry, chokecherry, and redstem and evergreen ceanothus (Arno and others 1985). Small meadows and grassy openings and a variety of early seral herbaceous plants would also have been abundant (Gruell 1980; Arno and others 1985; Steele and Geier-Hayes 1993; Stickney 1990). As a result of the moderately frequent fires and variable fire severities, stands often formed a complex and intricate mosaic on the landscape. However, young seral stands and young seral components of mixed-age stands were abundant (Baker 1993; Keane and others 1996, 1998a; Romme 1982).

Current Conditions and Future Trends

By the late 1800s, the historical role of fire on the landscape had been reduced in many areas by heavy livestock grazing that removed fine fuels and by disruption of burning by Native Americans (Arno and Gruell 1986; Boyd 1999). By the late 1930s, fire suppression had become effective in reducing the annual extent of fires, even in large wilderness areas in the northern Rocky Mountains (Barrett and others 1991; Brown and others 1994). The Selway-Bitterroot Wilderness has had the most active program to restore natural fires in the region (since 1973), allowing some lightning fires to burn, taking only limited suppression on others and carrying out full suppression on the rest. Despite these outstanding efforts to restore natural fire, the program has still produced a significant reduction in average area burned compared to the pre-fire suppression period (Brown and others 1994). Moreover, the political repercussions of the 1988 Yellowstone fires have further limited the application of natural fire programs throughout the western United States (Parsons and Landres 1998). The natural fire program in the Selway-Bitterroot Wilderness has produced a somewhat higher proportion of stand-replacement and a lower proportion of nonlethal and mixed-severity burning than was characteristic of the pre fire-suppression period in the same area (Brown and others 1994, 1995a).

A study of fire regimes in Glacier National Park concluded that fire suppression had been very effective in areas that previously had a mixed-severity fire regime, but much less effective in areas of stand-replacement fire regimes (Barrett and others 1991). A detailed study of the entire inland portion of the northwestern United States also concluded that areas historically under a nonlethal or mixed-severity fire regime have now shifted toward stand replacement regimes (Morgan and others 1998; Quigley and others 1996). By the late 1990s, mixed-severity fire regimes have been reduced to about 30 percent of the landscape, and nonlethal regimes occupy only about 10 percent, whereas forests typically burning in stand-replacement fires now encompass about 60 percent of the national forest lands (Quigley and others 1996).

The effects of substantial reductions in areas burned in historical mixed-severity fire regimes are predictable and observable (Keane and others 1996). Intensive comparisons of historical (circa 1900) and modern stand structures in unlogged areas near the eastern boundary of the Selway-Bitterroot Wilderness show major declines in ponderosa pine, western larch and whitebark pine, and corresponding increases in Douglas-fir at lower elevations and subalpine fir at middle and high elevations (fig. 2) (Arno and others 1993, 1995; Hartwell and others, in process). Lodgepole pine has maintained its historical abundance, but young lodgepole communities (which contain numerous early seral undergrowth species) have become less common.

On landscapes such as large wilderness areas, the effects of fire exclusion tend to include greater uniformity in stand ages and in stand composition and structure, together with a declining diversity of undergrowth species (Arno and others 1993; Keane and others 1996). Basal area and numbers of trees per acre may increase dramatically (Arno and others 1997). This results in increased physiological stress and the opportunity for extensive forest mortality caused by epidemics of insects and diseases (Fellin 1980; Monnig and Byler 1992; Biondi 1996). Fire exclusion and related advancing succession also brings increased loadings of dead and living (ladder) fuels across the forest landscape, which increases the likelihood of unusually severe and extensive wildfires (Barrett and others 1991; Barbouletos and others 1998; Quigley and others 1996; Morgan and others 1998). When a large and unusually severe fire occurs in a wilderness environment, it ultimately creates a correspondingly large mass of heavy fuels, starting 12 to 15 years after the fire when much of the dead timber has fallen (Lyon 1984). This becomes incorporated into a new dense fuel bed with small conifers and large shrubs, which can readily support another severe wildfire, or "double burn" (Barrett 1982; Brown 1975; Wellner 1970).

Modeling suggests that the effects of continuing this trend will be higher proportions of large stand-replacement fire in wilderness landscapes (Baker 1992; Keane and others 1996, 1998a). There will be a loss of multi-aged stands of seral tree species. The intricate, fine-grained landscape mosaic of diverse stand structures and compositions will be replaced by a coarser pattern of even-aged stands (fig. 3). Longer fire intervals will cause seral herbaceous and shrub species to decline because they will have difficulty surviving under extended periods of dense conifer coverage—the "stem-exclusion stage" (Oliver and Larsen 1996). In addition to

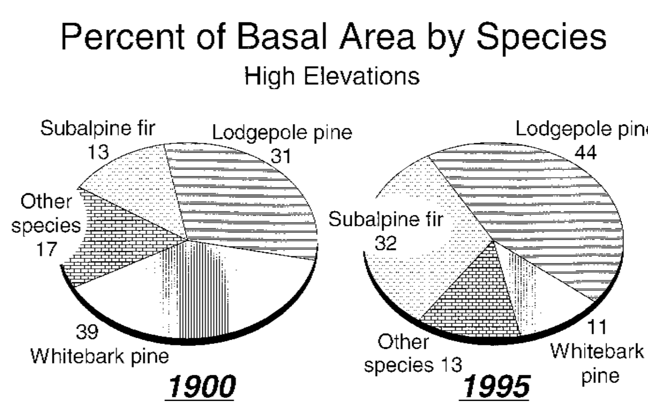

Figure 2—Historical and modern stand structures in an unlogged upper elevation forest zone on the Bitterroot Range, Montana (from Hartwell and others, in process). The historical forest was in a mixed-severity fire regime; the modern forest is influenced by fire exclusion.

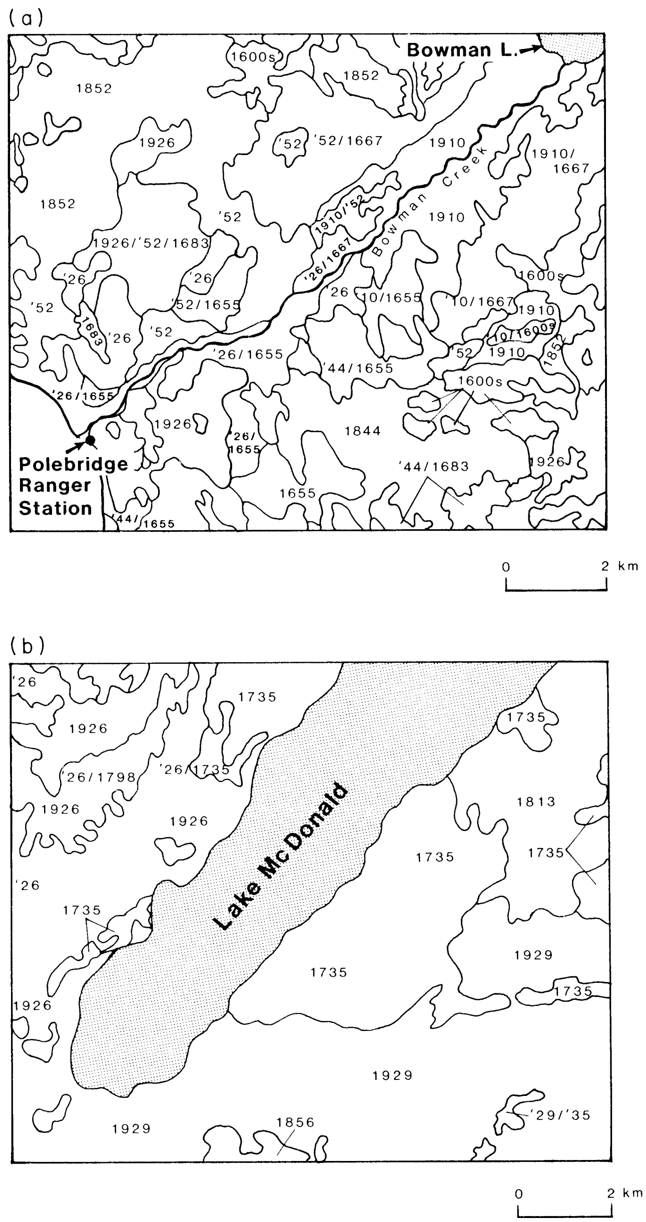

Figure 3—Age-class mosaics resulting from a mixed-severity fire regime (a) and a stand-replacement fire regime (b) in Glacier National Park, Montana. Dates indicate fire years that resulted in establishment of seral western larch and lodgepole pine age classes (from Barrett and others 1991).

ecological impacts, the accompanying pattern of larger and more severe wildfires will pose increasing health risks due to smoke production, as well as risks of fire escaping the wilderness and threatening people and private property (Hill 1998).

An Example From the Bob Marshall Wilderness

On July 11-15, 1998, we conducted field observations in the South Fork Flathead drainage, Bob Marshall Wilderness, at the request of District Ranger Carol Eckert. During this trip, we also discussed the management implications associated with the area's fire ecology with a group of national forest managers and staff.

Much of the Bob Marshall Wilderness was historically characterized by a stand-replacement fire regime, with fire intervals of 150 to 250 years in a given stand (Keane and others 1994). Today, this fire regime is generally considered to be functioning within its "historical range of variability" (Morgan and others 1994) as a result of periodic wildland fires and some lightning fires allowed to burn under prescription. Our observations are directed to mixed-severity fire regimes that occur in the drier areas of the South Fork Flathead drainage (Gabriel 1976). We observed two kinds of forests that historically experienced mixed-severity fire regimes, based on abundant fire scars found on living trees, multiple age-classes of seral fire-dependent trees and intricate stand mosaics. (In addition, there is a historical nonlethal fire regime associated with nearly pure ponderosa pine stands on dry, gravelly river terraces.) In this area, forest types historically maintained by the mixed-severity regime are ponderosa pine-mixed conifer and larch/Douglas-fir/lodgepole pine. The ponderosa pine-mixed conifer forest type covers a few thousand acres in the South Fork Valley, below 5,000 feet. The larch/Douglas-fir/lodgepole pine type is widespread and extends up to about 5,500 feet.

The ponderosa pine-mixed conifer type contains large ponderosa pines 200 to 600 years of age, but few less than 60 years old. They are being replaced by younger Douglas-fir, Engelmann spruce and lodgepole pine. In the areas we examined, past fires occurred at intervals of about 25 to 40 years, with the most recent burns, dated from increment borings, having occurred in about 1929. One living ponderosa pine a mile south of Big Prairie Ranger Station is about 410 years old and has well-formed scars from at least seven different fires. We also found several lodgepole pines, often growing among scattered ponderosa pines, that have three fire scars dating between the mid-1800s and the early 1900s. Although these stands appear to have once been open and parklike, today they are generally dense with young Douglas-fir, lodgepole pine and other conifers, and they contain substantial quantities of duff (including deep mounds at the base of old trees) and down woody fuels. Under current conditions, a summer wildfire that escaped suppression could easily become a large, stand-replacing burn. Successional studies indicate that such a fire would probably give rise to new stands of lodgepole pine and Douglas-fir, with little if any ponderosa pine (Arno and others 1985). These post-fire stands would probably have a dense, even-aged structure, as well as abundant fire-killed downed trees, favoring continuance of a stand-replacement fire regime in the future (Scott 1998).

The larch/Douglas-fir/lodgepole pine mixed-severity type extends up tributary drainages, where it adjoins the stand-replacement fire regime types. In response to historic mixed-severity fires, stands generally have a multi-aged structure. Many of the larch, Douglas-fir and some of the lodgepole pines have one to three scars from past fires. In one stand near White River Butte, we found a large larch with scars from four different fires and a fallen old-growth Douglas-fir with scars from five fires.

In the ponderosa pine-mixed conifer type, it has generally been 70 to 100 years since the last fire, two to four times as long as the average historic fire interval. Current fire-free intervals in the larch/Douglas-fir/lodgepole pine type are probably approaching two times the length of historic mean intervals. These lengthened intervals are not necessarily unprecedented in any one stand; however, because current intervals since the last fire in most stands are near or beyond the upper end of the historical range of fire intervals, associated fuel accumulations provide the opportunity for unusually large, stand-replacing fires. Lodgepole pine is a common forest component in the mixed-severity fire regimes, and it is susceptible to mass mortality as a result of bark beetle epidemics when it reaches ages of 80 years in dense stands (McGregor and Cole 1985). Landscapes of beetle-killed lodgepole pine are at high risk of large, stand-replacing fires (Brown 1975). Frequent fires of the past provided a natural mosaic of diverse stand structures, which reduced chances of large, stand-replacing fires in the mixed-severity fire regime (Barrett and others 1991).

Unusually severe fires in mixed-severity and nonlethal fire regimes have been linked to effects of fire exclusion (Agee 1993; Barbouletos and others 1998; Barrett 1988; Steele and others 1986). The North Fork Flathead Valley in Glacier National Park, an area characterized by a mixed-severity fire regime, experienced the unusually large and severe Red Bench Fire in 1988, after the fire-free interval had more than doubled due to successful fire exclusion (Barrett and others 1991). In 1994, Park managers used prescribed natural fire and confine-and-contain strategies on two nearby wildfires to accomplish 14,000 acres of mixed-severity burning in an adjacent area within this fire regime (Kurth 1996; Van Horn, personal communication).

Possible Restoration Strategies ___

Any effort to restore fire to a more natural role in wilderness must recognize a great paradox: Direct human intervention—suppression of natural fires—has greatly altered fire frequency and fire severity, important processes that historically shaped wilderness ecosystems. Moreover, this intervention will surely continue. Wilderness management (like wildland forest management in general) still operates largely under a fire suppression strategy. Although the concept of eventually returning fire to a more natural role is often accepted by land managers, wilderness fire programs are greatly restricted by concerns about liability for fires escaping wilderness, public safely, smoke pollution and possible complaints from the public. In 1963, a panel of scientists called upon by the Secretary of Interior concluded that the exclusion of natural fire is not consistent with maintenance of ecosystems in national parks—or, by extension, in wilderness (Leopold and others 1963). Although this advice did result in prescribed burning on a small scale in some areas, it has had little affect on landscape-scale management in most national parks or wilderness areas (Parsons and Landres 1998). Restoring natural fires in wilderness requires much stronger support on behalf of the fire manager. Today, if a manager chooses to use or allow fire, he or she is exposed to considerable risk (Czech 1996; Mutch 1997). Conversely, choosing to put out any and all natural fires is relatively risk-free. Ironically, each natural fire suppressed within or near wilderness may be construed as an act of "trammeling" inconsistent with the concept of wilderness as a place where the forces of nature act without human interference (The Wilderness Act: Public Law 88-577, 1964).

Restoration of fire in nonlethal and mixed-severity regimes requires special care because fuel and stand structures in many areas are outside the historic range of variability (Morgan and others 1994; Quigley and others 1996). Some naturally ignited fires burning under these altered conditions might adversely impact natural biodiversity (Covington and others 1997; Harrington 1996). Depending on the situation, we have listed the following four approaches, which might be useful for restoring a semblance of the conditions historically associated with the mixed-severity fire regime in wilderness. These approaches could apply to restoring any natural fire regime, but may be especially pertinent to mixed-severity regimes because a range of fire intensities and effects is acceptable. Any effort to restore natural fire processes requires careful fire management planning (Brown and others 1995b), education within all cooperating agencies and the public and a willingness to accept some degree of risk. All alternatives for restoring fire would be aided by developing low-risk fuel conditions—for example, thinning combined with fuel removal or prescribed burning—in strategic locations along the boundary of the park or wilderness. Such treatments are, however, likely to be expensive and politically sensitive.

1. Allow all or most lightning fires to burn.

Since suppression of lightning fires has been the major factor creating the current situation, a plausible goal could be to fully restore lightning fires as an ecological factor. However, this may not be desirable where the current buildup and continuity of fuels allow lightning fires to become unusually severe and threaten adjacent areas. Still, restoration for the effects of the historical fire regime is essential if wilderness areas are going to support natural ecosystems. It will be challenging to allow most lightning fires to burn. A valuable asset to this approach would be an improved ability to predict fires or fire seasons likely to become severe so that only those situations will require suppression. Such prediction will require modeling of potential fire consequences, using tools such as FOFEM (Reinhardt and others 1997) and FARSITE (Finney 1998). Overall, the goal of this approach is to maximize the use of lightning ignitions to return fire to its natural role; realistically, however, it may be more expedient to use some prescribed fires, as explained below.

2. Reignite suppressed lightning fires.

Conceptually, it is an act of human interference to suppress a lightning fire in a wilderness area. Therefore, when a land manager finds it necessary to suppress a natural fire, we propose the following strategy to "restore" that fire as soon as conditions permit. Determining acceptable prescriptions for reigniting suppressed fires is the key to this approach. This strategy may be especially useful in the initial round of fire reintroduction. If the reignition criteria are too stringent, the resulting fire may be ineffective and insignificant. If the burning conditions are favorable, but a sudden, extreme weather event results in a costly suppression effort or property damage, the manager needs to be buffered from accepting calculated risk, provided proper procedures were followed. Ignition shortly before a season-ending rain or snow storm is a possibility; but accomplishing significant fire size in this case might require ignition at many points.

Although the reignition of lightning fires may seem easy to justify on philosophical grounds (for returning a natural process), it poses a unique problem. It is nearly impossible to attain the hypothetical burned area and severity pattern lost when the fire was suppressed because it was out of prescription. There is rarely enough time before snowfall or season-ending rain events to recoup this acreage or to recreate the pattern of fire severity. Therefore, some other means may be necessary to burn the area left unburned when the fire was suppressed. A possible procedure might be to simulate the behavior of the suppressed fire in a spatially explicit fire-growth model such as FARSITE to compute the total area that the fire might have burned using the daily weather that actually occurred. Then, near the end of the season or the following year, this area could be burned using conventional prescribed fire methodologies.

3. Reignite suppressed fires from past years.

This approach has appeal as a way to reverse effects of past fire suppression in a manner consistent with letting nature take its course. However, if the fuels are beyond the historical range of variation or if ignitions are made under cooler or wetter conditions, the result may not mirror the natural role of fire. If the fire is relit in the same location where a fire was originally suppressed, there is at least some hope of simulating a historical natural fire. Whether the actual fire fulfills this promise is problematical.

4. Use prescribed fire as a preparation for restoring lightning fires.

In this discussion, prescribed burning is defined as systemmatic manager ignition of certain areas under conditions prescribed to accomplish desired effects—in this case, to reduce excessive fuels and return to a semblance of historical ecological conditions. Many alternatives are available for use in obtaining the desired result including varying the season of burning, time of day, prescribed weather, fuel moistures, ignition method and ignition pattern (Brown and others 1995b; Kilgore and Curtis 1987). Managers of some of the large national parks in the Canadian Rocky Mountains are using prescribed burning largely as a substitute for lightning fires (Woodley 1995). For larger U.S. National Parks and wilderness, we propose prescribed burning as a way to return fuel conditions that will allow lightning fires to again play a more natural role.

Using prescribed burning to restore conditions that can allow natural processes to proceed again is logical. Nevertheless, it does involve subjective decisions as to when, where, under what conditions and so forth. Some will see this as inappropriate in wilderness, so a strong case needs to be made for why it may be the only option in some cases. This will raise issues related to methods. The uncertainty of outcome in allowing natural ignition to meet planned objectives is the "risk." Use of prescribed fire minimizes this risk by management choosing time, place and conditions.

Concluding Remarks

Restoration strategy number 1—allowing nearly all lightning fires to burn—is probably not attainable and perhaps not ecologically desirable under current conditions. It could be viewed as the long-term goal for large national parks and wilderness areas. Strategies 2 through 4 all involve prescribed fire applications, methods opposed by many wilderness advocates as inappropriate and unacceptable in wilderness. They argue that any human decisions on when or where fires burn constitute management of natural processes, which counters the intent of the 1964 Wilderness Act. They fear that prescribed burning (by managers) would be used to intentionally manipulate wilderness conditions; that fire would become a manipulative tool rather than a natural process in wilderness (Nickas 1999). As a counterpoint, we maintain that human activities and constraints, such as fire suppression and the artificially confining boundaries of wilderness ecosystems, have already significantly affected these areas and limited how we can manage them. The use of prescribed fire applications provides a critical tool to mitigate such impacts, as long as the ultimate goal of restoring natural processes is not compromised. We fear that the apparent willingness of some wilderness supporters to accept continued fire suppression and fire exclusion rather than the interim use of prescribed fire in wilderness will further exacerbate the problems of accumulating fuels and loss of structural diversity. On the other hand, we recognize the concern that wilderness would lose much of its value if it becomes more of a human-determined landscape. Land managers have the responsibility to document and justify the need for management ignitions on a case-by-case basis.

At the other end of the philosophical spectrum, some people argue for some form of mechanical manipulation to restore more natural or manageable conditions, so that fire can be used or allowed to burn. This may be pertinent in the immediate vicinity of human developments or areas of cultural or historic value, such as backcountry ranger stations, where removing ladder fuels could greatly reduce risk and allow lightning fires to burn instead of being suppressed. However, we argue that mechanical manipulation should be considered inappropriate in general for lands managed as wilderness.

All the options for returning fire to wilderness require better information on fuels, vegetation inventories, successional dynamics, fire effects and so forth (Keane and others 1998b). On the other hand, we are degrading these ecosystems rapidly in some cases, and we cannot afford to "do nothing" and thereby continue the damaging process of fire exclusion. "No action" is a conscious decision with a definite impact. We need to build the case to get started, area by area, monitor what we do, learn from it, and adapt. This is adaptive management.

In summary, restoration of fire is critical to assure long-term sustainability of mixed-severity (and nonlethal) fire regime ecosystems. Most likely, success in achieving goals (and they must be clearly articulated) will come from some combination of the above 4 strategies tailored to fit each wilderness area. Plans for restoring a semblance of the natural fire regime need to be made and then acted upon expeditiously.

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