RESTORING NATURAL FIRE TO WILDERNESS: HOW ARE WE DOING?

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ABSTRACT

The restoration of natural fire to wilderness ecosystems poses a significant challenge to the federal land management agencies. The U.S. Department of the Interior, National Park Service and U.S. Department of Agriculture, Forest Service have conducted progressive prescribed natural fire (PNF) programs for more than two decades. The U.S. Department of the Interior, Bureau of Land Management has only recently approved the use of PNF in a few wilderness areas, whereas the U.S. Department of Interior, Fish and Wildlife Service has relied primarily on the use of management-ignited fires to accomplish wilderness objectives. Despite recognition of the role of natural fire, suppression continues to play a dominant role in wilderness fire policy for all four wilderness management agencies. Ways must be found to substantially increase the acreage burned through prescribed fire in wilderness.

Unfortunately, differences in program approaches and criteria for reporting the occurrence of prescribed natural fire and management-ignited fire in wilderness units managed by the four agencies make it extremely difficult to fully assess accomplishments of wilderness fire management programs. There is an urgent need to improve reporting as well as develop criteria and standards by which to judge the success of wilderness fire programs.

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INTRODUCTION

Fire suppression efforts during the 20th century have had a significant effect on many lands managed as wilderness. In the last several decades, scientists and managers have worked together to develop and implement the rationale and techniques needed to restore fire as a fundamental process in natural ecosystems. In this paper we assess the progress that has been made by the four federal wilderness management agencies in restoring natural fire to wilderness. We review operational and reporting procedures for wilderness fire and make recommendations for improving future wilderness fire management.

WILDERNESS

Passage of the Wilderness Act in 1964 codified a long history of reverence for nature and wildness in the United States (Nash 1982). The Wilderness Act secured, "for the American people of present and future generations the benefits of an enduring resource of wilderness." During the 32 years since passage of the Wilderness Act over one hundred subsequent laws have built the National Wilderness Preservation System to what it is today: more than 103,500,000 acres (41,886,450 hectares) in 630 units managed by four different federal agencies (Table 1).

During the early days of wilderness management, the emphasis was largely on protecting scenery and recreational opportunities (Graber 1995). Although there were early advocates for the need to protect wildness for its own sake (e.g., H. D. Thoreau, John Muir, Aldo Leopold), it was not until the late decades of the 20th century that scientists, and subsequently, land managers, recognized the importance of preserving ecosystems as "biotic wholes," including the processes that influence those ecosystems (Leopold et al. 1963).

Efforts to eliminate fire played a key part in the early "protection" of wilderness and other natural areas (Parsons 1981). The assumption that fire destroys life and property and should be avoided at all costs overshadowed the ecological understanding that many species and communities depend on periodic fire. It was not until the 1970's that the negative effects of fire suppression were fully recognized. During recent years, there have been many efforts to document the importance of fire and the effects of fire suppression on various natural ecosystems (Mooney et al. 1981, Kilgore 1987, Agee 1993, Brown et al. 1995). For many plant communities it is now understood that pre-European settlement fire-return intervals ranged from a few years to several decades, contrasting sharply with the near century of fire exclusion that has characterized the 1900's (Kilgore 1987, Swetnam 1993). Today, fire suppression is recognized as one of the (if not the) leading impacts on wilderness ecosystems (Christensen 1995, Cole and Landres 1996). Wilderness managers are struggling with how best to restore fire as a critical ecosystem function.

WILDERNESS FIRE MANAGEMENT

The action taken on a fire in wilderness depends on specified land management objectives. Fires in wil-

Table 1. Number of wilderness areas and total wilderness acreage by management agency.

Agency	# Areas	Acres[a]
Bureau of Land Management	136	5,227,063
Forest Service	399	34,676,493
Fish & Wildlife Service	75	20,685,372
National Park Service	44	43,007,316
Total	630[b]	103,596,244

[a] 1 acre = 0.4047 ha.
[b] The total is not additive due to overlapping responsibilities.

derness are suppressed if they cause unacceptable social risk (e.g., by causing too much smoke), economic risk (e.g., by threatening property or commodities that are inholdings or beyond the wilderness boundary), or resource damage. Suppressed wildland fires can be human-caused or ignited by lightning. In most cases, wildland fire is suppressed when there is any social or economic risk. The adverse ecological impacts of suppression are rarely considered. Fires that meet management objectives include fires started by lightning (prescribed natural fires or PNF) or by managers (management-ignited fires or MIPF) that are permitted to burn under specified conditions to accomplish specific goals. PNF are generally accepted as the preferred long-term means for restoring fire in wilderness. MIPF are used to accomplish such specific goals as fuel reduction or habitat restoration, or in some cases, to simulate the effects of natural fire where conditions do not permit reliance on PNF. Each of the wilderness management agencies has developed its own approach to managing fire in wilderness. The extensive fires of 1988 (often referred to as the Yellowstone fires) caused a major reassessment of wilderness fire management policies and programs in all federal resource agencies.

Recognition of the detrimental effects of fire suppression on natural ecosystems led to a decision in 1968 by the National Park Service (NPS) to permit two lightning-ignited fires to burn in the subalpine forest zone of Kings Canyon National Park (Kilgore and Briggs 1972). This initiated the first natural fire management program in the United States. This program was soon expanded to include most areas above about 6,500 feet (1,981 meters) in elevation in Kings Canyon, Sequoia, and Yosemite National Parks. By 1993, 889 natural fires (PNF) had burned a total of over 86,000 acres (34,804 hectares) in these three parks (Parsons and van Wagtendonk 1996). The prescription criteria were comprehensive, including fire weather and behavior, and availability of staff to monitor, manage, and if necessary, suppress the fires. By 1988, 26 national parks had operational PNF programs (Botti and Nichols 1995). In addition, many parks have utilized MIPF to either reduce unnatural fuel accumulations or simulate the effects of natural ignitions.

The U.S. Department of Agriculture, Forest Service (USFS) revised its policy of total suppression to permit PNF in wilderness in 1971. The first lightning-ignited fires permitted to burn on Forest Service land were in the Selway-Bitterroot Wilderness in 1972. By 1988 the USFS had approved about 50 wilderness fire plans (Williams 1995). In the Northern Region alone, 4.8 million acres (1.94 million hectares) of wilderness and nonwilderness lands were being managed to allow use of prescribed natural fires. The Selway-Bitterroot (Brown et al. 1994) and Gila (Webb and Henderson 1985) Wildernesses had become particularly well-known for their progressive wilderness fire programs. A 1985 revision to Forest Service policy permitted the use of management ignitions within wilderness if necessary to reduce unnaturally high fuel hazards (Kilgore 1990). Although there has been limited use of management-ignited prescribed fire in USFS wilderness, there is a growing recognition of its importance as a tool to both restore and maintain natural conditions.

Although the Bureau of Land Management (BLM) participated in a joint PNF with the Forest Service in the early 1980's, the agency has been slow to incorporate prescribed fire into its wilderness management program. The first BLM wilderness fire plan permitting PNF was approved in 1990. As of 1995 no PNF had been permitted to burn on BLM wilderness. Fire exclusion continues to dominate BLM planning (Miller et al. 1995, Mahoney, personal communication, 1996).

Although the Fish and Wildlife Service (FWS) has endorsed the use of PNF in wilderness, as of yet, no refuge has found that prescribed natural fire is the preferable strategy for achieving their wilderness objectives. They do make extensive use of limited suppression and containment strategies, especially in Alaska (Leenhouts 1995). Management-ignited prescribed fires are widely utilized within FWS wilderness areas to achieve the specific resource objectives for which individual refuges were established (Leenhouts, personal communication, 1996).

Effects of the 1988 Fires

In 1988, extensive fires, including some that started as PNF, burned more than 3.7 million acres (1.5 million hectares) throughout the western United States. These fires had a significant and immediate impact on the wilderness fire programs of the federal agencies. The publicity and concern these fires generated forced a national reexamination of federal wilderness fire policy (Elfring 1989). All wilderness fire plans were suspended as the Secretaries of Agriculture and Interior conducted department-level reviews. Although the Fire Management Policy Review Team concluded that policy objectives were fundamentally sound, they recommended that implementation of policies be refined and strengthened. Since that time, the departments have revised their policies and the agencies have diligently worked to revise their wilderness fire management guidelines (see Kilgore and Nichols 1995 for NPS example).

No prescribed natural fires were conducted in 1989 by any federal agency. In the succeeding years gradually increasing numbers of areas have been able to reinstate their PNF programs. By 1992, 17 national parks and 13 Forest Service wilderness areas again had operational PNF programs (Botti and Nichols 1995, Williams 1995). The area burned in PNF has been

slower to recover to pre-1988 levels (Botti and Nichols 1995). This is largely attributed to the more restrictive prescription constraints that have been incorporated into revised agency policies and plans. For example, there are now limits on the number and size of most fires, as well as requirements for daily certification that resources are available to immediately suppress a fire if necessary. The guidelines now in effect for many areas are so restrictive that they preclude many natural ignitions from being classified as PNF (Kurth 1996, Mahoney, personal communication, 1996). Whereas it is clear that tighter prescriptions have reduced risks from PNF, the effects of increased constraints on the restoration of natural fire regimes is of great concern. It is likely that many of the largest and most intense (and often the most ecologically significant) fires are being eliminated or significantly modified.

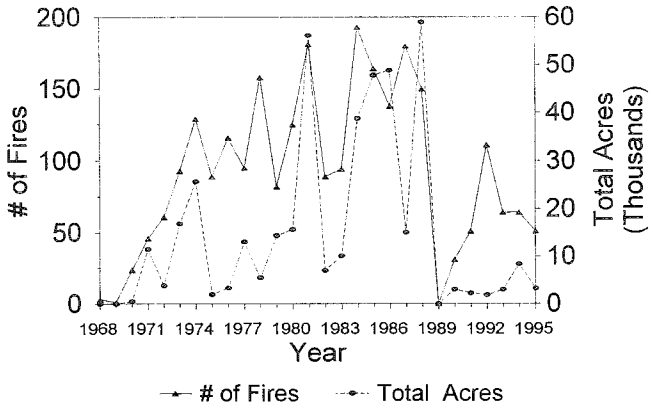

Fig. 1. Number of Prescribed Natural Fires (PNF) and total acreage burned by PNF in the National Park Service, 1968–1995. One acre = 0.4047 hectare.

ACCOMPLISHMENTS OF PNF PROGRAM

Our goal in developing this paper was to assess the accomplishments of the land management agencies in restoring natural fire to wilderness in the United States. We had hoped to present comparable information from all four agencies on the number of wilderness areas with PNF programs and the acreage burned by year and by vegetation type and to compare these numbers against the total number of areas and acreage in need of treatment. Unfortunately, the lack of consistent records and reporting procedures limit such comparison. We found that none of the agencies' reporting procedures permit full evaluation of the number of fires and acreage burned by PNF (or MIPF) in wilderness. The data are even weaker if assessment by vegetation type is desired. PNF accomplishments for each of the wilderness management agencies are discussed below.

U.S. Department of the Interior, National Park Service (NPS)

The NPS has the most complete records, including, since 1968, the number of fires and total acreage burned by fire type (PNF, MIPF, or wildfire) for each unit in the system. For the purposes of assessing wilderness fire, these records are inadequate because there is no separation of fires occurring within or outside of designated wilderness within the parks. Yet, since the NPS manages nearly all of its large natural areas (whether Congressionally designated or not) essentially as wilderness, and virtually all of the PNF programs are found in these types of areas, we have included all Park Service PNF in this assessment. Thus, Glacier National Park (not designated wilderness) and Sequoia National Park (designated wilderness), as well as nonwilderness portions of Sequoia that are under a PNF program, are all included in the PNF statistics of the NPS. The problem is more significant for MIPF in that there is no designation of which of these fires are within portions of parks managed as wilderness and which are in developed or nonwilderness areas of those same parks.

As of 1995, only 20 NPS areas had approved PNF programs; six less than had approved programs in 1988 (Parsons and Botti 1996). Of these 20, only 10 are designated wilderness, meaning less than one fourth of the national park system wilderness areas have approved PNF programs. Nonwilderness areas with PNF programs include such areas as Glacier, Rocky Mountain, and Zion National Parks. The number of PNF on NPS land since inception of the program in 1968 and the number of acres burned by PNF per year are shown in Figure 1. The dramatic effect of the 1988 fires and slow recovery of the program since then are evident. Of even greater concern is the fact that the average size of a PNF in national parks between 1983 and 1987 was 206 acres (83 hectares), whereas between 1990 and 1995 it was only 58 acres (23 hectares). Total annual area burned has shown similar dramatic decreases since 1988 (Figure 1). These declines may be the direct result of the increased constraints imposed following the 1988 fire year (Botti and Nichols 1995). On the other hand, the number of fires and acreage burned in MIPF in NPS units with PNF programs (although not necessarily within the wilderness portions of these units) has increased substantially since 1988 (Botti and Nichols 1995). It is not clear the extent to which these fires are being used to replace natural ignitions or what the long-term consequences of such a replacement might be.

Efforts to compare area burned with the area that would need to be burned to approximate presettlement fire frequencies for different vegetation types have been limited. Parsons (1995) documented that in the giant sequoia *(Sequoia gigantea)* groves of Sequoia and Kings Canyon National Parks recent (since 1968) fire management practices have produced a fire-return interval only a fraction of that documented from fire scar records. van Wagtendonk (1995) calculated fire-return intervals in Yosemite National Park, and concluded that they varied from 49 years in white fir *(Abies concolor)* to 21,073 years in whitebark pine *(Pinus albicaulis)* forests. These fire-return intervals are considerably greater than our best estimates of the

Table 2. Number of approved prescribed natural fire (PNF) plans, # PNF, and # acres burned by PNF by U.S. Forest Service regions for 1995.

Region	# PNF plans	# PNF	Acres[a] burned
Northern	7	26	272
Rocky Mountain	1	0	0
Southwestern	9	5	64,928
Intermountain	4	16	550
Pacific Southwest	2	0	0
Pacific Northwest	11	6	1,527
Southern	14	4	82
Eastern	1	1	3,058
Alaska	0	0	0
Total	49	58	70,417

[a] 1 acre = 0.4047 ha.

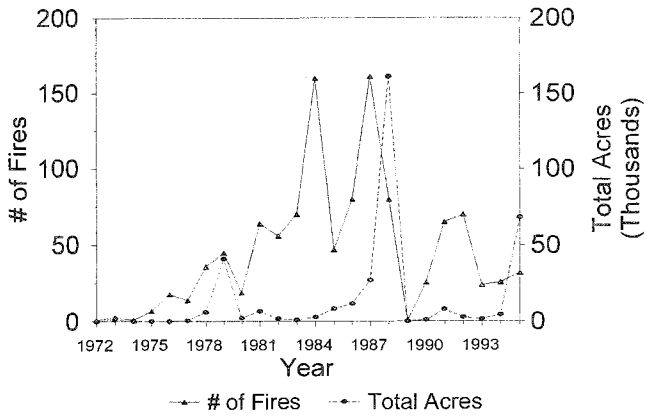

Fig. 2. Number of Prescribed Natural Fires (PNF) and total acreage burned by PNF on USFS wilderness lands, 1972–1995. One acre = 0.4047 hectare.

return intervals occurring under pre-European settlement fire regimes. Despite a paucity of quantitative data, it appears that the area being burned in such units will have to be significantly increased if presettlement fire regimes are to be restored.

U.S. Department of Agriculture, Forest Service (USFS)

Although the Forest Service is much more diligent than the Park Service about keeping separate records for occurrences within as opposed to outside of wilderness, fire records for USFS wilderness are incomplete and inconsistent. No effort has been made to pull together historical fire records for the agency's 399 wilderness units. We searched files maintained at the National Interagency Fire Center in Boise, the Annual Reports on Wilderness Management produced for Congress by each Forest Service region, as well as scattered publications and internal documents, and found inconsistent and incomplete record keeping.

There is no question that the Forest Service built on the early experiences of the Selway-Bitterroot Wilderness PNF program to implement similar programs in other areas. Although Williams (1995) reported that "about 50" wilderness fire plans had been approved for implementation by 1988, we were unable to ascertain whether these plans covered many more that 50 wildernesses (some plans did cover 2 or more wilderness areas), or whether all of these plans actually included provisions for PNF (some may have been suppression only plans). The 1994 Annual Wilderness Reports document 55 approved wilderness fire management plans, with an additional 150 in various stages of preparation. However, some of these plans do not include provisions for PNF. For example, of the 12 approved wilderness fire plans reported for the Eastern Region, only one (the Boundary Waters Canoe Wilderness in Minnesota) includes provisions for PNF. One other (the Hercules Glade Wilderness in Missouri) contains provisions for MIPF. All of the other wilderness fire plans for that region are strictly suppression programs.By 1995 at least 49 USFS wilderness areas were covered by fire plans allowing for PNF (some plans covered more than one wilderness) (Table 2). Table 2 documents that in 1995 at least 58 PNF burned 70,417 acres (28,498 hectares) in USFS wilderness. These data could only be gathered from individual contacts with those involved with fire and wilderness management in each of the Forest Service regions. In some cases we found different numbers being reported by the fire and wilderness staffs within the same region. In addition, confine or contain suppression strategies are used by some Forest Service areas to help achieve PNF goals, further confusing fire reporting. It is encouraging to note that the Forest Service has recently embarked on a major effort to reform agency reporting procedures in a way that will permit analysis of the types of questions we have asked (Bunnell, personal communication, 1996).

There can be great variability among years in PNF acres burned, often with a single area providing most of the burned acreage. The 70,417 acres (28,498 hectares) burned in 1995 compares with a total of 8,343 acres (3,376 hectares) burned in PNF in 1994, and 9,742 PNF acres (3,493 hectares) in 1993. We believe the increased burned acres in 1995 are more a reflection of variability in fire conditions (e.g., regional drought) than changes in PNF implementation plans. The 1995 figures are also largely accounted for by over 64,000 acres (25,900 hectares; slightly over 92% of the total Forest Service PNF acres burned during 1995) burned in four PNF in Arizona and New Mexico. Similarly, the Southwest Region provided nearly 80% of the PNF acres burned during 1993, and nearly 60% of the acres burned during 1994. Figure 2 presents the best available data on the number and acreage burned by PNF in USFS wilderness since 1972.

Assessment of the effectiveness of the USFS wilderness fire program in restoring presettlement fire regimes are limited to the comparison by Brown et al. (1994) of the prescribed natural fire program of the 1,300,470 acre (526,300 hectares) Selway-Bitterroot Wilderness with the presettlement (defined as pre-1935, or prior to effective suppression) fire regime for eight major forest types. They concluded that average annual area burned by both stand replacement and understory fire prior to suppression was 1.5 and 1.9 times greater respectively than during the recent period

(1979–1990). Such numbers are probably within the range of historical variability for at least most forest types. This study supports the idea that the Selway-Bitterroot program has been at least partially successful in restoring natural fire regimes.

U.S. Department of The Interior, Bureau of Land Management (BLM)

The BLM approved its first Wilderness Management Plan that permitted prescribed natural fire in 1990. However, the areas covered by the plan, the Mt. Trumbull and Mt. Logan Wildernesses in northwestern Arizona, have not yet administered a PNF. These areas have utilized MIPF for fuel reduction purposes. In 1995 three additional wilderness plans permitting the use of PNF in BLM wilderness were approved for areas in southeastern Arizona and eastern Nevada (Mahoney, personal communication, 1996). No PNF have occurred in these areas to date. Several other plans permitting the use of PNF are currently being developed by the BLM.

Since the BLM does not maintain a wilderness designation for tracking of its fire records it is impossible to assess the extent to which specific types of fire are occurring on BLM wilderness lands. The BLM expects new national policy direction on wilderness fire and prescribed fire reporting to be released shortly (Ferry, personal communication, 1996).

U.S. Department of the Interior, Fish and Wildlife Service (FWS)

The Fish and Wildlife Service has no specific provisions for wilderness fire. Although the FWS has not implemented PNF programs for any of its management units, it has burned extensive areas in Alaska under a limited suppression program. The FWS has determined that it is better able to accomplish specific refuge objectives through a combination of limited suppression of wildfires and management-ignited prescribed fire (Leenhouts 1995, personal communication, 1996). This is due, in part, to the small size of most FWS wilderness areas outside of Alaska. Records for both MIPF and wildfire within FWS units do not designate whether the fires include lands designated as wilderness. This makes it impossible to assess accomplishment towards restoring wilderness fires on FWS lands.

Interagency Comparisons

The lack of consistent reporting precludes effective comparisons between wilderness fire program accomplishments for the four wilderness management agencies. Table 3 summarizes the best available data on the number of units with PNF programs, the number of PNF allowed to burn, and the total acreage burned in PNF for 1995. These numbers are taken from a variety of sources, many of which are inconsistent even within the agencies' own records. It is clear that areas currently being burned in wilderness, even when wildfires are included, are a small fraction of that required to restore presettlement fire regimes. Yet, the fact that agencies generally recognize the importance and appropriateness of restoring fire to its natural ecological role in wilderness (including the use of both PNF and MIPF strategies) leaves the door open for significant future expansion of wilderness fire programs. Current PNF programs are almost exclusively in large wilderness areas. This reflects the high risk associated with burning in small areas where boundary issues are of concern.

Table 3. Number of wilderness areas with approved prescribed natural fire (PNF) programs, # PNF fires, and acres burned by PNF, by agency, for 1995.

Agency	# of active PNF programs	# PNF	Acres[a] burned
Bureau of Land Management	5	0	0
Forest Service	49	58	70,417[b]
Fish & Wildlife Service	0	0	0
National Park Service	20[c]	51	3,171

[a] 1 acre = 0.4047 ha.
[b] 64,928 acres burned in Arizona and New Mexico in four PNF.
[c] Includes nondesignated wilderness.

MANAGEMENT-IGNITED PRESCRIBED FIRE

There are many situations in which PNF will not be sufficient to restore natural fire regimes. In addition to the constraints imposed following the post-1988 review, many wilderness units are simply not conducive to PNF programs. Some are too small to rely on natural ignitions, many of which start outside the wilderness boundary. Others are located adjacent to high value urban, cultural, or other human resources. In other situations, fuel accumulations, either inside or adjacent to the wilderness boundary, are too great to avoid resource damage. In these cases serious consideration must be given to the use of management ignitions both to reduce high fuel accumulations, as well as to allow the natural role of fire (see Brown 1992, and Mutch 1995 for further discussion). At other times it may be appropriate to substitute a management ignition for a lightning fire that had to be suppressed at an earlier date (Christensen 1995).

Current policy for each of the four wilderness management agencies permits the use of management ignitions to accomplish certain objectives. The extent to which the agencies have utilized this option varies widely. The NPS and FWS have made extensive use of MIPF in wilderness for reasons varying from boundary constraints (DeBenedetti 1990) to the belief that prescribed burns are of greater utility in accomplishing resource objectives (Leenhouts 1995). Despite being permitted by policy, the BLM has only utilized MIPF to a limited extent in wilderness.

The Forest Service has traditionally had the most restrictive policy of all the federal agencies regarding the use of MIPF in wilderness. Forest Service policy allows management ignitions in wilderness to reduce

unnatural buildups of fuels only if necessary to reduce the risk of wildfire under conditions where lightning fires would pose serious threats to life, property, or natural resources. This policy does not permit the use of management ignitions to accomplish specific resource objectives, including the simulation or replacement of natural fire. Concern over the restrictions this policy places on the management for naturalness in small or urban-proximate wildernesses has prompted several efforts within the Forest Service to justify a broader interpretation of the need for management ignitions. In May 1995, the Chief of the Forest Service approved a program for FS wilderness areas in Florida to "permit the use of management-ignited fire to accomplish wilderness management objectives when lightning [caused fires] cannot be managed at a frequency or intensity within the natural range of variability." In the West, plans are underway in a number of areas to justify the use of MIPF in accomplishing ecosystem restoration objectives. For example, the personnel responsible for the relatively small Lee Metcalf Wilderness in Montana are taking a programmatic look at how to best restore fire to the entire Madison Range, including both wilderness and nonwilderness lands. They have concluded that MIPF must play a role for the program to be successful (Schlenker, personal communication, 1996). Anticipated revisions to FS wilderness fire policy are expected to permit wider use of management ignitions.

SUMMARY

Although the lack of consistent reporting within and between agencies makes it impossible to fully evaluate the current status and recent progress made in restoring fire to USFS, NPS, BLM, and FWS wilderness, it is clear that we are faced with immense challenges. Serious scientific, managerial, and philosophical questions must be asked and answered, commitments made, and actions taken. These questions include: What was the historic fire regime and role of fire in an area? What course of action should be taken if there is insufficient knowledge about fire regimes and the role of fire in an area? How do natural area managers balance competing values and risks? How do agencies with different mandates, policies, and cultures develop consistent fire programs and reporting? And should fire be manipulated in wilderness when we know that our knowledge about this process and its effects is incomplete and in most cases inadequate? With fire, the stakes are always high and long term. In this case, our efforts at restoring the natural process of fire during the next decade will be critical in shaping the future of our wilderness legacy. Because of current inadequacies there is a critical need for increased cooperation among the federal wilderness management agencies in the study, planning, management, and reporting of fire in wilderness.

FUTURE CHALLENGES AND RECOMMENDATIONS

In developing this paper, we have identified a number of important issues that must be addressed if fire is to be successfully restored as a natural process in wilderness. These include both reporting and action needs:

- Inconsistencies in agency reporting requirements and record keeping must be corrected if we are to evaluate the effectiveness of wilderness fire programs. The incompleteness of current records make it difficult to assess accomplishments to date or compare programs and progress among agencies. At a minimum, all agencies need to maintain annual records for each fire burning all or partially within wilderness, including information on fire type (PNF, MIPF, wildfire), total acreage burned (broken down by wilderness and nonwilderness if applicable), and if possible, acreage of each vegetation type burned. Recent advances in GIS technology hold great promise for keeping track of areas burned in wilderness and in different vegetation types (van Wagtendonk 1994, Bourgeau-Chavez et al. 1997).
- Ways must be found to substantially increase the acreage burned through prescribed fire in wilderness. This includes greatly expanded prescribed natural fire programs as well as consideration of increased use of management-ignited fire to accomplish resource objectives. The latter is especially important in small areas where social and political constraints must be weighed against possible compromises in ecological values (i.e., the role of fire as a natural process). Of course, the ecological benefits of an expanded PNF program will need to be balanced and coordinated with the social and economic risks of smoke and damage to property and commodity values.
- It will be necessary to increase cooperation (both planning and action) between agencies and across boundaries. Fire is a landscape-scale process that does not recognize political or administrative boundaries. All too often we hear stories of how proximity to wilderness or agency boundaries limits or prohibits the use of fire. The recently released interagency Federal Wildland Fire Management Policy And Program Review (USDI and USDA 1995) provides an excellent basis for revision of individual agency policies and programs to address this and other issues facing wilderness fire managers.
- Increased support for and utilization of the latest technology and best science will be needed to determine objectives, evaluate success, and improve the predictive capabilities needed to understand the likely consequences of management options. Techniques such as the latest developments in fire spread (Finney 1995), fire effects, and ecosystem dynamics modeling provide exciting prospects for future fire planning. In those cases where fire is simply not an option, consideration may have to be given to the use of such alternatives as mechanical manipulation.

As decisions to use such options in wilderness will be controversial, they must be based on the best possible information. This includes evaluation of all alternatives, including doing nothing.

- MIPF are used to accomplish two different goals, and these goals must be clearly defined. The goal of simulating or restoring the natural process of fire is accomplished either through PNF (the preferred means) or MIPF. The goal of restoring natural conditions (e.g., reducing fuel accumulations) is generally accomplished through MIPF. Therefore, MIPF are used for accomplishing two different goals, and the criteria and standards used to evaluate success of a MIPF will differ depending on which of these goals is driving the action. Evaluating the success of any resource objective requires clearly defined goals; the use of MIPF in wilderness is no exception.
- There is an urgent need to develop criteria and standards by which to judge success of wilderness fire programs. These should include consideration of natural fire regimes and their effects on current vegetation composition and structure. Such information could then be compared on national, regional, or individual management unit scales in relation to vegetation type and recent accomplishments. Without these criteria and standards, it is impossible to evaluate success and effectiveness of prescribed natural fires in wilderness areas.

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Authors' Note: In June of 1997 the National Wildfire Coordinating Group (an interagency group of fire managers) adopted new terminology that recognizes only two types of wildland fire: (1) wildland fire, any non-structure fire, other than prescribed fire, that occurs in the wildland, and (2) prescribed fire: any fire ignited by management actions to meet specific objectives. The terms prescribed natural fire and management ignited prescribed fire will not be used beginning in 1998. Lightning fires to be managed to restore or maintain natural fire regimes will apparently be called wildland fires. At this time it is unclear how this change in terminology might affect agency prescribed natural fire programs.

LITERATURE CITED

Agee, J.K. 1993. Fire ecology of Pacific Northwest forests. Island Press, Washington, DC.

Botti, S.J., and H.T. Nichols. 1995. Availability of fire resources and funding for prescribed natural fire programs in the National Park Service. Pages 94–104 *in* J.K. Brown, R.W. Mutch, C.W. Spoon, and R.H. Wakimoto (eds.). Proceedings: symposium on fire in wilderness and park management. General Technical Report INT-320, U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Ogden, UT.

Bourgeau-Chavez, L.L., P.A. Harrell, E.S. Kasischke, and N.H.F. French. 1997. The detection and mapping of Alaskan wildfires using a spaceborne imaging radar system. International Journal of Remote Sensing 18:355–372.

Brown, J.K. 1992. A case for management ignitions in wilderness. Fire Management Notes 53–54:3–8.

Brown, J.K., S.F. Arno, S.W. Barrett, and J.P. Menakis. 1994. Comparing the prescribed natural fire program with presettlement fires in the Selway-Bitterroot Wilderness. International Journal of Wildland Fire 4:157–168.

Brown, J.K., R.W. Mutch, C.W. Spoon, and R.H. Wakimoto. 1995. Proceedings: symposium on fire in wilderness and park management. General Technical Report INT-320, U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Ogden, UT.

Bunnell, D. 1996. Personal communication: U.S. Forest Service, Interagency Fire Center, Boise, ID.

Christensen, N.L. 1995. Fire and wilderness. International Journal of Wilderness 1:30–33.

Cole, D.N., and P.B. Landres. 1996. Threats to wilderness ecosystems: impacts and research needs. Ecological Applications 6:168–184.

DeBenedetti, S.H. 1990. Managed fire in wilderness: a necessity at Pinnacles National Monument, California. Pages 401–406 *in* D.W. Lime (ed.). Managing America's enduring wilderness resources. University of Minnesota, St. Paul.

Elfring, C. 1989. Yellowstone: fire storm over fire management. Bioscience 39:667–672.

Ferry, G. 1996. Personal communication: Bureau of Land Management, Interagency Fire Center, Boise, ID.

Finney, M.A. 1995. Fire growth modeling in the Sierra Nevada of California. Pages 189–191 *in* J.K. Brown, R.W. Mutch, C.W. Spoon, and R.H. Wakimoto (eds.). Proceedings: symposium on fire in wilderness and park management. General Technical Report INT-320, U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Ogden, UT.

Graber, D.M. 1995. Resolute biocentrism: the dilemma of wilderness in national parks. Pages 123–135 *in* M.E. Soule and G. Lease (eds.). Reinventing nature?: responses to postmodern deconstruction. Island Press, Washington, DC.

Kilgore, B.M. 1987. The role of fire in wilderness: a state-of-knowledge review. Pages 70–103 *in* R.C. Lucas (compiler). Proceedings-national wilderness research conference: issues, state-of-knowledge, future directions. General Technical Report INT-220, U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Ogden, UT.

Kilgore, B.M. 1990. Fire in wilderness ecosystems. Pages 297–336 *in* J.C. Hendee, G.H. Stankey, and R.C. Lucas (eds.). Wilderness management. North American Press, Golden, CO.

Kilgore, B.M., and G.W. Briggs. 1972. Restoring fire to high elevation forests in California. Journal of Forestry 70:266–271.

Kilgore, B.M., and T. Nichols. 1995. National Park Service fire policy and programs. Pages 24–29 *in* J.K. Brown, R.W. Mutch, C.W. Spoon, and R.H. Wakimoto (eds.). Proceedings: symposium on fire in wilderness and park management. General Technical Report INT-320, U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Ogden, UT.

Kurth, L.L. 1996. Examples of fire restoration in Glacier National Park. Pages 54–55 *in* C.C. Hardy and S.F. Arno (eds.). The use of fire in forest restoration. General Technical Report INT-GTR-341, U.S. Department of Agricul-

ture, Forest Service Intermountain Research Station, Ogden, UT.

Leenhouts, B. 1995. U.S. Fish and Wildlife Service wilderness planning considerations. Pages 124–126 *in* J.K. Brown, R.W. Mutch, C.W. Spoon, and R.H. Wakimoto (eds.). Proceedings: symposium on fire in wilderness and park management. General Technical Report INT-320, U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Ogden, UT.

Leenhouts, B. 1996. Personal communication: Fish and Wildlife Service, Interagency Fire Center, Boise, ID.

Leopold, A. S., S.A. Cain, C.M. Cottam, I.N. Gabrielson, and T.L. Kimball. 1963. Wildlife management in the national parks. Transactions of the North American wildlife and natural resources conference 28:28–45.

Mahoney, K. 1996. Personal communication: Bureau of Land Management, Arizona State Office, Phoenix.

Miller, M., C. Gossard, and K. Mahoney. 1995. Fire management considerations for BLM wilderness areas. Pages 230–232 *in* J.K. Brown, R.W. Mutch, C.W. Spoon, and R.H. Wakimoto (eds.). Proceedings: symposium on fire in wilderness and park management. General Technical Report INT-320, U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Ogden, UT.

Mooney, H.A., T.M. Bonnicksen, N.L. Christensen, J.E. Lotan, and W.A. Reiners (technical coordinators). 1981. Proceedings of the conference: fire regimes and ecosystem properties. General Technical Report WO-26, U.S. Department of Agriculture, Forest Service, Washington, DC.

Mutch, R.W. 1995. Prescribed fire in wilderness: how successful? Pages 38–41 *in* J.K. Brown, R.W. Mutch, C.W. Spoon, and R.H. Wakimoto (eds.). Proceedings: symposium on fire in wilderness and park management. General Technical Report INT-320, U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Ogden, UT.

Nash, R. 1982. Wilderness and the American mind. Yale University Press, New Haven, CT.

Parsons, D.J. 1981. The role of fire management in maintaining natural ecosystems. Pages 469–488 *in* H.A. Mooney, T.M. Bonnicksen, N.L. Christensen, J.E. Lotan, and W.A. Reiners (technical coordinators). 1981. Proceedings of the conference: fire regimes and ecosystem properties. General Technical Report WO-26, U.S. Department of Agriculture, Forest Service, Washington, DC.

Parsons, D. J. 1995. Restoring fire to giant sequoia groves: what have we learned in 25 years? Pages 256–258 *in* J.K. Brown, R.W. Mutch, C.W. Spoon, and R.H. Wakimoto (eds.). Proceedings: symposium on fire in wilderness and park management. General Technical Report INT-320, U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Ogden, UT.

Parsons, D.J., and S.J. Botti. 1996. Restoration of fire in national parks. Pages 29–31 *in* C.C. Hardy and S.F. Arno (eds.). The use of fire in forest restoration. General Technical Report INT-GTR-341, U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Ogden, UT.

Parsons, D.J., and J.W. van Wagtendonk. 1996. Fire research and management in the Sierra Nevada national parks. Pages 25–48 *in* W.L. Halvorson and G.E. Davis (eds.). Ecosystem management in the national parks. University of Arizona Press, Tucson.

Schlenker, K. 1996. Personal communication: Galletin National Forest, Bozeman, MT.

Swetnam, T.W. 1993. Fire history and climate change in giant sequoia groves. Science 262:885–889.

U.S. Department of Interior and U.S. Department of Agriculture. 1995. Federal wildland fire management policy and program review: final report. Washington, DC.

van Wagtendonk, J.W. 1994. Spatial patterns of lightning strikes and fires in Yosemite National Park. Proceedings of the Fire and Forestry Meteorology Conference 12:223–231.

van Wagtendonk, J.W. 1995. Large fires in wilderness areas. Pages 113–116 *in* J.K. Brown, R.W. Mutch, C.W. Spoon, and R.H. Wakimoto (eds.). Proceedings: symposium on fire in wilderness and park management. General Technical Report INT-320, U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Ogden, UT.

Webb, D.R., and R.L. Henderson. 1985. Gila Wilderness prescribed fire program. Pages 413–414 *in* J.E. Lotan, B.M. Kilgore, W.C. Fischer, and R.W. Mutch (eds.). Proceedings-symposium and workshop on wilderness fire. General Technical Report INT-182, U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Ogden, UT.

Williams, J.T. 1995. Managing risk in wilderness fire management. Pages 22–23 *in* J.K. Brown, R.W. Mutch, C.W. Spoon, and R.H. Wakimoto (eds.). Proceedings: symposium on fire in wilderness and park management. General Technical Report INT-320, U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Ogden, UT.