# The History and Evolution of Wildland Fire Use

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## ABSTRACT

Wildland fire use as a concept had its origin when humans first gained the ability to suppress fires. Some fires were suppressed and others were allowed to burn based on human values and objectives. Native Americans and Euro-American settlers fought those fires that threatened their villages and settlements but left others to burn unabated. Even with the advent of a fire suppression capability in the late 1880s, control efforts were focused on areas of human development while fires in remote areas were largely ignored. When the Forest Service was established in 1905, fire suppression became its reason for being, although some foresters questioned the economic logic of suppressing all fires. Fire suppression was the only fire policy for all federal land management agencies until the late 1960s when the National Park Service officially recognized fire as a natural process. Lightning fires ignited in special management zones in parks were allowed to run their course under prescribed conditions. The Forest Service followed suit in 1974 and changed its policy from fire control to fire management, allowing lightning fires to burn in wilderness areas. The programs in both agencies grew slowly as managers became comfortable with allowing fires to burn under controlled conditions. Various terms were used to describe these programs including "Let Burn," "Prescribed Natural Fire," and now "Wildland Fire Use." Setbacks such as the Yellowstone fires in 1988 and the Cerro Grande fire in 2000 resulted in reviews and updates of federal fire management policies. The Fish and Wildlife Service, Bureau of Land Management, and Bureau of Indian Affairs joined the other two agencies by implementing fire use programs in the late 1990s and early 2000s. Today wildland fire use is a vital link in the fire and fuels programs of each of the federal land management agencies with nearly 6,000 fires burning over 1,400,000 ha (3,500,000 ac) annually. The future of restoring fire to fire-prone ecosystems will have to rely on increasing the use of wildland fire.

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## INTRODUCTION

Fire has been a dynamic ecological force in fire-prone ecosystems for millennia. Not until humans felt the need to control or use fire was the role of fire altered in natural ecosystems. Native Americans were the first humans to influence fire regimes by controlling fires near their villages and by using fire to enhance the production of food items and basketry materials (Anderson 2006). Their effect was not pervasive, however, and varied over the landscape (Vale 2002). Remote areas were less likely to be tended than areas near habitation

and, as a result, fire regimes across large areas remained unaltered by humans.

When Europeans arrived in North America, they caused dramatic changes to fire regimes. Cutting down forests for agriculture, decimating Native American populations with disease, and tilling vast areas of grasslands all caused the role of fire to change. Logging debris often caught fire and indiscriminate burning allowed fires to burn in areas and during times when they would not have naturally burned. Although there was no real fire protection organization, local fire districts attempted to extinguish human-caused and lightning-caused fires near settlements whenever possible. Wildland fire management did not occur until the late 1800s when federal land was set aside as parks and preserves.

## 1872-1967: THE FIRE PROTECTION YEARS

Yellowstone National Park was established in 1872 as the world's first national park. For the next several years, administration of the park languished until 1886 when the US Army was assigned the responsibility for its protection. Upon its arrival in the park, the Army found numerous fires burning in developed areas as well as in areas where it was not reasonable to control them (Rothman 2007). The commanding officer decided that human-caused fires along roads posed the biggest threat and that the Army would concentrate its suppression efforts on the control of those fires. There were not enough soldiers to fight all of the fires, and thus came the first conscious decision by a manager of federal land to allow some fires to burn while others were controlled. The policy of fire suppression was also applied to Sequoia, General Grant, and Yosemite national parks when they were established in 1890, and Army patrols were initiated to guard against fires, livestock trespass, and illegal logging. In 1916, the National Park Service was established and took over management from the Army. Fire suppression remained the only fire policy in the national parks for the next five decades.

The Forest Service was established in 1905 and one of its primary missions was the suppression of all fires on the forest reserves it administered. The extensive fires of 1910 solidified the Forest Service as the premier fire control organization (Pyne 2006), and the National Park Service followed its lead. Complete fire suppression was the objective. Briefly, between 1916 and 1919, Roy Headley, the Assistant District Forester for California, implemented a program to allow low intensity fires to spread in remote areas unless they threatened high value timber or improvements. His proposal was based on the costs of suppressing those fires relative to the values to be protected (Pyne 1982). Once again in 1934, Headley, now the Chief of Fire Control for the Forest Service, and Elers Koch, the Forest Supervisor of the Lolo National Forest, proposed that backcountry areas not receive the same level of fire control as front country areas. Supporting them were Forest Service wilderness advocates Aldo Leopold and Robert Marshall (Pyne 1982). They were overruled and the policy of extinguishing all fires by 10:00 AM of the next burning period was implemented. That policy remained in effect until the 1970s.

There were also rumblings within the National Park Service about the universal application of fire suppression to all lands. Eivind Scoyen was the Superintendent at Glacier National Park during the 1930s and had seen the futile efforts to control large fires in the remote backcountry. In 1950, he was the Superintendent of Sequoia National Park and supported designating the Kaweah Basin in the upper Kern River drainage as a research area that would not be subjected to fire suppression (Rothman 2007). The Regional Director accepted the principle that fire should not

be immediately suppressed in some remote areas of the park system, but made sure that the Director of the National Park Service understood that the Kaweah Basin presented a unique situation that would signal no service-wide policy change (Rothman 2007). Although the only fire that occurred in the basin during the experimental period was a suppressed campfire, the program was unique because the reason to allow fires to burn was not just economic, but was also ecological.

In 1964, George Briggs, the assistant chief ranger of Yosemite National Park, discovered a fire at 2,860 m (9,380 ft.) that had burned only 0.04 ha (0.1 ac) in 3 to 4 days (Briggs 1966). Based on this observation, he recommended that all fires above 2,438 m (8,000 ft) not be suppressed if a reconnaissance and evaluation showed that the fires would be contained by natural fuel breaks, that there was little fuel, and that little "damage" would result. Although reduced suppression costs were one of the cited reasons for the recommendation, he stressed that allowing fire to play a natural role was also a benefit. This recommendation was not acted upon for six years.

## 1968-1977: THE EXPERIMENTAL YEARS

In 1962, the Secretary of the Interior asked a committee to look into wildlife management problems in the national parks. This committee, named after its chair, Dr. Starker Leopold, the son of Aldo Leopold, did not confine its report to wildlife, but took the broader ecological view that parks should be managed as ecosystems (Leopold *et al.* 1963). As a result, the National Park Service changed its policy in 1968 to recognize fire as an ecological process. Fires were to be allowed to run their courses as long as they could be contained within fire management units and accomplished approved management objectives.

Sequoia and Kings Canyon National Parks established a natural fire management zone in 1968 immediately after the policy changed (Bancroft *et al.* 1984). Leading this effort was George Briggs, who had become the forester at Sequoia and Kings Canyon, and Dr. Bruce Kilgore, a former graduate student of Starker Leopold, who was assigned to the parks as a research biologist. The "Let Burn Zone," as Kilgore and Briggs (1972) called it, included areas above 3,000 m (9,000 ft) except where fuels were continuous across the park boundary. Two fires were allowed to burn during the first season, and by 1971, 52 fires had burned 250 ha (617 ac). The first large fire was the Bubbs Creek fire in 1971 that burned 183 ha (452 ac). The following year, the Ball Dome fire burned 47 ha (115 ac) (Figure 1). The Sequoia and Kings Canyon wildland fire use program continues to be one of the leading programs in the nation.

Saguaro National Monument (now Saguaro National Park) was the next park area to initiate a wildland fire use program in 1971. Coined "Natural Prescribed Fire," the program required that all natural fires be extinguished except those that occurred between July 1 and September 15 and met a set of prescribed conditions (Gunzel 1974). Between 1971 and 1974, 24 out of 46 fires were allowed to burn over 360 ha (900 ac).

Yosemite National Park started its "Natural Fire Management" program in 1972. The natural fire zone was restricted to areas above 2,440 m (8,000 ft), and 3 fires burned less than 0.2 ha (0.5 ac) the first year (van Wagtendonk 1978). The following year the zone was doubled in size to 188,450 ha (465,670 ac) and included areas down to 1,220 m (4,000 ft). The first test of the program came in 1974 when the Starr King fire burned over 1,500 ha (3,700 ac) and had to be controlled on one side to preclude smoke from drifting into Yosemite Valley. Although considerable smoke entered

**Figure 1.** The Ball Dome fire in Sequoia and Kings Canyon National Parks is typical of many fires that have burned as part of the wildland fire use program in the Sierra Nevada national parks. It burned to 47 ha (115 ac) in 1972.

the Valley, there was little public controversy (van Wagtendonk 1978).

At the same time that the Starr King fire was burning in Yosemite, Grand Teton National Park was contending with the equally large Waterfall Canyon fire, which was pouring smoke into Jackson, Wyoming. Considerable public outcry occurred when the smoke obscured the mountains, and some accused the park of having a "scorched earth" policy (Kilgore 1975). The fire burned into October when late autumn snows extinguished it.

The impetus for wildland fire use in the Forest Service came from fire and wilderness managers in the northern Rocky Mountains. As early as 1969, a wilderness workshop was held in Missoula, Montana, to discuss, among other topics, allowing fire to play a more natural role in wilderness areas. This workshop was followed by a wilderness fire management study in 1970 that led to the establishment of the White Cap Fire Management Area in the Selway-Bitterroot Wilderness on the Bitterroot National Forest in Idaho (Mutch 1974). The first fire in the White Cap ignited in 1972 on the same day that the Chief of the Forest Service signed off on the plan. The following year the Fritz Creek Fire burned over 650 ha (1,600 ac) (Figure 2).

The Gila Wilderness in New Mexico was the next Forest Service area to initiate a wildland fire use program. The first fire in the Gila managed under the new program occurred in 1975, and in 1978, the Langstroth fire burned 1,295 ha (3,200 ac). The Gila and Selway-Bitterroot programs would grow to become the premier Forest Service wildland fire use programs. Information gained from these experiments was instrumental in changing Forest Service fire policy from fire control to fire management (DeBruin 1974). In 1978, the Forest Service abandoned the 10:00 AM policy

**Figure 2.** The Fritz Creek fire in 1973 was the first large fire to occur in the White Cap Fire Management Area of the Selway-Bitterroot Wilderness on the Bitterroot National Forest.

in favor of a new policy that encouraged the use of wildland fire by prescription.

## 1978-1989: THE RE-EVALUATION YEARS

Three events between 1978 and 1988 precipitated a major fire policy review in 1989: the Ouzel fire in Rocky Mountain National Park, the fires in and around Yellowstone National Park, and the Canyon Creek fire in the Bob Marshall Wilderness on the Lewis and Clark National Forest.

The fire management plan for Rocky Mountain National Park was originally written in 1973 and revised in 1974 and 1975 (Rothman 2007). The 1977 plan defined a "Prescribed Natural Fire" zone generally above 3,048 m (10,000 ft) where risks were considered low and fires would be monitored and allowed to burn; a moderate risk zone where fires would be allowed to burn only under a set indexed condition; and a high risk zone where all fires would be suppressed immediately. The Ouzel fire was ignited by lightning on August 19, 1978, in the low risk zone, and was monitored for more than a month before high winds caused it to threaten a community outside the park's boundary. After the fire was controlled in October, a board of review was convened to investigate the circumstances surrounding the event. The board concluded that the fire plan was not properly implemented, did not adequately incorporate ecological information about the park, and did not have enough emphasis on external considerations such as adjoining development (Laven 1979). In addition, insufficient fire-fighting resources were available to suppress the fire when it exceeded its prescription (Rothman 2007). The Rocky Mountain National Park program was suspended pending revision of the plan.

Ten years later, the fires of 1988 caused considerable controversy when 562,310 ha (1,389,500 ac) burned in the greater Yellowstone area. Based on a plan written in 1972, Yellowstone National Park allowed several lightning fires to burn in a remote corner of the park in late June. At the same time, Forest Service managers of the Absaroka-Beartooth Wilderness just north of Yellowstone were monitoring the Storm Creek fire. By the end of July, unusually dry conditions coupled with high winds convinced managers of both agencies to suppress all fires that were currently burning as well as all new starts (Schullery 1989). Human-caused fires from outside of the park added to the problem. In fact, the North Fork fire, which threatened Old Faithful Village, was started by a woodcutter's cigarette on the adjacent Targhee National Forest. Ninety-five percent of the area that burned was burned by nine major fires. Six of those fires were ignited outside the park, and four of them were human caused (Schullery 1989). Accusations of irresponsible management were common and the National Park Service was left with a serious public relations problem (Rothman 2007).

At the same time that Yellowstone was burning, the Canyon Creek fire was being allowed to burn in the Bob Marshall Wilderness on the Lewis and Clark National Forest. It escaped the wilderness and burned over 100,000 ha (250,000 ac). The town of Augusta, Montana, was threatened and private property was damaged before it was suppressed. The media coverage of the fire was local as most attention was focused on Yellowstone.

The Secretaries of Agriculture and the Interior convened a fire policy review team to evaluate the National Park Service and Forest Service wilderness fire policies. The team reaffirmed the fundamental importance of fire's natural role but recommended that fire management plans be strengthened by establishing clear decision criteria and accountability, and that interagency cooperation be improved (Rothman 2007). Until new fire management plans were prepared, the

Secretaries suspended all prescribed natural fire programs in parks and wilderness areas.

## 1989-1999: THE MATURING YEARS

Wildland fire use programs restarted slowly after the 1989 review. The programs at Yosemite, Sequoia, and Kings Canyon national parks, as well as several national forest wilderness areas, came back on line in 1990, but progress was slow to recover in other areas. A complete review and update of the federal wildland fire management policy and program was conducted, and wildland fire use was reaffirmed as a legitimate program (USDA and USDI 1989). After the review, the Forest Service and National Park Service programs began to grow as the number of fires and area burned increased.

Yosemite National Park had revised its fire management plan to meet the requirements of the policy review before the start of the1989 fire season, but the moratorium on prescribed natural fire programs precluded implementation that year. In 1990, the program was reinitiated, and 20 fires were allowed to burn out within the prescribed natural fire zone. In early August, a lightning storm ignited two fires within seconds of each other outside of the zone. Although immediate suppression actions were taken on the two fires, they burned a total of 10,464 ha (25,857 ac). All subsequent fires for the remainder of the year were suppressed. Succeeding years saw the program reach maturity as lightning fires burned together into a jigsaw pattern and either went out or reburned with reduced intensity (Figure 3) (Collins *et al*. 2007).

Glacier National Park was also experiencing some controversy with the Howling fire in 1994 (Rothman 2007). This fire remained small for over six weeks before it burned 906 ha (2,238 ac). Local Forest Service managers and the media called for its suppression, but the superintendent stood firm and the fire was extinguished by rain and snow in early October.

More controversial was the South Canyon fire, ignited by lightning in a fire exclusion zone on the Grand Junction District of the Bureau of Land Management in Colorado on July 2, 1994. Suppression action was taken on the wildfire within two days of its start, but a blow-up two days later killed 14 fire fighters. An interagency team was formed and issued their report in August. They cited several direct and contributory causes of the fatalities including fire behavior, personnel profiles, and incident management procedures (Rosenkrance *et al.* 1994).

The South Canyon incident led to the first comprehensive review and update of federal wildland fire policy in decades. The report reiterated that the first priority of all federal wildland fire programs was firefighter and public safety (Philpot *et al.* 1995). With regard to prescribed fires and prescribed natural fires, the report stated that, "Wildland fire will be used to protect, maintain, and enhance resources and, as nearly as possible, be allowed to function in its natural ecological role." Recommended actions for the federal agencies for the reintroduction of fire included: 1) jointly developing ecosystem condition criteria for reintroducing fire, 2) jointly implementing ecosystem-based fire management programs, and 3) conducting a collaborative fire research program. In 1998, the agencies convened a task group to write an implementation procedures reference guide for moving policies into actions. This guide used the term "wildland fire use" to describe what had previously been prescribed natural fires. By the end of the decade, the 1995 policy reinvigorated "wildland fire use" programs and gave managers the support they needed to enable the programs to continue to grow and mature. During the four years between 1996 and 1999, the Forest Service had an average of 122 fires and 23,000 ha (56,900 ac) burned per

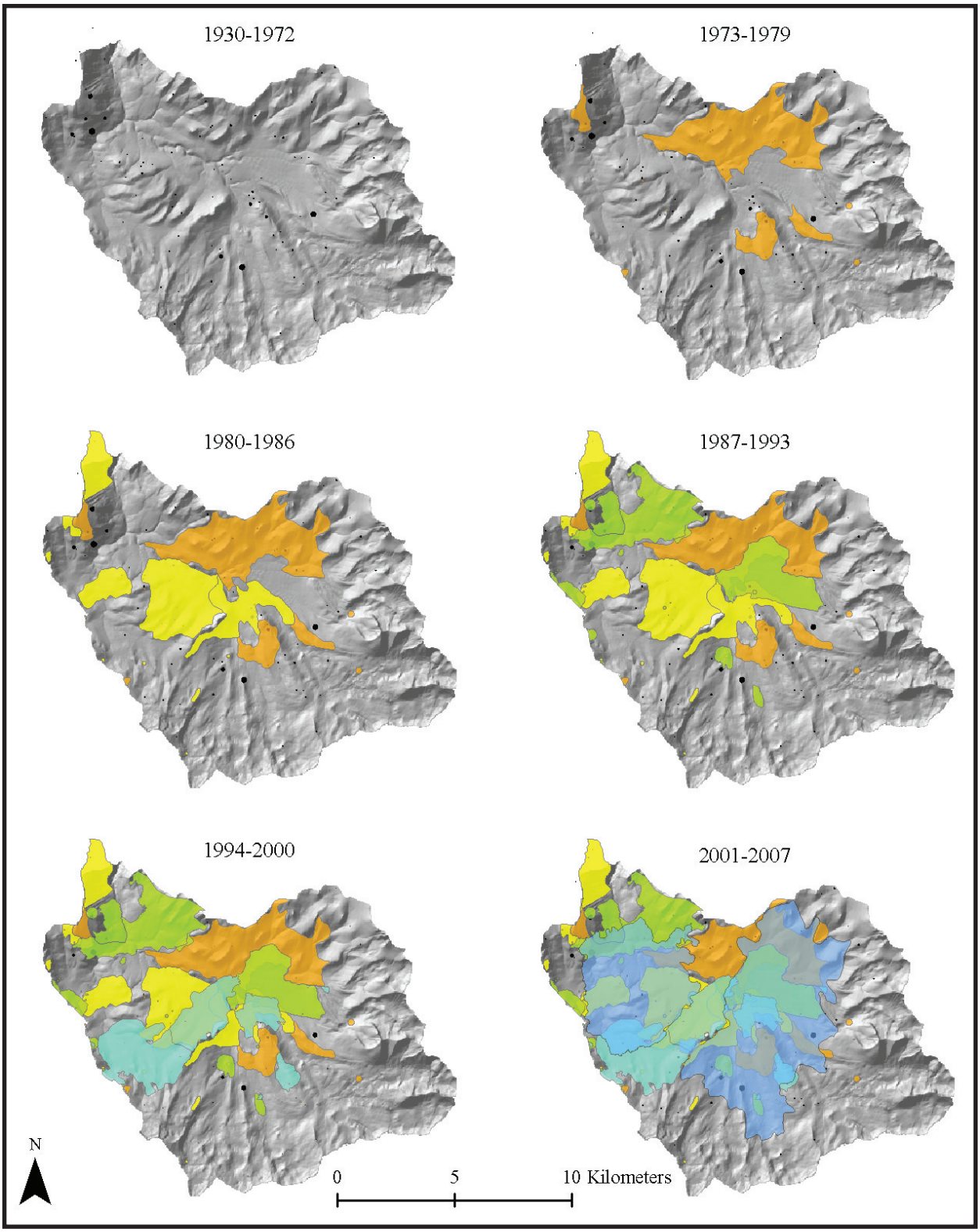


**Figure 3.** Fires in the Illilouette Creek Basin in Yosemite National Park before and after the wildland fire use program was initiated in Yosemite National Park. Between 1930 and 1972, fires appear as black dots. Fires in successive seven-year periods appear as orange (1973-1979), yellow (1980-1986), green (1987-1993), aqua (1994-2000), and light blue (2001-2007). Significant reburning occurred in the latter years as indicated in the transparent images between 1994 and 2007.

year, while the National Park Service averaged 98 fires and 8,540 ha (21,100 ac).

## 2000-2006: THE YEARS AFTER CERRO GRANDE

A prescribed fire set by fire managers on the Bandelier National Monument in 2000 was declared a wildfire and escaped onto the adjacent Santa Fe National Forest. The fire burned into the Los Alamos National Laboratory and the town of Los Alamos. Over 19,400 ha (48,000 ac) were burned and 255 homes destroyed before it was extinguished. Public outcry was immediate and the National Park Service held an investigation that placed blame on improper implementation of the prescribed burn and on inadequate contingency resources to successfully suppress the fire (Rothman 2007).

The Secretaries of Agriculture and the Interior reconvened the interagency federal wildland fire policy review working group to review the status of the implementation of the 1995 policy and to address specific issues raised by the Cerro Grande investigation teams. The group found that the policy was generally sound and continued to provide a solid foundation for wildland fire management activities (Douglas *et al.* 2001). The group recommended several changes to the 1995 policy to clarify purpose and intent and to address issues not fully covered in 1995. The statement for the use of wildland fire remained the same as in 1995, except the following sentence was added: "Use of fire will be based on approved Fire Management Plans and will follow specific prescriptions contained in operational plans." Finally, the working group found that the multiple terms used to describe wildland fires were confusing, but was silent on the terminology they preferred.

The 2001 policy recommendations prompted an interagency team to revise the wildland fire use implementation guide based on the 1995 policy (USDA and USDI 2005). The new document provides direction, guidance, and assistance for the planning and implementation of wildland fire use for each of the five federal wildland fire agencies. In order to be consistent with terminology, the Wildland Fire Coordinating Group (2006) officially sanctified the term "wildland fire use."

Progress implementing wildland fire use programs varies among the five agencies. Wildland fire use statistics have been very difficult to obtain because each agency reports them differently (Parsons 2000). Recently, the National Interagency Fire Center compiled wildland fire statistics going back to 1998 (www.nifc.gov/stats/wildlandfirestats.html). Table 1 shows the number of wildland fire use fires that have occurred and the area burned for each agency in all states including Alaska from 1998 through 2006.

The Forest Service has continued to build its wildland fire use program and now leads the other agencies in number of fires and area burned. Since 1998, there have been 1,854 fires that have burned 384,538 ha (950,211 ac) on Forest Service land, 66 % of the total for all agencies (Table 1). Fires are starting to reburn previously burned areas, and interlocking patterns of burned, reburned, and unburned areas are emerging.

In addition to the pioneering programs on the Selway-Bitterroot and Gila wilderness areas, other areas were beginning to show the effects of previous fires (Rollins *et al.* 2000). For example, in 2000, the McDonald II fire in the Bob Marshall Wilderness on the Flathead National Forest in Montana was projected to be 20,200 ha to 40,400 ha (50,000 ac to 100,000 ac); however, it ran into 1988 and 1996 fires and burned only 2,260 ha (5,580 ac). Also in 2000, the Hash Rock fire burned almost all of the Mill Creek Wilderness on the Ochoco National Forest in Oregon before it was suppressed. When the wildfire reached the 1996 Mill Creek fire, which had been

**Table 1.** Number of wildland fire use fires and area burned by those fires for the five land management agencies, 1998-2006.

| Year | Bureau of Indian Affairs | | | Bureau of Land Management | | | Forest Service | | |
|---|---|---|---|---|---|---|---|---|---|
| | fires | ha | ac | fires | ha | ac | fires | ha | ac |
| 1998 | 4 | 3 | 8 | 25 | 0 | 0 | 255 | 19,600 | 48,432 |
| 1999 | 2 | 0 | 1 | 43 | 542 | 1,339 | 195 | 13,715 | 33,891 |
| 2000 | 0 | 0 | 0 | 0 | 0 | 0 | 60 | 15,333 | 37,889 |
| 2001 | 3 | 0 | 0 | 56 | 4,165 | 10,293 | 143 | 25,318 | 62,562 |
| 2002 | 0 | 0 | 0 | 26 | 3,706 | 9,158 | 269 | 16,177 | 39,974 |
| 2003 | 10 | 17 | 42 | 32 | 669 | 1,652 | 193 | 105,555 | 260,831 |
| 2004 | 0 | 0 | 0 | 45 | 2,912 | 7,195 | 196 | 13,532 | 33,437 |
| 2005 | 1 | 1,489 | 3,680 | 78 | 1,045 | 2,582 | 279 | 116,954 | 288,999 |
| 2006 | 1 | 42 | 105 | 12 | 1,225 | 3,026 | 264 | 58,354 | 144,196 |
| Total | 21 | 1,552 | 3,836 | 317 | 14,263 | 35,245 | 1,854 | 384,538 | 950,211 |
| Average | 2 | 172 | 426 | 35 | 1,585 | 3,916 | 206 | 42,726 | 105,579 |

| Year | Fish and Wildlife Service | | | National Park Service | | | Total | | |
|---|---|---|---|---|---|---|---|---|---|
| | fires | ha | ac | fires | ha | ac | fires | ha | ac |
| 1998 | 0 | 0 | 0 | 73 | 5,059 | 12,501 | 357 | 24,662 | 60,941 |
| 1999 | 0 | 0 | 0 | 94 | 16,365 | 40,439 | 334 | 30,623 | 75,670 |
| 2000 | 0 | 0 | 0 | 22 | 622 | 1,538 | 82 | 15,956 | 39,427 |
| 2001 | 1 | 19 | 48 | 70 | 8,394 | 20,743 | 273 | 37,897 | 93,646 |
| 2002 | 0 | 0 | 0 | 111 | 3,291 | 8,131 | 406 | 23,174 | 57,263 |
| 2003 | 1 | 17,321 | 42,800 | 106 | 10,363 | 25,608 | 342 | 133,924 | 330,933 |
| 2004 | 3 | 119 | 295 | 65 | 32,946 | 81,410 | 309 | 49,508 | 122,337 |
| 2005 | 2 | 11,018 | 27,225 | 74 | 66,427 | 164,145 | 434 | 196,933 | 486,631 |
| 2006 | 2 | 124 | 307 | 79 | 7,046 | 17,412 | 358 | 66,792 | 165,046 |
| Total | 9 | 28,601 | 70,675 | 694 | 150,514 | 371,927 | 2,895 | 579,469 | 1,431,894 |
| Average | 1 | 3,178 | 7,853 | 77 | 16,724 | 41,325 | 322 | 115,894 | 286,379 |

managed under the wildland fire use program, it went out. Similarly, in 2003, the Lost Packer Meadow fire in the Frank Church-River of No Return Wilderness on the Nez Perce National Forest in Idaho left areas burned in 1990 and 1996 fires untouched (Figure 4).

Although the National Park Service was the initial leader in allowing lightning fires to burn under prescribed conditions, the agency has become increasingly restricted in its approach to wildland fire use. Smoke, threatened and endangered species, and the high costs associated with managing wildland fire use have been major concerns. The small size of many parks and their proximity to urban areas exacerbates these problems. From 1998 through 2006, 694 fires have restored fire to 150,514 ha (371,927 ac) (Table 1). Some programs, such the ones at Sequoia and Kings Canyon National Parks and Yosemite National

**Figure 4.** In 2000, the Lost Packer Meadow fire burned around fires that burned in 1990 and 1996, forming a pattern of burned and unburned areas.

Park, still lead the way for other parks and agencies.

The Fish and Wildlife Service established a formal fire management program in 1978; however, only nine fires have been allowed to burn under prescribed conditions since 2001, mostly in Alaska (Table 1). The area burned each year has varied with large areas burning when conditions are favorable in the refuges in Alaska. During intervening years, a small number of fires burned a reduced amount of area.

In 1981, the Bureau of Land Management issued its first fire management policy for designated wilderness areas. Between 1998 and 2006, a total of 317 fires have been classified as wildland fire use fires and have burned 14,263 ha (35,245 ac) (Table 1). Most of these fires were in Alaska, but there are 4,860,000 ha (12,000,000 ac) in the lower 48 states that will be approved for wildland fire use in the near future.

The Bureau of Indian Affairs was an early leader in the use of fire in western ecosystems, but has been slow to implement wildland fire use. Although many fire management plans authorize wildland fire use, only a few tribes are prepared to implement the program. Since 1998, there have been 21 fires that have restored fire to 1,552 ha (3,836 ac) (Table 1). As the

program gains acceptance, these numbers are expected to grow.

## FUTURE YEARS

Many challenges face wildland fire use programs in the future. Among them are the wilderness-urban interface, air quality, wildlife habitat effects, invasive species, and cultural resources. New policies, implementation guides, and terminology will also affect the program. Opportunities will also arise, particularly with the use of management ignitions in wilderness and the application of wildland fire use to non-wilderness areas.

The wildland urban interface has become the wilderness urban interface as increasingly more homes are built adjacent to wilderness areas. In Tucson, new houses are being built on the boundary of the Pusch Ridge and Saguaro wilderness areas, and in Montana, continuous forests connect the Selway-Bitterroot Wilderness with ranchettes in the Bitterroot Valley. Many wilderness areas contain wildland fire use zones, but their proximity to human developments that need to be protected from fire confounds the opportunities for fire to play a natural role in these areas. Homeowners will need to become more active in creating fire-safe environments (Cohen 2000).

Air quality poses one of the biggest challenges for managers of wildland fire use programs. Fires that burn for weeks or even months cast palls of smoke in inhabited areas and can cause air quality standards to be violated. Active measures to manage smoke will have to be taken. For example, Yosemite National Park has extinguished many candidate lightning fires in the wildland fire use zone because another fire was already burning in the same airshed. Land management agencies must work with the Environmental Protection Agency and local air pollution control boards to inform them about the importance of wildland fire use programs for meeting land management objectives.

As ecosystems have evolved with fire, so too have the plants and animals. Human activities have altered many of the relationships between fire and plants and animals. Fire exclusion could lead to the extirpation of fire-adapted species, and habitat fragmentation coupled with fuel accumulation can leave plants and animals vulnerable to fire. Care will be needed to accomplish the complementary goals of restoring fire as a natural ecological process and maintaining plant and animal species that depend on habitats created by fire.

Many non-native invasive plants are adapted to fire. Plant invasions into wildland ecosystem present a particularly vexing problem for fire managers. Fire often exacerbates plant invasions that can lead to changes in fire regimes. Examples include the invasion of cheat grass (*Bromus tectorum*) in the Great Basin, melaleuca (*Melaleuca quinquenervia*) in the Everglades, spotted knapweed (*Centaurea maculosa* ) in the Rocky Mountains, and yellow star thistle (*Centaurea solstitialis*) in California. On the other hand, fire can also be an important tool for managing plant invasions. Managers of wildland fire use programs should consider the potential interactions of invasive plants with fuels, fire behavior, and fire regimes to ensure that their fire management goals and objectives can be met in the presence of these non-native plants. At the very least, land managers should monitor for invasive plants following fires and take mitigating measures as appropriate.

Much of the remaining evidence of past cultures consists of resources that are either combustible or are altered by fire. Obviously, fire can consume combustible resources, but less obvious are the effects on non-combustible artifacts such as obsidian tools, pictographs, and petrogylphs. Information is lost by altering hydrations rates within obsidian, which allow the date of manufacture to be estimated. Images either painted on or carved into rock faces can also be obscured or destroyed by fire. Surveys need to be done in wildland fire

use zones to develop pre-fire plans to protect cultural resources.

While constraints often preclude the use of wildland fire, management-ignited prescribed fires can be used to complement naturally occurring fires. This has been common practice in National Park Service wilderness areas, but is just becoming accepted in Forest Service wilderness. By controlling the timing and location of prescribed fires, managers can avoid threatened and endangered species, invasive species, cultural resources, smoke sensitive areas, and adjacent development. Care must be taken, however, to try to mimic the natural fire regime as closely as possible.

It is also important to note that wildland fire use is not always possible or desirable. A well-informed fire management plan must carefully considers all the factors present in an area (fire history, invasive plants, threatened and endangered species, human developments, cultural sites, etc.) before designating that area as a wildland fire use zone.

Additional opportunities apply to Forest Service areas that are not in wilderness. The Northern Rocky Mountain Region expanded the wildland fire use program beyond designated wilderness in 2007, and other regions are sure to follow. Part of the rationale for this expansion is economic, because suppression costs keep rising.

The history of wildland fire use has shown that the program is often held hostage to the whims of policy and procedures. Even today, as enlightened as the public and decision makers might be, a shift in policy could doom the program. Currently, the concept of "Appropriate Management Response" (AMR) is in vogue. Appropriate Management Response is defined as any specific action suitable to meet fire management unit objectives (National Wildfire Coordinating Group 2006). Typically, the AMR ranges across a spectrum of tactical options from monitoring to intensive management actions. Monitoring would be the appropriate management action for most fires in the wildland fire use zone. Regardless of the terminology used, the ecological rationale for allowing wildland fires to burn under prescribed conditions, coupled with an economic incentive, will insure the continuation of the program in the future.

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