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31. Wilderness Fire Management in Yosemite National Park

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Introduction

Yosemite National Park encompasses a broad range of vegetation types, from chaparral stands at 2,000 feet to alpine fell-fields at 13,000 feet. Not only the vegetation varies; also included within this range are variations in the nature of fuel and, consequently, the probability of fire as well. In these varieties of vegetation, natural fire plays different roles—from a dynamic force in the chaparral and mixed conifers to an insignificant factor in certain alpine types. The National Park Service recognizes these differences and is managing each type so that fire can play its natural role. This has not always been the case.

Evolution of a Fire Policy

Historical Conditions

Before national parks were established, natural fires were prevalent in many of the parks that later joined the park system. Lightning has been the primary source of natural fire ignitions, particularly in the mountainous West (Komarek 1967). These fires burn with varying intensities and periodicities depending on the nature of the vegetation and climate. Among the important roles played by fire in these vegetation types are the recycling of nutrients, the removal of undergrowth, and the perpetuation of fire-adapted species. Dominant trees such as ponderosa pine (*Pinus ponderosa* Laws.) evolved with a regime of periodic surface fires and were favored in many areas. Lodgepole pine (*Pinus contorta* Dougl.), through adaptations such as serotinous cones, was able to reproduce in areas subject to less frequent high intensity fires.

Cultural burning by Indians was also a factor in some park areas.

The reasons for this burning are not clearly understood, but it is thought that fires aided in food procurement and played a part in religious ceremonies (Reynolds 1959). These fires also varied in intensity and served to maintain certain vegetation types.

With the advent of European man, a period of indiscriminate burning began. Settlers used fires to clear the forest for farming and grazing purposes, and loggers set fire to timber slash and remaining trees. In California, it was a common practice for miners to ignite large areas of timber and brush to aid in prospecting and mining activities. Such fires not only destroyed timber and structures which were valuable to the new inhabitants, but also changed natural environments for which they had little or no value.

Suppression Policies

As a consequence of widespread fires and the concern for preserving park values, a policy of suppressing all fires on national park lands evolved. It began in 1866 in Yellowstone National Park and in 1890 in Yosemite National Park (Agee 1974). The purpose was to reduce the damage from human as well as natural sources. The thought was that fire was a destructive force in the forest, rather than a dynamic element of the forest system. The act which established the National Park Service in 1916 implicitly reiterated the suppression policy by stating that the "natural and historic objects and wildlife therein" would be left "unimpaired for the enjoyment of future generations." A total fire exclusion policy was justified by stressing the protection of objects rather than the perpetuation of natural processes.

Coupled with the suppression policy was a vigorous fire prevention campaign designed to reduce the number of man-caused fires. An outgrowth of this program was the idea that all fires were bad, the only good fire being a dead fire.

Leopold Report

The management of national park lands under the policy of fire exclusion caused many changes. Overprotection from natural surface fires permitted the forest floor to become a tangle of understory vegetation and accumulated debris. Thickets of shade-tolerant species increased and caused a shift in the flora and fauna away from the

natural successional pattern. This increase in undergrowth and debris became so thick that the inevitable wildfire soon reached catastrophic proportions.

These changes were noted by the Special Advisory Board on Wildlife Management for the Secretary of the Interior (Leopold et al. 1963). The report, known as the Leopold Report, recommended that each park be restored as nearly as possible to the conditions that existed when European man first visited the area. It went on to state that the controlled use of fire is the most "natural" means of accomplishing such a restoration.

Current Management Philosophy

In 1963, the Leopold Report was incorporated as Park Service policy for natural areas of the national park system. The new policy included natural and prescribed fire management as well as the traditional suppression of wildfires. The presence or absence of natural fire in an ecosystem was recognized as one of the ecological factors perpetuating that system. Under this policy, natural fires were allowed to run their course as long as they could be contained within predetermined management units and when the burning was consistent with approved management objectives.

Prescribed fires may be used as a substitute for natural fires to achieve resource management objectives, if it is determined that natural fires cannot meet the objectives and if prescriptions can be developed for such fires. In addition, prescribed fires may be used for fuel hazard reduction and to reinforce fire management zone boundaries.

Any fire which is caused by man, or threatens human life, the destruction of historic or natural resources or park facilities, or resources or facilities outside of park boundaries will be extinguished. This would include the extinguishment of fires which do not further management objectives or which exceed the burning prescriptions.

Wilderness Fire Management

Within wilderness areas, management objectives are determined by the Wilderness Act. Specifically, the act directs that wilderness be "protected and managed so as to preserve its natural conditions."

This is interpreted to mean that natural processes such as fire are part of the wilderness ecosystem. Both the U.S. Forest Service and the National Park Service have established natural fire zones in areas designated or proposed as wilderness.

Yosemite's Experience

Fire histories indicate the importance of natural fire in the vegetation types of Yosemite's wilderness areas. Over the past nineteen years, there have been a total of 1,135 known lightning fires. The least number during any year was two, while the maximum number was 121. Although there is some variation in the areas of incidence from year to year, the distribution over time is uniform, with the mixed conifer and red fir types receiving the preponderance of lightning fires. This is to be expected since fuel and weather conditions in those types are more conducive to fire ignition and spread.

In 1972, the first natural fire management zone was established in the park, comprising a total of 187,007 acres. During that summer, two fires occurred in the zone while an additional six fires were allowed to burn outside the zone after it was determined that they would meet management objectives. The largest of the fires in 1972 burned 0.1 acre, and the total acreage was 0.31 acres. Five of the fires were in snags; the remainder burned in brush or duff.

The zone was expanded in 1973 to encompass 465,651 acres. Twenty-five natural fires occurred within the zone boundaries, and two fires were allowed to burn outside of the zone. A total of 35.09 acres were covered of which 30 acres were on one burn near Ostrander Lake. All of the twenty-two natural fires in 1974 burned within the zone. Nineteen of these fires were less than one acre in size and two less than 100 acres. The remaining fire, called the Starr King Fire, spread across nearly 4,000 acres before being extinguished by an early winter storm.

Perspective. Near Yosemite National Park, fire-scar histories dating from 1390 indicate the continued presence of fire in the region (Wagener 1961). These fires were either set by lightning or by Indians, and the interval between them averaged eight years (Wagener 1961, Biswell 1963, Kilgore 1972). Shorter periods are indicated by computer simulation models integrating weather, fuel, and fire

variables (van Wagtendonk 1972). During such a relatively short period, fuel build-up was not sufficient to produce a high intensity fire. The resultant forest was open with patches of tree reproduction and brush interspersed with needles or various grasses for forbs. Ponderosa pine and giant sequoia (*Sequoia gigantea* [Lindl.] Decne.) are dependent on frequent low-intensity fires to reduce competition from the more shade-tolerant incense cedar (*Libocedrus decurrens* Endl.) and white fir (*Abies concolor* [Gord. and Glend.] Lindl.) in the mixed conifer zone of the park.

From the time Yosemite Valley was first seen by European man in 1851, to 1890, settlers replaced the Indian as a fire starter. At that time the park was established, and attempts were made to eliminate all fires. Active protection began in 1900, when army troops were detailed to the park to prevent trespassers and intruders from entering. The establishment of the National Park Service in 1916 transferred the protection duties to park rangers, and during the next fifty years, the policy of total fire exclusion was continued.

With the incorporation of the Leopold Report into the administrative policies, a new era of fire management began in Yosemite National Park. The first prescribed fire was set in the spring of 1970. Since then, twenty-four prescribed fires have burned over 2,500 acres. These fires were set to reduce fire hazards and to restore meadow and forest land to their natural condition. In 1972, a natural fire management zone was established, and fifty-seven fires have been allowed to run their course during the past four years.

Total Fire Management. Fire management in Yosemite National Park presently falls into six operations: routine wildland fire control, structural fire control, prescribed burning, natural fire management, conditional fire management, and loose-herding of wildland fire. Within the natural fire zone, all naturally caused fires will be allowed to burn. In the remaining area, all fires will be suppressed unless it is determined that a specific fire would meet management objectives. In that case, the fire would be loose-herded by minimal crews. In addition, in certain areas designated as conditional fire management zones, natural fires will be allowed to burn if specific weather and fuel conditions have been met. Air reconnaissance flights are made throughout the fire season to detect new fires and to monitor fires which are either being suppressed or allowed to burn.

The Starr King Fire

Chronology. The Starr King Fire was started by a lightning strike on August 4, 1974, in the vicinity of Mount Starr King, just south of Yosemite Valley. An air reconnaissance reported one snag burning and a small surface fire on the west side of a small drainage basin at an elevation of 8,000 feet. The basin was surrounded by open granite ridges with sparse fuels above, opening below to a continuous forest with sufficient fuel to allow the fire to back down the drainage indefinitely. The primary vegetation in the area included Jeffrey pine (*Pinus jeffreyi* Grev. and Balf.), red fir (*Abies magnifica* A. Murr.), and western juniper (*Juniperus occidentalis* Hook.), with some lodgepole pine, white fir, and whitebark pine (*Pinus albicaulis* Englem.). Brush patches of green leaf manzanita (*Arctostaphylos patula* Greene) and huckleberry oak (*Quercus vaccinifolia* Kellogg) extended from the creeks to the ridge tops.

For the first ten days, the fire burned with such a low intensity that it went virtually unnoticed from the ground. By August 14, columns of smoke were visible from Glacier Point and Yosemite Valley, and by August 27, the fire had spread to the north and south covering 130 acres.

From August 27 until September 9, the fire spread an additional 930 acres and doubled in size to 2,250 acres during the next ten days. The greatest expansion was to the east and west through brush and Jeffrey pine growing in conjunction with some red fir, white fir, and western juniper. The fire spread more slowly to the north, where the major fuels were lodgepole pine and red fir and to the south where dense stands of lodgepole pine occupied the creek bottoms.

On September 28, a small control action was made to keep the fire inside the natural fire zone boundary. A fireline connecting Illilouette Creek and the granite faces of Mount Starr King was constructed and 420 acres were backfired. By October 1, the fire had reached its maximum extent of 3,920 acres, and after several days of rain and snow was declared out on October 31.

From 1930 through 1974, there have been nine other fires within the area burned by the Starr King Fire. All were suppressed. Three of these fires had approximately the same point of origin as the Starr King Fire.

Fire Effect. Three trips were taken into the fire to measure fire, fuel, vegetation, and weather variables. The dates of these trips were August 27, September 11, and September 24. The weather during this period did not fluctuate greatly. Daytime relative humidities ranged from 41 percent to 16 percent, with the average being 31 percent. Temperatures were in the 60s and 70s during the day and dropped to 40 degrees Fahrenheit at night. Windspeeds never exceeded 12 miles per hour and the average fuel stick moisture content was 5.5 percent.

Ground fuel depth measurements were taken before and after the fire passed over sample plots, in order to determine fuel consumption. The average consumption was 7.045 tons per acre. The least amount of fuel was lost underneath western juniper trees where only sparse fuels existed. The greatest consumption was in a red fir stand where a relatively intense fire consumed 34.17 tons per acre.

Rates of spread were measured at each plot and varied from 1 inch per hour to 120 feet per hour. Area rate of spread for the fire as a whole was greatest on September 20, when 200 acres burned. During much of August, the average area rate of spread was 5.42 acres per day.

Intensities were calculated using caloric values from Agee (1973) and the fuel consumption and rates of spread from the plots. They varied from .29 BTU/second/foot for the smoldering fire in the western juniper stand to 679.82 BTU/second/foot for the red fir stand. Underneath the Jeffrey pines, intensities varied from 29.49 BTU/second/foot to 539.48 BTU/second/foot. The moist creek bottoms where some lodgepole pine burned did so with an intensity of 2.67 BTU/second/foot. The fire was characterized by patches of intensely burned areas separated by lightly burned or unburned areas.

The effects of the fire on vegetation were related to the variations in burning intensity. Pockets of huckleberry oak and manzanita were completely consumed, and downed Jeffrey pine logs and snags burned intensely. Some standing green Jeffrey pines burned in cat faces. In some cases, clusters of red fir from 70 to 100 feet high were completely killed. It was estimated that not more than 3 percent of the mature canopy was actually killed by the fire. Only 60 percent of the area inside the fire perimeter was burned, most of the unburned area being open granite with little or no fuel accumulation.

The differential effect of fire in the various vegetation types was

well illustrated by this fire. Brush fields were almost entirely consumed as they would be periodically, since they are flammable within a few years after a fire. Jeffrey pine is much like ponderosa pine with low- to moderate-intensity fires burning the surface layers and only occasionally killing a live tree. Red fir, on the other hand, burned intensely when conditions were favorable, but not at all under more moist conditions. Since the proper conditions do not occur frequently, fuel accumulates and the eventual fire is intense. This is also true of the lodgepole pine, as evidenced by the low-intensity fire near the creek bottom. Another stand of lodgepole pine along a ridge top burned intensely, however, since conditions were drier there. Fire is not a significant factor for western juniper since fuel accumulations are small and individual trees are surrounded by granite.

Because of the low intensities and slow rates of spread, wildlife was little affected by the fire. Stacks of vegetation which are used by the Sierra mountain beaver *(Aplodontia rufu californica)*, were seen before and after the fire. California mule deer *(Odocoileus hemionus californicus)* were grazing within the burn during and after the fire. Three black bears *(Ursus americanus californiensis)* were also seen in the burned area.

Since the Starr King Fire burned within the watershed which is used to supply Yosemite Valley, water quality measurements were available for analysis. A comparison between post-fire measurements and similar periods in previous years showed no significant difference for water temperature, suspended sediments, major dissolved ions, or suspended organic elements.

From mid-August until the end of September, considerable amounts of smoke were produced by the fire. Each evening smoke would drift down into Yosemite Valley and would usually clear by 10 a.m. when up-slope winds would disperse it. One qualitative measure of the smoke came from a long-time resident who stated that there was much less smoke in the valley from the fire than there had been from campfires before the number of campsites had been reduced. Radiometer measurements of solar radiation at a research site ten miles northeast of the fire showed great reductions in langleys received when the wind was from the southwest.

The Starr King Fire is in an area which receives low recreational use. When the fire neared and crossed the only trail in the area, backcountry travel was restricted. Although no direct measures of

visitor reaction to the Starr King Fire were made, letters and comments for or against the program give a clue. Only one letter of complaint was received concerning the fire. Public comments at meetings held for the master planning process have been twenty-to-one in favor of the natural fire management program.

Other Wilderness Areas

The 100-square-mile White Cap Fire Management Area of the Selway-Bitterroot Wilderness in northern Idaho was the first such area established by the Forest Service. Studies began in 1970 to determine operational strategies for a more natural occurrence of fire in the wilderness area (Mutch 1974). As a result of these studies, prescriptions and guidelines were developed, and in 1972, the fire management zone was approved. The management plan is specific to the many different vegetation types in the wilderness and calls for suppression actions to protect human life and property or to contain fires in the management unit. In 1972, there was only one fire in the unit, while six fires occurred during 1973. One of these, the Fritz Creek Fire, burned more than 1,200 acres within the unit and 400 acres outside it. Control action was taken on the portion outside of the fire management unit. In 1974, another unit of 135,000 acres was designated in the Selway-Bitterroot Wilderness as a fire management area. In the summer of 1974, each unit had a single fire of less than one-quarter of an acre. The only other Forest Service wilderness to have an approved fire management area is Gila Wilderness in Arizona where 33,000 acres were designated.

Portions of the natural fire zones in ten Park Service areas have been proposed as wilderness and await enactment. Fire management within these zones would not change upon enactment since present policies are in harmony with the Wilderness Act. The Park Service already recognizes fire as a natural process; the Wilderness Act reiterates the philosophy of perpetuating such processes.

Natural fire management in the Park Service started in 1968, when Sequoia-Kings Canyon National Parks set up the first natural fire zone (Kilgore and Briggs 1972). Since that time, the zone has been expanded to include nearly 600,000 acres. Ninety-seven fires covering 7,800 acres have burned in the zone during the last seven years. The largest of these was the Comanche Fire, which burned 3,060 acres in 1974.

Everglades National Park was the first park to use prescribed fire, beginning their program during the 1950s (Robertson 1962). Natural fires have been allowed to burn since 1968, with seventy-three fires burning about 9,425 acres during the past seven-year period. Some of these fires were man-caused and were determined to meet management objectives.

A modified natural fire program is in use in Saguaro National Monument in Arizona (Gunzel 1974). There, natural lightning-caused fires (or wildfires) are allowed to burn under prescribed conditions. By analyzing the various fire and weather factors concerned, it was determined that fires from mid-July to mid-September would be of the desired low to moderate intensity. A total of twenty-eight out of fifty fires have been allowed to burn without control over 900 acres under this program.

The most widely publicized natural fire to occur has been the 3,700-acre burn in Grand Teton National Park during the summer of 1974. This fire was ignited by lightning in July and burned until it was put out by late autumn snows (Kilgore 1975). Two other smaller fires burned in the park last summer, while in nearby Yellowstone National Park, six more fires burned some 300 acres.

Other national park areas which have established natural fire management zones include Rocky Mountain with five fires, Carlsbad Caverns with one fire, Guadalupe Mountains with two fires, and North Cascades National Park with no fires (Kilgore 1974).

Conclusion

The management of natural fires within wilderness areas of the National Park Service will continue to be an active program. The end objective is to restore fire as a natural process in those parks where it was historically present. In Yosemite, it is hoped that, as fuels are modified through prescribed burning at the lower elevations, the natural fire zone will increase in size. This is currently happening, as the zone has been enlarged to 481,500 acres for 1975, with 132,738 additional acres in the conditional fire management zone. Eventually, all but the developed areas of the park will be managed with natural fire as a part of the environment.

With increased experience and research, there will be a better understanding of the role fire has played in the diverse ecosystems of the National Park System. By restoring fire to its natural role, the

Park Service is guaranteeing the perpetuation of these unique natural resources.

References

Agee, J. K. 1973. Prescribed fire effects on physical and hydrologic properties of mixed-conifer forest floor and soil. Ph.D. dissertation, University of California, Berkeley. *Also:* Contribution Report 143. Water Resources Center, University of California.

——. 1974. Fire management in the national parks. *Western Wildlands* 1(3):27–33.

Biswell, H. H. 1963. Research in wildland fire ecology in California. *Proceedings of the Second Annual Tall Timbers Fire Ecology Conference* (Tallahassee, Florida, 14–15 March 1963) 2:62–97.

Gunzel, L. L. 1974. National policy change—natural prescribed fire. *Fire Management* 35(3):6–8.

Kilgore, B. M. 1972. The ecological role of fire in Sierran conifer forests. *Quaternary Research* 3(3):496–513.

Kilgore, Bruce M. 1974. Fire management in national parks: An overview. *Proceedings of the Montana [Fourteenth] Annual Tall Timbers Fire Ecology Conference* (Fire & Land Management Symposium, Missoula, Montana, 8 to 10 October 1974) 14:45–57.

——. 1975. Restoring fire to national park wilderness. *American Forests* 81(3): 16–19, 57–59.

Kilgore, B. M., and G. S. Briggs. 1972. Restoring fire to high elevation forests in California. *Journal of Forestry* 70(5):266–271.

Komarek, E. V. 1967. The nature of lightning fires. *Proceedings of the Califotnia [Seventh] Tall Timbers Fire Ecology Conference* 7:5–42.

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.

Mutch, R. W. 1974. I thought forest fires were black! *Western Wildlands* 1(3): 16–22.

Reynolds, R. D. 1959. Effects upon the forest of natural fires and aboriginal burning in the Sierra Nevada. Master's thesis, University of California, Berkeley.

Robertson, W. B. 1962. Fire and vegetation in the Everglades. *Proceedings of the Annual Tall Timbers Fire Ecology Conference* 2:67–80.

van Wagtendonk, J. W. 1972. Fire and Fuel Relationships in Mixed Conifer

Ecosystems of Yosemite National Park. Ph.D. dissertation, University of California, Berkeley.

Wagener, W. W. 1961. Past fire incidence in Sierra Nevada forests. *Journal of Forestry* 59(10):739-748.