Role of Science in Sustainable Management of Yosemite Wilderness

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Abstract—Since its earliest occupation by Euro-Americans, scientific information has been instrumental in the designation and management of Yosemite as a National Park and as Wilderness. Descriptive at first, but increasingly sophisticated as theories and methods evolved, science has been the underpinning of the protection and sustainable management of Yosemite National Park and the Yosemite Wilderness. As visitor use increases, it will be critically important that the wilderness resource and the wilderness experience be perpetuated unimpaired for future generations. This paper traces the role science has played in the history of the Park, in the current management of the Yosemite Wilderness, and the role it might have in the future.

Introduction

Science has been instrumental in the management of Yosemite since before its designation as a National Park in 1890. It has played a role in the various legislative acts that designated the area as a National Park, and subsequently as a unit of the National Wilderness Preservation System. That role intensified as back-country use increased in the 1970s and wilderness was designated in Yosemite in 1984. Since then, the wilderness management system there has been adjusted and refined as research and management methods have evolved. This trend should continue into the future.

Historical Perspective: Yosemite National Park and Yosemite Wilderness

Yosemite has come full circle from when it was managed by Native Americans for subsistence and shelter. It has passed through a period of legislation that established and adjusted the boundaries of the Park for visitor benefit and enjoyment, and finally to designation of a majority of the park as wilderness to preserve wilderness resources and values.

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Native American Management

Native Americans have been present in the Yosemite region for over 3,000 years. During this time they did more than inhabit the landscape, they also shaped its ecological relationships (Anderson 1996). They tilled the soil for bulbs and corms, burned meadows for basketry materials, hunted for deer and other game, and gathered seeds and acorns. All of these practices were based on an inherent scientific knowledge of ecology. The wilderness that faced the first European invaders was, in part, a landscape managed for the needs of diversity and abundance (Anderson and Nabhan 1991).

Early Park Legislation

Early legislation relating to Yosemite includes:

- The1864 act that set aside Yosemite Valley and the Mariposa Grove as a State Reservation.
- The 1890 act that established Yosemite National Park.
- The 1906 joint resolution that ceded the Yosemite Valley and the Mariposa Grove back to the Federal Government and changed the boundaries of the park.
- The 1916 act that established the National Park Service.

Each of these acts was based, to a greater or lesser degree, on scientific information.

Yosemite Valley Grant Act of 1864—The act that granted Yosemite Valley and the Mariposa Grove to the State of California was the first act by a national government to establish a park. Huth (1948) considered the Yosemite Valley Grant Act as the birth of the "National Park" idea. The act specified that the purpose of the park was for public use, resort, and recreation, and that it should be inalienable for all time. Although the legislation was not directly based on scientific studies, the impetus behind the act was to prevent destruction of the scenic and natural values of the Valley and the Grove.

Yosemite National Park Act of 1890—The nation's first preserve consciously designed to protect wilderness values was established in 1890, when the mountains above Yosemite Valley became a National Park (Nash 2001). John Muir received much of the credit for bringing about the establishment of Yosemite National Park. Although not considered scientific writing by today's standards, Muir (1890a,b) wrote eloquently about the treasures and features of the proposed park. These descriptions were based on Muir's detailed observations of natural phenomena of the area including meadows, rivers, mountains, and glaciers (fig. 1). Nowhere is his scientific expertise more evident than in the passages in which he describes the

Figure 1—The area above Yosemite Valley is a vast wilderness landscape of domes, mountains, glaciers, rivers, and waterfalls.

value of protecting the wilderness above the Valley as an integrated harmonious unit rather than protection of an unsustainable fragment.

Joint Resolution of 1906—Preceded by the cessation of Yosemite Valley and the Mariposa Grove by California to the Federal Government, the Joint Resolution of 1906 accepted those lands as part of Yosemite National Park and adjusted the boundaries of the new park. The cessation was deemed necessary because development and commercialization were impacting scenic and natural values. The boundary adjustments were based on a report by Chittenden (1904) and included deletions and additions, with a net result of a 30-percent reduction. He conducted a 2-week study of the park and concluded that lands containing substantial private claims, mineral-bearing ores, or commercial timber should be excluded from the park and added to the forest reserves. The addition included the remainder of the Tuolumne River drainage, making it possible to manage the entire watershed.

National Park Service Organic Act of 1916—Fifty-two years after the Yosemite Grant Act, 44 years after the Yellowstone National Park Act, and 26 years after the Yosemite National Park Act, the National Park Service was finally established. The new bureau had the responsibility for managing the National Parks to:

> Conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations (Sellars 1997).

Science was not specifically mentioned in the act and could not be inferred from the language in any of the sections (Sellars 1997).

Wilderness Legislation

Two acts were instrumental in designating wilderness in Yosemite:

- The Wilderness Act of 1964, which established the National Wilderness Preservation System.
- The California Wilderness Act of 1984, which specifically designated the Yosemite Wilderness.

Wilderness Act of 1964—Although the Wilderness Act originated out of dismay over trends affecting roadless areas on National Forests, it also was applied to lands of the National Park Service because of concerns about the erosion of roadless blocks within units of the National Park system (McCloskey 1994). The National Park Service was never an active proponent of the Wilderness Act (Sellars 1997). For the National Park Service, opposition to the Wilderness Act centered on the question of discretion. The 1916 Organic Act gave no clear guidance on the question of how much park wilderness should be protected. The scenic, natural, and cultural features were to be protected, while at the same time providing for their use and enjoyment. As administratively interpreted, the Organic Act gave discretion to the Park Service to strike a balance between maintaining wilderness and providing facilities that were accessible by modern means of transportation. The Wilderness Act changed that by specifying that wilderness zones in parks would have added protection from roads, commercial facilities, motorized vehicles, and mechanized equipment. The Act also specifically mentioned science as one of the purposes of wilderness.

California Wilderness Act of 1984—Legislation to extend wilderness was introduced in every Congress between 1974 and 1982. Not until the debate concerning the adequacy of Forest Service recommendations for wilderness in the State was resolved in 1984, did the California Wilderness Act finally become law. The Act designated 646,700 acres (261,710 ha) of Yosemite Park as Wilderness and 3,500 acres (1,416 ha) as potential wilderness additions. Congress directed the Park Service to produce maps and descriptions of the Wilderness area as soon as practicable after passage of the Act. This task was assigned to the Park's Science Office and completed with input from all staff associated with wilderness. A Geographic Information System (GIS) analysis of the boundary, based on 7.5-minute quadrangle maps, showed that there were 704,624 acres (285,151 ha) of Wilderness and 927 acres (375 ha) of potential wilderness in the Congressionally designated Yosemite Wilderness, comprising 94.2 and 0.1 percent of the park, respectively.

Science in Support of Management of Yosemite Wilderness

During the late 1960s and the early 1970s, the proposed wilderness areas of Yosemite experienced a dramatic increase in use (fig. 2). When a scientist was assigned to the park in 1972, work began immediately on a program to support management of the proposed wilderness. By the time the California Wilderness Act passed in 1984, the

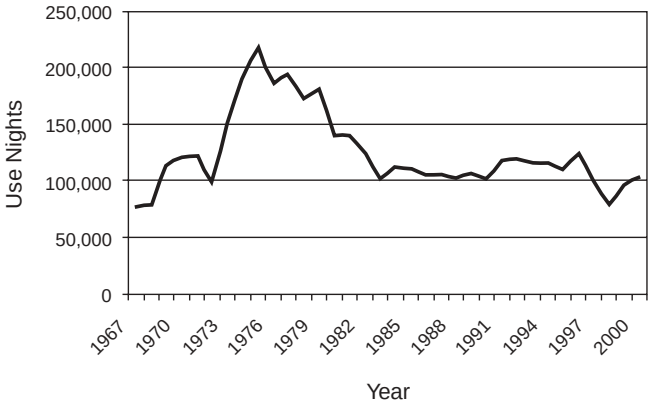

Figure 2—Visitor use nights in the Yosemite Wilderness increased rapidly in the early 1970s and then dropped to about 50 percent of the peak level.

results from this research had already been applied. Evolving use patterns and new research techniques prompted a resurgence of research designed to refine and improve management of the Yosemite Wilderness.

Early Programs

For many years, use figures were determined from voluntary campfire permits from which subjective estimates of total use could be made. Implementation of a mandatory permit system in 1972 for all overnight users alerted managers of the magnitude of wilderness use and its rate of increase. Within 1 week after the program was established in Yosemite that year, the scientist was assigned the task of inspecting conditions in the backcountry and assessing use. From these initial observations, a plan was developed to investigate impacts, determine use limits, and design a system for controlling use through permits. In addition, investigations into the role of fire in wilderness ecosystems were to be initiated.

Visitor Impacts—Holmes and others (1972) inventoried trails and campsites in the backcountry for human-caused impacts and found hundreds of campsites around popular lakes, trampled vegetation in heavily used areas, and eroded and multiple trails throughout the proposed wilderness. Guided by results of the survey, Parmeter (1976) conducted studies of human impacts on vegetation, soil, water, and microclimates. Experiments were also conducted to quantify direct impacts from trampling and urine (Holmes 1979). These studies concluded that although impacts increased as use increased, the relationship between use and impacts was influenced by many other factors and that the determination of acceptable impacts was a subjective decision.

On the other hand, Keay and van Wagtendonk (1983) found a positive relationship between use levels and incidents with black bears and recommended that use be reduced in areas of high conflict. Availability of food from human sources, however, was believed to be the primary cause of the conflict. Hastings and Gilbert (1987) also studied the interactions of bears and humans and offered a partial solution; a bear-resistant food canister that could be carried by backpackers.

Social impact studies were also conducted to determine the relationship between use levels and the wilderness experience. Lee (1977) and Absher and Lee (1981) interviewed visitors about their attitudes toward crowding, resource impacts, and satisfaction. They also observed the same visitors in the backcountry and concluded that there was no relationship between expressed attitudes and behavior. Enjoyment was affected more by human behavior and resource condition than by total number of people encountered (Absher and Lee 1981). For example, visitors were willing to encounter more people if they were friendly than if they were not.

Use Limits and Permits—Since use had obviously exceeded acceptable levels in some areas, interim use limits were applied while the ecological and sociological studies were being conducted. In 1973, overnight capacities were set for travel zones within the proposed wilderness based on the area of the zone, the number of miles of trails it contained, and its ecological fragility (van Wagtendonk 1986). The larger an area, the greater its ability to absorb use, and because trails disburse use, more trails allow additional visitors to be accommodated. Ecological fragility scores were used to reduce the limit of a zone based on its rarity, vulnerability, recuperability, and reparability.

Zone use limits were implemented through permits that were issued to each backpacking party. If a proposed zone had reached its capacity, the party was directed to camp in another location. Adjustments were made to the use limits based on data that showed that 8 percent of the parties did not get permits and that, on average, trips were shortened by one-half day (van Wagtendonk and Benedict 1980). The use limits were effective in shifting use from peak summer months and from heavily used travel zones without reducing overall visitation (van Wagtendonk 1981). Based on 4 years of data collected from the permits that related zone to trailhead use, a trailhead quota system was implemented in 1977 (van Wagtendonk and Coho 1986). Trailhead quotas allow visitors the maximum amount of freedom and ensure that the wilderness resource and experience are maintained.

Refined Programs

After the initial surge of research, management of the Yosemite Wilderness proceeded with only minor adjustments made each year based on observations and feedback from wilderness rangers. By the mid-1980s, however, long-term monitoring of trail and campsite impacts indicated that conditions were changing and that efforts might be necessary to restore certain areas (Sydoriak 1989). Restoration programs were followed by additional monitoring of campsites and meadows that were being grazed by recreational packstock. New methods of sociological research also made it possible to integrate resource, social, and managerial components into carrying capacity decisions.

Trail and Campsite Restoration—As a result of monitoring programs, campsite restoration programs were started in 1987 at three subalpine lakes in the Yosemite Wilderness (Hadley and Moritsch 1988). Moritsch and Muir (1993)

evaluated the effectiveness of the revegetation efforts at those lakes and found that transplanting locally collected native plants contributed to vegetation recovery on some sites. The effects on species richness were clearer than those on species cover. Based on these results, the campsite restoration was expanded to other areas of the wilderness. Trail restoration efforts were also underway.

Severely eroded trails and trails with multiple ruts were prevalent in many heavily used areas. Figure 3 shows an area near Tuolumne Meadows as it appeared in 1973. Restoration experiments were begun that year by Palmer (1979) and were completed in 1988 (Alexander 1989). Figure 4 shows the area as it appeared in 2001. Eagan and others (2000) restored the natural hydrology and soils to a similar 0.8-mile (1,300-m) section of abandoned trail that had two to six 11.8-inch (0.3-m) deep ruts. Fill material from nearby ephemeral drainages was used to bring the ruts up to grade. Plants from locally collected seeds and transplanted sod from between the ruts were used to replant the trails. Both were equally effective, but the transplants were less costly. These restoration projects showed that it is possible to restore areas that had not recovered naturally.

Campsite and Grazing Monitoring—The 1972 and 1986 surveys showed the value of repeated monitoring for detecting changes. A third 10-year monitoring cycle was completed in 1999 using a subset of sites and measurements (Boyers and others 2000). The initial results indicate an overall improvement in conditions due to the restoration program, decreased use, and increased visitor education. While the number of moderately and heavily impacted sites decreased in comparison to the two previous surveys, lightly impacted sites increased. Some of these sites are probably new, although many are restored sites that are still discernable. The monitoring program also alerted managers to the fact that off-trail use is increasing.

Although recreational livestock grazing impact surveys had been conducted in Yosemite in the 1930s through the 1960s, no systematic method of monitoring using standard measurements existed. Moore and others (2000) began a study in 1994 to establish a relationship between grazing intensity and meadow response. They found a consistent negative relationship between utilization and productivity, and a variable response between utilization and species composition. These findings will be incorporated into a meadow monitoring plan for use by wilderness rangers.

Carrying Capacity Decisionmaking—As new sociological theories and tools became available, Yosemite managers decided to take a new look at carrying capacity issues. Echoing the results by Lee (1977), Manning (2001) found that visitors to Vernal Falls had an absolute tolerance for four times as many people in the viewscape as their stated preference (fig. 5). Specifically, they wanted to integrate resource, social, and managerial considerations into their deliberations. Although conceptualized by van Wagtendonk (1979) as early as 1976, the managerial component of carrying capacity had not been incorporated into previous models. Newman and others (2001) are currently conducting a study that includes all three indicators of quality into a decisionmaking framework. The first phase of the project will inventory and map selected setting attributes of wilderness experiences using a Geographic Information System. Workshops with managers and scientists were held to define indicators and standard of quality. The second phase will ask visitors to evaluate tradeoffs among competing setting attributes or indicators using surveys and conjoint analysis. This research will enable managers to weigh the effects of use limits based not only on the effect visitors will have on resources and each other, but also on the effect the management action might have on either.

Figure 3—Multiple ruts in a trail near Tuolumne Meadows as it appeared just prior to restoration experiments in 1973.

Figure 4—The same area near Toulumne Meadows as it appeared in 2001 after restoration efforts were completed in1988.

Figure 5—Although visitors to Vernal Falls preferred to have relatively few people in their view, they were willing to tolerate many more.

Future Direction

Science has been an integral part of the management of the Yosemite Wilderness since before its designation. This role is expected to continue as increasing population pressures increase demand for recreational experiences. Dramatic growth has occurred in communities within 2 hours driving time of Yosemite National Park, much of it in populations that have not been traditional users of wilderness. Science will be called upon to help managers meet the challenges of a shifting cultural base. The appropriateness of new technologies will have to be investigated from legal, environmental, and sociological points of view. Perhaps most importantly, the changing role of wilderness in society will need exploring. Callicott (2000) suggests that wilderness areas might best be considered biodiversity reserves where species that do not coexist well with humans could be protected. Such designations would necessitate a science program of both basic and applied research in the field of conservation biology. If, on the other hand, the vision for wilderness is more in line with Foreman's (2000) view that wilderness should continue to provide opportunities for primitive recreation while at the same time protecting biodiversity, the science program will have to also include a sociological component. Either way, science will play an essential role in the management of wilderness.

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