

Management of Giant Sequoia in the National Parks of the Sierra Nevada, California¹

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Abstract: Management of giant sequoia (*Sequoiadendron giganteum* [Lindl.] Buchholz) in Sequoia, Kings Canyon, and Yosemite National Parks focuses on the need for maintaining and, where necessary, restoring natural ecosystem processes. Such a program includes restoration of natural fire regimes, mitigation of impacts from visitor use, support for basic research and monitoring, and careful evaluation. Research includes studying the effects of air pollution. Interpretation translates information on the ecology and management of giant sequoia for the public.

Management of national parks has long been guided by the philosophy of preserving examples of ecosystems unaffected by human activities. In those areas where heroic or otherwise special species grow, placing the value of the total ecosystem above that of individual species often becomes difficult. The giant sequoia or Sierra redwood (*Sequoiadendron giganteum* [Lindl.] Buchholz) is an example. If the long-term survival of a "natural" giant sequoia community is to be assured, managing for a healthy ecosystem is needed and not just protecting individual trees.

Because they are limited to localized groves in the central and southern Sierra Nevada of California, giant sequoias are the focus of public interest and concern (Vale 1975). The giant sequoia represents only one part of a complex ecosystem (Harvey and others 1980). This complexity makes the task of preserving the natural state of the sequoia-mixed conifer forest a difficult one. Management of giant sequoia in national parks must aim at perpetuating the processes that make the environment suitable to the species' regeneration, growth, and survival. Faced with impacts from visitor use, fire suppression, and air pollution, park managers must devise policies that emulate natural ecological conditions despite a limited understanding of the ecosystem processes.

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HISTORY

Early Protection

The first European settlers to view giant sequoias were awed by their imposing dimensions (Hartesveldt and others 1975, Strong 1975). Recognition of the uniqueness of these giants led to placing the Mariposa Grove---in the area that was to become Yosemite National Park---under State protection in 1864. Concern over threats of exploitation by the timber industry and a desire to protect many prime sequoia groves spurred the creation of Sequoia, General Grant (incorporated into Kings Canyon National Park in 1940), and Yosemite National Parks in 1890. In succeeding decades, giant sequoias were strictly protected by the U.S. Cavalry and later by the National Park Service (after its creation in 1916). In those early years the big trees were specifically protected from logging or fire, but little attention was given to preserving the processes upon which the health of the sequoias depends. National Park Service management focused on the protection of natural objects and the pleasure of visitors (Graber 1983).

Evolution of Policy

The 1963 Report of the Special Advisory Commission on National Parks (Leopold and other 1963) stressed the importance of managing entire ecosystems to preserve examples of natural communities. The report specifically discussed the effects of fire suppression in shifting species composition and increasing hazardous fuels in Sierran coniferous forests. Report recommendations, which were incorporated into National Parks Service policy in 1968 (Bonnicksen and Stone 1982b), provided a unifying direction for management of natural areas in national parks (Graber 1985, Kenner 1985, Lemons and Stout 1984). However, inconsistencies and ambiguities left certain aspects of management policy open to creative interpretation (Bonnicksen and Stone 1982b, Graber 1983).

To preserve natural ecosystem processes, it is necessary to understand the ecological relationships of the communities to be managed. The lack of such information for most presettlement ecosystems presents a serious problem for park managers. Leopold and others (1963, p. 63) recognized this need in advocating a "greatly expanded research program, oriented to management needs." Much of the basic biology of giant sequoia is now understood (Hartesveldt and others 1975, Harvey and others 1980, Kilgore 1973, Rundel 1971, Stark 1968). A continually expanding prescribed burning program (Bancroft and others 1985) has helped to identify additional research needs. These include basic community ecology, expanded monitoring of fire effects, evaluation of impacts of different intensity, seasonality and frequency of burns, and resolution of questions regarding interpretation of National Park Service policy (Parsons and others

1986). Concern over the potential impacts of visitor use and air pollution on giant sequoias has led to the identification of additional information needs.

CURRENT POLICY

The principal aim of National Park Service resource management in giant sequoia groves, as in other natural areas, is the unimpeded interaction of native ecosystem processes and structural elements. Such a policy requires management intervention only when necessary to (1) reverse or mitigate the effects of human activities (e.g., suppression of wildfire), (2) protect a featured resource (such as a "showcase" or historical area), or (3) to protect life or property. Thus, while the overall goal is to minimize human intervention, such unnatural activities as fire suppression, prescribed burning, and selective cutting or mechanical fuel removal may be desirable under certain conditions (Parsons and others 1986).

Policy concerns, such as the definition of "natural," the precision with which management objectives must be achieved, the methods by which an area is selected to be a featured resource, and the relative importance of "ecosystem" versus "esthetic" values, continue to be the subject of spirited debate (Bonnicksen and Stone 1985, Graber 1985, Parsons and others 1986). One compromise that has resulted in part from such exchange is the concept of showcase areas. Unlike the major area of the Parks, showcase areas are managed primarily for esthetic objectives, and natural processes are not always permitted to operate fully.

The overall giant sequoia management program in the National Park Service includes research, management, monitoring, and interpretation.

1. Research. The research program is designed to provide basic information on giant sequoia ecology and the effects of different management practices. Studies have included fire history; effects of trampling, fire, fire suppression, and air pollution on forest structure and composition; fuel accumulation and decomposition; nutrient cycling; and associated fauna. Research has been designed primarily to understand ecosystem structure and processes and how these have been affected by human activities. The results help to direct the management program.

2. Management. The management program is designed to mitigate the effects of human activities. Management actions include prescribed burning to reduce fuel accumulation resulting from fire suppression, and the removal of roads, buildings, and water and sewer lines from affected areas. For the most part, these programs are designed to reverse the effects of years of misguided management activity, and to allow natural processes to influence ecosystems as fully as possible in the future.

3. Monitoring. Monitoring provides a means of measuring the effects of the management program and of evaluating its success in achieving objectives. Monitoring generally consists of field measurement before, during, and after management actions, and follow-up analysis and evaluation of data. It provides feedbacks to management strategy and tactics (Parsons and others 1985).

4. Interpretation. Interpretation plays the important role of informing park visitors on basic sequoia ecology as well as the reasons behind management actions. Translation of information from research and monitoring programs into a form understandable to both managers and the public is an essential part of the overall program. It helps to build support for, and thus assure, the long-term success of all National Park Service activities.

Fire Management

Research on the importance of periodic fire in maintaining natural giant sequoia forests has justified the need to restore a natural fire regime in those areas where fire suppression has been most effective. The first experimental prescribed burns were carried out in the Redwood Mountain Grove of Kings Canyon National Park in 1964. Research on the effects of these early burns documented the importance of fire in giant sequoia regeneration and in creating a mosaic of vegetation types (Harvey and others 1980).

In the late 1960's and early 1970's, additional prescribed burning was carried out in the Redwood Mountain Grove. Objectives at that time typically called for removal of 100 percent of the dead and downed fuel and removal of 70-100 percent of sapling and small pole trees (Bancroft and others 1985). Small (30-50 acres or 12-20 ha) blocks were burned uniformly with strip headfires. Objectives were met, although occasional foliage scorch over 100-200 feet (30.5-70.0 m) high occurred. These hottest fires interestingly produced the greatest number of sequoia seedlings. In contrast, in the Mariposa Grove of Yosemite National Park, young white fir (*Abies concolor* [Gord. & Glend.] Lindl. ex Hildebr.) were manually cut and burned. This labor-intensive approach mimicked some of the effects of fire, but avoided unappealing effects such as dead trees and charred trunks.

A growing recognition of the natural role of fire in creating and maintaining mosaics of different ages and species (Bonnicksen and Stone 1981, 1982a), cycling nutrients (St. John and Rundel 1976), and controlling disease organisms (Piirto and others 1984) led to reevaluation of the fire management program. Today the principal goal of fire management in the giant sequoia groves of Sequoia, Kings Canyon, and Yosemite National Parks is to restore or maintain the natural fire regime to the maximum extent possible so that natural ecosystems can operate essentially unimpaired by human interference (see field trip handout in *appendix*). Prescribed burns are now conducted by igniting fires in a spot pattern, and allowing fuels, weather, and topography to produce a mosaic of fire behaviors and effects. Compared with the early Redwood Mountain burns and the extensive thinning of the Mariposa Grove, both ground and standing fuels are removed less completely. Crown scorch height averages about 30 feet (9.1m), although small areas that contained much deadwood have scorch heights of 60-100 feet (18.3-30.5 m). This mosaic of intensities and fire effects may well approximate the poorly documented historic role of natural fire in the giant sequoia-mixed conifer zone of these parks.

Objectives of individual prescribed burns are carefully designed to reduce fuels to the point where natural (lightning) ig-

nitions can again be allowed to burn. Identifying areas where natural ecosystems have been most altered by fire suppression helps managers to place priorities on prescribed burning of areas to reduce unacceptably high fuel loading. Computer models such as FYRCYCL (van Wagtenonk 1985) can also help managers determine if and when a prescribed burn is needed by identifying the "natural" range or variability of fuel accumulation for a given area. Once fuels have been reduced to more acceptable levels, lightning ignitions will again largely be permitted to determine the fire regime. We anticipate that some natural ignitions will have to be replaced by prescribed burns where natural fires must be suppressed for safety or political reasons. The success of such a fire management program will depend upon the ability to predict fire spread and intensity under varying conditions, the number and size of natural fires allowed to burn, and public acceptance of the program.

Recently, burning prescriptions have been refined to the point where prescribed fire can be successfully used to modify forest structure. However, rather than dictate a given forest structure as desirable, the National Park Service has established the goal of restoring the natural role of fire to the forest and then allowing the structure and function to return to equilibrium. Realizing that the 60 years of successful fire suppression are merely a flash in the ecological time scale of giant sequoia, we consider allowing natural fire after prescribed reduction of fuels to be a conservative approach that minimizes subjective judgment of which trees are good and which are bad.

The use of prescribed fire in Sierra Nevada National Parks can best be viewed as an evolving program. As is the case with many natural processes, it is impossible to know exactly what the long-term impacts of the program will be. For this reason, the program must be carefully monitored and frequently reevaluated. The study of unburned controls as well as areas burned with different intensities will help evaluate the long-term effectiveness of the program in restoring natural fire regimes. At the same time, additional research on fire history, fuel dynamics, fire spread rates, and fire effects is needed to make the conceptual and computer models upon which the management program is based as realistic as possible.

Showcase areas, where evidence of fire is minimized, have been designated in a few high visitation areas. Such areas are limited in size and used either to portray how an area appeared at a given point in time, or to present an esthetically and subjectively pleasing forest where the effects of fire or other disturbance are minimized. Managing to preserve natural processes and managing for an unburned appearance are inherently contradictory. The maintenance of showcase areas is achieved only at a severe biological cost. Even in such areas, the forest depends on fire for nutrient cycling and reproduction. To date, showcase areas are limited to a few heavily visited zones, such as around the General Sherman Tree in Sequoia National Park and around the General Grant Tree in Kings Canyon National Park.

Visitor Use

Early concern over the impacts of human use on giant sequoia groves focused on the fear that soil compaction from foot and

vehicular traffic would lead to root damage and the eventual demise of the trees. However, soil compaction actually increased sequoia growth due to decreased evapotranspiration and competition from young trees and herbaceous plants (Hartesveldt 1964). This was an unnatural influence that could have long-term negative impacts, particularly through the exposure of surface roots. Additional impacts from the development of visitor facilities have included cutting roots and covering soil by buildings and asphalt (Vale 1975). Piirto and others (1984) suggested that soil and root disturbance associated with roads, trails, and other construction may initiate premature failure of giant sequoias.

The need to replace water and sewage facilities as well as dilapidated structures in the Giant Forest in Sequoia National Park raised the question of whether such development could continue to be tolerated. Concern over such impacts resulted in moving campgrounds out of the Giant Forest during the 1960's. Proposals and associated environmental assessments to move remaining structures were approved in 1979. The National Park Service and Guest Services Incorporated (the Park concessioner) are building new facilities at Clover Creek and Lodgepole, a few miles to the north, and out of the grove.

Air Pollution

Air pollution recently has been recognized as a potential threat to the health of the coniferous forests of the western United States (Miller 1980, 1985; Roth and others 1985). Ozone, in particular, has been implicated in forest damage in southern California (Williams and others 1971).

While mature giant sequoias are generally considered to be relatively tolerant of ozone, seedlings may be sensitive. Research funded by the National Park Service is investigating the sensitivity of sequoia seedlings to varying levels of atmospheric ozone. This work includes artificial fumigation of sequoia seedlings. Additional comprehensive studies of the potential effects of acid deposition as well as the use of remote sensing to detect changes in forest health are also underway in Sequoia National Park (Parsons and Graber 1985). Such information is critical to the long-term preservation of the giant sequoia ecosystem.

CONCLUSIONS

While an active---but conservative---management program continues, much remains to be learned about the ecology and fire history of giant sequoia ecosystems. The management programs in Sequoia, Kings Canyon, and Yosemite National Parks must still be looked on as partially experimental. It is, and will continue to be, impossible to accurately predict all of the ramifications of management activities. However, while the optimum level of fuel reduction or scorch height during prescribed burns can be debated, one fact remains: the exclusion of fire is unnatural.

All living organisms must eventually die. Giant sequoias are no exception. The fact that sequoia trees may fail due to root disease or fire scars should not in itself be cause for alarm. These

are part of the natural ecological process and must be allowed to continue if natural ecosystems are to be preserved. However, it is when changes in these processes result from human activities that managers must be concerned.

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