Objects or Ecosystems? Giant Sequoia Management in National Parks [1]

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Abstract: Policies and programs aimed at protecting giant sequoia *(Sequoiadendron giganteum)* in the national parks of the Sierra Nevada have evolved from the protection of individual trees to the preservation of entire ecosystems. We now recognize that the long-term preservation of giant sequoia depends on our ability to minimize and mitigate the influences of human activities. National Park Service management strategies for giant sequoia focus on the restoration of native ecosystem processes. This includes the use of prescribed fire to simulate natural ignitions as well as the movement of visitor facilities out of the groves. Basic research is being carried out to improve our understanding of the factors influencing giant sequoia reproduction, growth, and survival. Future management decisions must recognize that giant sequoia are only part of a complex ecosystem; they cannot be managed as objects in isolation of their surroundings.

Management of giant sequoia (*Sequoiadendron giganteum*) on national park lands has evolved from emphasizing the protection of individual trees to recognition of the species as an integral part of a complex ecosystem. Improved understanding of the complex and dynamic nature of the giant sequoia ecosystem, including its dependence on periodic disturbance and its sensitivity to human activities, has forced the USDI National Park Service to periodically reassess management policies and practices.

It is now recognized that the overriding goal of preserving naturally functioning ecosystems can often not be achieved by simply letting nature take its course. Impacts from fire suppression, air pollution, visitor use and associated facilities, and other human induced changes must be mitigated through active management action. This requires difficult decisions based on the best possible scientific data. Management objectives and strategies must be scientifically based, clearly articulated, and periodically reassessed.

Within the National Park system the giant sequoia is native only to Sequoia, Kings Canyon, and Yosemite National Parks in California. The history of management of giant sequoia within these parks has closely mirrored the history of National Park Service resource management policy. From an "era of spectacles" in which objects and scenes (big trees, deep canyons, and high mountains) were "protected" from all injury, the management of National Park resources has evolved to an emphasis on the restoration and preservation of natural biotic communities (Graber 1983). In the case of giant sequoias, management concern now focuses on restoring natural fire regimes, mitigating the impacts of increasing visitor use and associated developments, and understanding the effects of such external threats as air pollution and projected human induced climatic change. The challenges associated with assuring the long-term preservation of giant sequoia have become increasingly complicated as we have learned more about the complexity and inter-relatedness of the greater Sierra Nevada ecosystem.

This paper briefly reviews the history of giant sequoia management in the National Parks of the Sierra Nevada, emphasizing a gradually improved understanding of giant sequoia ecosystems and how management has attempted to incorporate this understanding; outlines current management philosophy and strategies; and reviews issues and concerns for the future of giant sequoia management in national parks.

History of Giant Sequoia Management in National Parks

Giant sequoia have been "protected" within the boundaries of Sequoia, Kings Canyon, and Yosemite National Parks since the creation of the three parks in 1890 (the portion of Kings Canyon containing giant sequoia was originally established as General Grant National Park). The strategies employed to insure this protection have evolved from relatively simple protection from logging, fire, and visitor abuse to more complex efforts to preserve naturally functioning ecosystems, including the restoration of fire as a natural process.

Deeded to the State of California as part of the Yosemite Act of 1864, the Mariposa Grove of giant sequoias was included in the first public reservation designated by the Federal government for the long-term protection of natural features (Runte 1990). This action protected the Mariposa Grove from the extensive logging activities that devastated many sequoia groves in the years that followed. Such protection was extended to include other groves with the creation of Sequoia, General Grant (enlarged to become Kings Canyon in 1940), and Yosemite National Parks in 1890. Interest in protecting remaining intact sequoia groves from timber harvest was a primary motivation in the creation of these parks (Dilsaver and Tweed 1990). For the next 26 years park management consisted largely of Cavalry troops patrolling to stop poachers and illegal timber harvest and to deal with the growing problems associated with increasing visitation. Creation of the National Park Service in 1916 symbolized the beginning of a new era, characterized by on-site, year round management attention and an increased emphasis on attracting tourists and developing a supportive clientele.

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In the early days, National Park Service management of giant sequoia focused on protection of the big trees from logging, fire, and other injury. Fire and pests were aggressively controlled and the cutting of live trees prohibited. Often phrased in terms of "preservation," the actual practice was a hands-off policy of protection (Hartesveldt 1962). Many of the larger trees were named after generals or other heroic figures, emphasizing their status as objects apart from the surrounding ecosystem. Little thought was given to preserving the ecological processes necessary to preserve the health of the giant sequoia ecosystem.

As early as 1864 concern was first expressed over the importance of preserving the "natural scene" of the Mariposa Grove from expected increases in human visitation (Olmsted 1865). Yet many decades passed before this wisdom was widely accepted. Well into the 20th century giant sequoia management in the national parks continued to focus on "protecting" the big trees from damage, while simultaneously providing for a pleasurable visitor experience.

The 1916 Organic Act which created the National Park Service called for leaving resources "unimpaired." Yet the meaning of this term was not clearly defined, often leaving policy direction ambiguous and imprecise. A 1926 report by the forest pathologist Meinecke (1926) emphasized the importance of protecting the largest and oldest specimen sequoias because of their inherent attractiveness. Hartesveldt (1962) has detailed the struggles of National Park Service administrators to protect giant sequoias in the decades following Meinecke's report. During this time, trees continued to be named and protective fences were built-including one best described as a "barbed wire entanglement,"-around the more popular specimens. Campgrounds, visitor centers, parking lots, lodging facilities, and roads and trails were built within the sequoia groves. And whereas great care was often taken to hand excavate around the larger feeder roots, little concern was shown for the potential long-term effects of soil compaction or the eventual failure of underground water and sewer systems on the shallow rooted big trees. Fire continued to be viewed largely as a destroyer of forest values.

Understory thinning carried out in the 1930's in the Mariposa Grove to reduce both competition from white fir *(Abies concolor)* and hazardous fuel accumulations spurred considerable debate over the need for active management in the sequoia groves. For the first time it was suggested that both preservation in the "natural" or "original" conditions was an impossibility and fire protection should be regarded as unnatural and steps be taken to compensate for its effects (Hartesveldt 1962). A limited understanding of the ecology of the giant sequoia ecosystem together with an apparent inability to clearly define such ambiguous terms as "natural," "unimpaired," "protection," and "preservation," hindered development of definitive objectives for giant sequoia management. Thus the need for scientific data upon which to make management decisions first became recognized.

Mitigating Human Impacts:

Increased recognition of the importance of scientific data eventually led to the support of comprehensive studies of management and visitor impacts in the giant sequoia groves. The combination of Hartesveldt's studies of human impacts to soil and vegetation in the Mariposa Grove of Yosemite National Park (Hartesveldt 1962) and subsequent studies in Sequoia and Kings Canyon (Hartesveldt 1963, 1965) were the first to quantitatively analyze the effects of historic management practices-which had been a concern since at least the 1920's (Hartesveldt 1962).

Other than occasional fences, understory thinning, or rerouting of trails and roads one of the first major efforts to mitigate the effects of human activities on giant sequoias involved the movement of campgrounds and picnic areas from the heart of the Giant Forest Grove during the 1960's. In the 1970's a development plan was approved to move most of the other visitor facilities out of the Giant Forest. Today, construction continues on new visitor facilities outside of the grove. When completed, only roads, trails, and a small visitor contact center will remain in the grove. All lodging and food facilities will be moved and the heavily impacted portions of Giant Forest restored to a more natural condition.

In Yosemite's Mariposa Grove, extensive understory thinning has been used to reduce fuel hazards and open vistas. The heavy visitor use in this grove is now restricted to access by foot or through an interpretive tram system. Other than a museum, the once extensive visitor facilities and access by private auto have been eliminated.

Fire Management:

Concern over the effects of fire suppression on increaseing fuel hazards in the mixed-conifer forests of the Sierra Nevada (Agee 1968, Biswell 1961, Leopold and others 1963) led to the first experimental burns in the Redwood Mountain Grove of Kings Canyon National Park in the mid 1960's. Studies conducted in conjunction with these first burns documented significant fuel reduction and the dependence of giant sequoia on fire for regeneration (Hartesveldt and Harvey 1967, Harvey and others 1980). By 1972 prescribed burning had become firmly established as a routine management program in all three Sierra Nevada parks. Burns in the sequoia groves of Sequoia and Kings Canyon were conducted with minimal preburn manipulation whereas extensive preburn cutting of understory species was carried out in the Mariposa Grove of Yosemite. Scientific studies accompanying these early burns provided an improved understanding of the effects of fire on ecosystem properties (Kilgore 1973) as well as documentation of the results of individual prescribed burns (Parsons and van Wagtendonk 1994).

Goals for sequoia/mixed-conifer prescribed burns conducted during the 1970's focused largely on fuel reduction and understory removal. Burning prescriptions were based on fire behavior characteristics and burns were usually of small size and uniform intensity with little attention given to

preserving the patchiness of the forest (Bancroft and others 1985). If areas were left unburned additional fire was added. As the program matured there was increased recognition of the natural role of fire in creating and maintaining species and age class mosaics, cycling nutrients, and controlling disease organisms. More recently, evidence has been presented supporting the importance of locally high intensity fires in opening the canopy and favoring the establishment of giant sequoia (Stephenson and others 1991). Such information led to a revaluation of the goals of the fire management program and subsequent adoption of the overall goal of restoring "natural" fire regimes. As a result, prescribed burns are now ignited with spot ignitions and fuels, and weather and topography are permitted to produce a mosaic of fire behaviors and effects. Burn units are larger, frequently in the hundreds of acres, and if some areas within a unit do not burn they are left unburned.

The program of prescribed burning in the sequoia groves has been criticized for failure to recognize the "unnaturalness" of the preburn forest structure (Bonnicksen and Stone 1982) and for the visual impacts of bark char and canopy scorching (Cotton and McBride 1987). These issues stimulated a thorough review of program objectives and practices. Today, individual prescribed burns are classified as either restoration burns or simulated natural fires depending on the unnaturalness of preburn fuel conditions. Monitoring of fire effects is now much more comprehensive while extensive new research has been undertaken on fire history and the effects of fire intensity on forest structure and pathogen populations (Parsons 1990).

Current Management Philosophy and Strategies

Today, approximately 33 of the 75 natural groves of giant sequoia are under national park jurisdiction (Rundel 1972). These include the Redwood Mountain Grove in Kings Canyon and the Giant Forest Grove in Sequoia National Park, the two largest remaining uncut groves. The combined 33 groves occupy about 11,223 acres of giant sequoia, including over 54,400 trees greater than one-foot in diameter *(table 1)*. All of the sequoia groves on National Park land are managed as natural areas.

National Park Service Management Policies (NPS 1988) for natural zones call for the "protection of natural resources and values for appropriate types of enjoyment while ensuring their availability to future generations." They further state that management "will not attempt solely to preserve individual species (except threatened or endangered species) or individual natural processes; rather, they will try to maintain all the components and processes of naturally evolving park ecosystems." As applied to the giant sequoia, this policy simply emphasizes the importance of understanding and preserving the entire ecosystem rather than focusing solely on the sequoia. It also emphasizes the importance of restoring the fire regime, including its varying nature and its myriad of effects, not simply the restoration of the process of fire itself. Other significant direction found in the Management Policies includes recognition that change is "an integral part of the functioning natural system" and "that management activities may be required to either reverse past human activities or to maintain the closest approximation of the natural ecosystem where a truly natural system is no longer attainable" (NPS 1988).

Given this policy direction, strategies for managing giant sequoias in national parks today focus on the restoration of fire as a natural process, the removal of visitor facilities from groves and mitigation of associated impacts, and increased emphasis on education and research. Most recently, the importance of coordinating such activities with surrounding land management agencies has been emphasized.

Fire Management:

The use of prescribed fire to restore more natural conditions to ecosystems provides an excellent example of the value of proactive management and clearly articulated management objectives. Yet, since many aspects of the nature and effects of varying fire regimes remain unknown, it is often difficult to be sure what specific objectives would be most appropriate for individual burns. Burns designed to restore some previous condition are dependent on an understanding of that condition. Arguments in favor of either protecting individual trees as objects or restoring or maintaining sequoia groves in a static state, as if they were a snapshot in time, the (Leopold and others 1963, Bonnicksen and Stone 1982) run counter to current management policy (Parsons and others 1986, Lemons 1987). Today, the parks' fire management programs attempt to restore fire as a natural process, burning in the range of frequencies and intensities and with a similar range of effects as would have occurred had modern humans not interfered. Although this goal may never be fully attained, it provides both a target and a means for establishing standards against which success can be evaluated. The major obstacles continue to be the difficulty in understanding just what is natural and thus articulating specific objectives for individual burns.

Specific techniques designed to minimize blackening of the bark and scorching of the crown on sequoia trees are now incorporated in the Fire Management Plans for the Parks. These techniques, which include the removal of fuels around the base of trees, burning out from the base, use of foam or water to protect fire scars, and burning with moderate prescriptions (Sequoia and Kings Canyon 1992), are designed to reduce the aesthetic impacts of prescribed burning to which Cotton and McBride (1987) and others object (Parsons 1990). In addition, Special Management Areas (SMAs), where small burns are conducted emphasizing scenic and smoke management concerns, have been identified in several groves (Sequoia and Kings Canyon 1992). The long-term effects of such concessions to protect visual resource values at the expense of natural ecosystem processes are largely unknown.

Table 1- *Giant sequoia groves, including size and number of trees over 1 foot in diameter (dbh) for the three Sierran National Parks.*

Park	Grove	Acres	#Trees>1'dbh
Kings Canyon	Big Stump	257	2,237
	Grant	154	411
	Redwood Mountain	3,154	15,809
	Sequoia Creek	21	35
	Total:	3,586	18,492
Sequoia	Atwell	1,335	4,619
	Cahoon Creek	14	96
	Castle Creek	197	790
	Clough Cave	0.5	3
	Coffeepot Canyon	5	41
	Dennison	11	49
	Devils Canyon	6	34
	East Fork	751	4,773
	Eden Creek	361	1,327
	Garfield	1,130	7,254
	Giant Forest	1,800	8,411
	Homers Nose	245	1,108
	Horse Creek	42	157
	Lost	54	220
	Muir	272	1,163
	New Oriole Lake	21	50
	Oriole Lake	147	693
	Pineridge	94	122
	Putnam-Francis	0.1	1
	Redwood Creek	105	217
	Redwood Meadow	223	2.727
	Skagway	94	254
	South Fork	210	917
	Squirrel Creek	2	2
	Surprise	4	37
	Suwanee	100	289
	Total:	7,224	35,354
Yosemite	Mariposa	333	-
	Merced	45	-
	Tuolumne	35	-
	Total:	413	-
	Total:	**11,223**	**53,846**

In practice, fire management in national park sequoia groves continues to include active suppression of all fires not either intentionally set or, if lightning ignited, falling within preestablished prescriptions. It is hoped that prescribed burns can be used to reduce fuels to the point where natural ignitions can be permitted to burn without fear of escape or unnatural effects. The long-term goal is to include the sequoia groves and the rest of the mixed-conifer forest, in a prescribed natural fire zone in which most lightning ignitions would be allowed to burn. Under such a condition, fires starting within the groves, or burning into the groves but suppressed for safety or other reasons, would be simulated by prescribed burns set at a later date. Fire growth models are being developed to help understand which fires would have burned into the groves had they not been suppressed (M. Finney, pers. comm.). Other computer models that identify the "natural" range or variability of fuel accumulation for a given area are available to help managers determine if and when a prescribed burn is needed by (van Wagtendonk 1985).

Although two lightning ignitions (burning 150 acres in the Muir Grove in 1986 and 720 acres in the Atwell Grove in 1991) have been permitted to burn within sequoia groves and shown what is thought to be relatively natural behavior and effects, no target date has been set for the placement of all sequoia groves within a natural fire zone.

Despite the increased understanding of both the role of fire in giant sequoia forests and the techniques of prescribed burning, numerous problems and questions remain unanswered. If the effects of fire suppression from the past century are to be fully mitigated, methods must be found to increase the acreage burned. Problems of smoke production and restrictions on burning due to air quality controls must also be resolved. The task of emphasizing the importance of fire to the public must be continued and intensified. And finally, we must continue to improve our understanding of the long-term effects of different intensities and seasons of fires on various ecosystem properties. As the goals of individual burns change from fuel reduction to the mimicking of natural conditions, increased attention must be given to simulating the variability of behavior and effects of natural fire regimes, including the variable effects on ecosystem properties.

Human Intrusion:

In addition to the efforts to restore fire as a natural ecosystem process, National Park Service management of sequoia groves now emphasizes managing human intrusion in the groves. In the early years of the Parks, the sequoia groves presented a tremendous aesthetic attraction and thus much of the early development was concentrated within them. Recognition of the negative aesthetic, ecological, and safety impacts of excessive development (a visitor was killed by a falling tree while picnicking in a designated picnic area in 1969) has led to the progressive removal of visitor facilities over the years (Dilsaver and Tweed 1990).

The impacts of human intrusion on the giant sequoia have especially affected the Giant Forest of Sequoia National Park. Facilities within the Giant Forest include a lodge, cabins, dining room, cafeteria, gift shops, market, parking lots, and employee housing. Together with antiquated water and sewage facilities and increasingly hazardous trees, these facilities negatively impact the health, safety, and appearance of the area. Public hearings in the early 1970's provided direction for the removal of most developments within the Giant Forest (Dilsaver and Tweed 1990). A new visitor center and associated lodging, food, and employee facilities were to be built outside of the grove. Today, 20 years later, most of the Giant Forest facilities continue to be used. Campgrounds and picnic grounds have been moved and a new Visitor Center built. Yet, while construction is underway on major new lodging and food facilities that will finally permit the abandonment of most of the remaining facilities in Giant Forest, funding problems have pushed the projected completion date into the 21st Century. But once the facilities have been constructed considerable effort will remain in removing existing facilities and rehabilitating the disturbed sites. No plans exist for removing roads, campgrounds (Atwell Grove), cabins (Merced Grove), or museums (Mariposa Grove) from other groves with such developments.

Education:

Education provides one of the most effective strategies for assuring the long-term perpetuation of giant sequoia. An understanding of the nature and sensitivity of the species and its surrounding ecosystem provides both managers and visitors with the tools and motivation necessary to minimize many potentially damaging impacts. The Sierra Nevada national parks have given significant emphasis to developing diverse interpretive and education programs to provide information on factors influencing giant sequoia. These include guided walks, evening seminars, park newspapers, and books and brochures. A review of the effectiveness of the interpretive program in Sequoia and Kings Canyon in providing information on the prescribed fire program confirmed the value of these efforts (Quinn 1988). Other issues that are routinely addressed in interpretive programs and publications include wildlife associated with the big trees, the effects of air pollution, and the value of sequoia tree rings in understanding fire and climate history and the influences of climate on tree growth.

Research:

Scientific research and associated monitoring provide the understanding necessary to make management decisions. The recent evolution of management policies as well as specific management decisions related to giant sequoia have been largely based on improved scientific data. Beginning with the studies of Hartesveldt (1962, 1963) on human impacts, and Harvey and others (1980) and Kilgore (1973) and others on fire ecology, a firm basis has been provided for decisions to remove visitor intrusions and establish a prescribed fire program. Challenges to the prescribed fire program (Bonnicksen and Stone 1982, Cotton and McBride 1987) have spurred additional studies which in turn have provided increased understanding and an improved basis for adjusting policies and strategies (Parsons 1990). Today, research emphases include collection of basic data on forest dynamics (recruitment, mortality, influences of disturbances, etc.) as well as development of a forest simulation model that will permit managers to ask "what if' questions related to different fire, climate, or management scenarios (Stephenson and Parsons 1993). In addition to a continuing emphasis on research, a scientifically based monitoring system is in place to help with the periodic evaluation of management actions as well as the detection of possible change.

Regardless of the strength of the research history associated with giant sequoias, the need for improved understanding of ecosystem processes and management consequences cannot be overemphasized. Specific questions regarding fire effects must still be addressed. These include the effects of burn intensity, seasonality, and frequency; the unnaturalness of ground or crown fuels; and the effects of predicted future increases in air pollution or human induced climate change on the distribution of the species. Research

on fire and forest ecology, air pollution effects, and potential effects of global climate change (Stephenson and Parsons 1993) should be continued in order to answer such questions.

Issues and Concerns for the Future

Despite the fact that giant sequoia have been a focus of public attention and management dilemma for well over a century, we are only now beginning to understand many of the factors influencing recruitment and survival of the species. For example, recent research has provided a greatly improved understanding of the often subtle interactions of climate, fire, and vegetation. It has also improved our understanding of the effects of human activities, such as trampling and air pollution, on giant sequoia. Yet, despite these advances in knowledge, most management decisions continue to be made without sufficient information to accurately assess either the short or long-term ramifications of the action. It is virtually impossible to fully anticipate future issues and concerns.

The importance of continued and enhanced monitoring and research, coupled with mechanisms to assure that new information is incorporated into management decisions, cannot be overemphasized. The ultimate goal of such programs should be the development and testing of predictive models capable of forecasting the consequences of alternative management strategies. It will become increasingly important that managers understand the implications of decisions before they are made.

In addition to improving our information base, key ecosystem management decisions should be based on a regional or even global perspective. We now recognize that many of the most important influences on species distributions and general ecosystem health transcend administrative boundaries. Climate, air pollution, and large scale fires, for example, operate without regard for such administrative delineations. An increasing emphasis on a bioregional approach to resource and management issues is evident in ongoing research on global climate change (Stephenson and Parsons 1993), a new statewide interagency memorandum of understanding on biodiversity and bioregional planning (State of California 1992), and the formation of an interagency managers group to deal with diverse resource issues (Parsons 1991 a). These early stages of interagency cooperation need to significantly expand if the land management agencies can adequately face the key resource issues likely to arise in the next century.

Many resource issues related to giant sequoia are likely to become intensified in the 21st century. Growing population in the neighboring regions can be expected to increase visitation to the parks. This will mean larger numbers of people driving to the parks, walking the trails, and desiring food and lodging facilities. The parks will need to address these needs by considering improved transportation systems and locations for new facilities. Air pollution, which has already been shown to impact other tree species in the parks (Duriscoe and Stolte 1989) can be expected to increase, with uncertain effects on giant sequoia and its associated species. Prescribed burn programs to both reduce unnatural fuels and simulate natural fires must face the challenge of increasing restrictions on smoke production designed to protect air quality. In addition, management must address the increasing evidence that locally intense fires may have played an important prehistoric role in opening the canopy and preparing favorable microsites for sequoia recruitment (Stephenson and others 1991). Yet, perhaps the most uncertain of the future stresses is that associated with predictions of human-induced climatic change. Such change could be expected to alter species distributions, disrupt communities as we know them, and increase the frequency and intensity of extreme climatic events (and concomitantly the frequency and intensity of fires). Such changes could force a re-examination of the role of national parks (Parsons 1991b), including a redefinition of the goals of preserving examples of "natural" ecosystems.

The long-term preservation of giant sequoia will require an improved understanding of the factors controlling species distribution and other natural ecosystem processes. An accelerated research and monitoring program must be accompanied by an increased emphasis on education. By applying these programs, managers and the public will help assure the long-term preservation of both the species and associated ecosystem. It is critical that science play an increasing role in the difficult decisions that must be made to ensure the long-term preservation of both giant sequoia and the greater Sierra Nevada ecosystem.

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