Restoring Fire to Giant Sequoia Groves: What Have We Learned in 25 Years?

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Giant sequoia *(Sequoiudendron giganteum)* ecosystems are well adapted to periodic fire. Fire suppression following the 1890 creation of Sequoia and General Grant (later to become Kings Canyon) National Parks represents the longest fire-free interval in the sequoia groves of the Sierra Nevada for at least the last several thousand years (Swetnam 1993). Recognition of the effects of fire suppression on inhibiting sequoia reproduction, increasing hazardous fuel accumulations, and generally changing forest structure led to the implementation in 1968 of a prescribed burning program in the sequoia-mixed conifer forests of the two Parks (Bancroft and others 1985). This program has been accompanied by an extensive research effort designed to improve both our understanding of the historical role of fire and the effects of varying fire frequencies and intensities on ecosystem properties (Parsons 1990).

PROGRAM HISTORY

Based on an understanding that fire suppression was changing the character of the giant sequoia forest, early program goals and burn objectives emphasized reducing accumulated ground fuels, thinning shade tolerant understory trees, and encouraging sequoia reproduction. Burns were generally characterized by strip headfires of relatively uniform intensity. As more was learned about the natural role of fire in sequoia forests, including the importance of patchy, variable intensity fires, these goals, objectives, and techniques were modified to emphasize the restoration of fire as a "natural" process (Bancroft and others 19851.

Prescribed fire technology has now advanced to the point where fire managers can create almost any desired pattern of forest structure or function. However, the definition of what is desired has continued to be a problem. One of the greatest challenges to the prescribed fire program has been in defining what is "natural" (Kilgore 1985). For example, should any fire ignited by lightning be considered natural, or only if it is burning in "natural" fuel conditions? In the giant sequoia groves it is recognized that the fire suppression era has created fuel and forest structure conditions that have not occurred in the last several millennia. They would not have occurred today, had fires been permitted to continue to burn.

When we speak of restoring natural fire b the sequoia groves, we mean the restoration of fire burning at similar frequencies and intensities and with similar effects as would have occurred ifmodem man had never come on the scene. This requires an understanding of past vegetation and fire regimes as well as the effects of varying fire frequencies and intensities.

Since the prescribed burning program was initiated in 1968, 3,643 of the 10,810 acres (33.7%) of giant sequoia in Sequoia and Kings Canyon have been burned by management-ignited fires (Fig. 1). The average of 146 acres (1.35%) burned per year translates to a fire return interval of 74 years. An additional 764 acres have been burned in prescribed natural fires during this time (raising the average to 176 acres or a return interval of 61 years). This contrasts with a mean fire interval of 4.1 years (for the period AD. 500 to 1900) that has been documented from fire scars for the Circle Meadow area of Giant Forest (Swetnam and others 1992). Approximately 2,637 acres (24.4% of the groves) per year would need to be burned to achieve a 4.1 year mean fire interval for the sequoia groves of the two Parks.

WHAT HAVE WE LEARNED?

Over two decades of research and monitoring associated with the sequoia-mixed conifer forest prescribed fire program has documented numerous fire effects. Early findings included understanding the importance of heat in opening sequoia cones and releasing seeds, exposing mineral soil to

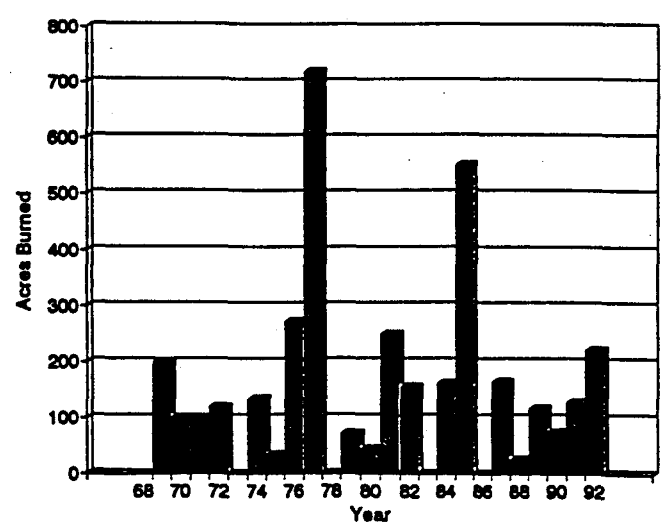

Figure l-Total acreage of giant sequoia forest burned each year by management ignited fires in Sequoia and Kings Canyon National Parks. In addition, 150 acres were burned in 1966 and 614 in 1991 in prescribed natural fires.

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prepare seedbeds for sequoia seedling establishment, reducing flammable ground fuels, thinning of shade-tolerant understory trees, and stimulating shrub and hardwood sprouting (Kilgore 1972). An increased survival of sequoia seedlings following especially hot fires (Harvey and Shellhammer 1991) and the release of usable forms of nitrogen have also been documented.

Paleoecological studies of sequoia forests have confirmed a striking interdependence between vegetation, climate and fire over the past several thousand years. Pollen and plant macrofossils from meadow sediments document a significant shift in species dominance in current sequoia groves, including a marked increase in giant sequoia over the past 10,000 years, a time period characterized by increasingly moist conditions (Anderson 1990). This high temporal variability in species composition and structure suggests a dynamic community that is responsive to shifts in climate and disturbance. Vegetation-based targets for ecosystem restoration will need to reelect this dynamic nature rather than the traditional view of a static, climax forest. The difficulty in identifying a "natural" vegetation for these areas has become increasingly apparent.

Tree-ring reconstruction of past giant sequoia fire regimes shows high temporal variability of fire frequency and size. Mean fire intervals from AD. 500 to 1900 ranged from 3.0 to 4.1 years for different groves (range = 1 to 23 years; Swetnam and others 1992). No fire-free period in the last 2,000 years has been as long as that during the recent suppression era. In addition, historic periods of high iire frequency were apparently characterized by patchy fires (few trees show the same scar year), whereas periods of low-frequency fire were characterized by large fires (many trees show the same scar year). Climatic variation appears to account for much of the variability in past fire regimes (Swetnam 1993). One implication of the high temporal variability of the past fire record is that "natural" fire regimes cannot be characterized by a single fire frequency or mean fire interval estimate.

Despite concern over the effects of fire suppression, it is clear that sequoia ecosystems represent a dynamic forest type that is well adapted to environmental change. We now believe that no species have been lost or introduced to the sequoia forest as a result of fire suppression and that claims of increases in young white fir (Bonnicksen and Stone 1982) can only be confirmed once we have an improved understanding of normal population dynamics of mixed conifer forest species. The most significant finding in recent years has been documentation of the importance of patchy high-intensity fires in the perpetuation of giant sequoia (Stephenson and others 19911.

The scenic and emotional values associated with giant sequoia are immense (Cotton and McBride 1987; McBride 1993). In 1985, concern over the impacts of prescribed burning on scenic values (creating and enlarging fire scars and causing bark char) shut down the prescribed fire program for a year (Parsons 1990). Partly in response to such concern, extra efforts are now made to remove heavy fuel from around the base of giant sequoias before burning. In addition, in the most heavily used areas, Special Management Areas have been designated where burn boundaries and burning techniques are largely determined by scenic criteria.

THE FUTURE

A 1993 review of the prescribed fire program at Sequoia and Kings Canyon National Parks recommended the following wording be used to state the goal of the prescribed fire management program: To restore and perpetuate the fire regime and the vegetation structure (or range of structural variability) that would have existed today had Europeans not come on the scene.

This wording formally recognizes the important ties between the fire process and the resulting vegetation. And although it is readily acknowledged that sufficient understanding of past vegetation and the interactions of iire, dimate and vegetation do not exist to establish final vegetation-based objectives at this time, such a goal does provide a target to help direct future management actions and research studies.

To accomplish this goal it will be necessary to burn at an accelerated rate by expanding burning windows and increasing the use of larger, variable-intensity fires. Prescription changes will be needed to permit some fires that open the canopy. Beburning of areas burned in the recent past will need to be increased. It is unclear whether such changes can be effectively made in the face of a myriad of program constraints.

Constraints

Among the significant constraints that threaten future progress of the giant sequoia prescribed fire program are funding and staffing limitations, air quality restrictions, public and concessioner use conflicts (including the effects of smoke), cultural and archeological concerns, requirements for expensive fuel manipulation around sequoias, and the lack of basic knowledge of long-term fire effects.

Research Needs

The long-term success of the prescribed fire program is dependent on an improved understanding of past forest conditions, the effects of variable fire regimes and fire characteristics on ecosystem properties (including mortality, recruitment, pathogens, nutrient cycling, and so forth), the ecological and health effects of smoke, and smoke dispersion patterns. It will also be necessary to define the range of desired forest structure, develop models of forest and fuel dynamics and fire spread potential, and begin long-term studies of the effects of different burning patterns.

Management Options

A number of significant challenges must be addressed if larger acreages are to be burned and the desired effects achieved. These include the need to increase the use of larger, variable-intensity ignitions that minimize the construction of firelines and to expand burning windows to permit burning under a wider range of conditions. It will also be necessary to explore options for increasing the use of natural ignitions. Models of forest and fuel dynamics and fire spread will need to be increasingly relied on to project the consequences of alternative management strategies. Feedback from monitoring and research findings will need to be improved both to refine objectives and techniques and to evaluate program success.

Finally, the time has come when the Parks must seriously consider alternatives to the use of fire for areas where it simply isn't possible to achieve natural fire frequencies. This may include the use of physical manipulation of fuels and vegetation. Long-term study areas may need to be established to demonstrate and learn the effects of alternative management strategies.

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