An Ecological Comparison of Fire and Fire Surrogates for Reducing Wildfire Hazard and Improving Forest Health: A Research Proposal

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Abstract

Current coniferous forests in many areas of California and elsewhere in the western U.S. are denser and more spatially uniform, have more small trees and fewer large trees, and have greater quantities of fuel than their presettlement counterparts. Widespread treatments are needed to restore ecological integrity and reduce the high risk of destructive, uncharacteristically severe fires in these forests. Among possible treatments, however, the appropriate balance among cuttings, mechanical fuel treatments, and prescribed fire is often unclear. For improved decision making, resource managers need much better information about the consequences of alternative management practices involving fire and mechanical/manual "fire surrogates." Land managers and researchers, working collaboratively, need to design and implement long-term interdisciplinary studies to quantify those consequences. We propose here the outline of such a design. Suggested treatments are: (1) untreated control; (2) prescribed fire only, with periodic reburns; (3) initial cutting, followed by prescribed fire; only fire used periodically thereafter; (4) initial and periodic cutting, each time followed by prescribed fire; fire alone also could be used one or more times between cutting intervals; and (5) initial and periodic cutting, each time followed by residue removal and/or mechanical fuel treatment; no use of prescribed fire. Non-control treatments would be guided by one or two desired future conditions. Treatments should be replicated at least 3 times at a research site. Each treatment plot should be at least 25 to 35 acres in size. A number of disciplines should be involved to study a wide variety of responses to the treatments. Results related to treatment costs and implementability, and short-term ecological effects, should be available relatively quickly. However, many answers would come only from longer-term research. Discussions have been initiated with potential management partners concerning possibilities for conducting such studies in the southern Sierra Nevada, the southern Cascades/northern Sierra Nevada, and the Klamath Mountains. Additional study areas are desirable.

Introduction

Current coniferous forests in many areas of California and other parts of the west are denser and more spatially uniform, have more small trees and fewer large trees, and have greater quantities of forest fuels than their presettlement counterparts (Bonnicksen and Stone 1982, Chang 1996, Parker 1984, Parsons and DeBenedetti 1979, Weatherspoon and Skinner 1996). Causes include fire exclusion, past grazing and timber harvests, and changes in climate (Skinner and Chang 1996). The results include a general deterioration in ecosystem integrity and sustainability and a considerably increased probability of large, high-severity wildfires. These conditions are prevalent in short-interval fire-adapted forest ecosystems throughout much of the western United States (Agee 1993, Mutch and Cook 1996). The report of the Sierra Nevada Ecosystem Project (SNEP) highlighted these problems and explained the need for large-scale and strategically-located thinning (especially of small trees), fuel treatment, and use of prescribed fire (SNEP 1996, Weatherspoon and Skinner 1996). Testimony before the California State Legislature (Skinner 1997) emphasized these problems to State lawmakers. A recent speech by Interior Secretary Babbitt (1997) pointed out that similar problems and the need for similar solutions are now being acknowledged nationally by high-level policymakers.

The need for large increases in the use of restorative management practices is clear (e.g., Hardy and Arno 1996). Less clear, however, is the appropriate balance among cuttings, mechanical fuel treatments, and prescribed fire (SNEP 1996, Weatherspoon 1996). Economics and practicability in light of current stand and landscape conditions are important considerations. However, to restore and maintain forest ecosystem integrity, we also need to understand more about the ecological consequences and tradeoffs of alternative management practices. The frequent, low - to moderate - severity fires that characterized presettlement disturbance regimes in most of our forests (Skinner and Chang 1996) affected not only overall forest structure, composition, and fuel levels, but also a wide range of other ecosystem components and processes (Chang 1996). What components or processes are changed or lost, and with what effects, if fire "surrogates" such as cuttings and mechanical fuel treatments are used instead of fire, or in combination with fire? Currently, information necessary to answer such key questions is largely anecdotal or absent.

Land managers, researchers, and other interested parties, working collaboratively, need to design and implement long-term research to learn the consequences of producing and maintaining one or more desired stand conditions using (1) cuttings and mechanical fuel treatments alone (i.e., without fire), (2) fire alone (via multiple prescribed burns), and (3) combinations of cuttings, mechanical fuel treatments, and prescribed fire. Untreated controls would also be necessary. Only in this way will it be possible to determine which ecosystem functions of fire can be emulated satisfactorily by other means, which may be irreplaceable, and the implications for management.

Discussions have been initiated with potential management partners and other stakeholders concerning possibilities for conducting such research in the southern Sierra Nevada, the southern Cascades/northern Sierra Nevada, and the Klamath Mountains. The level of interest has been high. We believe that the subject of the proposed study outlined in this paper is of sufficient importance and wide applicability to warrant a regional or west-wide study with a number of installations and a common design. This design, to which our proposal might contribute, could greatly enhance development of broadly applicable models of ecosystem responses to fire and fire surrogate treatments.

Objectives

The proposed research should address three broad objectives:

1. Assess the ecological consequences of alternative fire and fire surrogate treatments for improving forest health and reducing wildfire hazard in mixed-conifer and other short-interval fire-adapted coniferous forests.
2. Within the first 5 years of the study, collect baseline data, carry out cutting/mechanical and prescribed fire treatments, document short-term responses to treatments, and report results.
3. Over the life of the study, conduct interdisciplinary research to quantify a wide spectrum of ecosystem responses to specified management treatments (including appropriate controls), develop and validate models of ecosystem structure and function, develop and successively refine recommendations for ecosystem management in relevant forested areas, and report results.

Research Approach

Management activities in forested ecosystems usually manifest themselves most directly through (1) changes in vegetation structure and/or composition, (2) disturbances to soil, forest floor, and woody residues, and (3) the spatial and temporal distributions of these items. These changes result in a wide array of effects on other ecosystem components and processes, including soil biota, nutrient cycling, wildlife communities, and watershed properties. Various combinations of manipulative activities—cutting trees or other vegetation, using prescribed fire, and mechanically treating residues or scarifying the soil—will therefore comprise the experimental treatments in the proposed research. Treatment combinations will include those that address widely-shared concerns about forest health and wildfire hazard -- e.g., thinning and fuel treatment; those that deal with environmental concerns; and those most operationally practical. Consistent with the long-term focus of the study, treatments will be repeated periodically to represent real management approaches.

The basic study design outlined in the following sections is a good place to begin. However, this basic design may need to be modified to fit the particular forests chosen for study and to meet the needs and interests of the participants and other anticipated stakeholders in the most useful way.

Fire/Fire-Surrogate Treatments

The following suite of five fire/fire-surrogate (FFS) treatments is proposed:

1. Untreated control.
2. Use of prescribed fire only, with periodic reburns.
3. Initial cutting, followed by prescribed fire; only fire used periodically thereafter.
4. Initial and periodic cutting (at intervals appropriate to the forest type and site -- e.g., 20 years), each time followed by prescribed fire; fire alone also could be used one or more times between cutting intervals.
5. Initial and periodic cutting (at the same intervals as in 4), each time followed by residue removal and/or mechanical fuel treatment; no use of prescribed fire.

These five treatments should span a useful range both in terms of realistic management options and anticipated ecological effects. FFS treatment 3, the treatment with perhaps the least obvious management utility, is intended to expedite achievement of desired stand (tree-based) structure and composition, using a single initial cutting, in an area in which restoration and maintenance of natural processes (including use of prescribed fire) are emphasized.

After initial prescribed burns in FFS treatments 2, 3, and 4, subsequent burns will be conducted at irregular intervals, with times determined by the best available information on distribution of presettlement fire intervals on the kinds of sites represented in the study. It seems likely that important elements of ecosystem diversity were promoted historically by natural variability in fire intervals (Agee 1993, Skinner and Chang 1996).

Desired Future Conditions

The non-control FFS treatments (treatments 2 through 5) would be guided by one or two desired future conditions (DFCs) or target stand conditions. Table 1 shows the overall design for one versus two DFCs, with each "3" indicating three replications (for example) of a given treatment combination. The nature of the FFS cuttings and prescribed burns might differ considerably between two different DFCs. If this proposal becomes part of the basis for a regional or west-wide study, significant advantages could accrue from adopting one DFC for implementation at all study installations (at least for a given forest type). A second DFC then could be designed to be responsive to more localized considerations, such as forest and site conditions, management objectives, and public desires.

We recommend considering for DFC #1 a stand condition characterized by a mosaic of small even-aged groups or patches. Silvicultural cuttings that would best lead toward this condition would be small group (1/4 to 2 acres) selection along with thinning in the "matrix" of other age classes between the group regeneration cuttingss. Six to 10 age classes covering a group rotation length of 200 to 300 years could be considered. For purposes of the proposed study, some benefits of this DFC and associated silvicultural method include:

1. Best silvicultural approximation of general structural effects of dominant presettlement fire regime (frequent low - to moderate - severity fires) (Weatherspoon 1996) applicable to forests addressed in this proposal.
2. Development and maintenance of a continuous and substantial large-tree component throughout the treated stands
3. Improvement of forest health and reduction of wildfire hazard by reducing stand density, increasing height to live crown, and developing a stand structure characterized more by horizontal separation of size classes and less by multiple vertical canopy layers. (Treatment of surface fuels, which will be a component of each non-control treatment, is a key part of fire hazard reduction.)
4. Opportunity to measure response variables within a wide range of age classes (seral stages) at any given time.

Table 1. Fire/fire-surrogate treatment matrix for three (3) replications of one or two desired future conditions (DFCs).

		FFS#1	FFS#2	FFS#3	FFS#4	FFS#5
1 DFC	DFC#1	3	3	3	3	3
2 DFCs	DFC#1	3	3	3	3	3
	DFC#2		3	3	3	3

A possibility for DFC #2 might be a two-storied stand that also would maintain large trees throughout the stand, would allow for regeneration of shade-intolerant tree species, and would be approximated silviculturally using retention shelterwood cuttings (Weatherspoon 1996). Another alternative is to have DFCs #1 and #2 be generally similar in stand structure but differ significantly in stand density.

Given the same starting point of stand and fuel conditions, moving toward different DFCs using FFS treatment 2 (fire only) clearly will be a much less precise process than silvicultural cuttings and will require a number of burns. Some desired changes in stand structure—e.g., "thinning" relatively large trees without doing excessive damage to the overall stand—may not be feasible. However, skilled and innovative use of prescriptions, firing techniques, and other methods such as stage burning should, over several successive burns, permit considerable progress toward DFCs using prescribed fire alone.

Other Considerations

Assuming three replications of each treatment (probably in a randomized block design), this design would result in 15 treatment plots if one DFC is used, and 27 plots if two DFCs are used (table 1). To accommodate inherent spatial variability in the DFCs and allow for repeated entries, each plot probably needs to be at least 25 to 35 acres in size. This plot size would be adequate for relatively localized response variables such as vegetation, soil, and some fire and fuel attributes. It also should be satisfactory for measuring responses of smaller-ranging animal species. In contrast, wider-ranging wildlife species, fisheries and other watershed-level responses, and other landscape-level concerns could be studied at this scale only indirectly -- e.g., via habitat attributes and modeling approaches. It may be desirable in some locations to augment these relatively small, replicated plots with a subset of key treatments implemented on a much larger scale and in an adaptive management-type mode in collaboration with land managers. These large treatment areas could provide useful information concerning operational-scale economics and some indications about larger-scale ecosystem responses (especially if linked to the smaller plots via appropriate models).

In order for results to be broadly applicable within the forest types studied, treatment plots generally should be located in widely-distributed stand conditions, which usually will be characterized by previous timber harvests. In some cases, however, it may be desirable to include late-successional forests as part of the study. Participants would need to discuss the most appropriate locations of the experimental blocks in terms of more specific current stand conditions, aspects, slope classes, slope position (including whether to extend treatments into riparian zones), and other site conditions.

The proposed research is designed to be open-ended in terms of scientific disciplines and associated response variables that can be accommodated. Clearly, the greater the number and diversity of investigators involved, the greater the range of questions related to ecosystem structure and function that can be addressed, and the greater the opportunities for interdisciplinary synergy. Desired cooperating disciplines include, but are not limited to, entomology, fire ecology, forest genetics, geography, microbiology, micrometeorology, plant ecology, plant pathology, silviculture, soil science, and wildlife biology. To the extent possible, baseline or pretreatment data for each discipline should be collected. The design of the study, however, permits new research to be initiated after treatments are in place - even several years thereafter - and still yield valid results.

A significant component of the study necessarily will involve identifying and testing appropriate response variables or measures to assess important differences between fire and fire surrogate treatments. These measures then could form much of the basis for management monitoring of operational treatments to improve forest health and reduce wildfire hazard.

Spatiotemporal analyses of data at various scales, along with exploration of cross-disciplinary relationships, will be enabled and encouraged by several attributes of the study: relatively large plot sizes, spatial referencing of all data to a grid of permanent sample points to be established in each treatment plot, acquisition of high-resolution digital orthophotography of the study area, and incorporation of all data into a GIS-based data base.

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