Effectiveness of Thinning and Prescribed Fire in Reducing Wildfire Severity[1]

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The severity of recent fire seasons in the United States has provided dramatic evidence of the increasing complexity of wildfire problems. A wide variety of indicators suggest worsening dilemmas: extent of area burned, ecosystems at risk, funds expended, homes destroyed or evacuated, and human fatalities and injuries; all seem to be on the increase or have peaked in recent years. The National Fire Plan (and ongoing initiatives by the USDA Forest Service and Department of Interior) and President Bush's Healthy Forest Initiative in response to the 2002 fire season have stimulated heightened interest in fuel treatments.

This paper describes the scope of fuel management practices by providing an ecological, socioeconomic, and spatial/temporal context to the practice of fuel treatments. The state of science, which focuses on findings from two successive studies of treatment effectiveness to reduce wildfire severity, is described next. The first study (supported by the Intermountain Fire Sciences Laboratory) looked at fuel treatments following the 1994 fire season. The Joint Fire Science Program sponsored the second study, which started in 1999. Together, these two studies provide the most extensive database available on fuel treatment effectiveness in long-needle pines. This paper concludes with comments on how the current body of science is informing management and policy and a recommended agenda for future scientific work.

Scope

Fuel treatment has traditionally focused on biomass reduction to reduce wildfire hazards. More recently, emphasis has broadened to include treatments designed to reduce fuels, not only to reduce hazards but also to restore the role of fire in native ecosystems. Earlier, most fuel treatments were carried out as part of fuelbreak construction and maintenance activities. Most evidence for fuel treatment effectiveness (or ineffectiveness) is anecdotal, not relying on systematic comparisons between treated versus untreated areas, nor providing statistical analysis of results.

By contrast, the study described here focuses on the severity of wildfires that have burned through areas subjected to precommercial or "waste" (in other words, small-diameter) thinnings, in some cases with subsequent application of prescribed fire, as compared to untreated control plots of similar aspect and elevation. All of the areas in the study were burned by wildfires that spread into stands that were treated recently (less than 10 years before wildfire outbreak) to reduce fuel hazards.

Ecological Context

Fire exclusion has resulted in unsustainable forest conditions, including increased density of shade-tolerant trees, dead fuel accumulations, and live fuel canopy closures. Drought has exacerbated the situation, leading to unprecedented, extreme fire behavior—especially in

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frequent, low-severity fire regimes characterized by long-needle pines (for example, *Pinus ponderosa*). This situation extends into the drier, mixed conifer zones populated by fire-adapted species (for example, *Sequoia gigantea*) as well. Higher-elevation subalpine systems characterized by infrequent, severe, or mixed severity regimes have been less affected by fire exclusion in terms of fuel accumulations although effects of fire suppression may be unknown.

Socioeconomic Context

The expansion in urban interface areas has compounded the likelihood that fires will destroy or damage homes and disrupt commerce or people's livelihoods. Reservoirs, power lines, and transportation corridors (ground and air) are also at risk. High wildfire costs and losses have stimulated public interest but also raised questions about proposed remedies, such as expanded mechanical thinning and prescribed fire programs. Some view the proposed expansion in thinning activities as a veil to allow private industry greater access to logging large trees and old-growth on National Forests (through increases in the diameter of trees considered for removal) and in relatively remote areas. Related concerns include proposed relaxation of environmental protection processes, including public input and legal appeals. Concerns extend to issues regarding roads and endangered species protection.

Public concerns with prescribed fire include risk of escape and smoke. Interestingly, debates about prescribed fire seem less contentious than those about thinning. Fuel mitigation costs are also of concern, as well as the scant information on the effectiveness of thinning as an ecosystem restoration tool.

Fire interacts with many disciplines, including ecosystem science, wildlife and fish biology, and political and social sciences. Other discussion topics at this conference that influence or are affected by fire incidence include climate and landscape change over time, forestry and watershed management (including the fire-flood sequence and biogeochemical cycling), and biological complexity concerns (including invasive plants).

Spatial and Temporal Context in the Sierra Nevada

Fuel treatments are of concern throughout the Sierra Nevada and southern Cascades owing to the presence of flammable vegetation types, including ponderosa pine, mixed conifer, and Jeffrey pine (*P. jeffreyi*) forest types as well as montane chaparral communities. Lower- to mid-elevation systems characterized by frequent, low-severity fire regimes have been most affected by fire exclusion and simultaneously present some of the greatest urban interface challenges because of population ingrowth. Fuel treatments to reduce fuel hazards are more acceptable in these areas. The need for fuel treatments at higher elevations is debatable, with the possible exception of fire restoration efforts using managed lightning and intentional ignitions.

The scope of the proposed expanded treatments is controversial throughout the Sierra Nevada bioregion although there is general agreement that something needs to be done. President Bush's Healthy Forests Initiative follows on the heels of numerous earlier efforts to counter the growing risk of wildfires. Previous initiatives include the 2000 National Fire Plan, the Sierra Nevada Ecosystem Project, Quincy Library Group, and fire restoration efforts in the southern Sierras since the 1970s. In fact, fuel treatments have been practiced in the Sierra Nevada since the early 20th century, including the so-called light-burning controversy (Carle 2002; Pyne 1982) and Ponderosa Way fuelbreak in the 1930s. As early as 1929, E.B. Show had proposed the 650-mile Ponderosa Way and Truck Trail to span the length of the Sierra Nevada, creating a foothills buffer between montane chaparral and timbered areas. Installed with Civilian Conservation Corps labor in the 1930s, the 100- to 300-foot wide fuelbreak fell into disrepair by the 1950s but was largely resurrected by the early 1970s (Pyne 1982). More recently, experiments with prescribed fire and lightning ignitions in higher elevations have been conducted in national parks (Yosemite and Sequoia-Kings Canyon) and Calaveras State Park, following pioneering research by Dr. Harold Biswell during the 1960s.

State of the Science

Most research to date on fuel treatments, particularly prescribed fire, has taken place in frequent, low-severity regimes, such as ponderosa pine and lower mixed conifer, for example, Giant sequoia and white fir (*Abies concolor*). An overview of this research is presented by McKelvey and others (1996). Higher-elevation red fir (*A. magnifica*) systems also have been studied, with emphasis on national parks (Kilgore 1973). Thinning prescriptions are fairly well-established for meeting timber stand–improvement objectives but not for fuel hazard reduction or ecological restoration objectives. Thinning provides more exact control over the trees removed and retained in a stand but does not replicate burning processes (soil albedo, nutrient cycling, patchy mosaic, and removal of fine fuels).

Forest structural influences on wildland and prescribed fires are described by Agee (1996). Prescriptions for burning in low-severity regimes are fairly well-established (for example, van Wagtendonk 1974). Fuel treatments have been associated with reductions in wildfire severity in ponderosa pine *(fig. 1),* though the degree of effectiveness is variable (Omi and Martinson 2002, Pollet and Omi 2002). Residual tree diameters and historic fire regimes appear to be particularly important for distinguishing stand damage in untreated stands compared with treated stands. The most effective treatments will likely be those that complement ecological restoration objectives. Relatively little data are available from the Sierra Nevada although the findings presented here should be broadly applicable to long-needle pine and drier mixed conifer types.

Results of Statistical Comparisons

Fire	Crown Scorch	Stand Damage	Ground Char
Hi Meadow, CO		*	
Megram , CA	**	***	***
Webb, MT	***	*	
Cerro Grande, NM	***	**	**
Tyee, WA	****	***	***
Cottonwood, CA	****	****	n/a
Hochderffer , AZ	*****	*****	n/a
Fontainebleau, MS	*****	*****	**

*	**	***	****	*****
p<0.1	p<0.05	p<0.01	p<0.001	p<0.0001

Figure 1— Summary of differences in crown scorch, stand damage, and ground char in untreated versus treated stands in eight wildfires occurring during 1994–2000.

Fire and fire surrogate studies (McIver, these proceedings) should provide additional insight. But inferences from fuel treatment projects applied at the stand level may not extend to landscape-scale fire disturbances. Similarly, fuelbreak (also called "defensible fuel profile zone") effectiveness is controversial and has not been established at the landscape scale. Still, fuelbreaks provide options for managing wildfires, anchor points for prescribed fires, and safer access and egress for firefighters (Agee and others 2000).

Uncertainty about fuel-treatment effectiveness is highest in higher-elevation systems, such as lodgepole pine (*Pinus contorta*), and subalpine systems, characterized by mixed or high-severity fire regimes, or both. Extrapolating results from lower-elevation, frequent, low-severity regimes is inappropriate for these systems.

Treatments are effective if they improve options for managing wildfires, but firefighting crews must be able to access and exit a treated area safely in order to make a stand against oncoming fire or to take advantage of airtanker retardant drops. Otherwise, the fire would be expected to spread through the treated area, although with reduced-fire severity, before spreading through the untreated areas.

Drought conditions may obscure changes in fire behavior because of fuel treatments; however, fuel treatments are not intended to stop wildfires. Fire severity may be reduced, for example, when a crown fire drops to the surface once it encounters an area where surface and ladder fuels have been reduced. This effect may be obscured when a wildfire encounters a treated area during a drought. Also, increased solar insolation from the opening of an overstory canopy can result in higher biomass of fine fuels (for example, grasses) that can increase fire spread rates.

During drought, risks and hazards may be high for frequent, low-severity and dry mixed regimes (ponderosa pine and giant sequoia, respectively) throughout the Sierra Nevada. Historically and currently, these areas have the greatest number of ignitions (lightning- and human-caused), and the biological integrity of these systems have been compromised the most by fire exclusion and urban incursions. The 2002 drought demonstrated that fire size and severity may exceed historic ranges of variability in these low-severity regimes. When this occurs, ponderosa pine seed sources may be scarce or nonexistent in extensively burned areas. Furthermore, as witnessed this year, these fires can spread with high severity and threaten lower mixed conifer zones, including valued giant sequoia groves. In the Sierra Nevada as elsewhere, numerous jurisdictions are affected because fire respects no administrative boundaries, including National Forests, national and state parks, and private lands.

How Current Knowledge Informs Management and Policy

The extent to which current knowledge is informing management and policy is difficult to assess. Policy makers and vocal detractors often rely more on political motivations than available science, which can be limited in many instances. Information and tools are probably adequately used, although improvements are always possible. Policy statements tend to deal with the real world in terms of absolute, black and white distinctions, whereas scientific knowledge includes understanding of the inherent variability of natural systems and management interventions. Given this disparity, there is mutual benefit to be derived from improved communications among managers, policy makers, scientists, and the lay public.

Conference proceedings should inform future management decisions. Current interest is high with regard to thinning standards (threshold tree diameters and types of thinning—low, canopy, and so forth), effects on wildfire severity, and treatment and suppression cost reductions.

Future Management Challenges and the Role of Science

The greatest challenges will be the creation and maintenance of sustainable (fire-safe) forests and willingness to accept the adaptive management paradigm. Other challenges relate to optimal strategies for managing higher-elevation systems and translation of results from stands and projects to the landscape scale. The role of science can have the greatest impact in pointing out historical precedents; understanding current ecosystem dynamics; identifying future desired conditions based on historical regimes; identifying tradeoffs, knowledge gaps, and areas of uncertainty associated with various alternatives; assisting in developing defensible positions; monitoring; and evaluation. The public must understand that there will be no quick fixes or magic bullets—undoing the effects of a century of fire exclusion will require patience, cooperation, and tolerance for mistakes. In 1980, the late Dr. Harold Biswell noted, "We cannot expect to undo the failures of the past …in a short time. That is, neglecting to understand nature and [work] in harmony with it. We must exercise great patience and persistence, too" (Carle 2002, p. 7).

Policy makers and the public need to realize that fuel treatments should always be viewed as work in progress in a changing environment. Once installed, a treated area will require maintenance and tuning. Also, a constantly changing environment may result in a revised perspective toward treatments and their maintenance. Examples of a changing environment include future wildfires, human population incursions, episodic drought, warming and cooling trends, and insect and pest outbreaks. Maintenance questions might revolve around desired species and age distributions, changing tree densities in treated areas, and needs for tree removal, planting, or both.

Recommended Agenda for Future Research

Future research is needed in all aspects of fuels treatment and ecological restoration activities. Possible topics include: (1) effectiveness of fuels treatment and ecological restoration efforts across a spectrum of vegetation and topographic gradients; (2) off-site impacts (including sedimentation in streams) from wildfire and fuels treatments; (3) scale of treatments (including subsequent maintenance) required to manage fire effectively at the landscape level; (4) wildfire and treatment effects on threatened and endangered species, invasive plants, and riparian zones; and (5) social impacts.

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