Impacts to Fire Behavior and Ecosystem Services Following Fuel Treatments in the Wildland-Urban Interface

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INTRODUCTION

Vegetation is both an asset and a liability in the wildland-urban interface (WUI). The same trees and shrubs that provide tangible and intangible benefits to society are prone to burn with great intensity and destruction. Therefore, emphasis is often placed on fuel reduction treatments to reduce the risk of wildfire losses. However, while fuel treatments can moderate wildfire hazards, they may simultaneously impact environmental benefits provided by vegetation, such as air pollution removal, and carbon sequestration and storage.

The purpose of this study is to determine if varying fuel treatment types differ in their ability to change fuel properties, subsequent fire behavior, and multiple environmental benefits in three ecoregions of California, including mixed-conifer forests in the Klamath and Sierra Nevada Mountains and chaparral shrublands in southern California (Figure 1). The hope is that the study will help WUI stakeholders understand the potential tradeoffs in fire hazard versus other social values when implementing fire mitigation actions.

Figure 1. Study Areas (north to south): Klamath Mountains, Central Sierra Nevada, Peninsular Ranges (Large, 2008).

Klamath Mountains Mixed-Conifer Forests

The Klamath Mountains in northern California cover 22,500 km^2 (8,690 mi^2), with elevations ranging from 30 m (100 ft) to 2,755 m (9,038 ft). The multilayered, multi-aged forests there are dominated by Douglas-fir (*Pseudotsuga menziesii*) and ponderosa pine (*Pinus ponderosa*) in association with Pacific madrone (*Arbutus menziesii*), white fir (*Abies concolor*), and a wide variety of other understory species. Four treatment types were examined in this ecoregion, including (1) Fire-only, (2) Thin-only, (3) Thin+Fire, and (4) Thin+Pile & Burn.

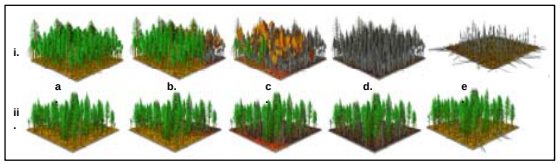

Figure 2. Output obtained using the Stand Visualization Simulator in FFE/FVS. The top row (**i**) is an untreated stand and the bottom row (**ii**) is a stand treated with a thin, pile, and burn prescription. A simulated fire was modeled at Time 0, with **a.** showing the initial stand, **b .– d.** showing the expected fire behavior, and **e.** showing the stand ten years later.

Custom fuel models were created for an untreated control and for each treatment type based on surface and canopy fuels data. Fire behavior was then calculated for each by NEXUS and the Fire & Fuels Extension of the Forest Vegetation Simulator (FFE/FVS). All 4 fuel treatments caused a reduction in rate of spread and fireline intensity compared to the untreated control (e.g., Figure 2). Subtle differences between treatment types were influenced by treatment-dependent changes to surface and canopy fuels.

However, all four treatments simultaneously caused a reduction in carbon storage and annual carbon sequestration rates (Figure 3). Thus, fuel treatments may play an increasingly important role as carbon markets and trading become common in the future.

Further, all four treatments also caused a reduced capacity to remove air pollutants, including PM10 particulate matter (Figure 4), which was correlated to the amount of leaf area removed in each treatment.

Thus, while fuel treatments will certainly ameliorate fire hazard, they simultaneously impact ecosystem services that forests provide. By understanding trade-offs in various fuel management strategies, managers will be able to best tailor fuel treatment prescriptions to meet society's needs.

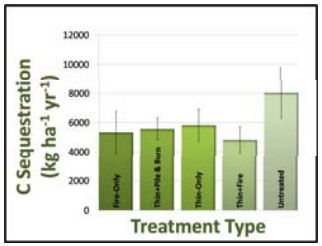

Figure 3. Annual carbon sequestration following various fuel treatments in Klamath mixed-conifer forests.

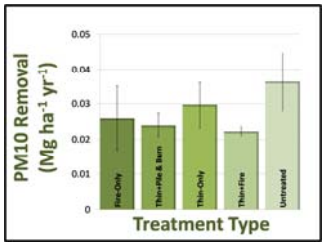

Figure 4. Annual air pollutant removal for the treatment types in the Klamath Mountains.

Sierra Nevada Mixed-Conifer Forests

Mixed-conifer forests in the central Sierra Nevada Mountains generally occur from 900 m (3000 ft) to 1800 m (6,000 ft) and include associations of ponderosa pine, Douglas-fir, white fir, sugar pine (*Pinus lambertiana*), and incense cedar (*Calocedrus decurrens*). A century of fire exclusion dramatically changed stand structure, composition, and fuel loading to extremely dense stands of shade-tolerant species. Study sites for this ecoregion were located in Yosemite National Park, Sierra National Forest, and Stanislaus National Forest. Five treatment types were examined in this ecoregion, including (1) Fire-only, (2) Thin-only, (3) Thin+Fire, (4) Thin+Pile & Burn, and (5) Thin+Mastication.

Preliminary results indicate that total 1-hr, 10-hr, and 100-hr timelag fuels (or dead, woody surface fuels <7.62 cm) were reduced most in the Fire-only, Thin+Fire, and Thin+Pile & Burn fuel treatments (Figure 5).

Further, all treatment types *except* Thin+Pile & Burn seem effective at decreasing canopy fuel loading. Canopy base height was increased in all five fuel treatment types.

Full analysis of treatment effects on fuels, fire behavior, and ecosystem services are forthcoming.

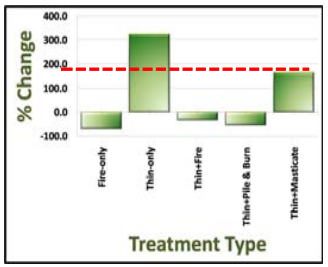

Figure 5. Pct. change in total surface fuels <7.62 cm following various fuel treatments in Sierra Nevada mixed-conifer forests.

Southern California Chaparral

This shrub-dominated ecosystem is prevalent in southern California. The common dominant species at the study sites in San Diego County were chamise (*Adenostoma fasciculatum*), manzanita (*Arctostaphylos glandulosa*) and black sage (*Salvia mellifera*). The area is characterized by high-intensity fires that threaten human development; however, urban sprawl and increased fire frequency imperil native chaparral. Thus, there is a great need for fuel management solutions that not only mitigate fire behavior, but do so with the minimal environmental impact. Four treatment types were examined in this ecoregion, including (1) Fire-only, (2) Lop & Scatter+Fire, (3) Integrated goat method, and (4) Mastication (Figure 6).

Figure 6. Treatments examined in southern California chaparral include (a) Fire-only, (b) Lop & scatter + fire, (c) Integrated goat method, and (d) mastication.

Methodology was vastly different than in mixed-conifer forests. Destructive sampling and the development of allometric equations were necessary to estimate fuels on each site. Data analysis is ongoing and includes investigating how the treatments impact surface and canopy fuels and subsequent fire behavior parameters, including rate of spread, flame length, and fireline intensity.

UFORE methodology is also slightly different for shrubs than for trees. The software can assess air pollution removal by shrubs, but not carbon storage or sequestration. Still, this analysis is critical given the poor air quality common in the southern California region.

CONCLUSIONS

At present, this multifaceted project is in various stages of analysis, interpretation, and dissemination. However, preliminary results in all ecoregions indicate that fuel treatments impact not only fire behavior, but also ecosystem services that benefit society. Our methodology is intended to better enable the prudent fire manager to better assess the impacts of fuel treatments from both fire behavior and environmental perspectives.

Full completion of the project is anticipated in Summer 2010. For news related to the project and for up-to-date results, please find us on our website at: http://www.nrm.calpoly.edu/research/firelab/FireVsBenefits/index.ldml.

ACKNOWLEDGMENTS

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