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In Plantations or Natural Stands: Ponderosa is Programmed to Partner with Fire

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Joint Fire Science Program

Fire Science Brief

RESEARCH SUPPORTING SOUND DECISIONS

In the Groveland Ranger District of California's Stanislaus National Forest, a prescribed burn makes its way through the Granite Plantation that was planted after the 1973 Granite Fire (osprey pictured flying above the fire). Credit: L. Kobziar.

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Summary

Ponderosa pine plantation forests cover nearly 400,000 acres of California's National Forests. Fire hazard is extreme both within and adjacent to many of these areas which has led to extensive fuel reduction plans for plantations and other forests on federal public lands. Although fuels treatments have been implemented on a limited basis in California's plantations, the effectiveness of varying methods has only recently received scientific attention. This project analyzed the effectiveness of individual and combination treatments to provide science-based guidance for fire hazard reduction in these areas. Prescribed understory fire, both alone and combined with pre-burn mastication, was most effective for reducing surface fuels and potential fire behavior. Likelihood of active crown fire was reduced in masticated stands because bulk density was decreased. Predicted torching, tree mortality and flame length were higher in masticated units than in prescribed burn units and controls.

Key Findings

- Prescribed understory fire was most effective at reducing surface fuel loads and decreasing modeled predictions of potential wildfire behavior and severity.
- Within one year of treatment, models predicted that some, but not all, components of wildfire behavior would be highest in masticated, unburned stands when compared to both burned and control units, and that they would likely remain high pending additional treatments or natural reduction of fuel loads from decomposition.
- Predictions of tree mortality were most severe for all tree size classes in masticated units under weather conducive to wildfire.
- Tree mortality following understory burning in masticated units is likely to be higher because deeper fuel beds cause trees to be subjected to greater direct and radiant heat for extended periods.

Will plantations reach their golden years?

In some regions and forest types, plantations are considered the most effective means of restoration after fire and are often planted in areas where fire is historically frequent. Plantations are structurally different than naturally occurring forest stands in that planted trees are evenly spaced and of similar age. In natural stands, trees of varying age are unevenly distributed.

But ponderosa in both arrangements share the same physical characteristics and potential lifespan and are subjected to similar environmental conditions—including the potential for ignitions and wildfire.

In California, hundreds of thousands of acres of plantation forests cover portions of the Modoc, Lassen, Plumas, Tahoe, Eldorado, Stanislaus, Inyo, Toiyabe, Sierra and Sequoia National Forests. Fire hazard is extreme in and around many of these plantations—a result of high planting success rates, dense undergrowth, low summer fuel moisture, mountainous terrain, and frequent ignitions from lightning and recreational activity.

And the plantations, interspersed with fire-prone, second growth forests and flammable shrublands, are burning. Nearly 70 percent of the Groveland Ranger District (GRD) of the Stanislaus National Forest has been impacted by large, high severity wildfires since the 1970s. After the 1973 stand-replacing Granite Fire, the burned area was almost completely salvage logged and re-forested as a ponderosa and Jeffrey pine plantation. Today nearly 15,000 acres of the district are covered with dense, relatively young plantation stands, with the entire area in need of fuels reduction attention.

"We wanted to find out what we could learn in the process of giving it that attention," says John Swanson, Principal Investigator and former District Ranger for the GRD. He was more than ready for definitive solutions given the increasing frequency and extent of severe fire occurring under his jurisdiction, which makes up a quarter of the Stanislaus. Fuels treatments had been done in plantations, but they hadn't been scientifically studied. In addition to the lack of science there was a lack of time and resources to support treatment efforts. During the years following the Granite Fire, thinning took a back seat to more pressing demands and constraints. The GRD continued to get large, stand-replacing fires virtually every six years. Two thirds of the district was consumed by stand-replacing fires between 1973 and 2003. Staff was literally too busy putting out fires to get around to taking action that would reduce their negative impacts.

"Just when we'd be ready to turn our attention back to these plantations we'd get another big fire, and once again we had to focus not only on putting it out, but on salvage," Swanson laments. "It was very difficult to get back around to thinning. Plus, it required money. If you thin trees that are only 5 or 10 years old they have no commercial value to help defray operational expense. So we just had to have blind faith that the plantations wouldn't burn up before we could get to them."

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Co-Principal Investigator and Assistant Professor of Fire Science at the University of Florida, Dr. Leda Kobziar, who along with Dr. Scott Stephens of the University of California, Berkeley, was responsible for all the on-the- ground work during the study, emphasizes the magnitude of the overgrowth. "There is at least a thirty-year accumulation of ground, surface, and aerial fuels, which is well outside of the historical range of variability for natural stands in that forest type. One of the sites I looked at had been burned and pruned in1990, but that was it. They had to do what they could with what they had over the last few decades. There had been no pre-commercial thin in the area and average tree diameter was 11 inches, so the plantations were very dense—about 350 trees for every two and a half acres."

Thirty years of surface fuel accumulation prior to treatment in the study area. Credit: L. Kobziar.

The study was designed to help figure out which treatment methods were affordable and effective at making young plantations more fire-resilient, so that the trees can grow large enough to meet the need for wood and all the other values that forests provide.

"More fires are wiping out more vegetation and we're doing more and more replanting," continues Swanson. "As a result, managers in the West have to manage more and more young stands of trees, particularly ponderosa pine. We wanted to determine the point at which we can reintroduce fire and see what we have to do mechanically to make young plantations more fire resilient in a way that's environmentally acceptable, so these trees can grow to be 100 or 200 years old," Swanson says.

"In addition, we're constantly being challenged socially, professionally and in the courts to make sure that the work we propose to do is scientifically based," he continues. "This study provides some scientifically sound, documented, citable information that can be used in environmental analyses and decision making that will hold up under challenge."

No variability in the vulnerability

Natural stands of ponderosa pine owe their inherent fire resilience to variable tree age and stand structure. Young ponderosa pines—whether in natural or planted stands—have relatively thin stems and bark. The crowns are close to the ground, and grass and brush grow around them at the same height. For the first couple of decades, the crowns are well within reach of a flaming front and very vulnerable. As trees mature their trunks and bark thicken, providing some fire-resistant girth and insulation. In a natural ponderosa system, staggered tree spacing and age creates a patchy, irregular mosaic of old and young trees. Over time, a clumpy pattern emerges with both dense areas and open spaces within the stand. The combination of uneven spacing and a broad range of tree ages help to insure the survival and persistence of the stand in the face of periodic fire.

In plantations, trees are all the same age and size, and evenly spaced. Thus, they lack the structural variability that provides fire resilience in natural forest stands. Credit: L. Kobziar.

Once trees have managed to reach the age where they have some fire-resistant qualities many of them will survive wildfire and continue growing taller, stronger and more fire-resistant. Fire will kill most thin-stemmed, thin-barked young trees. But the resulting space and sunlight paves the way for another generation to give life a try, naturally seeded by their surviving, more mature predecessors.

But plantations are crops. Trees are all the same age and size. If fire comes through when they're young they all go up in smoke. Increasingly this is happening when they are less than a quarter of the way through their life span. And once again, managers have to reforest from scratch.

Prescribed fire finishes first

The study took place between 2001 and 2006 in the 25–30 year old ponderosa/Jeffrey pine plantations that were established after the 1973 Granite Fire. All of the study stands were similar in aspect, slope, and soil type and were between 12 and 200 acres in size. Treatments included mastication alone (of understory vegetation and all trees less than 9 inches in diameter), mastication followed by understory prescribed fire, understory burning without prior mastication, and untreated control. Mastication took place in 2003 and early 2004 to decrease density and remove suppressed, diseased, or otherwise weakened trees. Understory shrubs and trees were also masticated, and residual slash was left on site. All burns took place in late June, 2005. Post-treatment data was collected within five months of mastication, and within three months of prescribed burning. Treatment effectiveness was evaluated using the fire modeling program—Fuels Management Analyst. It provides not only fire behavior predictions, but assessments of tree-level fire severity.

Prescribed fire proved to be the most effective fuels reduction technique in both masticated and un-masticated plantation stands. Understory burning alone or following mastication was most effective at decreasing predicted wildfire behavior and increasing fire-resilience, when compared to controls. Prescribed burned units had the lowest predicted tree mortality in all tree size classes. In addition, actual tree mortality was lower in burn only units than in units which had been masticated prior to prescribed burning. In both cases, prescribed fire-related tree mortality was within prescribed limits.

To assess the accuracy of modeled predictions, actual fuels and weather characteristics for the prescribed burns were used to predict fire behavior and effects. Model predictions of fire behavior were similar to actual fire behavior, while tree mortality was within 8 percent and 15 percent for masticated and burn only stands, respectively.

Mastication problematic for short-term

No other treatment proved to be less effective at reducing fuel loads than the use of mastication alone. For this treatment the researchers modeled tree mortality from hypothetical subsequent fire under moderate, high and extreme wildfire weather conditions. The model predicted loss of nearly all trees less than 12 inches in diameter, with overall losses averaging almost half of the stands. Mastication resulted in a higher potential for torching than controls, even with the decreased crown bulk density. Rate of fire spread was lower in masticated stands than in controls, but longer flame lengths contributed to a higher degree of predicted torching, and burned units had even lower rates of spread. Mastication opened up space between larger trees reducing predicted active crown fire, but neither this nor the increase in height to crown base offset the contribution of slash and its influence on wildfire behavior and high predicted tree mortality.

Conditions in masticated area prior to burning. Credit: L. Kobziar.

Kobziar explains that in the short-term, mastication increases surface and ground fuel loads. This makes both torching and internal damage to trees more likely if wildfire were to occur because the fire takes longer to consume the extra fuel and gives off more heat.

"Generally speaking, the faster a fire moves the shorter the residence time, or the duration of time that combustion is taking place in a given location. The increase in available fuels from mastication contributes to a longer residence time for fire. When this increased amount of fuel burns it exposes trees to a lot of heat which can injure or kill younger trees that lack sufficient bark thickness to protect them."

A prescribed underburn works its way through masticated fuels. Credit: L. Kobziar.

Swanson emphasizes however, that the mastication results should be viewed within the context of the short-term nature of the study. The resulting surface fuels were burned relatively soon—just over a year following mastication. Natural decomposition and compaction from snow during heavy winters would likely decrease potential fire behavior in these areas over several years.

Kobziar points out the possibility too, that the benefits of increased spacing created by mastication may eventually outweigh the negative effects of increased surface fuels, but no one knows how long that might take. "That's one of the missing pieces of information. How long will it take for those increased surface fuels to compact and decompose to the point where potential fire behavior is no longer increased in relation to pre-treatment conditions? We still need to know what that long term tipping point is." Until then the fuel bed will have lots of surface area and air flow conducive to ignition.

Pushing the envelope to save the farm

"Where we used prescribed fire, whether in previously masticated stands or areas that weren't thinned beforehand, we got the best results in terms of cleaning up the ground litter and fuels," Swanson says.

But in this forest type, when you add prescribed fire to the treatment mix you're likely to kill more trees. "Maybe even a bunch," Swanson continues. "But you're going to have a more thorough reduction in fuels. Then, when a wildfire comes through under bad conditions you'll lose a lot less in a stand that was treated with prescribed fire. Where you've thinned and under-burned you'll have better results in terms of the forest being there after the smoke has cleared."

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"When we burned we were pushing the edge of the envelope to find out where the edge of the envelope was," says Swanson. "We burned under some hotter conditions than we would normally specify in an operational context. We clearly stated in our burn plan that we would accept a higher level of tree mortality than we would on an operational basis. If we had only burned when it was nice and cool and gentle and damp we wouldn't have learned much."

What they learned was that operationally, it may be time to consider looking beyond low tree mortality as a measure of success for prescribed fire. Swanson points out that in a natural, Sierra ponderosa pine fire regime it would not be unusual to see 20 percent tree mortality in a wildfire, in relatively big patches in some cases.

Prescribed fire moving through a portion of the study area that was not pretreated.

"Today from the perspective of a National Forest manager, if you completely torch half an acre of ponderosa pine during a prescribed fire—it takes your breath away. Traditionally we'd say, 'My God we've really done something wrong here.' But if we apply a historical, long-term perspective it's really quite ecologically acceptable. That kind of effect is well within the historical range of variability in natural ponderosa pine forests. There are important ecological benefits to having holes punched in the canopy like that." Those benefits include recreating components of the natural, historical relationship between fire and ponderosa pine, and the diverse, fire-resilient forest structure it brings.

Relatively large areas of scorched and dead trees are well within the historical range of variability in natural ponderosa pine forests, and so may be an acceptable outcome of prescribed fire. Credit: L. Kobziar.

So there may be much to learn about the possible benefits of effects that have traditionally been viewed from the management perspective as error, or something to avoid. It all depends on management objectives—which are becoming increasingly diverse.

Expense and trade-offs

In the study, personnel costs for prescribed burning were relatively high because of the perceived risks and the small size of the burn units. Cost per acre for burning would go down significantly for larger scale, operational burns under more moderate conditions. The overarching question remains: Is effective fuels treatment less expensive than the fire that could result from doing nothing, or doing something unproven, in an overgrown plantation?

"That's really hasn't been answered yet," Kobziar says. "With the complexities involved in trying to predict whether wildfire is going to occur in a given place at a given time—it's really hard to conduct that cost/benefit evaluation for fuel treatments. This is something that we fire scientists really need to work together on, to provide the missing pieces to better inform management practices for effective wildfire mitigation."

Follow-up inquiry is needed in several areas including potential for post-treatment insect infestation, disease, and the potential contribution of scorched crowns and dead snags to future fire behavior. In terms of reducing potential fire behavior, mastication (including small trees) has positive effects on stand structure because density is reduced, but fuel loads and continuity are increased, particularly for the first several years. The relative ecological impacts of different manipulations must be taken in to account too.

"I hope that others will build on this because there is a lot more to be learned," adds Swanson. "We need more knowledge so we can continue to make good sound, defensible decisions."

Manage fire-adapted species with fire

The project was a successful collaborative effort, and included a monitoring team comprised of representatives from local environmental, industry, and Native American groups. Fifteen permanent plantation forest research sites were established, and are now demonstration areas for technology transfer to professionals and for the education of students and the public.

"The salient point for me is that we need to manage fire-adapted species with fire, regardless of whether the structure is natural or artificial," concludes Swanson. "We can pretend to substitute for it by thinning mechanically but ultimately until we get fire back into fire-adapted ecosystems we're not doing the full professional job. The Joint Fire Science Program allowed us to examine and quantify the return of fire, as well as the efficacy of pre-prescribed burning treatments in a way that hadn't been done before. That's the real value of the study."

Management Implications

- Across all size classes, prescribed burning resulted in 4 and 13 percent tree mortality in the masticated and burn only units, respectively. Following prescribed burning alone and after mastication, wildfire-induced mortality predicted by the model averaged 15 percent.
- In contrast, predictions of wildfire-induced mortality in pre-treatment and control stands exceeded 60 percent on average.
- Given prescribed fire tree losses, the burn treatment still results in stands which are twice as resistant to wildfire-induced tree mortality.
- Results can be immediately incorporated into adaptive management strategies to help managers reach fire hazard reduction goals.

Further Information: Publications and Web Resources

Final report: http://www.firescience.gov/projects/00-2-30/00-2-30_final_report.pdf

Fuels Management Analyst Plus (Don Carlton): http://www.fireps.com/software/ug_fma.pdf

Kobziar, L.N., S.L. Stephens, and J.R. McBride, (*In Press, 2009*). The efficacy of fuels reduction treatments in a Sierra Nevada pine plantation. *International Journal of Wildland Fire*.

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Kobziar Fire Science Lab at the University of Florida: http://www.sfrc.ufl.edu/Fire/index.html

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Scientist Profiles

John R. Swanson retired after 35 years with the USDA Forest Service, He is now Assistant Fire Chief for the East Bay Regional Park District in Oakland, California. During his years with the Forest Service he worked primarily in forest fire and timber management in the West. He served on several regional and national incident management teams and provided technical fire management assistance to numerous countries in Latin America, Europe as well as in Australia.

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