Joint Fire Science Program

Fire Science Brief

RESEARCH SUPPORTING SOUND DECISIONS

Mastication equipment used in the current study.

Masticating Fuels: Effects on Prescribed Fire Behavior and Subsequent Vegetation Effects

Summary

In fire management, there is an ongoing quest to find cost-effective, ecologically sound, and risk-reducing approaches to restoring dry conifer forests. So far little is known about the effectiveness of using mastication equipment in conjunction with prescribed burning to help meet management and restoration goals. Richy Harrod is the Deputy Fire Management Officer at the Okanogan-Wenatchee National Forest in Wenatchee, Washington. He and his colleagues began to address this knowledge gap and found that mastication may be a cost-effective and important tool for managers looking for additional support for prescribed burns. Mastication in this study appears to help meet restoration goals, and is comparable in cost to other methods. Furthermore, mastication and burning took place in the same year. According to their findings, any mastication effort helped support prescribed burning goals.

Key Findings

- All mastication treatments added fuel load to the forest floor, but the amounts varied by fuel size class and treatment.
- The mastication equipment used in this study was successful at thinning non-merchantable trees and there was minimal damage to residual overstory trees.
- Burning after mastication reduced fuel across treatments. Burning after mastication also significantly decreased fuel bed, litter, and duff depth.
- Soil heating was relatively low within all mastication treatment units that were burned.
- Fire following mastication generally supported forest management goals.
- Average cost was comparable to other fuel treatment methods, and may be more efficient.

Introduction

In fire management there is an ongoing quest to find cost-effective, ecologically sound, and risk-reducing approaches to restoring dry conifer forests. Many of these forests have experienced decades of fuel build-up as a result of changes in fire frequency and severity that include fire exclusion, harvest for commercially profitable timber, and long-term affects from grazing.

For managers interested in reclaiming healthy forests, an utmost concern is finding ways to restore forests to a more ecologically sound state that resembles forests prior to the era of changes described above, and, perhaps more importantly, to reduce the potential of severe wildfires that has, in many cases, resulted from those changes.

In many areas of the Western United States, forests have accumulated historically significant amounts of fuel and are now at risk of severe crown fires. As a result, managers and planners have adopted an ongoing search for ways to reduce the risk of such fires and to restore the land so that it is more ecologically resiliant and safe—for wildlife, humans, property, and the forests themselves.

Prescribed fire has become a well-known and often used approach. But there are also other tools people may use along with prescribed fire. Richy Harrod is Deputy Fire Management Officer at the Okanogan-Wenatchee National Forest in Wenatchee, Washington. His story is one example of how other tools may contribute more and more to forest management via prescribed fire.

About five years ago, Harrod and a team of other managers, had been working at a network of sites across Oregon, Washington, and Idaho. Their goal? "We were thinning non-merchantable trees," says Harrod. "And at each of our sites, we had 4 to 5 pieces of large mastication equipment. At one point, we had about 80 participants come to our site in Washington. There was a lot of curiosity and enthusiasm about the mastication equipment."

The enthusiasm and intrigue came, in part, from eagerness to know whether using this mastication equipment could lower the risk of crown fires. Harrod says, "The big question raised was this: What happens if there is a wildfire—what are the effects of using this equipment prior to fire?"

Harrod continued, "All those folks wanted to know the answer to that question. We all also wanted to know the cost in money, time, and the effects on the forest, fire behavior, and vegetation."

Harrod drafted a proposal to the Joint Fire Science Program (JFSP) to address these questions. With the funding in hand, Harrod—along with David Peterson and Roger Ottmar from the Pacific Northwest Research Station, and Peter Ohlson and Brad Flatten from the Okanogan-Wenatchee—set out to determine the effects of mastication on fire behavior and vegetation.

Mastication objectives

"Our primary objective was to really examine the effects of the equipment. If we use it, then burn, what happens to fire behavior, the vegetation, and the soil? And how much does it all cost?" says Harrod. "This was our guiding focus."

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"The managers were so curious, in part, because we just didn't know whether the mastication equipment we were using to thin non-merchantable trees could also be used to restore forest structure and function," continues Harrod. "Since we didn't know exactly how masticated slash would affect fire behavior, our goal was obvious."

The two main objectives of the work were, according to the JFSP final report, "to (1) thin dense stands of dry coniferous forest within historically frequent, low-severity fire regimes and (2) create surface fuel beds that produce prescribed fire behavior with positive effects on residual trees, understory vegetation, and soils."

Specifically, the team asked the following questions:

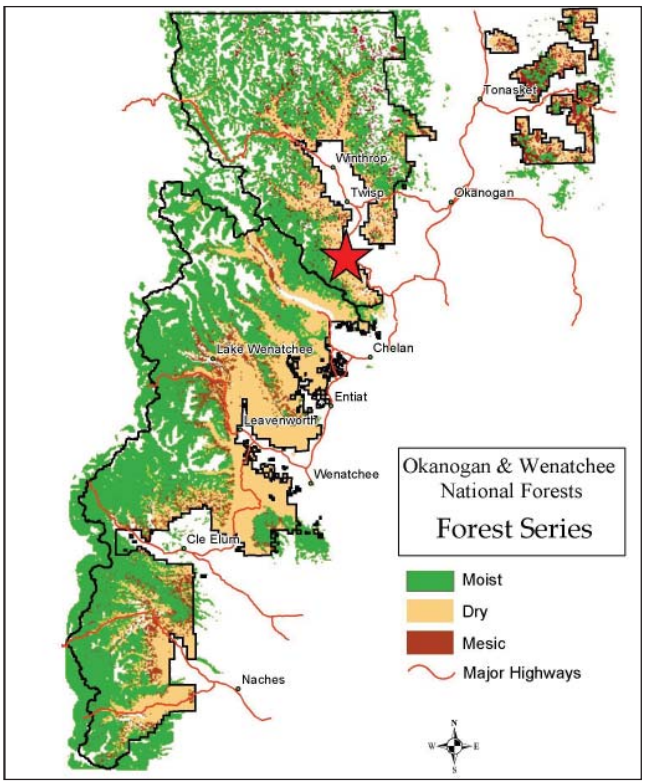
1. How does slash particle size and fuel bed depth affect fire intensity and severity?
2. How do different mastication efforts and subsequent prescribed fire affect overstory vegetation?
3. Does soil heating change from burning different types of masticated slash?
4. What are the differences in production costs among levels of mastication?

"We wanted to keep track of the amount of time we spent doing the actual mastication, so we would track the cost—both financially and in terms of time—that accrued for the different slash sizes we made," explains Harrod. "Then we could use that information and compare it to how the different slash sizes actually affected the fire behavior and vegetation, to see which slash size (and mastication effort) is the most cost effective."

Clearly, this information would be helpful information to managers and planners. Their answers would help determine not only how valuable mastication actually is, but also, what the best approach would be for the mastication effort itself.

To that end, Harrod and his team set up a straightforward experiment that included various slash sizes. These were fine, mixed, and coarse. The fine level "represented the most time (effort) spent per unit area" while the coarse level represented the least time spent. For each slash size unit, they tracked the amount of time and cost to generate the slash.

They created 18 experimental units at the Hungry Hunter Ecosystem Restoration Project area in the Okanogan-Wenatchee National Forest.



Study area in Washington state.

These areas each met "pre-commercial thinning criteria and allowed for operation of mastication equipment." Nine of the units were masticated and burned, while the remaining nine were masticated, but unburned. The crew also measured soil heat at the surface and two-inches below during the burn. The mastication and thinning of the sites happened between May and July of 2007 while prescribed burning took place during three cool and moist weeks in October of the same year. For more details of the experimental design, see the JFSP final report online at: http://www.fs.fed.us/r6/wenatchee/fire/mastication/index.shtml.

The study site is dominated by dense dry forest vegetation. The overstory is mainly Douglas-fir and ponderosa pine. The understory is typically grass or grass/shrub mix.

Fuels and fire behavior

"The most important result of all this," says Harrod, "is that we found that the least amount of effort is sufficient to do the work." Essentially, the researchers found that no matter what mastication effort is applied, the mastication combined with prescribed burning results in a favorable outcome in terms of burning goals.

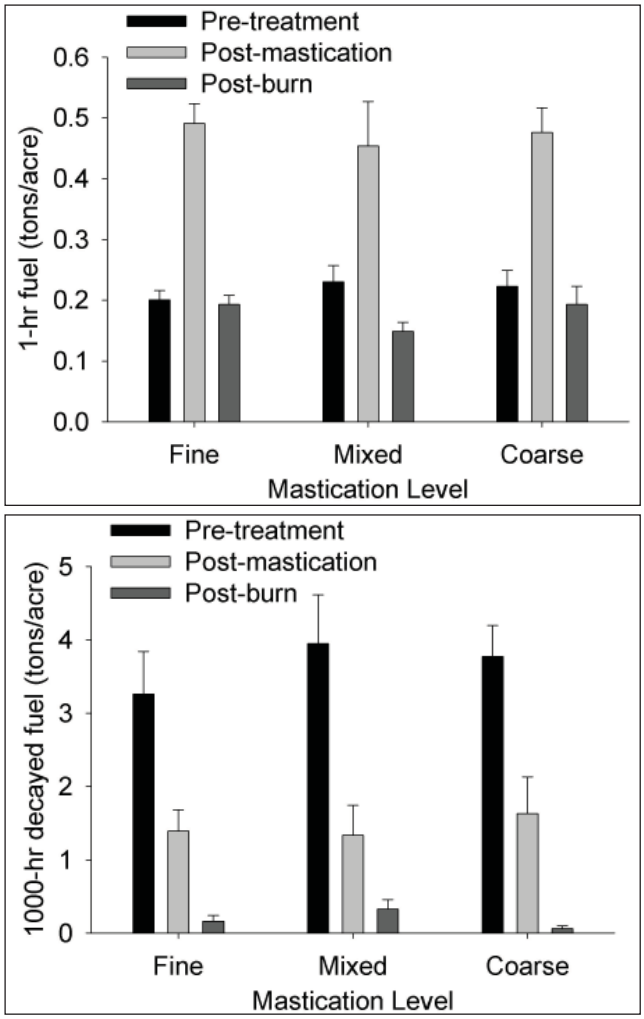
Post-thinning stands showing masticated fuels in a coarse treatment unit (left) and patchy fuels in a fine treatment unit (right).

As they expected, the mastication efforts increased the amount of coarse woody debris on the forest floor. But the amounts of slash varied by size, depending on the treatment type. The team measured debris as 1-hour fuels (less than ¼ inch in diameter), 10-hour fuels (¼ to 1 inch in diameter), 100-hour fuels (1 to 3 inches in diameter), 1000-hour fuels (greater than 3 inches in diameter), and 1000-hour "rotten logs."

All three of the treatments increased the load of 1-hour fuels while decreasing the 1000-hour rotten logs. Meanwhile, both 10-hour and 100-hour fuel loads remained similar to pre-treatment values in the mixed and coarse

treatment units. But in mixed and coarse treatments mastication added significant amounts of 1000-hour fuels. Litter and duff depth did not change between treatments, except that litter depth increased in the mixed treatment.

"One important thing to consider," says Harrod, "is that if you are trying to maintain large downed logs and rotting materials for the habitat, you'll loose many of them in mastication."



Changes to 1-hour (top) and 1000-hour (bottom) rotten fuel loadings following mastication and burning treatments.

But the bigger question is how did all this affect fire behavior?

"The burns went really well operationally," says Harrod. "They gave us the results we wanted across the board in terms of our prescribed-burns. It reduced the tonnage of different fuels on the forest floor. Also, the fuel bed and duff depth decreased after the fires."

"By combining the mastication with the prescribed burn, you'll be less likely to have a crown fire," says Harrod. "The fuel height to live crown raises."

Yet the researchers also found that fire behavior didn't change for any of the mastication variables. So mastication created favorable conditions for effective burns, but it didn't matter what level of mastication a site experienced. So masticating with the least amount of cost and effort (coarse) was just as valuable in terms of burning objectives as masticating to a fine level.

The prescribed burns themselves "were patchy within all mastication units, but all units had greater than 50 percent of the acreage blackened," according to the report. The weather was fairly cool at the time, with a relative humidity that varied from 30 to 70 percent which contributed to burn patchiness. The overall fire intensity was "low with flame lengths mostly less than 3.3 feet."

"We basically saw that burning in these masticated sites was a lot like burning light logging slash," says Harrod. "There was no excessive heating or fire spread, and the burning went really well. Plus, we did the mastication and the burn in the same year. That increases your efficiency quite a bit."

Examples of fire behavior in a fine treatment unit (left) and a mixed treatment unit (right).

Forest structure and soils

"We found that the mastication equipment worked really well. It was successful at thinning the small trees, and leaving the other ones undamaged. Actually, there was very little damage to the larger trees from either the equipment, or the subsequent fire," says Harrod.

So, the mastication equipment—which had inspired the team's initial enthusiasm and curiosity—was, in fact, successful at thinning non-merchantable trees less than 8 inches in diameter and at creating conditions for more successful prescribed burns.

Tree density and size class distributions were variable in each of the sites and this influenced the post-treatment overstory. "Everything vertical becomes horizontal," says Harrod. "You are adding fuel to the forest floor. And what you get depends on the initial stand density…a dense stand will result in more fuel on the floor."

Meanwhile, the team found that there was no excessive soil heating, but in general, heating levels varied across the sites because of the patchiness of the fires. As a result of this variability heating sensors, in some cases, did not record much increase in soil temperature at all.

Stand density before (left) and after (right) a mixed mastication treatment.

According to the report, "The coarse treatment had the highest average maximum temperature at the mineral soil surface (435°F) and at two inches deep (230°F). The highest temperature (872°F) recorded at any site was in a coarse treatment unit. Duration of heating above lethal temperatures (greater than 140°F) was also greatest in the coarse units with maximum duration over 2000 minutes."

There was little overstory mortality following the burns in any treatment. But tree seedling and sapling densities did decrease across every mastication treatment.

Most important to managers, is that "overstory tree density and size class distribution prior to mastication treatments were variable and influenced post-treatment overstory." So when creating management objectives in forests that will have prescribed burns along with mastication treatments, it is important to asses the pre-treatment forest and use that information to help determine the goals for post-treatment success.

Costs, guidelines, and more

"One thing we noticed right away, was that the cost and time we spent depended on the size of the trees in the site, not to the size of slash we generated," says Harrod. The bigger the trees on the site, the longer it took to masticate the site, regardless of whether the slash was fine, mixed, or coarse.

The cost of the mastication efforts did not differ between treatments. The team measured mastication effort as defined by "acres completed per hour." The average cost of mastication across all treatments was $452 per acre at 0.227 acre per hour. In general, stands that had larger diameter and taller trees took longer than stands with thinner, shorter trees. The team writes, "As compared to other treatment options, the mastication equipment used in this study might be better suited to thinning dense stands of very small diameter trees (less than 4 inches) rather than stands with larger trees."

"Plus," says Harrod, "we did a general comparison of the average cost of doing other kinds of stand treatments (e.g., chainsaw felling) to our mastication treatments, and the costs are comparable. And we did it all in one year! This is a quick and efficient way to get the work done." In addition, the overall cost of mastication may be less than other treatments if many acres are included at a time.

"We hope that forest managers will be able to use our information to decide if mastication is a tool that will work for them. There is not a lot of information out there yet on using mastication equipment in conjunction with prescribed burns, for restoration goals."

To that end, the research team has compiled a *User's Guide to Thinning with Mastication Equipment*. The guide includes the general techniques, approach, description of equipment, and overview of this study's results. It is specific to the area in terms of habitat; mixed-conifer with Douglas-fir, ponderosa pine, and some lodgepole pine. You can download the guide at: http://www.fs.fed.us/r6/wenatchee/fire/mastication/index.shtml.

"In the future, it would be good to focus on getting more information on how different mastication treatments affect the understory. This is something we will be working on in the future."

The team concludes in the report that, "Mastication followed by burning is a viable treatment option for reducing fuels and stand density within dense stands of non-merchantable trees." They highlight that mastication and burning is possible within the same year, an option not always possible with other kinds of treatment methods. Masticated fuels burn easily even in cool, moist conditions, and there is little apparent risk to the overstory.

Finally, any mastication effort helped support prescribed burning goals. The size of the trees to be masticated affected the cost more than the size of the slash. So, mastication at any level can support management goals.

Management Implications

- Masticating fuels prior to prescribed burning may be a cost efficient and effective way to help meet management goals.
- Mastication is effective even with the least time and effort applied to a site.
- Sites with larger and taller trees will take longer to masticate than sites with smaller, shorter trees.
- Mastication allows for prescribed burning of slash in the same year of treatment, which is time saving compared to alternative treatments.
- This new information on mastication used with prescribed burning will help managers make more effective decisions on forest restoration and management goals.

Further Information: Publications and Web Resources

JFSP Final Report for this project: http://www.fs.fed.us/r6/wenatchee/fire/mastication/index.shtml

User's Guide to Thinning with Mastication Equipment: www.fs.fed.us/r6/wenatchee/fire/mastication/index.shtml

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Scientist Profile

Richy J. Harrod is the Deputy Fire Management Officer for Fuels and Fire Ecology on the Okanogan-Wenatchee National Forest. Richy has been involved in forest and fire restoration planning and research for nearly 20 years. He has published numerous research papers and technical reports on various fire and forestry topics including fire effects on rare plants, forest restoration, biodiversity, and noxious weed management.

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