The Effects of Masticating Forest Fuels on Fire Behavior

Science brief prepared by Alex W. Kirkpatrick. Edited by Sonia A. Hall.

Key Findings

- Compared with fine mastication treatments, coarse treatments took *less* time to implement and were 15% *more* cost-effective in terms of money, treatment time and reduction in fire behavior in the lab.
- Flame lengths and rates of spread were low and variable in both prescribed burn experiments and lab experiments (Figure 2).
- Neither the rate of spread nor consumption of fuels differed between mastication treatments in the laboratory. However, consumption was significantly higher in fine treatments compared to course treatments in prescribed burns (Figure 3).
- Smoldering combustion lasted less than 2 hours in the laboratory where fuelbeds excluded duff and had varying moisture, and 6-22 hrs in the prescribed fire experiments.
- In lab experiments, fire consumed less of the 2-year old fuels than of the 1-year-old fuels.

Keywords. Combustion, fire intensity, fuel: treatments, trees: conifers, IFIRE, forest management: mastication

The production of this science brief was supported by the National Science Foundation through award DMS-1520873. The research described in this brief may have had other funding sources, which are acknowledged in the appropriate foundational publications.

It is common practice for land managers to thin forests in the western United States and then masticate fuels by mowing, chipping or mulching the downed trees, shrubs and herbaceous vegetation. The thinning reduces canopy fuels and then mastication redistributes the fuels on the forest floor. Fires burning in the dense, compact fuelbeds that result often burn with lower intensity and shorter flame lengths than fires burning in untreated forests. By performing mastication, managers can potentially reduce extreme fire hazards, decrease fire intensity and provide defensible space for firefighters. However, fires burning in the compact fuelbeds can smolder for longer periods, which can increase soil heating and smoke. Yet the effects of masticated fuels, and the resulting compact fuelbeds, on wildfire behavior are so far poorly understood.

To address this gap in understanding, researchers burned 54 masticated fuelbeds one and two seasons after mastication in a series of laboratory experiments. Additionally, they studied 75 masticated fuelbeds in prescribed fire experiments in ponderosa pine stands one growing season after treatment. Three replicate stands were selected for this study on the University of Idaho Experimental Forest West Hatter Creek Unit, located 20 km northeast of Moscow, Idaho. In early June 2014, 2 ha. in each stand were thinned and masticated. Mastication either produced coarse, chipped fuel or smaller, finer chipped fuel (Figure 1). Fuels in the first and second growing season after treatment were measured and collected for weighing and burning in subsequent laboratory experiments. These lab experiments were conducted in IFIRE, the University of Idaho's combustion facility. The results were then compared to stand-scale prescribed-fire experiments conducted *in situ* at West Hatter Creek.

Lab Burning Experiments

Fuelbeds were burned at three different fuel moisture content ranges: dry (5-10%), ambient (10-15%) and wet (over 15%) conditions. Average flame length was significantly greater in fine-mastication treatments compared to coarse-mastication treatments, but neither rate of spread nor consumption differed with treatment. Finely masticated particles had higher flame lengths than coarsely masticated fuelbeds in year 2 only (Figure 2).

Prescribed Burning Experiments

During these burns, coarse materials produced greater flame lengths. Moisture slowed the rate of spread in both coarse and fine mastication treatments. Consumption varied with mastication size and moisture content, but did not differ greatly from controls. It should also be noted

Figure 1. *Masticated fuelbeds in prescribed fire experiments in ponderosa pine stands. Mastication either produced coarse, chipped fuel (left) or smaller, finer chipped fuel (right). Photos: Aaron Sparks.*

A prescribed burn in a ponderosa pine stand with a masticated fuelbed.

that fire behavior may differ significantly from this study if burning occurs under extreme weather conditions.

Laboratory results produced poor predictions of field fire behavior and consumption. Laboratory fuelbeds were reconstructed based on field observations, but were unlikely to be fully representative of stand-scale conditions. For example, prescribed fire experiments included both duff and coarse woody debris, which were excluded in lab experiments. Fires also smoldered for much longer in prescribed fire experiments compared with laboratory experiments, likely due to the high fuel moistures observed in the field but not replicated in the laboratory (dry, 5–10%; intermediate, 10–15%; and wet, over 15% of oven-dry weight). Also, burning conditions differed as there was an average of 20% slope and wind (1.6–4.8 km per hour) in the prescribed fire experiments, whereas the laboratory experiments were conducted on 0% slope with no wind.

Management Implications

Implementing coarse mastication is faster and less expensive than fine mastication. Costs differed by \$0.57 per stem or \$471 per ha. With similar fire behavior, the coarse treatment was more cost effective because less machine and operator time was needed for treatment. However, the extended smoldering combustion suggests that fires burning in both fine and coarse masticated fuels may emit higher concentrations of particulate matter in smoke relative to control with no mastication. Furthermore, embers could be produced that ignite spot fires. More research is needed to determine the comparative efficacy of different mastication treatments.

There are observed benefits to implementing masticated fuel treatments. Mastication can result in lower flame lengths which can reduce impacts to trees. Fires burning in masticated fuelbeds can burn with lower intensity and shorter flame lengths than fires burning in untreated forests. However, land managers should take into account that the increased smoldering observed in masticated versus untreated fuelbeds could potentially lead to harder-to-control fires and spot fires resulting from embers and smoke. While in this study lab fire experiments did not produce lower flame lengths in masticated fuelbeds versus control fuelbeds with no mastication, this might be due to the relatively moist conditions. We need more coupled lab and field experiments to both understand the relationships between fuel treatments and fire behavior, and the potential tradeoffs between using different types of treatment.

Foundational Publications

Lyon, Z. D., Morgan, P., Stevens-Rumann, C. S., Sparks, A. M., Keefe, R. F., & Smith, A. M. (2018). *Fire behaviour in masticated forest fuels: lab and prescribed fire experiments.* International Journal of Wildland Fire, 27(4), 280-292. https://doi.org/10.1071/WF17145

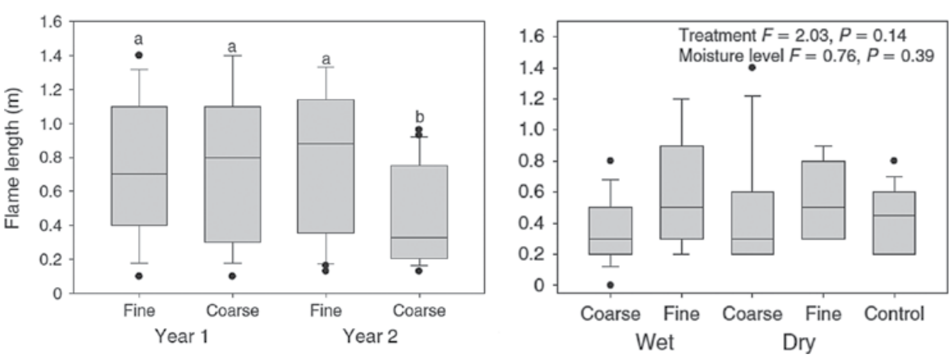

***Figure 2.** Effects of mastication treatments on flame lengths in laboratory (left panel) and prescribed (right panel) burns. Flame lengths were low and variable in both settings, without clear differences between coarse and fine mastication treatments. Only results from laboratory burns in year 2 fuelbeds using coarse mastication materials showed slightly lower flame lengths than the fine mastication treatment ("b" label in the left panel). Panels extracted from Figure 4 in Lyon et al. (2018), with permission from IAWF, obtained via the Copyright Clearance Center.*

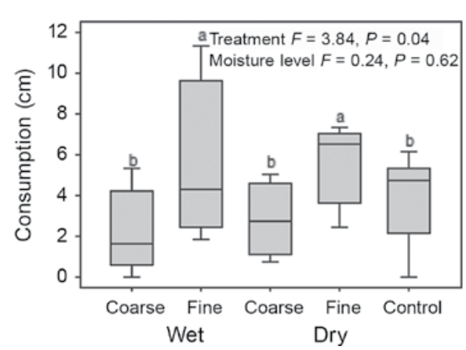

***Figure 3.** Effects of mastication treatments on consumption in prescribed burns. Consumption was higher in fine mastication treatments than coarse mastication treatments (different letters represent significant differences between treatments). These differences between treatments were not observed in laboratory burns. Figure extracted from Figure 5 in Lyon et al. (2018), with permission from IAWF, obtained via the Copyright Clearance Center.*