FIRE BEHAVIOR & ECOLOGICAL EFFECTS OF BURNING MASTICATED FOREST FUELS

NORTHERN ROCKIES FIRE SCIENCE NETWORK

Research Brief 4 | April 2018

Managers masticate fuels to redistribute fuels within a forest. They use machines to chip and shred whole trees, shrubs, and herbaceous vegetation to reduce the fuels in the canopy and move them to the forest floor. Fires burning in the dense, compact fuelbeds resulting from mastication often burn with lower intensity and shorter flame lengths than fires burning in untreated forests (Figure 1). However, such fires smolder for long periods, which can increase soil heating and smoke. We conducted prescribed fire and laboratory burn experiments to understand fire behavior and effects following thinning and mastication.

Research Questions

We were interested in the following research questions:

- Do masticated fuels burn with lower intensity and more smoldering combustion than non-masticated fuels?
- Do masticated fuelbeds exhibit greater consumption than non-masticated fuelbeds?
- How do moisture content and time since treatment affect consumption of masticated fuels?
- How does cost effectiveness compare for coarse versus fine mastication treatments?
- How does intensity of prescribed fires affect on-site tree growth after fire?

Methods

Approximately two hectares (5 acres) in each of three 30-year-old ponderosa pine stands were thinned in June 2014 using a boom-mounted brushing head on a CAT 320B excavator. Tree density was reduced by 30-70% in the treatments, and fuels were collected and measured to characterize fuelbeds averaging 6-14 cm (2-5 in) deep. For a coarse treatment, the operator sectioned the trees into lengths of approximately 0.5 m (1.6 ft) with the mastication head. For a fine treatment, the operator cut off the top and then slowly masticated each whole tree and top. We compared the coarse-masticated, fine-masticated, and controls for fuelbed characteristics, burn characteristics, and the effects of fuel moisture.

Prescribed Burning Experiments. Prescribed fire experiments were conducted in the upper half of each stand in October 2014. Before burning, we measured the fuel loading by size class (Figure 2, left). During burning, we measured the fuel moisture by size class, and we visually estimated flame length and rate of spread (Figure 2, middle). Tower-mounted infrared radiometers were used to measure fire radiative energy. Post-burn, we measured consumption as the change in the depth of the fuelbed (Figure 2, right). Although we planned to burn in Year 2, we were unable to do so because of a state-wide burn ban. After the ban was lifted, the sites were too moist to burn. In these burns, coarse materials had greater flame lengths (Figure 3). Moisture slowed the rate of spread in both coarse and fine mastication. Consumption varied with mastication size and moisture content, but was not greatly different than controls

Key Research Findings

- **Flame lengths (<1.5 m) and rates of spread (3.0 m per min) were low and variable in both prescribed burn experiments and lab experiments.**
- **During the prescribed fires, which were intentionally kept to low intensity to minimize tree injury, neither thinned nor masticated stands experienced a reduction in fire behavior compared to control sites.**
- **In prescribed fire experiments, smoldering combustion lasted 6-22 hours.**
- **In lab experiments, consumption was less for 2-year-old fuels than for 1-year-old fuels.**
- **Flame length and rate of spread results were similar for fine and coarse treatments. Finely chipped, wet fuels had higher consumption (reduction in depth) (2.5–8.0 cm) than coarse wet fuels (1.75–3.0 cm). Coarse dry fuel had higher consumption (5.0–7.0 cm) than either fine, dry or control fuels (2.0–5.0 cm).**
- **Coarse treatments were 15% more cost-effective than fine treatments in terms of monetary cost, treatment time, and reduction in fire behavior.**
- **Mature ponderosa pine radial growth decreased with greater fire intensity. Resin duct size and density (indicating increased tree defense to bark beetles) increased in prescribed burns regardless of fire intensity.**

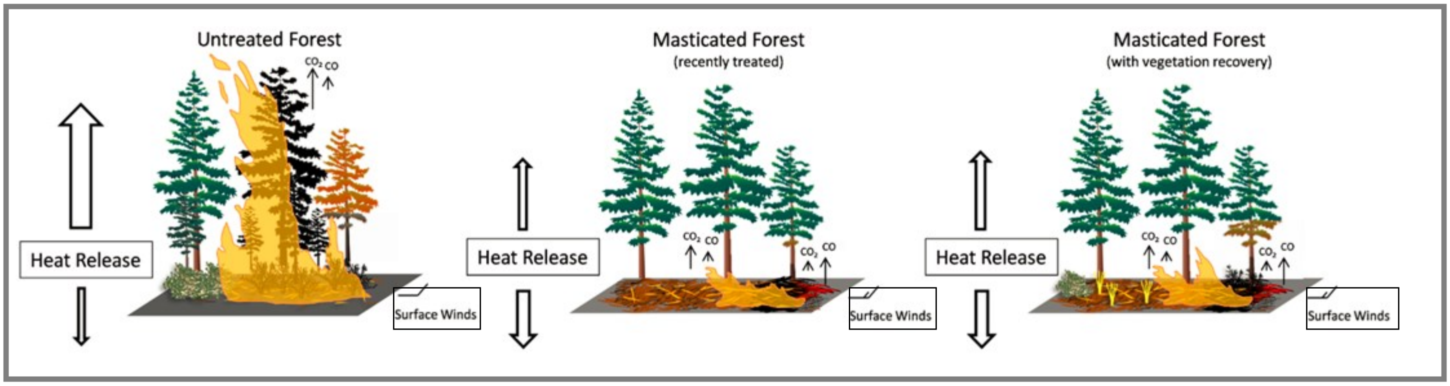

Figure 1. Hypothesized differences in heat transfer for untreated and masticated forests in different stages of recovery (From Kreye et al. 2014).

(Figure 3). Fire behavior in other areas may differ significantly from this study if burned under extreme weather conditions.

Lab Burning Experiments. Fuelbeds were burned at three different fuel moisture content ranges, which included dry (5-10%), ambient (5-10%) and wet (>15%). Fuelbeds were constructed from fuels collected separately in Year 1 and Year 2. —Average flame length was significantly greater in fine-mastication treatments (0.7 m or 2.3 ft) compared to coarse-mastication treatments (0.6 m or 2.0 ft), but neither rate of spread nor consumption differed with treatment (Figure 4). Flame length and rate of spread were greater in Year 1 where fuels were dry but not in Year 2. Consumption was higher in Year 1 than in Year 2. Finely masticated particles had higher flame lengths than coarsely masticated fuelbeds in Year 2 (Figure 4).

Cost Effectiveness

Mastication–costs were 15% higher for fine compared to coarse mastication. Costs differed by $0.57 per stem or $471 per ha. However, with similar fire behavior, the coarse treatment was more cost effective because less machine and operator time was needed for treatment.

Tree Growth and Resin Ducts

Post-fire relative radial tree growth was less where prescribed fires burned with greater intensity (Fig. 5). Resin duct size and density increased in the year of the fire regardless of fire intensity, which suggests that trees exposed to non-lethal surface fires may have increased resistance to bark beetles.

Figure 2. Sampling masticated fuels pre-burn (left), representative fire behavior ranging from low intensity (bottom row) to high intensity (top row) during prescribed fire experiments (middle), and post-fire fuelbed conditions (right). Fire intensity is indicated here as Fire Radiative Energy Density (FRED). Photos from Sparks et al. (2017).

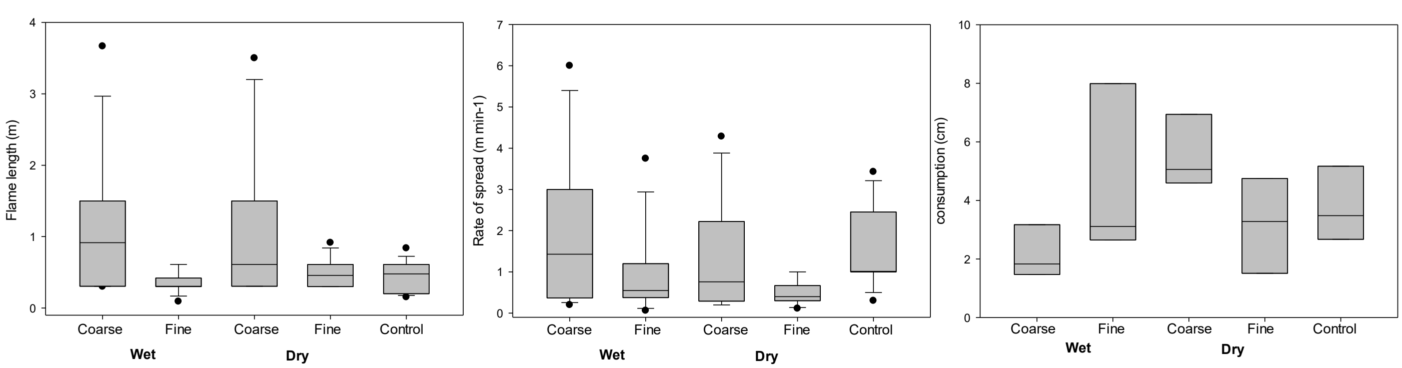

Figure 3. Prescribed burning experiment results for flame length (left), rate of spread (middle) and consumption (right). Box plots depict minimum, maximum, and median. Outliers are shown as dots (From Lyon et al. 2018).

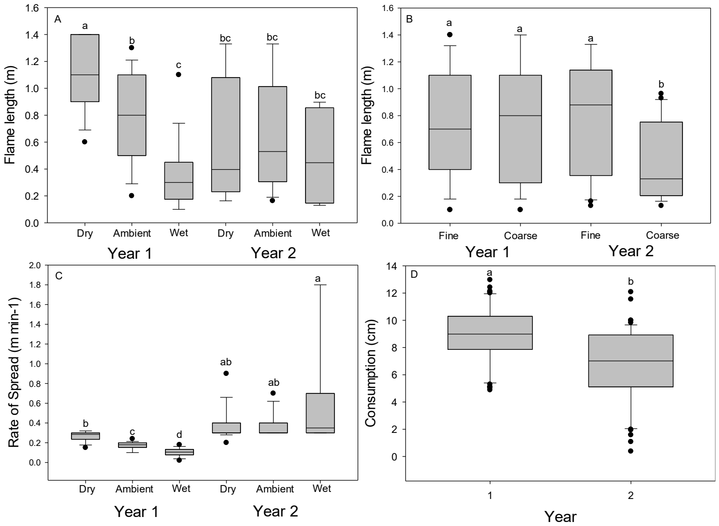

Figure 4. Lab burning experiment results illustrating (A) the effect of age and moisture on flame lengths, (B) the effect of age (year) and mastication type (fine and coarse) on flame length, (C) the effect of age and moisture level on rate of spread, and (D)the effect of age on consumption (From Lyon et al. 2018).

Management Implications

Many managers may choose to implement coarse mastication because it is faster and less expensive than fine mastication. The additional 22 seconds required to masticate individual stems when chipping fine fuels increases costs because of the time it takes to reposition the machine and process each tree stem. The extended smoldering combustion we observed suggests that (1) fires burning in masticated fuels may emit higher concentrations of particulate matter in smoke; and (2) embers could be produced that ignite spot fires. The resin duct research suggests prescribed fires could help reduce tree mortality from insect outbreaks. However, prescribed fire intensity must be low enough to limit reduced radial growth.

Additional Reading & Information

Heinsch, F.A., Sikkink, P.G., Smith, H., Retzlaff, M. 2018. Characterizing fire behavior from laboratory burns of multi-aged, mixed-conifer masticated fuels in the western United States. USFS Research Paper RMRS-RP-107. Fort Collins, CO.

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Kreye, J.K., Brewer, N.W. Morgan, P., Varner, J.M., Smith, A.M.S., Hoffman, C.M., Ottmar, R.D. 2014. Fire behavior in masticated fuels: A review. Forest Ecology and Management. 314: 193-207.

Lyon, Z., Morgan, P., Sparks, A., Stevens-Rumann, C., Keefe, R., Smith, A.M.S. 2018. Fire behavior in masticated forest fuels: lab and prescribed burn experiments. International Journal of Wildland Fire 27(4): 280-292.

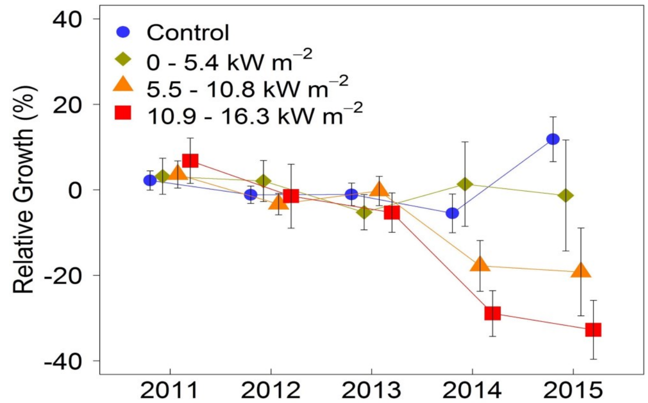

Figure 5. Post-fire (after 2014) relative radial growth of ponderosa pine decreased with increasing fire intensity (peak fire radiative power: kW per square meter (From Sparks et al. 2017).

Sparks, A.M., Smith, A.M.S., Talhelm, A.F., Kolden, C.A., Yedinak, K.M., Johnson, D.M.. 2017. Impacts of fire radiative flux on mature *Pinus ponderosa* growth and vulnerability to secondary mortality agents. International Journal of Wildland Fire 26: 95-106.

Research brief authors: ***Penny Morgan, Alistair Smith, Aaron Sparks, Camille Stevens-Rumann, Zack Lyon, and Rob Keefe,*** *Dept. of Forest, Rangeland and Fire Sciences, University of Idaho, Moscow, ID; and* ***Pam Sikkink****, Northern Rockies Fire Science Network and US Forest Service Rocky Mountain Research Station Missoula Fire Sciences Lab.*

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The Northern Rockies Fire Science Network (NRFSN) serves as a go-to resource for managers and scientists involved in fire and fuels management in the Northern Rockies. The NRFSN facilitates knowledge exchange by bringing people together to strengthen collaborations, synthesize science, and enhance science application around critical management issues.

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