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Assessing Mechanical Mastication and Thinning-Piling-Burning Treatments on the Pinyon-Juniper Woodlands of Southwestern Colorado

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RESEARCH SUPPORTING SOUND DECISIONS

Pinyon/juniper/sagebrush communities abound in Colorado—the same type of landscape observed in this study. Credit: Gary Kramer, USDA Natural Resources Conservation Service.

Assessing Mechanical Mastication and Thinning-Piling-Burning Treatments on the Pinyon-Juniper Woodlands of Southwestern Colorado

Summary

New knowledge of fire regimes in the pinyon-juniper woodlands of the interior western United States has altered management views. Once known as being at low wildfire risk, these woodlands are now at a higher risk for severe wildfires because of high tree densities exacerbated by ongoing drought and region-wide bark beetle (*Ips confusus*) infestation. To help reduce fuels and fire hazards and to create defensible space in the wildland urban interface, regional land managers have conducted thinning-piling-burning treatments. Recently, however, a different treatment has been used—mechanical mastication. Although mechanical mastication is typically more cost effective, there is concern about how these treatments may be affecting the existing soils, microbial populations, and vegetation, as well as the potential for non-native species invasion. To better understand these effects, the Dolores Public Lands Office-Service Center of the San Juan National Forest contacted the Rocky Mountain Research Station to conduct a study on three sites in southwestern Colorado. Researchers randomly assigned treatment methods—mastication, thinning-piling-burning, or untreated—within each site and took measurements before and after treatments to assess the treatment effects. Researchers then used the study results to confirm and communicate the consequences and benefits of these treatments.

Key Findings

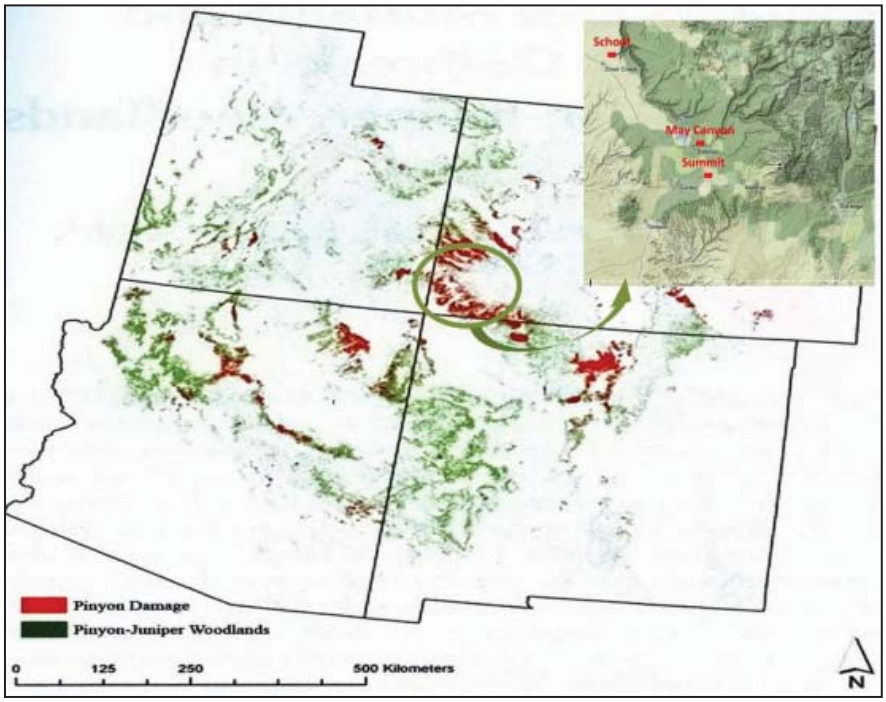
- Both mastication and thinning-piling-burning treatments created mosaics of vegetation and fuel conditions and resulted in adequate tree regeneration.
- Significant increases in non-native musk thistle (*Carduus nutans*) and cheatgrass (*Anisantha tectorum*) were found around burn pile scars.
- Mastication increased the amount of surface woody fuels while thinning-piling-burning either reduced or did not alter woody fuel amounts.
- Thinning-piling-burning treatments removed more trees than mastication.
- Soil bacteria populations increased with mastication while fungi populations did not.

A shift in severity

A familiar sight across the interior western United States, pinyon-juniper woodlands provide fuel wood and food (pinyon nuts) and refuge for animals such as elk, white-tailed deer, numerous species of birds, and the desert cottontail. In the past, these woodlands were viewed as being at a minimal wildfire risk, with low tree stand densities and a lack of continuous and dense ground cover. But as certain conditions arose and persisted—an ongoing drought, a region-wide infestation of the pinyon engraver beetle (*Ips confusus*), and a buildup in stand densities and fuel loadings—the potential for more severe wildfires has also increased.

To help reduce fuels and fire hazards and to create defensible space in the wildland urban interface, land managers have commonly used thinning-piling-burning treatments. Recently, however, managers have turned to mechanical mastication — primarily due to cost, as mastication is typically cheaper than thinning-piling-burning. Overall, the goal of these fuel treatments is to create a mosaic of open and wooded conditions that are capable of maintaining wildlife habitats and tree and shrub growth, increasing herbaceous production, and reducing the risk of severe wildfire.

Despite frequent use, there are concerns about the effects of mastication on the existing soil nutrient and microbial populations, vegetation, and potential for invasion of non-native species such as cheatgrass (*Anisantha tectorum*) and musk thistle (*Carduus nutans*). For this reason, the Dolores Public Lands Office-Service Center of the San Juan National Forest in southwestern Colorado approached the Rocky Mountain Research Station to conduct research on fuel treatment effects at three local pinyon-juniper sites.



Regional pinyon mortality in southwestern Colorado is indicated in red (according to the 2000–2005 Forest Health Protection, U.S. Forest Service, and U.S. Department of Agriculture). The three study site locations are highlighted in the inset.

Three sites, nine treatment areas

For this study, the following sites were chosen: (1) School, northeast of Egnar, (2) Summit, north of Mesa Verde National Park, and (3) May Canyon, north of Dolores. Pinyon species in this area included Colorado pinyon (*Pinus edulis*), Utah juniper (*Juniperus osteosperma*), Rocky Mountain juniper (*Juniperus scopulorum*), and the shrub form of Gambel oak (*Quercus gambelii*).

Three treatment areas were established, each consisting of three 14.2 hectare square plots. Each plot was then randomly assigned a treatment method, such as mastication, thinning-piling-burning, or no treatment (control). Mastication began in the fall and winter of 2005 and 2006 at a time of low beetle activity and was conducted using a large hydraulic mower mounted on a rubber-tired front-end loader.

Thinning-piling-burning treatments consisted of thinning between 40 and 60 percent of the canopy cover, targeting dense pockets of live trees and dead pinyon, retaining good saplings, clumps of trees, and trees bigger than 7.9 inches diameter at breast height, and thinning 50 percent of the brush canopy. The piles of wood were then burned in early 2006.

General mastication guidelines called for the creation of a random mosaic of small openings and strips. Density of trees 1–10 inches diameter at breast height was to be reduced. Eighty percent of the treated woody material should be less than one inch in diameter, 6 inches long, and 6 inches deep on top of the soil surface. Live pinyon trees and designated snags were to be protected and 50 percent of the brush canopy was to be retained.

A hydro mower leaves behind a sea of woody debris at the School site near Egnar, Colorado. Credit: Gerald Gottfried Rocky Mountain Research Station, U.S. Forest Service.

Before treatments were applied in 2005, researchers assessed overstory and understory vegetation, dead and down woody material, available soil nitrogen and carbon, and the soil microbial community. In 2006 and 2007, researchers measured post-treatment overstory vegetation, tree regeneration, dead and down material, and in 2006, 2007, and 2008, measured post-treatment understory vegetation and the soil microbial community. Available post-treatment mineral soil nitrogen and carbon were also measured on a continuous basis throughout the study.

Treatment effects exposed

Study results revealed that mastication was more effective at reducing shrub cover initially. However, Gambel oak had recovered to almost pre-treatment levels by the end of the study, while Utah serviceberry (*Amelanchier utahensis*) remained at or around the same level measured after the initial reduction following treatments.

Findings related to tree regeneration were encouraging. There were approximately 492 pinyon and juniper trees per hectare at the School mastication plot and approximately 1,221 trees per hectare at the May Canyon thinning plot. Although the number of trees needed for adequate regeneration for pinyon-juniper woodlands can vary, a value of 494 trees per hectare is often suggested by experts. Based on that guideline, all nine site-treatment combinations contained adequate regeneration.

Woody fuel loading fluctuated over the course of the study. The Summit site exhibited the highest surface fuel loading since it displayed the highest stand density, the greatest amount of Ips mortality, and a relatively large number of old and declining juniper trees. At all three sites, the controls and thinning-piling-burning plots experienced a decline in woody fuel amounts between 2005 and 2006 and a slight increase between 2006 and 2007. For masticated sites, the amount of woody fuels was amplified, thereby altering the fuel profile and slowing the decomposition rates of masticated materials.

It is also likely that the slow decomposition of masticated materials was due to the sensitivity of soil microbial populations to treatments. The ratio of fungi to bacteria is a useful indicator of microbial structure changes in the soil and organic matter inputs. Fungi respond favorably to greater carbon:nitrogen ratios in the organic matter inputs, and as the amount of fungi increases, the rate of wood decomposition increases.

Despite anticipated results, study findings revealed that fungi:bacteria ratios decreased with mastication in the second and third year after treatments and carbon:nitrogen ratios increased significantly over time in the litter layer but not in the mineral layer. These results indicate that the masticated material on the soil surface was not being decomposed by the microbial community, but functioned as a mulch, decreasing extremes in soil moisture and temperature. The mineral soil moisture and temperatures in masticated areas favored gram-negative and gram-positive bacteria, while thinning-piling-burning favored gram-positive bacteria, yet these changes did not alter mineralization of soil nitrogen content in the upper soil layer. It is now believed that small pieces of wood created by mastication, which increased the surface area of this material enhancing evaporation, created substrates that are inhospitable to decomposition contrary to the original hypothesis that the increased surface area would enhance decomposition. The negative aspect of this slowed decomposition is that this material creates a dense fuelbed on the soil surface, which, if burned, may increase fire severity due to the long duration of heat pulse.

In addition, there were findings that applied to both mastication and thinning-piling-burning treatments. For example, both treatment methods created mosaics of vegetation and fuel conditions. And, although neither treatment method had a considerable effect on the herbaceous plant community, both types of treatments influenced the presence of non-native plant species. Mastication increased the post-treatment presence of Canada thistle (*Cirsium arvense*) while thinning-piling-burning significantly increased the post-treatment presence of musk thistle and cheatgrass.

Within three years of mastication, Gambel oak sprouts dominated many areas with organic woody residues. Although a native shrub in this region, the proliferation of Gambel oak could increase shading and competition for resources with other native vegetation seedlings and regeneration—particularly pinyon pine. Credit: Steven Overby, Rocky Mountain Research Station, U.S. Forest Service.

Using management that makes sense

The components of a landscape can vary widely—from slope gradients and soils to climate and native vegetation—making it challenging for land managers to choose just one fuel treatment method. In this study, researchers discovered the advantages, disadvantages, and tradeoffs of mastication and thinning-piling-burning treatments in southwestern Colorado—and these tradeoffs have shown that land management in this region requires a balanced, thoughtful approach to determine which fuel treatment method makes the most economical and ecological sense for a given landscape.

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Both Gerald Gottfried and Steven Overby, the principal investigators, stated, "Both mastication and thinning-piling-burning left healthy stands where the objective is to retain a pinyon-juniper cover. Mastication is less expensive and should be favored where site conditions are satisfactory. The traditional thinning treatment is appropriate on steeper slopes or where soil conditions would not support heavy equipment without severe compaction or erosion. Thinning would be mandated where archeological sites are present. Managers can thin-pile-burn, thin and leave slash scattered, or leave these sites untreated; however, their actions should buffer archeological sites and make them less apparent."

Mastication in this region can provide a low-cost, low-risk alternative for fuel treatments. It does not have a negative impact on the short-term regeneration of pinyon and juniper and it can significantly reduce shrub cover, however, the post-treatment recovery of quick-sprouting shrubs may influence the long-term regeneration of native trees.

Furthermore, the amount of masticated residues is a concern. On this, Overby stated, "The lack of wood decomposition during the three-year study period was surprising although weather conditions would contribute to these results. The very slow decomposition of masticated woody material could be a problem in the future since woody fuels could accumulate to unacceptable levels."

Both treatment methods created favorable conditions for non-native invasive plants. Study results indicated that there was an increase in frequency of invasives following mastication but not to the extent seen with thinning-piling-burning. Therefore, if invasive, non-native species are present in an area, researchers recommend that managers attempt to control those species prior to treatment, and especially before thinning-piling-burning.

Canada thistle, a vigorous and competitive non-native plant that is difficult to control, can prosper after mastication treatments. Credit: John Randall, The Nature Conservancy, www.Bugwood.org.

More to monitor

As the environmental and wildfire conditions in the pinyon-juniper woodlands of southwestern Colorado change, the fuel reduction treatment methods being used on this landscape need to change as well. And, while managers can utilize the information provided in this study to help determine which treatments to use and when, there are still some long-term treatment effects that need to be considered and monitored.

Continued monitoring of tree regeneration and spatial qualities of stand regeneration is needed. In addition, researchers recommend monitoring the carbon:nitrogen

ratios of the surface organic matter and decomposition of masticated materials, as well as conducting an in-situ decomposition analysis of organic masticated residues of varying sizes.

At the Summit research plots in the third year post-treatment, cheatgrass flourishes after a pile burn. Credit: Steven Overby, Rocky Mountain Research Station, U.S. Forest Service.

Further investigation on the following is also suggested:

- Fungi response to mastication.
- Immobilization of nitrogen availability and its possible decrease over time.
- The effects of short-term increases in bacterial communities on plant nutrient availability.
- Prescribed burning in the masticated study areas to determine fire behavior and monitor post-fire ecosystem processes such as decomposition and nitrogen mineralization.
- Alternative treatments that have the potential to reduce the abundance of invasive plants prior to mastication.

Management Implications

Based on study findings, mastication:

- Is an effective, affordable, low-risk alternative fuel treatment method in pinyon-juniper woodlands.
- Does not negatively impact the short-term regeneration of pinyon and juniper.
- Can significantly reduce shrub cover in the short-term, however, sprouting shrub recovery can be quite fast and has the potential to negatively impact long-term tree regeneration.
- May affect nitrogen mineralization or begin to immobilize nitrogen in the mineral soil over the long term due to the slow decomposition of masticated materials.
- Favors Canadian thistle, while thinning-piling-burning strongly favors cheatgrass and musk thistle. If pre-treatment non-native invasive plants exist, researchers recommend that managers attempt to control these plants prior to treatment.

Further Information: Publications and Web Resources

Gottfried, G.J. and S.T. Overby. 2009. Overstory, fuel loading, and soil nitrogen changes following mechanical mastication or thinning pinyon-juniper stands in southwestern Colorado. Association for Fire Ecology Congress: Savannah, GA. December.

Scientist Profiles

Dr. Gerald Gottfried, a Research Forester in the Rocky Mountain Research Station's (RMRS) Forest and Woodland Ecosystems Science Program, earned a BS in biology from City College of New York, an MS in forestry, hydrology, and soil science from Michigan State University, and a PhD in watershed management and soil science from the University of Arizona. His research focus includes improving available information on the ecology and management of pinyon-juniper, encinal (oak), and semi-desert grassland ecosystems, with a particular interest on the impacts of silvicultural and prescribed fire practices. To date, Dr. Gottfried has contributed to more than 180 publications.

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Dr. Steve Overby has been a Soil Scientist with RMRS for 27 years. He has a BS in range ecology from Colorado State University (1983), an MS in environmental science from Arizona State University (1994), and a PhD in forestry from Northern Arizona University (2009). His research has focused on disturbance impacts to soil nutrients and microbial populations in Southwest ecosystems.

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