

# Mastication Considerations for Forest Landowners

## Introduction

Mastication is a forest management treatment that uses heavy equipment to shred small trees, woody shrubs, and downed wood into woody debris that naturally decomposes over time. Mastication is typically used to modify fire risk, prepare sites for planting tree seedlings, or thin out small trees. This document summarizes common uses for mastication, management considerations, and ecological effects.

## How is Mastication Used?

### Fuels Reduction

**Mastication moderates fire behavior by redistributing small trees and understory vegetation** (i.e., ladder fuels) into a layer of woody material on the ground (i.e., surface fuels). Masticating ladder fuels can break up vertical fuel continuity and reduce the chance that a fire can reach tree crowns. Mastication rearranges the fuel profile but does not immediately reduce the total fuel load on a site (Figure 1). **Fuel load reduction occurs over time as the masticated fuel bed decomposes or when mastication is followed up by other treatments like broadcast burning.**



**Figure 1:** Recently masticated area next to untreated manzanita as part of a fuels reduction project in Plumas County, CA. Photo: Amber Lennon

### Site Preparation

Mastication can help prepare a site for reforestation by shredding vegetation that would otherwise compete with planted tree seedlings. Mastication as site preparation is especially appropriate when competing vegetation is too large to treat by other means like herbicide or manual grubbing. The masticated fuel bed can create a mulching effect that helps suppress understory regeneration and increase water holding capacity of the soil. However, these benefits are dependent on mulch depth and may be counteracted by soil disturbance from machinery and increased light availability post-treatment.<sup>1</sup> Additionally, resprouting woody shrub species may quickly reoccupy the site because mastication only kills aboveground vegetation and does not affect root systems belowground. Mastication can also process slash left over from a previous timber harvest. Rather than piling logging slash and burning it, mastication can return nutrients to the soil by creating a compacted layer of woody debris that decomposes over time.

### Thinning

Mastication can be used to conduct precommercial thinning. **Thinning reduces stand density to improve growth for residual trees**, enhance forest health, recover potential mortality, or otherwise modify stand structure and composition. Due to narrower residual tree spacing, precommercial thinning requires more operator care and more flexible masticator equipment (e.g., small machines or boom-mounted cutting heads) to avoid damage to the trees left after treatment.

## Management Considerations

### Equipment Type

Masticators shred vegetation into smaller debris using a rotating disc or drum. Excavators, skid steers, tractors, loaders, and dozers can all be mounted with masticating head attachments. There are also purpose-built machines that only perform mastication (Figure 2). **There are many possible masticator configurations, but site characteristics and management objectives will dictate which style is most well-suited for a given project** (Table 1). See [Jain et al. 2018](#) or the [USFS Forest Operations Equipment Catalog](#) for more information on masticator equipment options.



**Figure 2:** Tracked masticator with front-end mounted drum cutting head. Photo: Amber Lennon

**Table 1:** Characteristics of various masticator equipment configurations.

| Masticator Component          | Component Strengths                                                                                                                                                                                             | Component Limitations                                                                                                                                                                       |
|-------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Cutting Head</b>           |                                                                                                                                                                                                                 |                                                                                                                                                                                             |
| <b>Disc</b>                   | <ul style="list-style-type: none"> <li>Processes material more quickly</li> <li>Works best on slash and shrubs</li> </ul>                                                                                       | <ul style="list-style-type: none"> <li>Creates larger, more uneven pieces</li> <li>Leaves ragged stumps</li> <li>Smaller cutting head</li> <li>Throws processed material farther</li> </ul> |
| <b>Drum</b>                   | <ul style="list-style-type: none"> <li>Creates smaller, more uniform pieces</li> <li>Leaves clean-cut stumps</li> <li>Wider cutting head</li> <li>Less scattered discharge of processed material</li> </ul>     | <ul style="list-style-type: none"> <li>Processes material more slowly</li> </ul>                                                                                                            |
| <b>Attachment Mount Style</b> |                                                                                                                                                                                                                 |                                                                                                                                                                                             |
| <b>Boom-mounted</b>           | <ul style="list-style-type: none"> <li>Can treat hard-to-reach locations, broken terrain, and steeper slopes</li> <li>Can masticate standing trees in place</li> <li>Can avoid driving to every tree</li> </ul> | <ul style="list-style-type: none"> <li>Smaller-width cutting head requires more passes in a given area</li> </ul>                                                                           |
| <b>Front-end mounted</b>      | <ul style="list-style-type: none"> <li>Larger-width cutting head</li> <li>Best on uniform, unbroken terrain</li> </ul>                                                                                          | <ul style="list-style-type: none"> <li>Limited reach requires driving to every tree</li> <li>Cannot masticate large trees in place</li> </ul>                                               |
| <b>Chassis Size</b>           |                                                                                                                                                                                                                 |                                                                                                                                                                                             |
| <b>Small machine</b>          | <ul style="list-style-type: none"> <li>Nimbler around homes or other tight spaces</li> </ul>                                                                                                                    | <ul style="list-style-type: none"> <li>Takes longer to treat large units</li> <li>Lacks power and size to process large trees</li> </ul>                                                    |
| <b>Large machine</b>          | <ul style="list-style-type: none"> <li>More efficient in large units and for large trees</li> </ul>                                                                                                             | <ul style="list-style-type: none"> <li>Harder to maneuver in stands with high residual tree densities or other tight spaces</li> </ul>                                                      |
| <b>Undercarriage</b>          |                                                                                                                                                                                                                 |                                                                                                                                                                                             |
| <b>Wheeled machine</b>        | <ul style="list-style-type: none"> <li>Can move more quickly across the landscape</li> </ul>                                                                                                                    | <ul style="list-style-type: none"> <li>Can cause rutting and soil erosion</li> <li>Cannot work on steep slopes (&gt; 30%) or broken terrain</li> </ul>                                      |
| <b>Tracked machine</b>        | <ul style="list-style-type: none"> <li>Reduces soil disturbance</li> <li>Can work on steeper slopes (30-50%)</li> </ul>                                                                                         | <ul style="list-style-type: none"> <li>Cannot move as quickly as wheeled machines</li> <li>Can cause damage to paved roads</li> </ul>                                                       |

## Fuel Bed Depth & Piece Size

A mastication project prescription should specify maximum allowable fuel bed depth and piece size (typically 6-12 inches in depth and 12-36 inches long). In addition to the factors discussed below, landowners should consider their personal aesthetic tolerance since masticated material and low-cut stumps can initially create a rough appearance.

High fuel bed depth can temporarily suppress plant germination, slow down decomposition, or lead to more intense fire behavior. Because masticators leave processed material in place, the volume of vegetation present pre-treatment will determine fuel bed depth post-treatment. Equipment operators can spread out or compact processed material to decrease fuel bed depth. Compacting masticated material into the soil can further aid decomposition, but may lead to increased smoldering during a prescribed fire.<sup>2</sup>

**In general, smaller pieces decompose faster than larger pieces.**<sup>3</sup> Greater fuel bed depth and higher moisture content can also slow down decomposition, and some plant species take longer to break down than others due to their chemical content. Masticators create woody debris in a variety of sizes and shapes (Figure 3). Masticating larger material (e.g., large-diameter trees) typically leaves larger pieces post-treatment. Spending more time processing the material can reduce piece size, but increases operating costs. Project prescriptions can specify the retention of large downed woody debris above a certain size to preserve wildlife habitat and reduce operating time.



**Figure 3:** Close-up of a one-year-old masticated fuel bed. Note the variety of sizes and ragged stump in the foreground. Photo: Kane Russell

## Operational & Safety Constraints

Equipment access requires roads, gates, bridges, and stream crossings at least 12 feet wide. At a minimum, road networks wide enough for a pickup truck may be accessible by a masticator. **Topography on the project site dictates machine selection:** rubber-tired models are restricted to even terrain under 30% slope, while tracked masticators can negotiate slopes up to 40-50%. Tethered equipment operated by experienced personnel can navigate steeper slopes >50%.

Most major masticator and drum-mulcher Original Equipment Manufacturer (OEM) guidelines mandate a 300-foot safety buffer in all directions around an operating mulching head to protect people and structures from flying debris. However, it is best to review and follow OEM guidelines for the masticator being used. Approach active mastication equipment only after communicating with the operator (via hand signals, radio, etc.) and the machine is fully shut down. Be aware that dust during active operations can inhibit visibility.

**Fire season introduces heavy seasonal restrictions.** Operations are often halted during summer heat or restricted to night shifts since sparks generated from blade contact with rock pose a critical wildfire risk. Experienced operators (ideally paired with ground recon) are essential to navigate steep ground, avoid concealed hazards such as barbed wire, and look out for fire starts. Environmental and wildlife regulations, such as noise restrictions near sensitive wildlife species during nesting seasons, can also limit work windows.

## Economic Limitations

Mastication is primarily designed for woody shrubs, small trees, and downed woody debris. While operators can theoretically process large standing trees with the right equipment, **cost per acre rises exponentially as targeted tree diameter increases.** Mastication of large standing trees is almost always cost-prohibitive and should be avoided unless there are no feasible alternatives that would achieve management objectives. Hardwoods also take more time and are therefore often more expensive to masticate than conifers.

Resprouting or seed bank germination can allow some understory species to quickly regenerate in masticated areas, diminishing treatment effectiveness (Figure 4). To protect the initial investment, pairing mastication with prescribed fire, herbicide, targeted grazing, or other treatments to manage regenerating vegetation can reduce long-term maintenance costs.



**Figure 4:** Manzanita regeneration in a four-year-old masticated fuel break with no follow-up treatment. Untreated manzanita is in the background. Photo: Kane Russell

## What Are the Effects of Mastication?

### Effects on Fire Behavior

Fire behavior in masticated fuel beds is influenced by residual fuel load, depth, moisture, size, and arrangement of the masticated material.<sup>2,4,5</sup> The amount of regenerating vegetation on-site (i.e., time since treatment) and environmental conditions at the time of the fire can also influence fire behavior.<sup>5,6</sup> **Woody surface fuel loads will always increase immediately following mastication,** which can lead to more intense, slower-moving surface fires with shorter flame lengths (Figure 5).<sup>7</sup> Densely packed masticated material can smolder for long periods of time, which can result in prolonged periods of soil heating, increased risk of damage to tree roots, and potential for embers to ignite fuels outside of the masticated treatment unit.<sup>2</sup> To help manage future fire behavior in masticated units, land managers can create strategic buffers or containment lines separating masticated fuel beds from surrounding areas. This can reduce fuel continuity and help with potential wildfire suppression activities.



**Figure 5:** Prescribed fire in masticated fuels and pine litter. Note the residual flaming of masticated fuels behind the initial flaming front. Photo: Ariel Roughton

### Effects on Soils

**Appropriately applied mastication treatments can mitigate negative impacts on soils.** The mulching effect of residual woody debris can help reduce erosion<sup>8</sup> and lead to increases in soil moisture.<sup>9,10</sup> Masticated material helps insulate the soil and lessen temperature extremes.<sup>9,11</sup> Soil nutrients are generally not affected within treated sites, though there are some cases where plant-available nitrogen increased post-treatment.<sup>9,12</sup>

The extent of soil compaction by mastication equipment depends on multiple factors, including soil texture, soil moisture content, the frequency and extent machinery drives over the project area, and whether machinery drives over slash.<sup>7</sup> While mastication is unlikely to result in widespread soil compaction,<sup>7</sup> best practices including operating on dry soils, driving on slash, and minimizing the movement of machinery within the project area can help reduce likelihood of detrimental impacts. When planning mastication projects, land managers can evaluate the risk of soil compaction at a given site using tools like the [Soil Disturbance Field Guide](#).<sup>13</sup>

## Effects on Understory Vegetation

The impacts of mastication on understory vegetation depend on existing vegetation, fuel bed depth, and post-treatment site conditions. In forested areas, shrub and herbaceous plant cover can be reduced by mastication for 2-6 years post-treatment on average,<sup>14</sup> with shade from residual overstory trees helping slow understory plant growth. Additionally, understory plant diversity can significantly decrease if masticated fuel bed depths are greater than 4 inches.<sup>15,16</sup> In shrub-dominated areas, mastication results in full sun exposure at ground level and greater plant growth and diversity post-treatment.<sup>17,18</sup> Regardless of vegetation type, mastication can trigger aggressive growth of resprouting tree and shrub species.

Introduction of invasive plant species can occur following mastication treatments. To minimize the impacts of invasive species, land managers can identify and treat potential invasive species populations around the treatment area prior to mastication, plan for post-treatment conditions that do not favor the establishment of undesired species, and ensure all equipment used is cleaned prior to entering the site.<sup>7,19</sup>

## Key Considerations

The feasibility and effectiveness of mastication depend on site characteristics, management objectives, and economic constraints. When deciding whether mastication is an appropriate treatment for your project area, consider the following:

- Are topography and access conducive to heavy equipment operations?
- Is there a high enough density of vegetation to justify the cost of mastication compared to alternative treatments (e.g., prescribed fire, hand thinning and piling, etc)?
- Is vegetation so dense that mastication would result in unacceptably high fuel bed depths across the site?
- Can any commercial value be realized from merchantable timber or chipped material that would otherwise be masticated and left on-site?
- Are there any factors (e.g., proximity to residential areas, air quality restrictions) that prevent the use of pile burning or broadcast burning?
- Will understory vegetation response after mastication require follow-up treatment in the near future?

## Funding Mechanisms

**Non-industrial forest landowners can use a variety of funding mechanisms to help pay for mastication projects**, including local grants through regional agencies and organizations, grants through state agencies (e.g., [CAL FIRE's California Forest Improvement Program \(CFIP\)](#), [CAL FIRE's Forest Health Grants](#), and [CAL FIRE's Wildfire Prevention Grants](#)), and grants through federal agencies (e.g., [Natural Resources Conservation Service's Environmental Quality Incentives Program \(EQIP\)](#), and [Natural Resources Conservation Service's Regional Conservation Partnership Program](#)). Generally, landowners are encouraged

to directly apply for CFIP and EQIP themselves. Landowners can work with local organizations (e.g., Fire Safe Councils or Resource Conservation Districts) to access the other grant funds mentioned above.

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