Mastication Planning Guidelines for the Colorado Front Range

As with any vegetation management tool, mastication has unique resource benefit values and limitations. The following guidelines are intended to aid natural resource professionals and land managers plan and design mastication treatments to maximize resource management goals and operational efficiency, while minimizing potential negative consequences. **Mastication involves the use of heavy machinery to grind, shred, or chop woody vegetation into smaller chunks that are rearranged on the landscape. Since mastication rarely if ever removes woody biomass from the project area, it is important to note fuels are not reduced, rather reconfigured.** The following guidelines refer to masticators and are not intended to cover use of other mulching equipment such as chippers, which produce uniform sizes of chipped material and have potential for woody biomass to be blown directly into trucks or dumpsters and removed from the site. Before choosing mastication as your management tool, it's best to develop a thorough plan, complete with specifications and expected outcomes, to determine if mastication is the best management action to achieve your resource management goals. The Front Range Roundtable recommends the following considerations to provide guidance on planning and designing any mastication treatment within the Colorado Front Range.

Planning Guidance

The planning and designs of mastication treatments should be developed and evaluated within the context of the resource benefit goals and expected impacts associated with soil, water, air, plant, and wildlife resources.

1. Determine specific vegetation management goals, whether changing fuel arrangement, improving grazing forage or wildlife habitat. Describe your desired conditions following mastication needed to achieve resource management goals, such as fuel loading and arrangement, tree basal area and canopy cover, forest structure and composition, soil disturbance, herbaceous plant abundance and diversity, etc. Tying the planning process to clear management objectives and goals will allow an assessment if vegetation rearrangement via mastication is an appropriate tool, or if single or multiple entries using a variety of management tools are required to achieve the resource benefit that is stated in the goal.
2. Inventory the vegetation to understand how mastication will benefit or impact the identified resources, particularly how much woody biomass will be deposited on the soil by mastication. Measure the type, quantity, and arrangement of vegetation in your management area.
    a. Based on inventory data for your management unit, use Table 1 to estimate the amount of woody material that will be rearranged from standing vegetation to the soil surface via mastication. Consider both mulch depth and distribution, as well as residual vegetation structure in achieving your goals.
        i. Will the predicted depth of masticated material on the soil surface help achieve or negatively impact your management goal?
        ii. After your desired basal area reductions via mastication are subtracted, does the residual standing vegetation accomplish your management goal? If not, how will rearranging additional material from aerial to the soil surface affect those goals?
    b. Assessing the density, arrangement, and type of vegetation is important for predicting whether mastication is the appropriate tool to accomplish your management goals. However, as a rough guideline in Colorado Front Range forests, mastication techniques are generally most cost effective and efficient when treating trees under 8 inches diameter at breast height (DBH). As the density and size of trees increases, the ability of mastication as

a forest management tool to efficiently and effectively accomplish many resource management goals generally becomes greatly reduced. When planning to masticate large amounts of trees that exceed 8 inches DBH, consider other management techniques that remove material from the site and increase opportunity for utilization.

3. Schedule mastication treatments to complement important wildlife nesting, fawning, calving and breeding seasons. Consider leaving particular plant species that are especially beneficial to wildlife, such as limber pine or Gambel oak, as long as fire mitigation goals are not compromised by leaving ladder fuels.
4. Determine resource benefits and impacts and recommend the appropriate type of mechanized equipment (light versus heavy, rotary versus drum, tracked versus rubber tired, etc.) to achieve the resource goal, i.e. soil limitations, wetlands, values at risk, etc. Match equipment to slopes and other terrain features found within the project area.
    a. Generally rubber tired masticators are more efficient and effective than tracked machines in Colorado Front Range systems. While tracked machines have the ability to work on steeper slopes and across broken terrain, the slower work rate generally reduces their efficiency and effectiveness. Consider hand crews, cable yarding systems, or other management techniques on especially steep slopes. As a guideline:
        i. Wheeled equipment generally is most effective on terrain with less than a 35-percent slope. On relatively consistent, unbroken terrain, wheeled equipment has been used on terrain with slopes up to 45 percent.
        ii. Tracked equipment generally is used on terrain with slopes greater than 35 percent. Maximum slopes for operation of tracked equipment are +/- 55 percent.
        iii. Broken terrain, areas where numerous drainages bisect a project area, are best treated using tracked machinery equipped with a mastication head mounted on a boom or arm to minimize driving machines in sensitive wetland areas.
5. Assess resource objectives and the expected longevity of initial treatment benefits. Make a long term plan to maintain treatment benefits by scheduling future management actions.
6. Consider how specific vegetation will respond following disturbance.
    a. If shrub retention or regeneration is desired, avoid masticating shrub species that do not readily recolonize via seed or sprouting, such as bitterbrush.
    b. When working in Aspen, Gambel Oak, and some other brush species, resprouting can be prolific. Monitor re-sprouting and growth rates. Plan ahead for the need for follow-up and maintenance treatments.

How much mulch to expect

Tree BA removed Ft2/ac (m2/ha)	Mulch fuel bed [litter + duff+1hr + 10hr] Tons/acre (Mg/hectare)	Approximate Average depth inches (cm)
22 (5)	5.4 (12.1)	0.4 (0.9)
44 (10)	9.7 (21.8)	0.6 (1.6)
87 (20)	18.4 (41.3)	1.2 (3.0)
130 (30)	27 (60.7)	1.7 (4.4)
174 (40)	35.7 (80.1)	2.3 (5.8)

Table 1. Data adopted from Battaglia et al. 2010. Surface Fuel Loadings Within Mulching Treatments in Colorado Coniferous Forests. Forest Ecology and Management, 260:1557-1566. Tree BA removed = Tree basal area rearranged from the canopy to the soil surface; litter = pine needles and dead, loose herbaceous vegetation; duff ; partially decomposed organic material above the soil surface; 1hr = woody debris 0.1 - 0.25 inches diameter; 10hr = woody debris 0.26 – 1 inch diameter;

Suggested Specifications

Provide measurable objectives and implementation specifications based on the information provided in the goals, inventory assessment, and resource limitations. For fuel reduction and other resource protection purposes, specify both depth and distribution guidelines for masticated woody debris, such as:

1. **Average woody biomass depth** (e.g. the average depth of masticated material shall be XX inches when measured throughout the entire treatment area).
2. **Distribution of woody masticated material** (e.g. no more than XXX percent of the treatment area shall have ground covered with masticated material).
3. **Maximum allowable woody biomass depth** (e.g. masticated woody material on soil surface shall not exceed XXX inches in any one spot within the treatment area). Ranges of debris depths are inherent in mastication operations, but excessively deep accumulations of woody biomass may be undesirable.
4. **Maximum heavy loading patch size** (e.g. areas no larger than XXX square feet or acres can be continuously covered with woody material between XXX inches (minimum) and XXX inches (maximum) depth of masticated material). An uneven distribution of masticated material is inevitable and often desirable when using mastication, resulting in some areas with deeper debris than the desired average. However, large areas with heavy woody debris should be minimized.
5. **Maximum size of masticated material** (e.g. masticated debris should be no larger than XXX diameter and XXX length following mastication). This ensures operators chop and mulch debris to desired specifications.

Resource Protection

Current research in masticated areas that have not yet experienced prescribed or wildfire has generally not found long term overall detrimental ecological effects on tree regeneration, soil nutrients, shrubs, or herbaceous plants. Concerns remain about masticated woody debris accumulation and it's impact on fire behavior, fire suppression effectiveness, and post fire ecological impacts. The following is intended to provide information and suggestions to design mastication treatments that minimize risk of unintended consequences when wild or prescribed fire burns in masticated fuels.

Wildfire Hazard Reduction

The use of mastication as a wildfire hazard reduction treatment alternative often presents a tradeoff when compared to other treatment methods that remove fuels from the site. Research demonstrates that mastication effectively rearranges fuel loads from aerial to surface fuels and increases canopy base heights, important factors for reducing wildfire and crown fire hazards. However, due to woody materials not being removed from the site, increased surface fuel loadings must be factored into the expected outcomes to achieve desired ladder and aerial fuel reductions, tree density, and spatial arrangement. For example, surface fuel loadings have been found to increase 3 to 6 times compared to pre-treatments conditions following mastication in Colorado (Battaglia et al, 2010). In addition, the fuels switch from whole logs or heavy fuels > 3" in diameter with needles and litter, to a fuelbed dominated by smaller, irregularly shaped and sized pieces of wood < 1" diameter with lesser proportions of needles and litter. Depending on the volume of material masticated and deposited, this small wood can form a dense, compact, and continuous fuelbed. Generally, the more fuel that is masticated and left on the ground, the higher risk for increased surface fire intensity and severity. As the depth and

distribution of masticated woody debris left on site increases, the risk of higher fire severity also increases for factors such as soil heating, fire residence time, tree mortality, and associated post fire erosion. While woody debris is less easily ignited than herbaceous or needle litter fuels, it has a potential to produce more heat for longer periods of time, especially when fuels are dry under conditions when wildfires typically occur.

Rearranging ladder and aerial fuels to surface fuels via mastication has shown some utility to change fire behavior and facilitate successful fire suppression actions in both prescribed and wildfire scenarios. However, increased surface fuel loading following mastication has also exacerbated fire spread and intensity, leading to reduced effectiveness of suppression actions. The tradeoffs of using mastication as a fire mitigation treatment to potentially increase suppression effectiveness must be balanced with an associated higher risk of post fire ecological severity and increased surface fire behavior. If fire mitigation is the primary treatment objective and mastication is the only planned management action, a thin layer and uneven distribution of masticated material may better achieve this goal, leaving some bare ground and minimizing surface fuel quantity and continuity. If you would like to reduce the risk of adverse effects from mastication, consider other treatment options that have less risk and remove biomass from the site, such as whole tree harvest, chipping into trucks, or prescribed fire, in order to most effectively reduce fuel loadings and increase fire mitigation treatment effectiveness.

Managing Debris Distribution

Efforts should be made to reduce areas with heavy accumulations of woody material within treatment units, but creating an uneven distribution of woody debris is important to allow for plant regeneration, soil health, and discontinuous surface fuels. Mastication operators often have limited ability to control the distribution of resultant woody residue on the soil surface, but the direction machines approach standing vegetation can alter where material is projected onto the soil by as much as several hundred feet. Approaching all vegetation in a treatment area from the same direction (e.g. east to west) will leave a more even distribution than approaching trees or brush from varying directions, which will cause areas of heavier accumulations but also areas lacking masticated material and discontinuous fuels. Boom mounted masticators add additional discretion where masticated biomass is directed. Larger masticated treatment areas in Colorado (several acres or more) average about 60% cover of woody material on the soil surface following mastication (Battaglia et. al, 2010). Cover of masticated material on any given square foot within a treatment area ranges from no cover to 100%.

Managing Debris Depth

The depth of residual debris can be managed by specifying targets for sizes of trees or brush to masticate (e.g. diameter, height, clump size and distribution), or the size of clumps or groups of vegetation to retain. If less residual masticated material is desired on the soil, other treatment options that remove biomass from the site, such as whole tree harvest or chipping into roll off dumpsters, are recommended as a complimentary management tool. Actual depth of masticated material on the forest floor can vary greatly across a treatment area; for example, in Colorado depths often average only 0.5 to 2-inches in most areas, with localized pockets of heavier accumulations (Battaglia et. al, 2010).

Resource Protection – Special Considerations For Mastication

1. Make sure mastication treatments do not disturb soils or vegetation that protects the bottom surface of valleys from soil erosion and sediment transfer. If additional information on erosion

control is needed, consult the publication "Colorado's Best Management Practices for Protecting Water Quality," available through the Colorado State Forest Service.

(http://static.colostate.edu/client-files/csfs/pdfs/ForestryBMP-CO-2010.pdf)

2. Avoid the deposition of mastication by-products such as chips and chunks in waterways, including perennial streams, drainage ditches and culvert basins. Consider providing riparian buffers during project layout and boundary marking.
3. When working in areas where buried water supply or utility infrastructure may be located, be advised of high pressure and/or shallow water, gas, or electrical lines, and if crossing points may be necessary to prevent cave in on buried lines. Utility providers may need to be consulted for the safety of the mastication crews, their equipment as well as damage to utility infrastructure.
4. Consider proximity of treatment areas to structures. Conduct mastication treatments so that debris is projected away from buildings and other infrastructure that may be damaged by flying chunks of biomass or rock.

On-site Operational Guidance

If you completed the planning process detailed in this document and determined that mastication can accomplish your management goals, consult the Colorado State Forest Service Mastication Operational Guidelines for on site resource protection and operator best management practices, including techniques to minimize soil disturbance from heavy machines, on site gasoline storage and use guidelines, protecting utility infrastructure, and other considerations.

(http://static.colostate.edu/client-files/csfs/pdfs/masticationoperationalguidelines.pdf)