

Rocky Mountain Research Station Science You Can Use Bulletin



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Is Mastication Right for Your Site? Science-Based Decision Trees for Forest Managers

Mastication, also known as slash-busting, mulching, or brush-cutting, is used to cut and chop or grind vegetation into smaller particles that are usually left on a site as mulch. By converting fuels into small chunks, standing live and dead fuels are converted into compact surface fuels. In this way, mastication can be used to prepare sites for prescribed fire, or used as a stand-alone treatment in areas where it is difficult to burn—either due to high fuel loads, shortened burn windows, risk of escape, smoke concerns, or the presence of homes and other structures. Land managers also use mastication to remove competition by less preferred species and prepare sites for natural or artificial regeneration.

In a recent review of studies examining mastication as a forest management tool, Terrie Jain, a research forester with the Rocky Mountain Research Station, worked with fellow RMRS colleagues Pamela Sikkink and John Byrne, and Robert Keefe with the Department of Forest, Rangeland,



SUMMARY

Mastication reduces forest vegetation into small chunks by grinding, shredding, or chopping material with specialized equipment. The type of equipment varies from using a front-end to a boom-mounted rotary blade to a drum-type head. Forest managers use mastication to remove competition, prepare a site for regeneration, release sapling-sized trees, and convert ladder fuels to surface fuels. This Science You Can Use article describes the potential benefits of mastication as a forest management tool, presented in the form of a set of decision trees that can guide land managers in choosing the right treatment option for a particular site and management objective. Depending on the management objective, if mastication is an option, then a thorough site evaluation includes consideration of slope, nonnative species invasions, vulnerability of soils to erode or compact, and treatment costs. Jain and colleagues also provide a land manager's perspective, with useful insights on the benefits as well as the limitations of mastication as a forest management tool. Operator experience can be one of the most important factors in determining outcomes; so we've included conversations with several veteran machine operators who speak to the challenges of mastication work.

A mastication machine treats surface fuels and provides a fire break surrounding buildings (photo: D. Mitchell, USDA Forest Service, Southern Research Station).

and Fire Sciences at the University of Idaho. [To masticate or not: Useful tips for treating forest, woodland, and shrubland vegetation.](#) Gen. Tech. Rep. RMRS-GTR-381 found that while mastication costs vary widely depending on the types of equipment used, the terrain where they are operating, site conditions, and operator skill, mastication does have important market and non-market benefits. If managers decide that mastication is an option for achieving resource management objectives, then a thorough site evaluation includes consideration of slope, nonnative species invasions, vulnerability of soils to erode or compact, and treatment costs.

“Mastication is increasingly used to treat vegetation, but there was no specific information to guide managers on how and when to use this treatment,” says Jain.

There is a wide range of equipment configurations used for mastication, each with its own advantages and disadvantages. This Science You Can Use Field Guide will only touch on these options in brief (for more detailed descriptions of carrier machines and cutting heads, see Gen. Tech. Rep. RMRS-GTR-381).

The aim here is to describe the potential advantages and disadvantages of mastication as a forest management tool, presented in the form of a set of decision trees that can help guide land managers in choosing the right treatment option for a particular site and management objective.

Jain and colleagues also provide the perspectives of a land manager—who has extensive experience in using mastication as a forest management tool—as well as several veteran machine operators who provide insights on the challenges of providing this service.

The Right Treatment, in the Right Place, at the Right Time

Jain and colleagues suggest that land managers conduct a thorough site evaluation to determine if mastication is an option for a particular land management objective. To aid in the evaluation, the researchers provided a series of decision trees built with a set of detailed questions based on a site evaluation to assist managers in

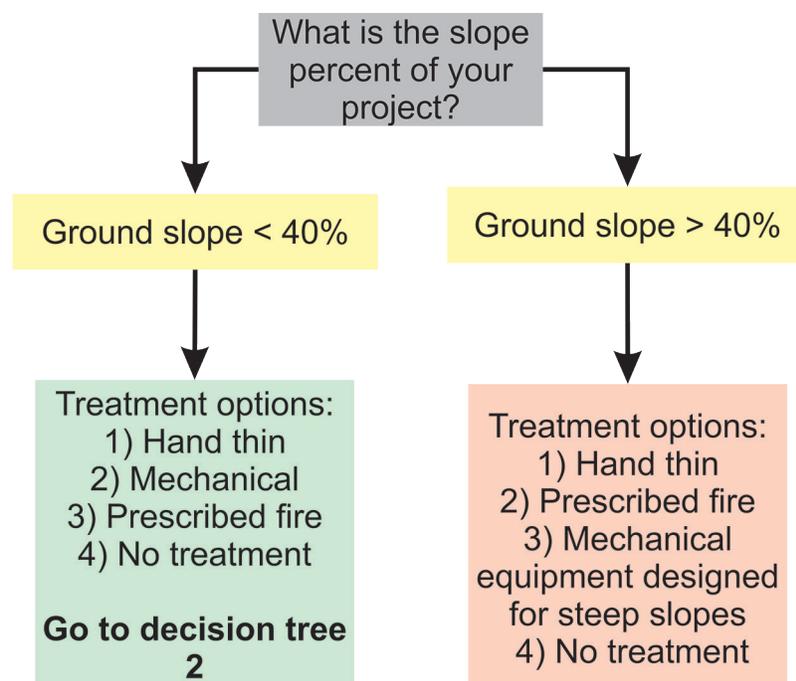
deciding what treatment method best fits their project.

Decision Tree 1 – How Does Slope Percent Influence Treatment Options?

Researchers, managers, and operators agree that slope and terrain factors are some of the most important factors for deciding on whether mastication can be used on a given site. Jain and colleagues found that treatment options for using mechanical equipment are limited to slopes below 40 percent, unless there is the possibility of using machines specifically designed to operate on steep slopes (up to 50 percent).

On slopes greater than 40 percent, managers can consider using

Decision Tree 1
The influence of slope when selecting treatment options



prescribed fire or hand slashing and piling. On slopes less than 40 percent, and especially below 35 percent, mechanical treatment becomes a safe and effective option in many situations. The researchers also point out that if the biomass does not create a fire hazard or the regeneration success does not require site preparation, then the site may not need treatment.

Decision Tree 2 – Does the Site Need Post-Harvest Slashing or Have Excessive Advanced Regeneration?

For sites with less than 40 percent slope, the next questions regarding

site treatment relate to the abundance, distribution, and type of noncommercial vegetation on the site.

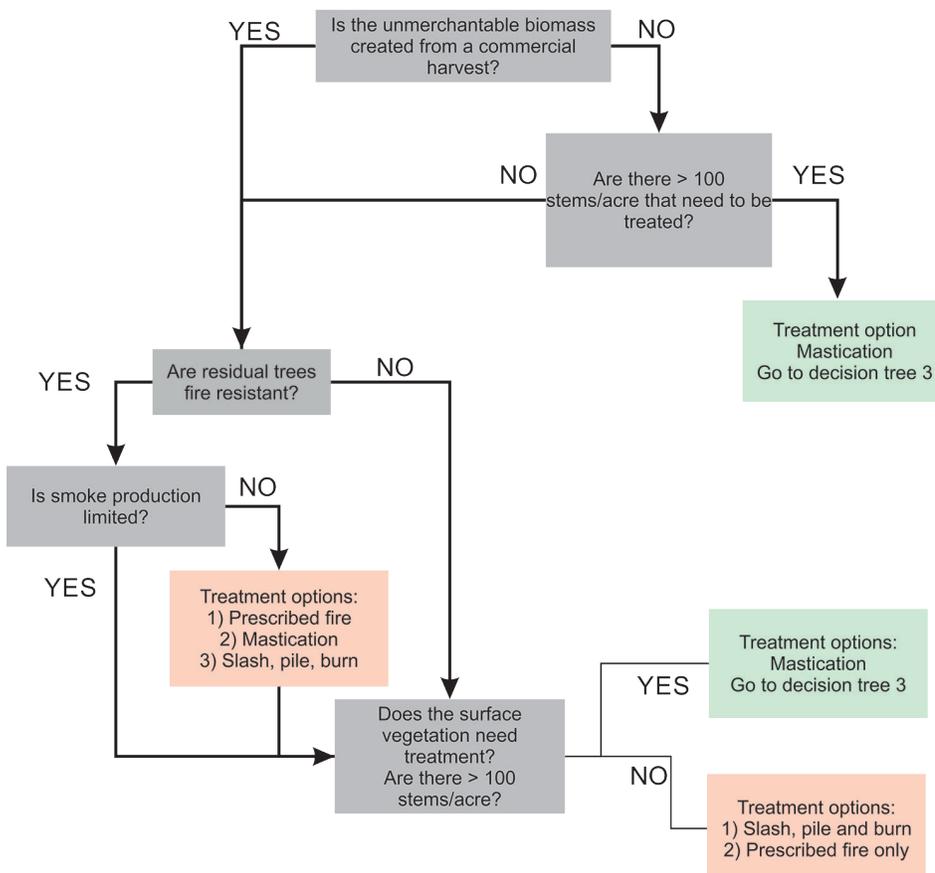
If the site contains logging slash, a shrub-dominated understory, or excessive advanced regeneration (defined as more than 100 stems per acre), then some type of mastication treatment is an option. On sites where the ability to use prescribed fire is limited, managers can use mechanical treatments, such as mastication or grapple piling.

Jain and colleagues found that mastication is most effective on sites where there is substantial advanced regeneration (> 100 stems/acre). However, if only a few trees or shrubs exist, then more practical, cost-effective options are available, such as hand slashing followed by either prescribed fire or grapple piling.

MANAGEMENT IMPLICATIONS

- Depending on the management objective, if mastication is an option, then a thorough site evaluation includes consideration of slope, nonnative species invasions, vulnerability of soils to erosion or compaction, and treatment costs.
- The experience level of an operator can heavily influence project costs and achieving mastication treatment objectives.
- Although research has not shown that mastication negatively affects soils, good management practices, such as implementing mastication on dry soils, driving on slash, and correctly choosing equipment, will help diminish soil scarification and compaction.
- Not all biomass on a site needs treatment or mulching into small pieces. Some trees can remain as down logs. These additional logs provide wildlife habitat and do not contribute to an increase in the fine fuels. Some trees can have tops cut (particularly with a boom-mounted masticator) and be left standing for future snag recruitment.
- The operator has the ability to adjust the piece size by using a vertical shaft that creates larger pieces or by minimizing the amount of time spent chopping each piece, resulting in larger pieces left on the ground.

Decision Tree 2
Treatment options for slopes < 40%



Decision Tree 3 – Is the Soil Prone to Compaction?

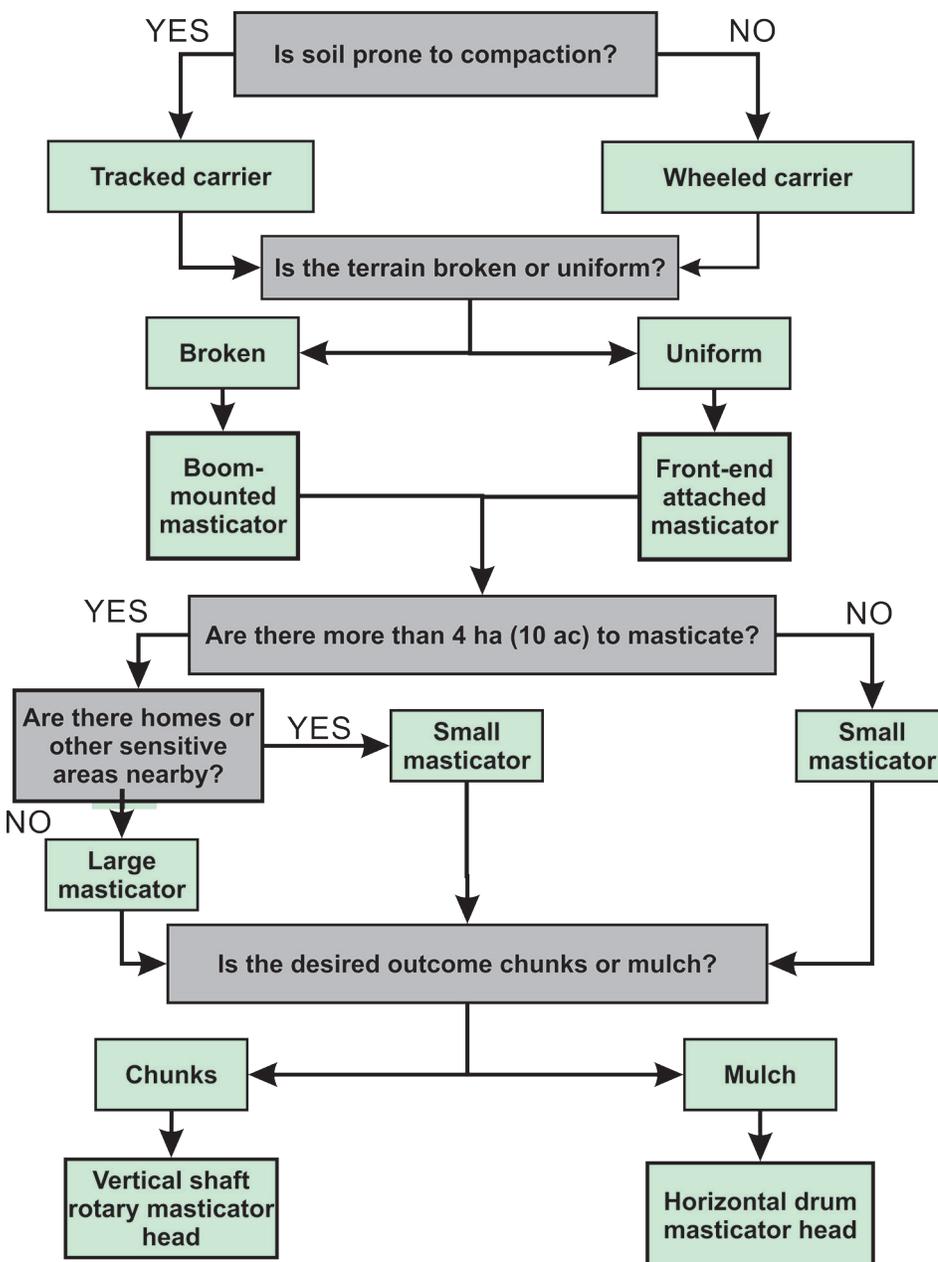
Decision Tree 3 can be used to match the masticator to the site and project objectives once the decision is made that mastication is an appropriate option.

Jain and colleagues found that the impact of machines on soil compaction and disturbance is driven by a number of factors. Here are general findings they

summarized from their literature survey:

- Dry soils lead to less compaction.
- Driving on slash mats can also decrease compaction.
- Wheeled carriers can create ruts, particularly on wet soils.
- Tracked machines generally cause less soil disturbance because the machine weight is spread over a larger area than wheeled carriers.
- Rubber tracks tend to offer the lowest pressure and are the best choice on sensitive soil conditions.
- Equipment with boom-mounted cutting heads can reach over difficult areas or maneuver around tighter spaces; therefore, this equipment avoids driving to every tree, which also diminishes soil disturbance.

**Decision Tree 3
Mastication combinations**



Jain and colleagues suggest that forest managers evaluate compaction potential on their sites using available tools like the Soil Disturbance Field Guide (Napper et al. 2009). The authors also recommend requiring operators to use best practices to reduce soil damage, such as limiting the number of passes, conducting the treatments when soils are dry, and having the machine walk over slash where possible.



Manager and Operator Perspectives: Andrew Saralecos

Andrew Saralecos is a forester for the Nez Perce Tribe in Idaho, who previously held the same position, and was a logging engineer for private industry, and a federal land manager. He has a great deal of experience with mastication as a land management tool, both as a machine operator and contracting land manager. Saralecos shared some of his thoughts on the benefits and limitations of mastication and provides suggestions for land managers thinking of using outside contractors and operators for mastication treatments.

He said the Nez Perce Tribe averages about 2,200 acres of mastication treatments per year, compared to about 450 acres of annual prescribed burning.

We [the Nez Perce Tribe] do a lot of prescribed burning. It's often the right tool at the right time. But if I'm treating logging slash with burning, we have airshed constraints for smoke management, which means very narrow burn windows. However, we also own two masticators and have several more on a standing contract that we can run 11 months out of the year. They can cover a ton of acres and get our desired conditions and objectives done no matter what's going on. It is dependable production I can bank on.

Saralecos said he often uses mastication to prep sites for prescribed burning.

Very seldom do we have continuous fuel loading across the site. Often, there'll be an area that's really brushy, and you have 20-foot high ladder fuels of Hawthorne and blackberry bushes and small reproduction. We use mastication to get it knocked down so that we have a good, low fire.

We do see some issues with fire severity if the mulch gets deep and we burn it on the hot side. You can end up impacting the root zone. But our experience has been that it is pretty reasonable and manageable.

Saralecos notes limitations on the types of sites where mastication is effective, particularly in relation to stem size.

From a production standpoint, I don't want to be mulching anything that's over 6 inches DBH [diameter at breast height]. There are machines and operators out there that will say, "Oh yeah, we can mulch this." But you can't do it productively and sustainably in a way that is cost effective. A lot of these machines and a lot of our newer machines, they can run all day long and crank out acres productively in that 5- to 6-inch material. It's possible to take a 10-inch tree at DBH and auger down that last 4 and a half feet to say a 12-inch plus stump, but that's not a great use of their time. And in our case, I have a market for that product, so I'm better off logging it and putting it on a truck. So really from a production standpoint, it comes down to knowing your piece size.

Another issue that arose in Jain and colleagues' research on mastication, as well as in conversations with Andrew Saralecos, is the role of operator skill and experience in mastication outcomes.

In a forest environment, you need to have an operator who's able to understand the specifications for what you're doing. You need them to understand tree species or brush species, a whole range of things, and be able to work independently. Also, they need to realize they aren't working on a prepared site. If you have somebody who's used to running equipment on a construction site or highway project that's flat or relatively flat, now they're dealing with trees and branches and stuff that falls on you and going over stumps and rocks and hillsides. That's not for everybody. Unless you have an operator that's used to working in that kind of terrain, their productivity very rapidly plummets. I can't emphasize enough how low that productivity can drop. You can take a top-shelf operator on flat ground, put them on a slope in the forest and accomplish basically nothing.

Finally, Saralecos has suggestions and considerations for managers to keep in mind when setting up a mastication contract and directing the work.

Figure out what your hundred percent in terms of production is for the day. And then tell the operator to back it off to say 80 percent to 85 percent and maintain that rate. So, at the end of the day you haven't dinged up a bunch of leave trees. You haven't made a mess and you've been very consistently productive. That takes a lot of skill.

What is your tolerance for site disturbance? If you know the operator and you know their capabilities, you might have somebody that'll go in, take care of the job and have zero site disturbance. But if it's going out on more of a low-bid, not a best value contract—you could have someone on the same project look like you rototilled the hillside. The question comes down to what is acceptable.

The other thing I would say that is huge for us is to understand the limitations of the machine and having the proper spacing. People make mistakes by trying to dive into equipment versus relying on the contractor to get them to the desired conditions. So they'll say, "I need to have this machine that has this kind of reach and does these things well," but the reality is that unless they really know their equipment, they've now specified something that might leave others out of the bid pool and their spacing is too tight for the machine they specified. Then they wonder why the project doesn't turn out. The best approach is to say, "Here's my spacing, the end product needs to look like this," and let the contractor do their job.



Other Mastication Considerations

Ecosystem impacts. One of the primary applications of mastication is as a fuels treatment, mostly as a means to convert ladder fuels to surface fuels. Mastication can increase the abundance of fine fuels and, if ignited, these fuels can smolder for long periods; therefore, depending on the quantity of fuels on a site and the depth of the slash that mulching can create, mastication may not always be an appropriate forest treatment.

Recent research has shown that erosion and compaction can be minimized when the machines are driven over masticated residue.

It is difficult to generalize about the impact of mastication treatments on wildlife, as post-treatment habitat conditions influence wildlife species and not necessarily the treatment itself. Different treatments create different vegetation composition and structure, which can favor some species over others.

Operator skill. An experienced masticator operator can move through a project efficiently and often is more likely to achieve desired site conditions with reduced ecosystem impacts. In their review, Jain and colleagues found that operator experience was the most important factor in project outcomes regardless of the machine—the more experienced the operator, the more cost efficient the project will be.

Table 1. Summary of ecosystem impacts from mastication treatments, based on literature review by Jain and colleagues (see Gen. Tech. Rep. RMRS-GTR-381 for more details).

Ecological response following mastication	Type of response	Response
Vegetation	Revegetation	Varied Time since treatment Vegetation type
	Invasive plant	Vulnerable in grasslands, shrublands and woodlands
Tree	Mortality	Minimal
	With prescribed fire	May increase regeneration
	Reduce competition	Increase seedling survival
Soil	Erosion	Not adversely affected
	Nutrition	Not adversely affected
	Insulation	Increased insulation and created uniform temperatures
	Infiltration	Decreased on pinyon-juniper woodlands Not adversely affected in conifer forests
	Microbial activity	Not adversely affected
	Moisture	Increased moisture on lodgepole pine and dry mixed-conifer soils
Wildlife	Habitat	Depends on the species



Mastication equipment (clockwise from top):

1. Tractor with a horizontal cutting head (photo: M. Peterson, Diamond Mowers Inc.).
2. Skid steer with forestry mulcher attachment (photo: M. Peterson, Diamond Mowers Inc.).
3. Vertical head masticator (photo: M. Peterson, Diamond Mowers Inc.).
4. Horizontal shaft cutting heads can have knives or teeth designed to work in different settings, such as on rocky soils (photo: Fecon Inc.).



Manager and Operator Perspectives: Roger Kinyon

Roger Kinyon, the owner of C.K. Excavation in Genesee, Idaho, ran a hydroseeding business for many years and has been doing mastication for 6 years. He uses a FECON 128 purpose-built, forestry mulcher. He works mastication contracts for the Nez Perce Tribe, Coeur d'Alene Tribe, and Northwest Management, a large timber management company in the Pacific Northwest.

Kinyon said that with the replacement of best-value contracting, where bids could be awarded based on experience and past performance, with straight low-bid contract awards, there has been an increase of inexperienced operators moving into the business with equipment that is not suited for forest management work.

Everybody thinks it's a great way to make a living on the weekends. So, they go out and buy a skid steer and a head. They bid these contracts for a hundred dollars per acre. Then they get into it and figure out that with the skid steer they're getting a quarter or half an acre done a day in the heavy stuff where I get about five or six. So, people offering contracts need to check into the type of equipment that people are bidding have or they could end up way over a barrel and have to pay to do it twice because the guy with the low bid just can't do it, their machines just won't do it. Then they have to pay me to come in and fix it.

Kinyon said experience working on forested landscapes is also a key factor in how productive a contractor will be in treating stands to desired conditions.

Masticating in mountain country, in the steep stuff, is a pretty serious situation. I've worked on the North Slope and I've worked a lot of places and done a lot of things, but forest mulching is probably the most dangerous work I've ever done. Because when things go wrong, it goes horribly wrong, and then you're just trapped in a machine. So, I've had guys come and cut for a day and say, "This isn't for me, I'm done." Another guy working with me now just loves being in the woods. He loves the thrill of it. But, it's not for everybody.

Site conditions are a big determinant of his ability to complete a contract profitably, Kinyon said. He prefers to have contracts "stair-stepped" with different rates for different stands depending on the size of the trees.

If I'm in 6-inch stuff, the rate is X. I can go through 6-inch stuff and not even hardly slow down. If I move into 8-inch stuff, the contract pays me a little bit more. Once we go over 12 inches, then it jumps a couple hundred dollars an acre because you just spend a lot of time chewing up trees into woodchips, so it just takes that much more time.



“Masticating in mountain country, in the steep stuff, is a pretty serious situation. I’ve worked on the North Slope and I’ve worked a lot of places and done a lot of things, but forest mulching is probably the most dangerous work I’ve ever done. Because when things go wrong, it goes horribly wrong.”

— Roger Kinyon,
mastication contractor,
owner of C.K. Excavation

In addition, minimizing turns and limiting the number of passes may reduce overall site impact, from tree damage to soil impacts.

More complex projects are likely to benefit from more experienced operators. Complex projects might include a high density of residual trees (> 100 trees per acre), the presence of houses or other structures, or the need to work on steep slopes (35 percent to 50 percent).

Experienced operators can create smaller or larger piece sizes (debris left on forest floor) by adjusting the time spent masticating a particular piece.

“What are we going to lose if we don’t go in here? Why don’t we mulch it up, put it back on the land, and use the organic matter. It stores water and it helps slow run-off. There are so many benefits of slash. We still don’t have a market for a lot of our small diameter, nondesirable species. Even ponderosa pine, you can’t sell it for poles, right? So what are your options? Let the beetles eat it or let fire consume it and give it a free ride into the atmosphere, instead of storing that carbon.”

— Chris Heffernan, mastication contractor, North Slope Resource in North Powder, Oregon

Manager and Operator Perspectives: Chris Heffernan

Chris Heffernan, owner of North Slope Resources in North Powder, Oregon, has a long history in forestry as a tree farm owner, forestry contractor, and policymaker. His tree farm has received multiple awards and he was named the Oregon Tree Farmer of the Year. He has also served on the Oregon Board of Forestry. Since 2003, when he worked as a contractor on the Columbia Complex Fire, he has been doing mastication work for private landowners as well as the Confederated Tribes of the Colville Reservation, the Nez Perce Tribe, and the Confederated Tribes of the Umatilla Indian Reservation. He uses a John Deere 2154D purpose-built forestry mulcher with a 54” ProMac cutting head.

It’s a big machine, but because of the big tracks, the compaction and pounds per square inch are minimal, especially when you consider we have a 36-foot reach in all directions. It doesn’t have huge horsepower, but does have huge hydraulic fluid power, which turns the head. It’s like a backhoe, but it’s a track hoe. Instead of a big bucket there, we have a disc that turns 2,000 RPMs, just like a flying saucer out in front of you. You grind from the top to the bottom. If you’ve been around some of them, it’s pretty impressive.

He says the advantage of a tracked swing machine is that it doesn’t have as much impact on the soil as other options.

There are applications where skid-steers, the little ones, are good, but they can’t reach very high. So the top falls off. Then they grind whatever they cut off down to the ground, but then they go back and forth, back and forth, back and forth. Just beat the hell out of the ground to try to get it chewed up. And then they got to go chase that top that fell off. Now we are sitting up there in this monster and she can reach 35 feet left and right up and down. We scatter the material uniformly across the landscape and you don’t beat an operator to death.

Heffernan said he wishes land managers would get over their unease with using mastication.

They’re so afraid of machinery. But what’s going to happen when it burns? What are we going to lose if we don’t go in here? Why don’t we mulch it up, put it back on the land, and use the organic matter. It stores water and it helps slow run-off. There are so many benefits of slash. We still don’t have a market for a lot of our small diameter, nondesirable species. Even ponderosa pine, you can’t sell it for poles, right? So what are your options? Let the beetles eat it or let fire consume it and give it a free ride into the atmosphere, instead of storing that carbon.

Heffernan agrees with Jain and colleagues that terrain is a make-or-break factor for mastication.

Steep terrain and rocks are our biggest enemy when it comes to slash busting. We can do it in a safe manner, but we have to be on 35% slope or less, the vast majority of it.



Heffernan believes that low-bid contracting in which bids are awarded solely based on the lowest price are challenging the ability of many experienced masticators to compete for projects.

Skilled operators can efficiently move the machine and cutting head and minimize the number of passes over a particular area, thus reducing project costs and ecosystem impacts.

Jain and colleagues suggest that a thorough site evaluation can help determine the operator skill needed to conduct the project successfully and efficiently.

Tree size. While the number of stems on a site is an important factor in deciding to use mastication, the head size and horsepower of the machine should be complementary to the tree size targeted for mastication. Vertical shaft masticating heads can typically treat trees effectively up to 6 to 8 inches in diameter when they are boom mounted. Some boom-mounted, horizontal-shaft masticating heads can treat larger trees (up to 30 inches in diameter), but larger trees require a more powerful and larger cutting head and a carrier machine that can deliver the necessary power to the head.

Desired conditions. Managers typically start with desired outcomes in terms of residual stand density and spatial distribution

when deciding on treatment options. These factors can influence the type of equipment used. Drive-to-tree mastication works best on sites with widely spaced trees because it takes less time. However, if a site has tight spacing between trees, a carrier machine with a boom-mounted cutting head has greater flexibility because the operator can move the cutting head into places that might have narrow tree spacing. For precommercial thinning of small trees (less than 2 inches diameter at base height), skid steers with a vertical shaft masticator can be the most cost-effective option, as they can maneuver easily and cut close to residual trees at a 14-foot spacing.

Piece size. The cutting head, how much time the operator spends masticating a particular piece, and the size of targeted biomass influence the post-treatment piece size of the slash left on the forest floor. Depending on the operator's skill level with the machine, both vertical shaft and horizontal cutting heads can create larger or smaller pieces. Operators can also influence the piece size by using slow, methodical passes or multiple passes across an area with the machine. Typically, the more time

the operator spends grinding, the smaller the pieces become; thus, when the operator moves quickly, the piece size increases.

Conclusion

While mastication does not fit every site or management objective, it can be effective in certain situations. The aim of this Science You Can Use article is to present the decision trees developed by Jain and colleagues to help decision-makers and land managers determine if mastication can help achieve their objectives. The decision trees are based on completion of a site evaluation, which includes consideration of factors such as nonnative species invasion, the vulnerability of soils to erode or compact, slope and terrain factors, vegetation characteristics, and treatment costs. If a manager selects mastication as a treatment option, then the manager can work with experienced operators to identify the carrier machine, cutting head, and mounting system best matched to the project goals and objectives.

KEY FINDINGS

- Mastication can increase the abundance of fine fuels and, if ignited, these fuels can smolder for long periods; therefore, mastication may not always be an appropriate forest treatment.
- Soil nutrition is not adversely affected by mastication, and erosion and compaction are minimized when the machines are driven over masticated residue.
- Post-treatment habitat conditions influence wildlife species and not necessarily the treatment itself. Different treatments create different vegetation compositions and structures, which can favor some species over others.

“In a forest environment, you need to have an operator who’s able to understand the specifications for what you’re doing. You need them to understand tree species or brush species, a whole range of things, and be able to work independently.”

—Andrew Saralecos, forester with the Nez Perce Tribe

FURTHER READING

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Science You Can Use Bulletin 

The purpose of SYCU is to provide scientific information to people who make and influence decisions about managing land.

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