Cost, Production, and Effectiveness of Masticated Fireline

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Abstract

Fire managers are continuously looking for improved methods to construct fireline with minimal resource damage. One option for fireline construction that has so far received limited attention is the use of mastication equipment. This study evaluated a masticating disk mounted on a self-leveling feller- buncher for the cost, speed, and adherence to fireline specifications while constructing approximately 5 miles of fieline across a range of terrain and fuel types. Field trials were conducted during the fall of 2015 on the University of Montana's Bandy Experimental Ranch. Production rates and cost of masticated fireline construction will be compared to traditional handline constructed to the same specifications (30-foot canopy break, 10-foot fuel break, 1- to 3-foot scrape to bare mineral soil). Equipment modifications will be recommended to address lapses in effectiveness as compared to fireline specifications.

Keywords: Wildland fire management; fireline construction

Introduction

Past production rate and cost studies of forest fuel mastication have focused on fuel reduction for wildfire prevention or wildlife habitat enhancement. In certain fuel types and under some burning conditions, mastication equipment may be useful to create fire breaks to assist in the containment of wildland fires. In these situations, mastication would be used to rearrange fuels to slow or stop the spread of fire without the often-excessive soil disturbance created by conventional fireline construction using bulldozers or similar heavy equipment. To date, only one known study has looked at the use of mastication equipment for fireline construction (Clark 2008) and took place during an equipment demonstration project, therefore production and cost results are unreliable. This project estimated production rates and costs associated with using mastication equipment for fireline construction through Northern Rocky Mountain mixed conifer fuel types where mastication is thought to be a realistic method to slow or stop the spread of wildfire.

Suppression of wildland fires accounted for 47% of the total US Forest Service budget in FY 2013 (http://www.fs.fed.us/aboutus/budget/2015/FY15-FS-Budget-Overview.pdf). If masticated fireline is shown to be effective under certain conditions in creating a barrier to fire progress and is similar in total construction cost to dozer- or excavator-built line, masticated fire line may then be more cost effective overall if post-fire rehabilitation work is not needed. A better understanding of masticated fireline production rates, costs, and level of effectiveness under a range of conditions will allow fire suppression managers a wider array of tools to manage a wildfire situation, potentially resulting in more cost-efficient, lower environmental impact fire suppression activities.

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Methods

Study sites were selected at the University of Montana's Bandy Experimental Ranch to represent a variety of slopes and vegetative cover types. The Bandy Experimental Ranch is a 3500-acre working ranch with approximately 2000 acres of forested land typical of many of the forest and shrubland types found across the northern Rocky Mountains. In addition to selecting a range of slopes and cover types, firelines were placed on the ground so as to create logical burning units approximately 10 acres in size that would be appropriate for students to burn at a later date.

Firelines were laid out in 100-foot (30.5 m) segments, GPS location was recorded and temporarily monumented in the field for all segment starting points, general slope information was collected for all segments, and additional site and vegetative cover information was collected for a subset (every-other or every third) of segments. In order to compare masticated fireline construction to standard handline construction, site and vegetation conditions were collected for three zones based on the prescribed treatment: 1-2 foot (0.3-0.6 m) scrape to bare mineral soil at the centerline of the segment; 10-foot (3 m) fuel break (5 feet (1.5 m) either side of the center line) where all vegetation is reduced to ground-level; and 30-foot (9.1 m) canopy break where overstory trees are spaced to at least 10 feet (3 m) between live crowns (Figure 1). All overstory trees greater than 3 inches (12.7 cm) within 15 feet (4.6 m) either side of the centerline were tallied by species and ocular estimate of 2-inch (5.1 cm) diameter class while all woody vegetation (shrubs and trees) greater than 0.5 feet (0.2 m) tall was tallied by species, growth form (shrub or tree), diameter at breast height to the nearest 1-inch (2.5 cm) if applicable, and estimated height to the nearest foot (0.3 m).

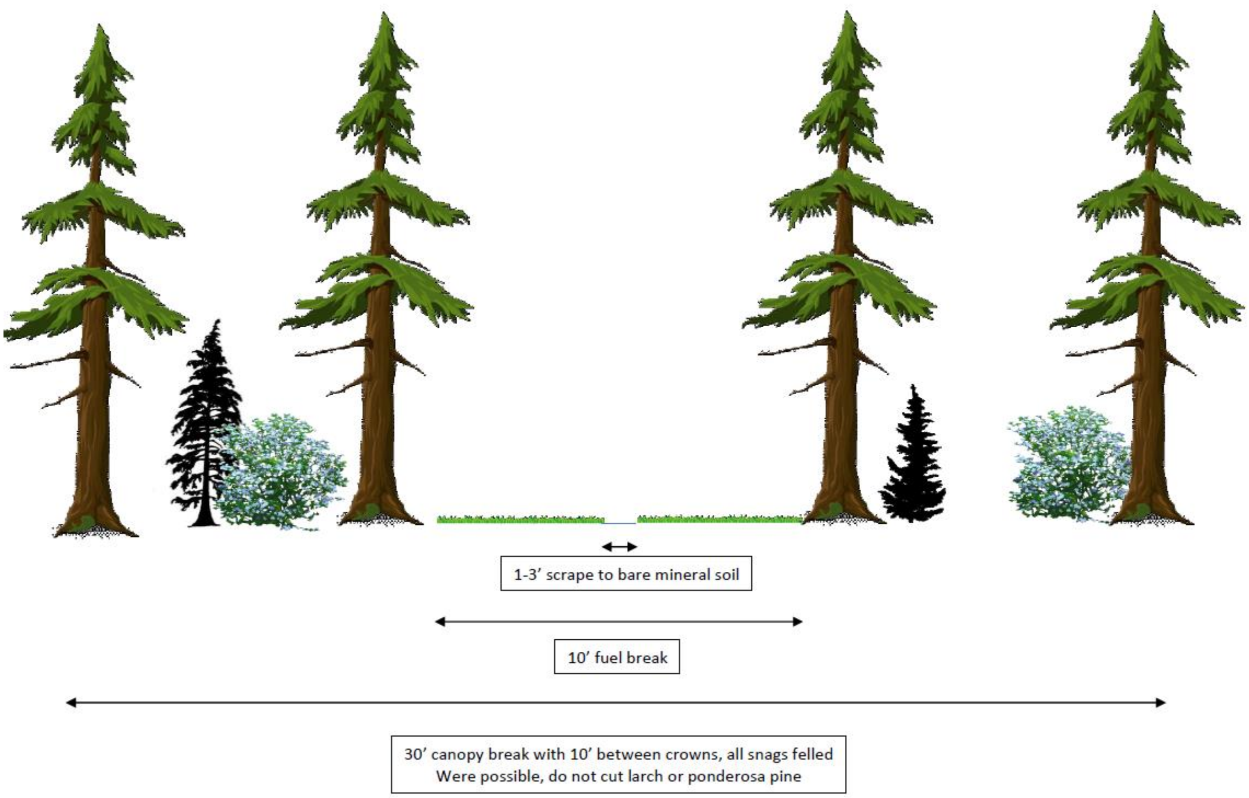

Figure 1: Fireline specifications

A self-leveling tracked Timberjack 608L with a Koehring Waterous disk felling head equipped with a disk containing cutting teeth both around the edge and on the bottom was used for fireline construction. During fireline construction trials, time to the nearest one-hundredth of a minute was recorded for each 100-foot segment and broken into mastication, scrape, travel, and delay time categories.

Effectiveness of fireline construction was evaluated after time trials were completed. Ideally, this evaluation would have been based on performance of fireline under actual burning conditions. As this was not logistically possible, the percent of each fireline segment that was constructed to specification as well as the reason(s) for noncompliance was assessed. A single evaluator paced each fireline segment and recorded the number of paces within each of the following categories: fireline constructed to specification; inadequate scrape to bare mineral soil; inadequate fuel break; or inadequate canopy break.

Results

Three hundred twenty three (323) segments covering 6.1 miles (9.8 km) were located in the field. Of these, complete vegetation data was collected for 125 segments. Slopes ranged from 0 to 54% with an average of 8%. Maximum side slopes were similar with a range of 0 to 56% and average of 10%. Basal area of overstory trees averaged 68.4 ft^2/ac (15.7 m^2/ha) and ranged from 0 to 240 ft^2/acre (55 m^2/ha).

Time and motion data was collected for 263 segments covering 5 miles (8 km) and 36.3 hours. Of this time, 25.5 hours were productive while 10.8 hours were consumed by delays. This results in a utilization rate of 70% and an average delay-free time of 5.8 minutes per 100-foot station or 10.3 stations/hour (313 m/hour). This production rate varied considerably, however, ranging from 1.9 to 93.8 stations/hour ((58 to 2858 m/hour). Considering delays, the average production rate across the range of conditions evaluated was 8.3 minutes per station or 7.2 stations/hour (220 m/hr). At a machine rate of $300/hour (USD), this average production (including delays) equates to $41.56/station, $0.42/foot ($1.36/m), or $2,194/mile ($1,363/km).

Using backwards stepwise regression, productive time per station was found to be dependent on the basal area per acre of trees larger than 3 inches (12.7 cm) within the canopy break, the number of down woody pieces within the fuel break, and the number of rocks greater than 6 inches (15.2 cm) within the fuel break:

$$\textit{Productive time} = 1.970 + 0.036BA + 0.214DWD + 0.038ROCK$$
$$R^2\ 0.6189$$
$$\textit{Adjusted } R^2\ 0.6067$$

Where:

Productive time = delay free time in minutes to construct one station (100 feet) of fireline

BA = basal area of stems greater than 3 inches within 15 feet either side of the centerline, expressed in ft^2/acre

DWD = number of pieces of down woody debris at least 6 inches in diameter within 5 feet either side of the centerline

ROCK = number of rocks at least 6 inches in size within 5 feet either side of the centerline

Comparing constructed fireline to the specifications given in Figure 1 found that only 5% of all firelines met all requirements for the full length of the segment. Less than half of all line constructed (46%) met specifications. The most common failing was an incomplete scrape to bare mineral soil, with 37% of all line constructed in this category. Sixteen percent (16%) of constructed line had an inadequate fuel break, primarily in the form of incomplete mastication of shrubs. Only one portion of one segment of line had an inadequate canopy break.

Discussion

The cost of a Type I IHC (Interagency Hotshot Crew – elite 20-person hand crew) is approximately $7845 per 14-hour day in 2015 USD. Published production rates of Type I IHC crews working in timbered areas (fuel models 8-10) are 10.5 chains/hour (211 m/hr), ranging from 9 to 12 chains/hour (181-241 m/hr), for direct line construction (Broyles 2011). Indirect line construction drops to 6.9 chains/hour (139 m/hr) with a range of 6.0-7.8 chains/hr (121-157 m/hr). This gives an average cost of direct fireline construction of $53.33/chain for direct line and $81.16/chain for indirect line. Comparatively, fireline constructed within this study using mastication equipment cost, on average, $27.43/chain and is likely most comparable to the indirect line construction scenario. It must be noted, however, that the line constructed within this study would require follow-up work, most likely by a hand crew, to complete line to specification. Most of this work would involve completing a scrape to bare mineral soil.

The most common failing in the constructed line within this study was an incomplete scrape. The operator drug the head with the disk stopped to create the scrape, often producing “skips” where the head floated over the ground surface, leaving grasses and forbs intact. One potential solution to this would be to attach a scraper bar on the back of the head such that it is parallel with the ground when grinding. This bar would be easier for the operator to see, would be flat against the ground as opposed to the round hotsaw head, and would be of the desired width for a scrape.

The cost of the mastication equipment used here ($300/hour) is significantly higher than the cost of the same machine used as a felling machine with a standard hot saw disk. There are several anecdotal reasons for this increase in cost. According to the operator who has used the same machine both for felling operations and for mastication, there are several differences in machine performance that impact cost:

- Fuel consumption is approximately 33% higher with mastication as compared with felling. For example, during this study the machine consumed approximately 100 gallons of fuel during a standard 10-hour day. The operator estimated the same machine would consume 70-75 gallons if felling under the same stand and site conditions for a similar amount of time.
- Repair and maintenance time is estimated by the operator to be “at least half again as much” masticating as compared to felling under the same conditions. This is due to the increased stress and strain on the head, boom, and swing functions during mastication. Additionally, the range of motion of the head is much greater masticating as compared to felling. During felling operations, the head generally operates within a few feet of the

ground. With mastication, the head is frequently lifted to at or near full height in order to reach tall shrubs and trees.

- During full-time mastication work, this machine will generally go through a full set of grinding teeth (the teeth on the bottom of the disk) in a standard work day. The 2015 cost of a set of grinding teeth was approximately $400. Wear of cutting teeth (those teeth around the edge of the disk as on a standard hot saw disk) would be higher, but more similar, to standard felling operations due to the increased likelihood of hitting a rock while masticating.

This particular machine was chosen for this study based on its ability to fall and bunch merchantable stems similar to a feller-buncher. This was viewed as important when constructing line through forested areas. Based on experience during this trial, it is not recommended to use mastication equipment not capable of felling large stems in forested areas unless some other means of felling and bunching are utilized, which then removes the advantages of a single machine. Therefore, production rates and other results of this study should not be extrapolated to other mastication equipment that does not have this felling capability.

From this study, it is unclear if line constructed using mastication equipment would need less rehabilitation work after a fire than standard line constructed using "traditional" methods of hand crews, crawler tractors, or excavators. This may be the case if no scrape is constructed; however fire managers did not view such a line (one that only contains a fuel and canopy break) as an effective control line.

Conclusion

Mastication equipment was used to construct fireline at a cost of approximately one-third that of a Type I hand crew. The equipment used in this study had difficulty maintaining a consistent scrape to bare mineral soil; however it is felt an inexpensive machine modification could greatly improve the performance of the equipment in this aspect of fireline construction.

This study was supported by the USDA Forest Service Southern Research Station.

Citations

Broyles, George. 2011. Fireline Production Rates. Available at: http://www.fs.fed.us/t-d/pubs/pdf/11511805.pdf. Accessed July 5, 2016.