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Tests of Biomass Removal Using Lightweight Portable Conveyors

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Introduction

Thinning crews slash trees for hand or machine piling during many fuel reduction treatments. Usually, the piles are burned later when weather conditions minimize fire risk and the effects of smoke. While widely used, this approach has several key limitations:

- The periods when conditions are suitable for burning (often called windows) are limited, but all the piles can be burned only during these periods.
- The piles represent an ongoing fire risk.
- Burning piles in wildland-urban interface areas requires close attention to the effect of smoke on air quality and heightened attention to the risk that fires might escape.

In 2005 a contractor approached the Forest Service about testing an innovative system for biomass removal that offered the potential for low-impact, cost-effective treatment of stands where slash has been hand piled. Partners from Carson City Renewable Resources, Miniveyor Systems, the Forest Service Lake Tahoe Basin Management Unit, Intermountain Region State and Private Forestry, the Missoula Technology and Development Center (MTDC), and the Southern Research Station collaborated on a 2-day test of portable conveyors (figure 1) to carry material out of the woods.

Highlights...

- When lands are thinned to reduce hazardous fuels, something has to be done with the slash.
- Opportunities to burn the piles safely with good smoke dispersal may be extremely limited, particularly in the wildland-urban interface.
- Two days of tests showed the technical feasibility of moving 7 green tons of chipped slash per hour using portable conveyors—with little disturbance to sensitive soils.

Figure 1—Early tests using a portable conveyor to remove slash were conducted in a gravel pit in Incline Village, NV.

The Lake Tahoe Basin Management Unit

The Lake Tahoe Basin Management Unit (LTBMU) is an example of public lands where standard piling treatments present management challenges. The LTBMU covers 150,000 acres of national forest land around Lake Tahoe straddling the border of Nevada and California. The primary management objective of the LTBMU is to protect water quality through integrated watershed management.

In areas such as this, fuel treatment operations must be conducted carefully to avoid soil disturbance and potential erosion. This is a particular concern on forest sites steeper than 30 percent and in the wildland-urban interface. Given the severe fire risk represented by fuels that have built up on the forest floor and small trees that have flourished in the absence of fire, the LTBMU has a very active program of fuel reduction work. Since 1995 more than 12,000 acres have been treated, including 3,000 acres of piled slash that were burned and an additional 1,000 acres that were underburned. A significant backlog of piles are waiting for appropriate burning conditions.

Removing biomass from the stand is an alternative to piling and burning slash. On slopes less than 30 percent, the LTBMU employs mechanical treatments including cut-to-length harvesting and mulching. Along roadsides, such material can be disposed of or recovered for utilization. Removal increases the project's cost and introduces the risk of ground disturbance—both critical factors for the LTBMU. Mechanically removing small, unmerchantable slash is also very costly because it is difficult to carry a full load on skidding equipment. Utilization of biomass offers the potential for revenue to offset some operational costs.

Portable Conveyors

Lightweight portable conveyors are commercially available from several manufacturers. They have been used for construction, mining, nursery, and other temporary material handling tasks. The conveyors can be powered by hydraulics or electricity. Individual sections of the portable conveyors can be connected to meet project needs. Depending on loading rates and material properties, portable conveyors can move as much as 20 tons of material per hour. A variety of accessories are available for these conveyors, including feed hoppers, support systems, turns and transitions, and discharge chutes.

If these conveyors were used to remove forest biomass, conveyor sections (figure 2) could be deployed into a stand that was being thinned. Hand crews could bring slash to the conveyor line rather than to hand piles. A conveyor could carry the biomass to the roadside where it would be piled or loaded into bins. A key benefit to this system is that there would be no traffic back and forth when material was removed. Soil disturbance would be minimal to nonexistent. In addition, a conveyor system has a constant production rate no matter how far it extends into the stand. For most alternative ground-based slash removal systems, productivity falls as the skid distance increases.

Conveyor sections are relatively simple to deploy. Individual sections are carried into the stand, positioned and supported, then connected to power. As the conveyor line is extended, the conveyor can carry additional conveyor sections into the woods. Portable generators or power packs can be used to supply electrical or hydraulic power. After corridors are selected for the conveyor line, a crew needs to set it up. This initial feasibility analysis estimated cost of operations and ownership of about $7 per hour for a 100-foot conveyor line. Manufacturers estimate that 120 feet of conveyor line can be set up in 15 minutes in construction applications. Setup in forests would probably take longer.

Figure 2—When the conveyor was set up in the woods for a more realistic test of slash removal, the conveyor sections were overlapped.

Tests of the Portable Conveyor

Tests were conducted near Lake Tahoe for 2 days during September 2005. The tests were conducted in a gravel pit where conditions could be controlled. Once the effectiveness of the conveyor system was established, additional tests were conducted in areas that had been thinned. Tests were designed to examine productivity, performance on slopes, effectiveness of moving wood chips and raw slash, and any problems that might arise when the conveyor sections were not connected in a straight line.

The portable conveyor system supplied by Miniveyor Systems Inc. consisted of six electrically powered sections (each 10 feet long) and one hydraulically powered section (20 feet long) with accessories (table 1). The 15-inch-wide belts were fabric-reinforced PVC with cleats. A single portable generator powered the 10-foot sections, while a hydraulic power pack ran the 20-foot discharge section.

The first test was conducted in a gravel pit with the conveyor line following a gradual horizontal curve up a steep grade. A portable chipper fed chips into the conveyor's loading hopper at the lower end of the line. The final 20-foot discharge section of the conveyor ran faster than the 10-foot sections so it could throw material into a dump truck backed under the uphill end of the conveyor line. This test examined the conveyor's ability to carry wood chips effectively.

The second test also was conducted in the gravel pit, but the chip hopper was removed and raw slash was loaded onto the belt. This test's objective was to document productivity and performance removing slash under controlled conditions. Three experienced members of a thinning crew picked slash from a 1,500-pound pile and loaded the belt. Part way through this test, the conveyor sections were realigned to reduce hangups and lost material. This test was repeated with the same slash pile positioned slightly farther from the belt's loading point.

Additional tests were conducted in a thinned stand with hand piles. A five-person piling crew brought slash from piles to the conveyor line. The test area was about 0.22 acre and had 11 separate slash piles. The average distance from the piles to the conveyor was 40 feet with the farthest pile 114 feet away. The six electric-powered sections of the conveyor were deployed into the unit with the final 20-foot section carrying material up a fill bank to the shoulder of the road. The average grade of the conveyor line in the forest was 17 percent. A portable chipper at the roadside chipped the residue and deposited the chips in a single pile. The volume and density of the pile was measured to get an estimate of productivity.

Table 1—Parts of a portable conveyor system.

Components Tested	Price (2007)
10-foot conveyor section with cleated belt 110 V AC, 300-watt single-phase motor 45 feet per minute [new model is 370 watts operating at 85 feet per minute] 165 pounds	$ 2,590
Aluminum side extensions (two per section)	$ 227 each
Clamp kit to tie sections together	$ 475
Support legs (set includes three different pairs)	$ 1,366
2,700-watt portable generator	$ 500
20-foot hydraulically powered conveyor discharge section 400 pounds variable speed	$ 3,590
Chip hopper for loading conveyor	$ 1,350
Control box (one for four sections)	$ 735
Interconnection cable	$ 145
Terminator plug	$ 126

Initial Testing in a Gravel Pit

During these tests, the alignment of conveyor sections, the distance slash had to be moved when loading it on the conveyor, and similar concerns were tested under controlled conditions.

Moving Chips—This test examined the technical performance when a chipper loaded the conveyor. To configure the conveyor to carry chips, each section has to be overlapped by a foot, shortening the conveyor line. During this test, the chipper could produce more chips than the hopper and belt could carry. Chips bounced out of the hopper and overflowed its sides. As chips moved up the line from the hopper, they were lost at gaps in the side extensions (figure 3). Most of the chips remained on the belt and were successfully transported into the truck.

Slash Productivity—This test was conducted twice. Initially, the 1,500-pound slash pile was close to the loading point. During the second test, the pile was about 20 feet from the loading point. The initial test took a total of 62.7 minutes with only 7.5 minutes of productive loading time (working time without delays). The delays were caused by slash falling off the conveyor, slash getting caught in the side extensions, or conveyor sections separating from one another.

The belt had problems moving certain types of slash, including long pieces, curved pieces, forked pieces, and lightweight pieces. Some of the problems occurred at the overlaps between sections. Other losses occurred when the conveyor sections were at an angle to one another rather than straight. The net manual loading productivity with three workers averaged 6 green tons per productive hour.

For the second test, the conveyor line was reconfigured with the sections butted straight, end-to-end. The slash pile was 20 feet from the loading point. The realignment significantly reduced delays, with a total test time of 14.3 minutes and productive loading time of 12.0 minutes (3.8 green tons per productive hour). Productivity was lower because the pile was farther from the belt. Even in this configuration, however, workers needed to stand along the belt to reload pieces of slash that fell off.

Figure 3—Chips fell from gaps in the conveyor's side extensions.

Tests in a Thinned Stand

The conveyor sections were deployed into the unit, blocked, and connected with a 1-foot overlap between sections (figure 4). The piling crew moved material from the piles (figure 5) to the belt. The operation ran for a total of 111.4 minutes with 72.7 minutes of productive time. Most of the unproductive time was spent replacing the side extensions after they were knocked loose by pieces of slash. As in the slash test in the gravel pit, there were problems conveying many types of slash. Additional personnel were required to keep material on the belt. After all the piles were removed and chipped, the volume of the chip pile was 761 cubic feet. Based on two measurements of chip density averaging 10.5 pounds per cubic foot, the chip pile weighed about 4 green tons. This averages to a production rate of 3.3 green tons per productive hour.

Figure 4—Even though the conveyor sections were overlapped and side extensions were installed, slash was difficult to keep on the conveyor.

Figure 5—Piled slash was removed during some of the tests of the portable conveyor.

Discussion

The portable conveyor system is clearly capable of moving wood chips from thinned areas. The problems noted with conveyor overflow could be addressed by modifying the loading hopper design and/or the discharge spout of the chipper. Continuous side extensions would be needed to prevent chips from falling off the sides of the conveyor and to direct material flow past the overlap between sections. The productivity of the chipping system would probably be limited by the conveyor's capacity (figure 6).

During these tests manual loading rates ranged from 3 to 6 green tons per productive hour. Slash farther from the conveyor line took more time to handle. Placing slash on the conveyor was not difficult and the belt took material away quickly. When two people arrived at the belt at the same time, one of them would have to wait slightly for the belt to clear.

Slash presented numerous problems on the conveyor. Pieces hanging over the edges of the side extensions often hung up between conveyor sections or got caught in gaps in the extensions themselves. Large round pieces of slash rode on top of the cleats and sometimes rolled backward down the belt. The system as tested could not transport raw slash. Extra workers were needed to keep the material flowing to the roadside, simulating productivity as if the system were configured to keep pieces of slash on the belt. Because slash is not as dense as wood chips, the slash loading rate is less consistent than the chipper's loading rate. The potential productivity of the portable conveyor system carrying slash is less than half that for carrying chips.

One of the requirements for a system that can be used in the woods is the ability to span rough terrain. A variety of methods were used to block up conveyor sections, including adjustable leg sets, cribbing blocks, and slash pieces. The system was configured to cross rocks, logs, and variations in terrain. A solid installation is important to avoid downtime when the conveyor separates or collapses. The tradeoff is extra time needed for setup.

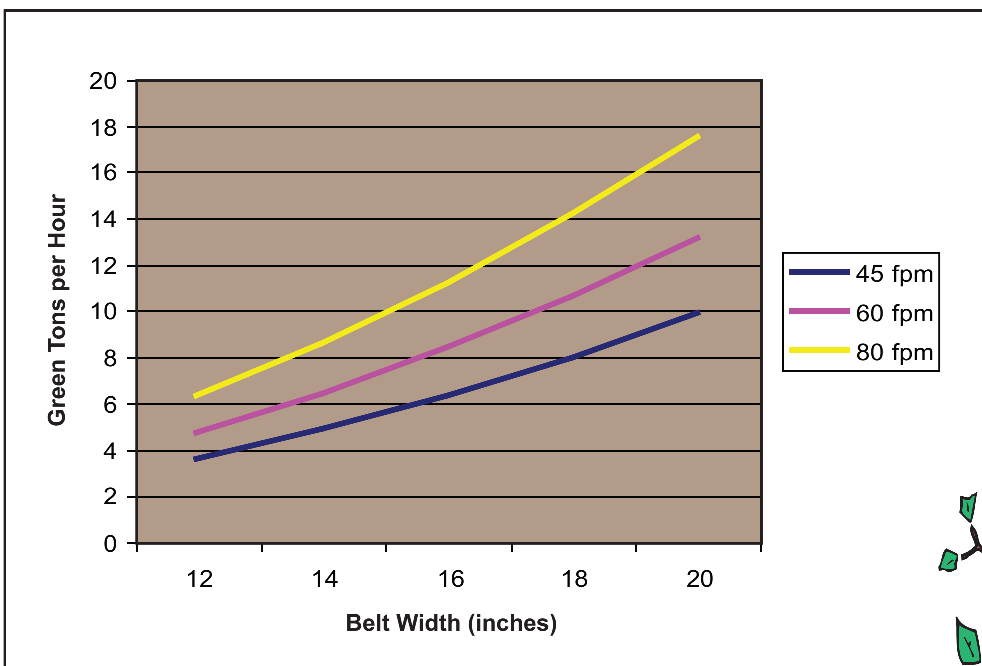

Figure 6—Theoretical production of a conveyor carrying wood chips at a density of 10.5 pounds per cubic feet (fpm stands for feet per minute).

The cost of the system is mostly the capital cost of the basic conveyor plus accessories. New models with more powerful motors only allow four sections to be connected electrically on one 30-ampere circuit. Four 10-foot sections complete with power, cables, side extensions and other gear would cost about $17,400. Assuming 2,000 scheduled work hours per year, a 5-year life, 75-percent productive time, 0.5 gallons per hour fuel consumption, 15 percent salvage value, and 20 percent for profit and overhead, this system would cost about $4 per productive hour for a 36-foot run. Costs are essentially a function of the length of the conveyor system (figure 7). Thus, a 180-foot conveyor line would cost $20 per productive hour. The system as demonstrated in the field would have cost about $11.70 per productive hour for purchase and operation, including overhead costs.

The manufacturer of the portable conveyor system we used recommended that a different configuration would be better for moving slash. Specifically, a wider belt (20 inch), three-phase motors, faster belt speed (85 feet per minute) and wider side extensions might address many of the problems observed during the field test. According to product specifications, a single generator could power up to thirteen 10-foot conveyor sections using three-phase motors. With the wider belt, each conveyor section weighs about 210 pounds and costs about $3,590. The extra cost of the three-phase motors is offset to some degree because the motors can power more than one section. Most of the accessories would be the same as with the tested configuration.

Assuming that the wider conveyor could handle the slash effectively, the limiting factor in the system's productivity would be the production rate of the crew. Studies of post-and-pole crews and shortwood crews found that five workers can fell, lop, and pile about 3 green tons per hour. The demonstration tests showed that if the slash can be kept on the belt, the conveyor could move it. If the crew's ability to keep up is the limiting factor, the ideal setup would require slash to be dragged no more than 50 feet or less. Assuming slash was being removed for 50 feet on either side of the

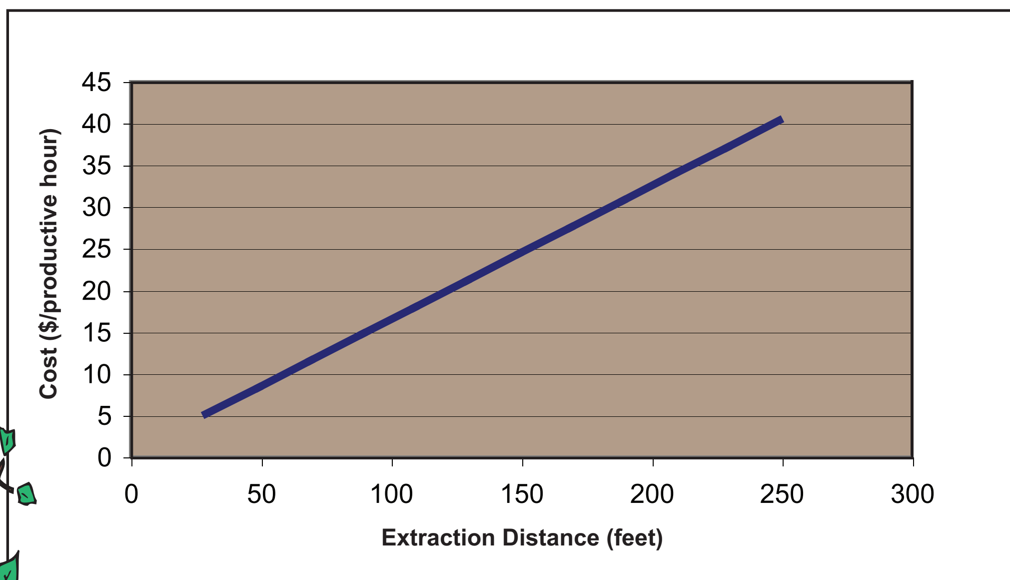

Figure 7—Cost per productive hour for the portable conveyor system as a function of the conveyor's distance into the stand.

conveyor, a 200-foot conveyor section would allow slash to be removed from about 0.5 acre (figure 8). This system (not including labor to operate it) would require about $115,000 in equipment and would cost about $27 per productive hour.

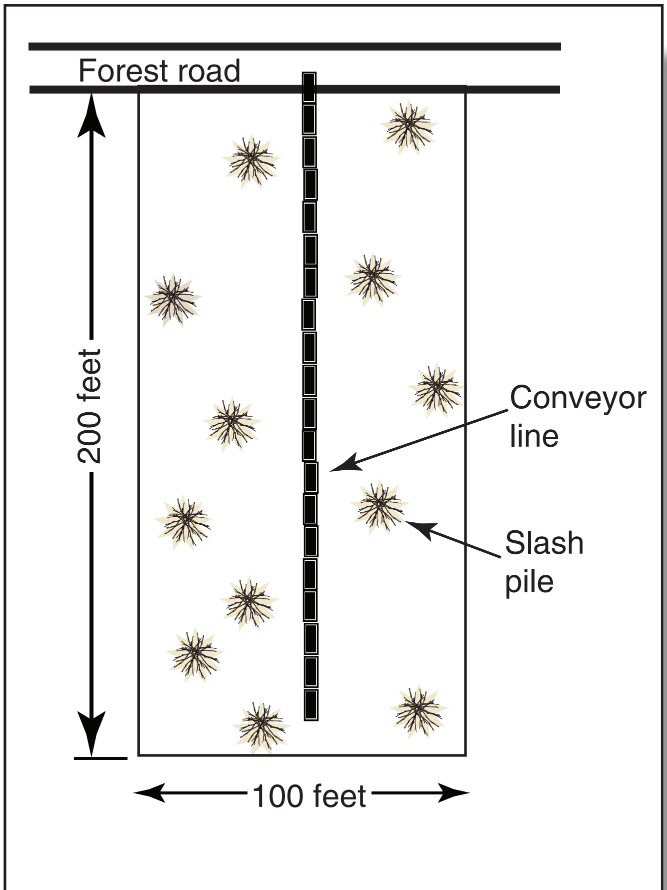

Figure 8—One potential layout for a portable conveyor system.

A spreadsheet was developed to compare alternative conveyor system layouts and operating costs. Total treatment costs increase as the fuel loading per acre decreases. The cost per ton of slash removed increases with the length of the conveyor because of the additional capital cost of each section. The labor required to pile or pull slash to the belt accounts for over half of total cost (figure 9). Setup cost for the conveyor (per ton removed) is significantly higher than the cost of moving the slash.

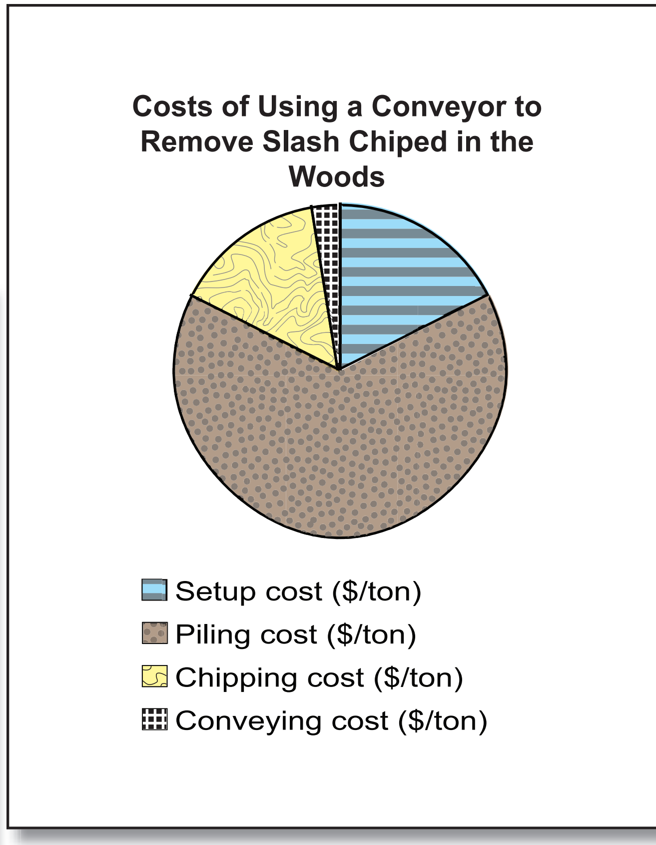

Figure 9—Distribution of costs for removing slash with a 200-foot conveyor when the slash is chipped in the woods.

Setup time is significant, particularly when the volume per acre is low. The total area accessed by a conveyor line is less than 1 acre, meaning that the costs of setup and takedown are charged to a relatively small amount of material. Setup and takedown tasks include clearing an area for the conveyor line, carrying the conveyor sections into the woods, blocking the conveyor sections, connecting the power, setting up the generator, attaching all side extensions, and attaching other accessories. Costs are affected by many variables, including strip width, extraction distance, volume per acre, piling productivity rates, and setup times. Specific conveyor applications should be carefully analyzed to understand the nature of these interactions.

Conclusions

The portable conveyor removed slash with minimal environmental impact. The system causes no soil disturbance other than foot traffic during setup, operation, and takedown. The tests showed the technical feasibility of conveying wood chips at a rate of at least 7 green tons per hour with minor modifications to chipper and hopper configurations. The system as demonstrated did not carry raw slash reliably, although other commercially available configurations might address these problems.

A conveyor carrying wood chips is at least twice as productive as one that is carrying raw slash. A 200-foot conveyor line could carry biomass to the roadside for about $40 per green ton in the form of slash or $20 per green ton in the form of chips.

About the Authors

Bob Rummer is the project leader for the forest operations research unit in Auburn, AL. The research program evaluates tools and technologies for implementing forest management prescriptions. Rummer has a bachelor's degree in forest management and a master's degree in forest products from the University of Idaho and a Ph.D. in industrial engineering from Auburn University (1988). He began working for the Forest Service in Alabama during 1983. His research focuses on new technology for forest work, forest operations safety, and the ecological effects of forest operations. He represents the United States in international standards work for forest machines and has written over 150 reports on research studies.

James "Scott" Groenier, professional engineer, began working for MTDC as a project leader in 2003. Scott earned a bachelor's degree in civil and environmental engineering from the University of Wisconsin at Madison and a master's degree in civil engineering from Montana State University. He worked for the Wisconsin and Illinois State Departments of Transportation and with an engineering consulting firm before joining the Forest Service in 1992. He worked as the east zone structural engineer for the Eastern Region and as a civil engineer for the Ashley and Tongass National Forests before coming to MTDC.

Library Card

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This report describes tests using portable conveyors to haul slash and chips from an area that had been thinned to reduce hazardous fuels. The tests were conducted in the Lake Tahoe Basin Management Unit where management focuses on maintaining the water quality of Lake Tahoe. Standard practices call for slash to be piled by hand and for the piles to be burned. Tests conducted over 2 days showed the technical feasibility of moving at least 7 green tons of wood chips per hour. The conveyors tested would have to be modified to move slash reliably.

Keywords: demonstrations, cost effectiveness, erosion control, Lake Tahoe Basin Management Unit, fuel reduction, slash removal, thinning, water quality

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