A Study of How to Decrease the Costs of Collecting, Processing and Transporting Slash

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Acknowledgements

Montana Community Development Corporation, working in a study group with forest industry and agency partners, reviewed the state of the art for transporting forest residues. The team concluded that roll on/off container transport was the technology most appropriate for testing with wood products.

Members of the study group then contacted forestry experts in Canada and Washington, and after a series of referrals, contacted two companies that use roll on/off containers to collect and transport pulp wood from logging operations. These companies were **DCT Chambers Trucking**, of Vernon, British Columbia, and **Longview Fiber**, of Longview, Washington.

From within its membership, the study group designated a special team consisting of personnel from **Missoula Cartage** (Missoula, MT) and the pulp mill operation (in Frenchtown, MT) of **Smurfit-Stone Corporation**. This team traveled to the Longview Fiber Company to view its operation, which, it was decided, could be adapted to different areas of Montana's in-woods slash program.

Smurfit-Stone then arranged to use roll on/off container technology on a test basis at two of its ongoing in-woods slash collection and processing projects. To that end, it agreed to receive the "hog fuel" at its facility. This in turn involved arranging for two sub-contractors, **Johnson Brothers Contracting** and **Cheff Logging**, to use their grinders to fill roll on/off containers in addition to standard chip vans.

The **Missoula Cartage Company** paid to have one of their drivers travel to DCT Chambers for specialized training on roll on/off container truck operations, and then to transport the leased equipment to Montana and finally back up to Canada. This driver operated the equipment throughout the test period.

The **US Forest Service's Forest Operations Research Unit** provided funding (in the form of a grant) to lease the roll on/off containers, container truck, and pup trailer for the test. It provided scientists and technicians to develop and conduct time/motion studies at each test site. It has also developed a user-friendly Excel spreadsheet to aid others in determining the economic viability of roll on/off container technology. The Forest Service will make this spreadsheet available on request and plans to post it on its website in early 2005.

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Introduction

Background and definitions

When trees are cut for commercial harvest or thinning, their limbs must be removed. When these limbs accumulate, they are referred to as "slash," which can be scattered or piled. Slash is generated at commercial sites in the forest, and also in the urban/wildland interface, at fuel reduction (or "thinning") sites. This study examined concentrated slash, in the form of piles located on a landing or along a road.

Slash can be fed into an industrial grinder, and the resulting chips can be used as fuel to heat boilers in co-generating facilities; in this form it is referred to as "hog fuel".

The term "chip van" refers to a tractor/trailer rig which uses a large-capacity, top- or end-loaded trailer that is designed to haul either hog fuel or chips.

The term "roll-off" refers to a straight frame tractor and pup trailer configuration in which modular containers are "rolled" onto and off of the straight frame tractor (commonly referred to as a "Hook Truck") and the pup trailer, by means of a tractor-mounted hydraulic grapple. A pup trailer is a four-axle trailer towed by the hook truck.

Processing and Transporting

On-site slash piles can be dealt with in any of three ways, each with its own set of advantages and disadvantages:

1. Slash can be left in piles on-site. This is easy, but has the disadvantage of creating a fire hazard.
2. Slash can be burned. This mitigates the fire hazard, but produces air pollution.
3. Slash can be carried to a co-generating plant to be converted to steam heat and/or electricity.

One advantage of Option #3 is that it helps generate revenue to offset the cost of fuel treatments. However, there are several inefficiencies inherent in the current methods for processing and transporting slash. For instance, the most common current method for removing biomass is to grind it in the woods and transport it offsite by chip van. This produces two problems:

1. Chip vans were built for highway use and often the suspension systems do not hold up or are too long for remote forest roads.
2. Expensive grinders have to move many times a day resulting in low production rates.

These problems created the need to search for useful alternatives. The Montana Community Development Corporation (MCDC), working with various other entities (see Acknowledgements) explored the feasibility of several concepts, some of which were novel and some which are currently used in other parts of the Pacific Northwest and Canada.

As the study evolved, other equipment combinations were tried, but not necessarily analyzed. Below is a list of systems that are based on the actual systems in place at the study's test sites. Each test-site system was designed to collect slash, grind it into "hog fuel", and transport the hog fuel to the Smurfit-Stone Container pulp mill in Frenchtown, MT.

A. Current System
   1. Move grinder to first site at logging job (at which slash has already been created and piled).
   2. Move loader (assigned to the grinder) to first site at logging job.
   3. Drive chip van to first site at logging job.
   4. Load slash in grinder and load resulting "hog fuel" directly into chip van.
   5. Transport hog fuel to a co-generating facility.
   6. Unload at co-generating facility.
   7. Move grinder, loader, and chip van to next site on logging job (1/4 mile - 1/2 mile)*.
   8. Repeat Step #7 as many as 20-40 times over the course of a project.

      * Often there is only enough slash at each site to fill between 1-3 chip vans. Also, the logistics of moving chip vans to narrow slash sites can limit the number of chip van loads to 3 or 4 per day.

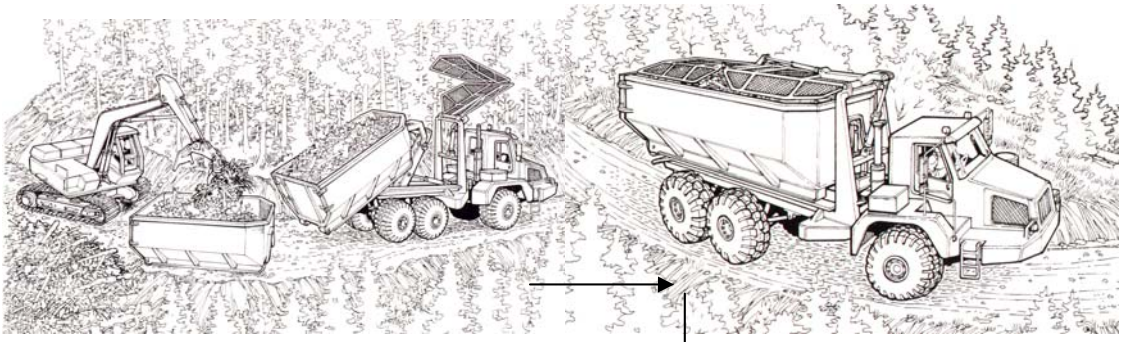
B. Nodal System with Roll-off Containers (Figure 1)
   1. Move loader to first site at logging job (at which slash has already been created and piled).
   2. Drive hook truck with roll-off containers to site, and offload containers.
   3. Load slash into roll-off containers.
   4 Pick up containers with hook truck.
   5. Drive truck to centralized location, or node, to dump slash.
   6. a. Once a minimum of 10-20 van loads have been accumulated, move "grinder" loader to centralized location.
      b. Move grinder to centralized location.
      c. Drive chip van to centralized location.
   7. Load grinder with slash and channel the resulting "hog fuel" into chip van.
   8. Transport hog fuel to a co-generating facility.
   9. Unload at co-generating facility.

C. Nodal System with Roll-off Containers and already-onsite Delimber
   1. Drive hook truck with roll-off containers to site, and offload containers.
   2. As part of whole tree log processing, delimb and load slash directly into roll/on off container.
   3. Pick up one container with hook truck (leaving other container to be loaded).
   4. Drive hook truck to centralized location, or node, to dump slash.
   5. a. Once a minimum of 10-20 van loads have been accumulated, move "grinder"

loader to centralized location.
b. Move grinder to centralized location.
c. Drive chip van to centralized location.

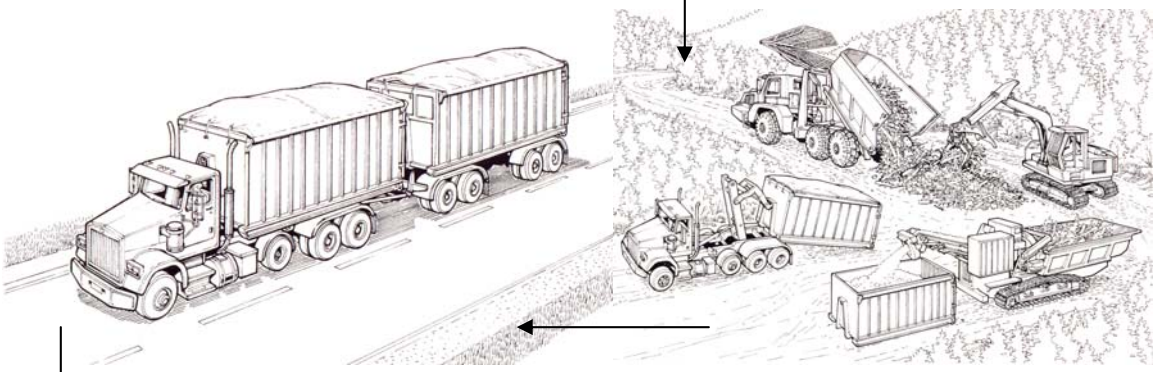
6. Load grinder and load resulting "hog fuel" directly into chip van.
7. Transport hog fuel to a co-generating facility.
8. Unload at co-generating facility.

(Note: Systems B and C have the advantage of allowing the grinder to be used continuously. As a result, these systems allow the daily transport of 9 to 10 chip van loads. In addition, Systems B and C are less subject to weather-created road conditions, because the equipment at the nodes is more likely to be located closer to county roads.)



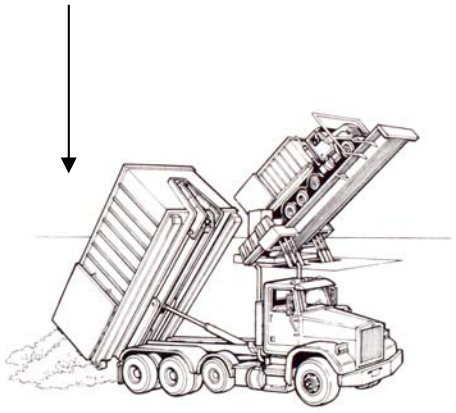
1. Actions in Woods

2. Transport on Logging Road

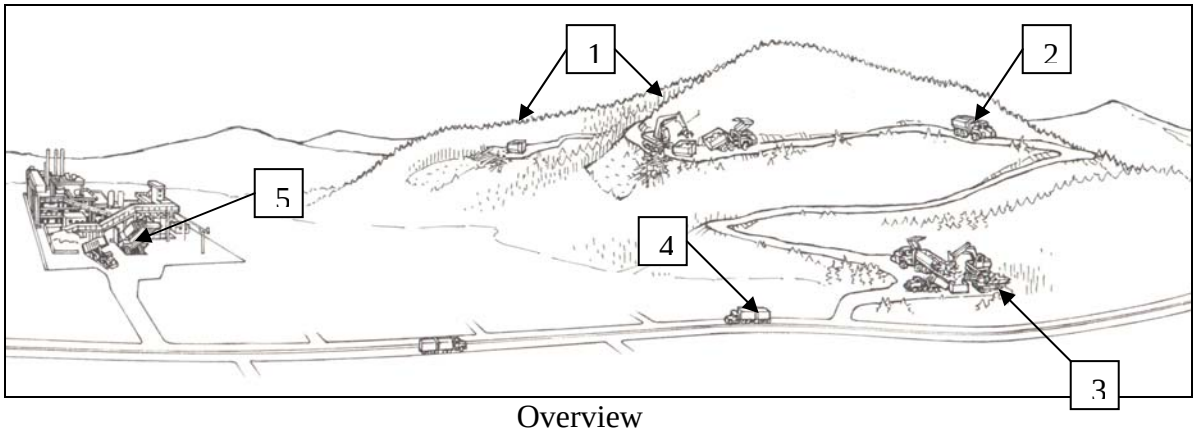


4. Transport on Highway

3. Actions at Landing



5. Unloading at Mill



Overview

Figure 1. Artist's conception of slash removal and transport using roll on/offcontainer technology.

Data was recorded and analyzed using scientific time/motion study methods. For systems B and C, the initial Transport cycle (from woods to landing area) was considered to consist of:

- Traveling to the woods with an empty container.
- Dropping the empty container.
- Loading the container.
- Transporting the loaded container to nodal site to be processed.
- Dumping the container.

Using this data, the Forest Operations Research Unit of the US Forest Service developed an Excel spreadsheet that incorporates variables such as type of equipment, hauling times, truck payload capacity, equipment operating costs, and labor costs. This downloadable spreadsheet can be used to determine the economic feasibility of operations similar to the systems tested, and to allow for quick financial assessment when system variables change.

Study Sites

(All tests conducted between May 24 & June 4, 2004)

Dry Creek

Although the Dry Creek study was the second in the series, the logistics involved were closest to System A (the current system), as described on page 5. Therefore it will be reviewed first.

The Dry Creek site is west of Missoula, 19 miles from the Smurfit-Stone pulp mill. This area was considered an excellent site for the test because of its proximity to the mill and the availability of material to be processed. At the site, the slash had been pre-bunched with a grapple skidder and stacked into piles with a log loader.

A modified Universal Refiner PDR-80-63 grinder (Figure 2) was positioned on a forest road and was fed by a log loader. The grinder loaded directly into either a chip van (Figures 3 & 4) or a roll on/off container.

Figure 2. At the Dry Creek study site, the grinder was a modified Universal Refiner PDR-80-63, 475-hp grinder with conveyor belt. The unit was converted to radio control and set on tracks. The loader operator controlled both the loader and the grinder.

Figure 3. A Daewoo Model 220LL Log loader was used to load slash into the Universal Refiner grinder at the Dry Creek site.

Figure 4. Loading chip van parked on forest road. 120 CY chip van shown.

The chip van proceeded directly to Smurfit-Stone after loading. However, since the road by the grinder was narrow and thus allowed for only one tractor/trailer rig at a time, the container truck driver devised the following logistical routine for parking by the grinder: He would park his pup trailer at a staging area about 1/4-mile from the grinder. Then, back at the logging site, once a container was loaded the driver would place the second empty container next to it and take the full container down to load it on the pup trailer. After his second empty container was loaded he would travel down to the staging area, attach the loaded pup trailer and container and proceed directly to Smurfit-Stone.

It should also be noted that at the loading site, the driver of the roll on/off container truck experimented by tilting the front end of the container up to aid in loading more quickly (Figure 5).

Figure 5. Loading tilted roll on/off container while on truck.

Cowboy Gulch

This study site was on Plum Creek Timber Company property in the Cowboy Gulch area north of Bonner, MT. The site was chosen because it is a difficult area to collect slash due to the characteristics of the steep terrain and narrow but adequate roads. The logistics of the operation at this site conformed to the above description of System B (Nodal System with Roll on/off Containers).

Slash was collected at three different areas in Cowboy Gulch. In the first area, the slash was piled at a log landing. One concept tested involved a Bucyrus-Erie crane (Figure 6) loading a stationary roll on/off container which was picked up (Figure 7) and hauled 1.3 miles down a forest road to the Stimpson Timber Company mill yard in Bonner for grinding a few days later. One container on the truck was used to transport material while the other container was being loaded.

Figure 6. Crane loading a roll on/off container. The Bucyrus-Erie 22B Transit crane was equipped with a locally-manufactured cable grapple. The crane had a 40-ft boom which allowed it to reach down over steep road embankments.

Figure 7. Loading roll on/off container for transport. The roll on/off container truck system used in the study was a cabover Freightliner tractor (430 hp) with a Stellar Industries hooklift conversion and a pup trailer. The roll on/off containers had a capacity of 48 cubic yards each. This system was leased from DCT Chambers of Vernon, British Columbia.

Slash was also hauled out using a 31.7 cubic yard capacity off-highway, 500-hp dump truck (Figure 8). The truck was very stout and should hold up well in the forest road environment. However it was not geared properly for the task at hand. It also had a large turning radius, which made it difficult to negotiate the sharper switchbacks in the mountain roads.

Figure 8. Slash was also hauled in a Caterpillar Model 769C off-highway dump truck (31.7 CY, rated 36 tons max.).

The second slash area in Cowboy Gulch was located on the downhill side of a forest road that was 1.5 miles up the road from the Stimpson mill yard. The roll on/off containers were placed on a forest road and filled by the Bucyrus-Erie crane (Figure 9). The container truck was able to turn around in a wide spot in the road next to the container.

Figure 9. Loading roadside staged roll on/off container.

A third area six miles up Cowboy Gulch was also used. The crane loaded slash from the downhill side of a small roadside landing (Figure 10).

Figure 10. Loading the off-highway dump truck and roll on/off container at roadside landing.

Samples of the slash coming off the hill were weighed on the Stimpson mill scales. Three roll on/off containers of slash averaged 19,000 pounds. The slash from all three Cowboy Gulch areas was stockpiled at the Stimpson mill yard (Figure 11) and later loaded and processed by a Bandit Model 3680 Beast (tracked) recycler (Figure 12).

Figure 11. Unloading roll on/off container contents at Stimpson mill yard.

Figure 12. Grinding operation at Stimpson mill yard. A Komatsu log loader was used to feed a Bandit Model 3680 Beast recycler. The Beast had an optional 62-hp centrifuge blower to load chips. “Hog fuel” was blown directly into either a chip van or roll on/off container truck with pup trailer.

The “hog fuel” was blown into a chip van (Figure 13) or a roll on/off container truck and pup trailer (Figure 14) for transport to the Smurfit-Stone pulp mill, which was 14.8 miles away (Figure 15). Samples of the hogged slash averaged 38% moisture content. The transport vehicles involved in the study were accurately tracked with GPS technology (Figure 16).

Figure 13. 148 cubic yard capacity chip vans were also used in the study. They could only haul about 34 tons (green) of product due to legal maximum weight restrictions.

Figure 14. Roll on/off container truck system complete with roll on/off pup trailer.

Figure 15. Chip van being unloaded at Smurfit-Stone. Roll on/off container truck unloading in the background.

Montana Truck Highway Speed

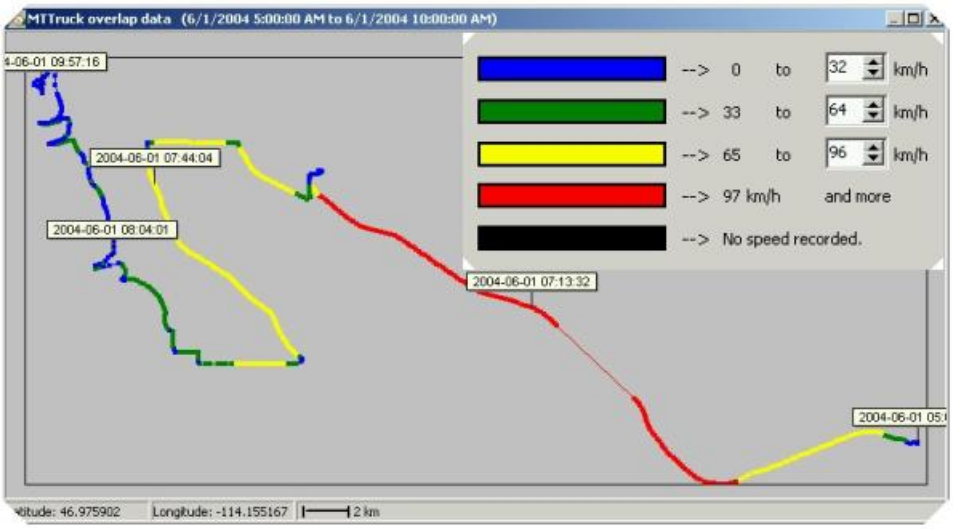


Figure 16. Transport truck distance and speed were accurately monitored with GPS technology.

Tarkio

The Tarkio site was an active logging sale 40 miles west of Missoula, MT, and 39 miles from Smurfit-Stone. The typical pre-study procedure at this site had been as follows: Whole trees were skidded to the landing, then, by means of a strokeboom delimber, the trees were processed into a deck of logs and a pile of slash. Once the slash started to interfere with the delimbing activity, it was repositioned on the landing using the strokeboom delimber. (These slash piles were typically burned at a later date, or a grinder and chip van were brought in to process the material for hog fuel.)

For the study, the above procedure was varied, in order to test the first steps of System C (Nodal System with Roll on/off Containers and Delimber). In other words, instead of repositioning the slash into piles on the side of the landing, the strokeboom delimber simply loaded the slash directly into a roll on/off container positioned on the landing. The full container was then picked up and driven several hundred feet down the road and unloaded for future grinding operations. (As this process was perfected over the course of the study, it was discovered that the use of containers created more room at the landing for stacking logs.)

Figure 17. Daewoo DH280 with Denis strokeboom delimber loading slash into roll on/off container.

Summary of Results

In order to compare bin transport options with conventional hauling, production and cost data from the study were summarized and a spreadsheet model of forest residue transport costs was developed. The computer model will be available in early 2005 at http://www.srs.fs.usda.gov/forestops and also on the Montana Community Development Corporation website (www.mtcdc.org).

Results can be summarized as follows:

Loading

• The Bucyrus-Erie crane filled a container in about 33.7 minutes. Using container volumes, this would be a production rate of about 10.5 bone dry tons (bdt) per hour.

• The stroke boom delimber took an average of 46 minutes to produce enough limbs to fill a container. 34 minutes of that time was spent delimbing, trimming, and stacking logs; 12 minutes was spent actually loading limbs into the container. This process resulted in an average production rate of 28 bdt per hour.

• If the strokeboom delimber is considered as part of the regular processing operation, then using this piece of equipment to directly fill roll on/off containers would be the most cost-effective approach.

• During the study, significant delay time (and extra labor costs) were incurred as the dump truck waited for the crane to completely fill its box. This delay time did not occur with the roll on/off container truck because while one bin was being filled the other one was being shuttled to and from the grinder.

• With the cable loader, a single container truck (with pup trailer) would be able to keep ahead of loading as long as the forest road haul was less than 5 miles. If the forest road haul was longer than 5 miles, additional containers and trucks would be necessary.

Grinding

• The Universal Refinery Contender grinder took an average of 20 minutes to fill a [roll on/off] container (22 bdt per hour).

Transporting

• Travel speeds (collected using GPS units on vehicles) averaged 60 mph on interstate highway, 50 mph on 2-lane highway, 30 mph on graveled county road, and 10.5 mph on logging roads.

Total Cost

• Costs were calculated for a system that uses a delimber directly loading roll on/off containers, which in turn carry slash 2.5 miles on a woods road to a centrally-located grinder, with the resultant hog fuel being transported 30 miles on a highway to a generating facility*. The resulting total cost is about $22/bdt, or $26.40/bdu.** About 40 percent of this cost is in the rehandling and chipping function. The swing container costs are another 40 percent, and the final 20 percent is highway transport.

> *This system conformed this study's definition of System C: a Nodal System with Roll-off Containers and already-onsite Delimber.
>
> **(1 bdu = 1 bone dry unit = 2400 lbs. of oven-dry fuel. Therefore a bdt or bone dry ton = 0.83 bdu's.)

• The delivered cost of hog fuel can easily vary by 50 percent with relatively small changes that affect system balance.

Disclaimers

Due to insufficient data resulting from bad weather and equipment problems, some of the tests initiated and equipment used were not included in the final analysis.

For instance, the off-highway dump truck data was not analyzed because there were only three cycles of data. In addition, the dump truck was much more costly to use than the roll on/off containers because of two factors. First, the dump truck had to sit idle during the loading phase, whereas the container truck could drop off a container to be filled while it shuttled a second container to and from the grinder. Second, the dump truck's load size was smaller than that of the roll on/off container.

The Bandit Beast was another piece of equipment whose production data were not analyzed.

Discussion

Chip vans are the most cost-efficient mode of transporting wood chips, *provided* the roads are suitable for the truck. However, there is a tremendous amount of logging slash that is not being utilized as hog fuel because it can't be accessed by chip vans, even when it is located close to the processing plant. The use of roll on/off containers makes this material accessible because the trucks that carry them can navigate narrow, windy, mountainous roads. This fact increases the *amount* of material available to businesses and reduces the transportation cost of material being hauled from long distances. It can also reduce air pollution, since fewer "open" piles need to be burned.

It is important to recognize that the cost of supplying hog fuel is sensitive to a number of variables and that each situation needs to be carefully examined. Several ways of using the containers can be considered. The containers can be used to haul slash (swing transport) to a central grinding location that has access to chip vans. This can be done either by "hot" loading the slash during an active logging operation, or loading slash after the logging is completed. Each situation has its advantages and disadvantages.

"Hot" loading can provide a "two birds with one stone" advantage. That is, it can allow the economical use of a piece of equipment, such as the strokeboom delimber, that is already on site. This machine and its operator would ordinarily already be handling slash piles for later disposal in the course of a logging operation. However, if the delimber deposits slash directly into containers, then slash is handled one less time—and the use of extra equipment is avoided. (See System C above: "Nodal System with Roll on/off Containers and Delimber".) This can provide substantial savings for the overall operation.

In yet another hot loading situation, the containers can be used to directly haul hog fuel to the processing plant when the grinder can be used at the landing site, provided the plant is not too far away.

Obviously, there are myriad combinations of variables, but the spreadsheet model developed by this project can provide substantial help in quickly evaluating these variables to see how they might affect total cost.

One thing that became apparent was the importance of the cleanliness of the slash. Contaminants such as dirt or rocks create the need for increased maintenance of the grinders, and cause problems for equipment such as boilers and scrubbers within co-generation facilities. Dirt and rocks can be introduced through activities such as dragging the slash through the woods or pushing it into piles with a dozer or front end loader. If piles are left near the sides of roads for extended periods, there is also the chance that road maintenance graders could add to the dirt and rock content of the pile. The delimber-with-container configuration (System C) helps avoid contamination by eliminating the steps in which slash is place on or dragged over the ground.

Conclusions

For any given distance, a roll on/off container system is not competitive with a regular highway chip van, *unless* part of that distance is inaccessible to the chip van. The roll on/off container system allows for recovery of residue from difficult-to-access locations.

A hot-loaded roll on/off container system traveling a short distance can be competitive with a chip van traveling long distances over the highway.

If the handling of slash can be incorporated into an active logging operation, there may be an opportunity to substantially reduce the cost of producing hog fuel. For instance, if strokeboom cost is considered to be part of the regular processing operation, then the roll on/off container system may be economical when used in conjunction with a strokeboom delimber. In fact, under the right conditions, this system can yield 9 to 10 chip van loads per day, as opposed to the current system's 3 to 4 loads.

There are many variables to consider when determining the cost of hog fuel production and a simple spreadsheet model has been developed to help evaluate those variables as users choose the best combination of options.

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