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Chipping logging residues with a delimber-debarker chipper

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ABSTRACT

FPInnovations monitored a residue chipping operation utilizing a delimber-debarker chipper on Vancouver Island.

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1. INTRODUCTION

There is a limited supply of economically affordable biomass in coastal British Columbia and competition for it is increasing. Biomass users are looking at existing sources of biomass that have been previously neglected due to lack of market, high cost, or contamination. Traditionally, it has been assumed that logging residue was too small (piece size) or too contaminated to make good quality chip feedstock. However, feedstocks derived from the chipping of logging residue may become viable if they can be harvested in a cost effective manner while meeting standards demanded by industry.

Campbell River Fibre (CRF) is attempting to develop an effective logging residue chipping operation in the mid-Vancouver Island region. The use of forwarders and bunk style logging trailer (hayracks) to haul residual tops to the chipper marks a first in the coastal bioenergy market. FPInnovations in partnership with Campbell River Fibre is monitoring CRF's logging residue chipping operation to determine productivities and best practices in this new endeavor.

2. METHODOLOGY

Summary

Moisture content sampling was performed for each load of chips throughout the trial and timing was recorded for all machines utilized. The number of turns and the volume of the turns were recorded for the skidders, hayracks and forwarder used to bring residue to the chipper. Chip loading times were recorded throughout the trial. Analysis was done to determine costing for each of the locations.

Site Description

Three sites were chosen for the trial.

Cumberland

The Cumberland trial site consisted of a mostly flat area near Cumberland, BC. The species consisted of approximately 90% second growth Douglas-fir with some western hemlock and western redcedar.

Buckley Bay

The Buckley Bay trial site terrain consisted of moderate slopes and benches and was located between Courtenay and Qualicum Bay, BC. The species mix consisted of 90% second growth Douglas-fir with some western hemlock and western redcedar.

Kay Creek

The Kay Creek trial site terrain consisted of steep slopes and benches and was located between Campbell River and Sayward, BC. The species consisted of 70% second growth western hemlock, 20% western redcedar and 10% amabilis fir.

Description of operation

Machines

Log loaders

A Hyundai log loader and a Hitachi log loader with power grapple attachments were used to pre-pile the residue in bunches in preparation for the skidder, forwarder or hayrack to haul to the chipper. They were also used to clean up around the landing and assist the chipper by moving residue within reach of the chipper's grapple. Loaders were used in the Buckley Bay site to load and unload hayracks (see Figure 1).

Figure 1. Hyundai log loader

Chipper

A Peterson 5000G delimber-debarker portable chipper was used to chip the residue (see Figure 2).

Figure 2. Peterson 5000G delimber-debarker portable chipper

Forwarder

A John Deere 1710D forwarder was used to haul residue to the chipper at the Cumberland site (see Figure 3). It was also used in a limited capacity to remove the chipper debris away from the chipper.

Figure 3. John Deere 1710D forwarder

Skidders

A Timberjack 460 grapple skidder was used to haul residue and support the chipper at the Cumberland site. A CAT 585B and Tigercat 630B grapple skidder were used to support the chipper at the Buckley Bay site and to haul residue and support the chipper at the Kay Creek site. The blades on the skidders were used to clear debris away from the chipper (see Figure 4). The skidders also hauled the chipper debris back to the cutblock.

Figure 4. Timberjack 460 grapple skidder

Hayracks

Two, three-axle hayrack trailers were used to haul residue to the chipper at the Buckley Bay site. The trailers were loaded in the cutblock and unloaded at the chipper with front-end loaders (see Figure 5). Tridem powered trucks hauled the trailers.

Figure 5. Hayrack filled with logging residue

Trucks

53 ft walking floor trailers were used to haul the chips to Campbell River Fiber (see Figure 6).

Figure 6. Tri-drive truck with 53 ft trailer

Operational overview

Pre-chipping

Prior to chipping, log loaders sort the debris to facilitate its transport to the chipper by skidders, forwarder or hayracks. Debris tops were collected and placed into bunches that could be easily picked up by the skidder's or forwarder's grapples (see Figure 7) or loaded onto hayracks by the log loader. Long butts and brush were left in the cutblock since the chipper could not chip pieces shorter than three meters. Pieces with excessive rot, sweep or crooks were also left behind because they have a tendency for getting stuck in the infeed of the chipper.

Figure 7. Typical turn pre-piled by log loader and transported by skidder to chipper

Chipper setup

The chipper had to be placed in a manner that would allow the following:

- Easy access for loading of the trucks.
- Easy removal of debris, even while the chipper was operating.
- Sufficient space for logging residue to sit in front of the intake.
- Sufficient space for incoming residue to be dropped and moved into reach of the chipper grapple by the skidder or forwarder.

Chipper sites are usually chosen near the center of the block to minimize the number of moves necessary and reduce the distance for the skidder, forwarder or hayrack to travel. The back of the chipper is usually angled away from the road center to allow access for the skidder to clear debris between its turns.

Residue is placed behind the chipper with the butt of the pieces facing towards the chipper infeed (see Figure 8) so that handling is easier. Piles are made to either side of the intake (where possible) to allow easy delivery of residue and to allow the chipper operator to roll material off the piles and into the area directly in front of the infeed.

Figure 8. Residue piled butt first for chipping

Feedstock collection

The skidder and forwarder travelled into the cutblock and retrieved the pre-piled turns. The skidder operators were usually able to combine two bunches to increase turn size. Operators determined that the forwarder was better suited to gather the residue that was further from the chipper because of its larger load capacity. This allowed the skidder to concentrate on making more short distance turns and increased the number of times it could return chipper debris to the cutblock, reducing the clutter around the chipper.

Hayracks were loaded and unloaded by the log loaders. Residue was placed into the trailers in two bundles, butt forwards. The two hayracks alternated between being loaded in the cutblock and unloaded at the chipper.

Chipping

The chipper filled the trailers from front to back (see Figure 9). The truck drivers moved the truck forward when required.

Figure 9. Chips being loaded into trailer

Moisture content

A chip sample was collected from each load of chips and was weighed at the time of collection. The samples were then transported back to the FPInnovations office in Vancouver and were heated to 200F for 24 hours and then weighed again. Moisture content was assessed using the wet basis formula.

Production

Timing

Chipper load times, as well as skidder, forwarder and hayrack turn times were collected using a stopwatch. Overall timing was collected using FPInnovations Multidat data collection devices. The MultiDats were downloaded daily.

Weights

Chip load weights were assessed in green tonnes by the scale located at Campbell River Fibre.

Volumes

Turn volumes for the skidder, forwarder and hayracks were collected visually due to the difficulty in collecting weights by scale for these machines. Turn volumes were also derived by taking the total load oven dry weights and multiplying by the density of the wood to get a total volume throughout the trial. Using the visual data as a means of determining size by comparison between turns, the average turn sizes for both machines were established.

3. RESULTS AND DISCUSSION

Moisture

Moisture content was highest at the Cumberland site at 46.1%. This was due to the short period of time between the initial harvest and the chipping operation as well as the time of year that the residues were harvested (see Table 1). It would be expected that the winter months of February and March would produce higher MC's than the autumn month of October. Both Buckley Bay and Kay Creek had lower moisture content because of the longer period of time between initial and secondary harvest, although Kay Creek was higher due to the time of year that the residues were harvested.

Table 1. Moisture content of chips

Date	Location	Moisture content (%)
March 2015	Cumberland	46.1
October 2015	Buckley Bay	25.7
February 2016	Kay Creek	35.0

Production

Chipper

Load Times

Load times when the operation started in Cumberland averaged approximately 64 minutes per load but decreased to approximately 52 minutes in Buckley Bay and 48 minutes in Kay Creek as the operators became more proficient with their machines and determined the most efficient way to interact (see Figure 10). Common sources of chipping delay occur when oversize materials clog the chute located in front of the chipper disc or breakdown and/or jam up of the debris pusher. These delays were common in Cumberland but decreased at the other sites as the operators became better at reading what the machine could handle.

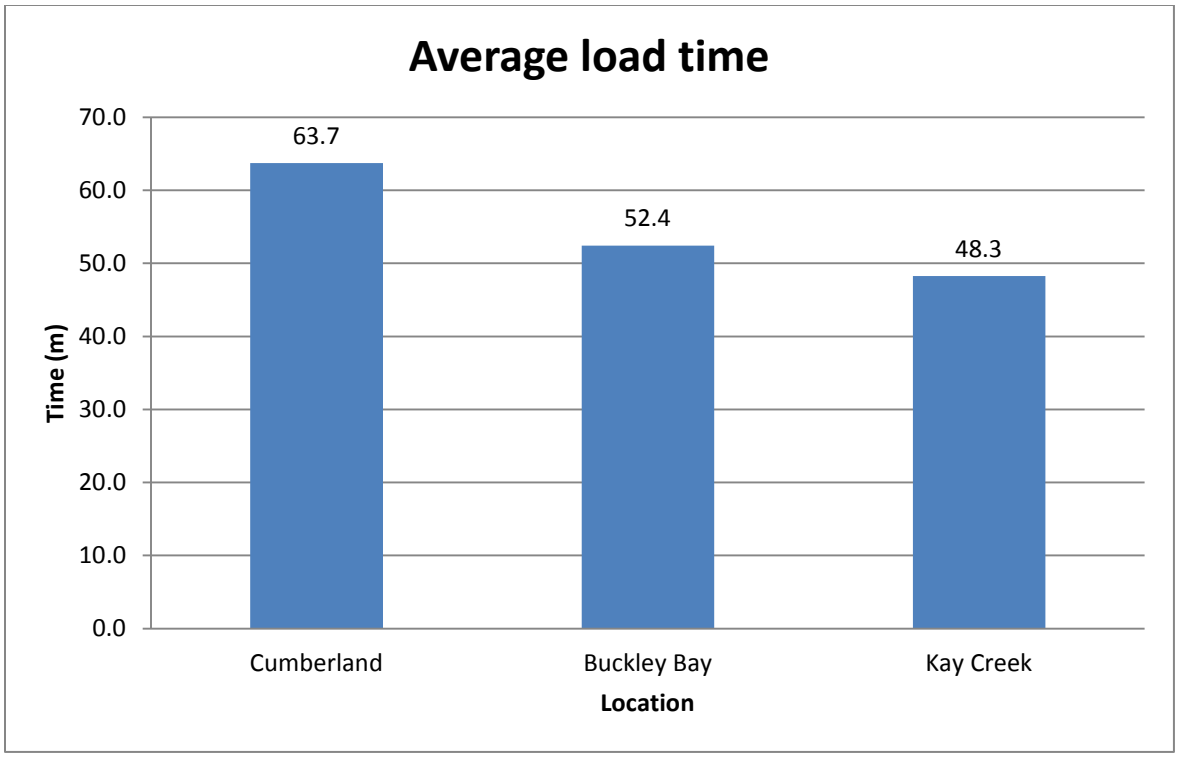

Figure 10. Chipper loading time

The number of loads per day increased from 4.8 loads per day at Cumberland to 6.5 loads per day at Kay Creek (see Table 2). This also displays the improvement in the operation as a whole. The operators feel that with more trucks available they could further increase the number of loads per day they produce.

Table 2. Chip loads per day by location

Location	Loads per day
Cumberland	4.8
Buckley Bay	6
Kay Creek	6.5

Trucks

Load Size

The load sizes (see Figure 11) varied from 15.1 odt per load in Cumberland to 16.1 odt per load in Buckley Bay and are correlated with the moisture content of the chips. When chip moisture content was high, overall green volume was high and oven dry volume was low. The reverse was true when moisture content was low.

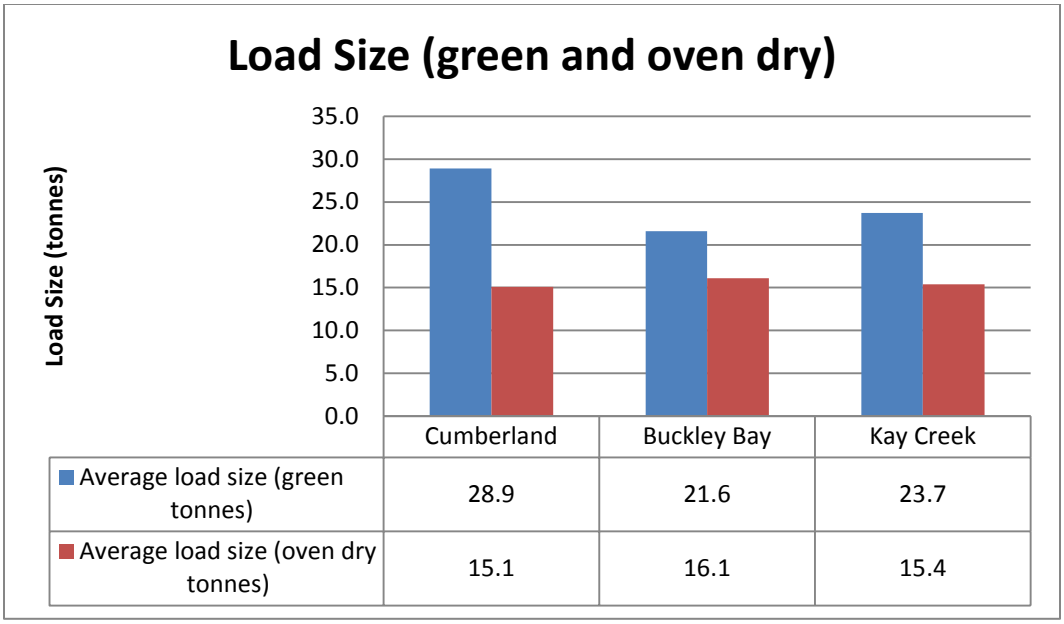

Figure 11. Load size

Skidders

Although the skidders carry less volume per turn than the forwarder or hayracks, they play an important part in the operation with their versatility and speed. The skidders also play a crucial role in clearing space in front of the chipper by returning debris to the cutover. Skidders were utilized in all three sites, although they were only used to move residue from the cutblock to the chipper at the Cumberland and Kay Creek sites.

Average turn size of the chippers was 1.7 m^3 per turn with little variability between the Cumberland and Kay Creek sites (see Table 3). Average turns per productive hour were approximately 6. There was little difference in turn time length between the Cumberland and Kay Creek sites, although this can vary depending on chipper location and road configuration.

Table 3. Summary of skidder productivity

Skidders	Average turn size (m^3)	Turns per productive machine hour
Cumberland	1.75	6.1
Kay Creek	1.65	5.8
Average	1.7	5.95

Forwarder

The forwarder has the capability to carry larger loads than the skidder and is more versatile than the hayracks because it can load materials independently (i.e. no loader necessary). The forwarder was only used at the Cumberland site in a limited capacity, but due to severe mechanical difficulties it was not used the entire time. Average load size of the forwarder was 7.8 m^3 (see Table 4). Average turns per productive hour were determined to be 0.95.

The operator believes that the forwarder could be a very effective tool for gathering residue because of its ability to maneuver off road and its self-loading capability. The capability of the forwarder to feed the chipper would also allow the chipper's grapple arm to perform other clean up functions around the chipper without impeding chipper production.

Table 4. Summary of forwarder productivity

Location	Average turn size (m^3)	Turns per productive machine hour
Cumberland	7.8	0.95

Hayracks

The hayracks were utilized at the Buckley Bay site. They can transport the largest volume of the three machine types used; however, they require a companion grapple loader. Average turn size of the hayracks was 30.4 m^3 (see Table 5). Turn time length was much longer than the skidders at 0.6 turns per hour.

Table 5. Summary of hayrack productivity

Location	Average turn size (m^3)	Turns per productive machine hour
Buckley Bay	30.4	0.6

The hayracks had difficulty turning around in some locations and needed the companion loader to turn the trailers.

Operational comparison

The total volume of residue per productive machine hour being transported from the cutover to the chipper was calculated for each of the trial sites (see Table 6). The Cumberland site and the Kay Creek site were similar at 18 and 19 m^3 per productive hour, respectively. The Buckley Bay site was substantially larger at approximately 36.5 m^3 per productive hour. This is reflected by the researcher's impressions that the machines in the Cumberland site and Kay Creek site were simply keeping up with the chipper, whereas the hayracks were creating a surplus for the chipper.

Table 6. Volume per productive machine hour comparison for three trial sites

Locations	Machine	Number of machines	Average turn size (m^3)	Turns per productive hour	Volume per productive hour (m^3)
Cumberland	Skidder	1	1.75	6.1	10.68
Cumberland	Forwarder	1	7.8	0.95	7.41
Cumberland Total					18.09
Buckley Bay	Hayrack 1	1	30.4	0.6	18.24
Buckley Bay	Hayrack 2	1	30.4	0.6	18.24
Buckley Bay Total					36.48
Kay Creek	Skidder 1	1	1.65	5.8	9.57
Kay Creek	Skidder 2	1	1.65	5.8	9.57
Kay Creek Total					19.14

It should be noted that Table 6 shows only the gross volume being transported to the chipper and not the cost associated with the respective volumes. The costing analysis below details the associated costs with each operational setup.

Cost analysis

A costing analysis was performed to compare the operating costs between the different operational configurations and to determine whether site or operational cost should be used determine the appropriate configuration.

In order to simplify the comparison a number of costs were removed from analysis because they were consistent throughout the trial. These assumptions were made:

1. Chipper operating cost – the chipper was never required to wait for material so an assumption was made that the chipper could operate effectively at 18 m^3 delivered per productive hour.
2. Pre-piling costs – it is assumed that pre-piling costs are consistent throughout the three sites.
3. Trucks – it is assumed that the number of trucks available was consistent throughout the three sites.
4. Utilization – it is assumed that the utilization of the support and delivery machines were similar.
5. Total volume – An arbitrary value of 500 m^3 of residue was used throughout the scenarios.

Tables 7, 8 and 9 show the cost to deliver and support the chipper for each of the sites in relation to the machines they utilized. Scheduled machine hours were determined using the volume per productive machine hour and a utilization value of 85%. Machine costs per scheduled hour were quoted by the operator.

Table 7. Total chipper delivery cost for 500 m^3 of residue at Cumberland site

Machines	Cost per scheduled hour ($)	Volume (m^3)	SMH	Total Cost ($)
Skidder	$120	500	32.5	$3,900
Forwarder	$170	500	32.5	$5,525
Loader - chipper assist	$130	500	32.5	$4,225
				$13,650

Table 8. Total chipper delivery cost for 500 m^3 of residue at Buckley Bay

Machines	Cost per scheduled hour ($)	Volume (m^3)	SMH	Total Cost ($)
Hayrack 1	$120	500	16.1	$1,932
Hayrack 2	$120	500	16.1	$1,932
Loader 1 – truck loading	$130	500	16.1	$2,093
Loader 2 – truck unloading and chipper assist	$130	500	32.2	$4,186
Support skidder	$120	500	16.1	$1,932
				$12,075

Table 9. Total chipper delivery cost for 500 m^3 of residue at Kay Creek

Machines	Cost per scheduled hour ($)	Volume (m^3)	SMH	Total Cost ($)
Skidder 1	$120	500	30.7	$3,684
Skidder 2	$120	500	30.7	$3,684
Loader – chipper assist	$130	500	30.7	$3,991
				$11,359

The costing analyses show that the Kay Creek configuration of two skidders had the lowest cost per cubic metre by a small margin, followed by the hayrack configuration utilized at Buckley Bay. However, it should be noted that the configurations utilized at these two sites were likely the best choices for the specific site (see Table 10).

Residue located long distances (> 1 km) from the chipper in Buckley Bay would likely have slowed down the skidder's delivery time and the narrow roads located at Kay Creek would have prevented the hayracks from turning around. Although the Cumberland site had the highest cost, it was the first site monitored so lower productivity as the operators learned the system was not unexpected.

Table 10. Summary of machine configuration best practice determined by road width and residue distance from chipper

Configuration	Road width	Residue distance from chipper
Hayracks and log loader	Wide	Long (> 1 km)
Multiple skidders	Narrow	Short (< 1 km)

4. GOING FORWARD

As stated earlier, the operator is interested in purchasing a higher quality forwarder. It would be extremely useful to document operational productivity with the forwarder added to the machine configurations.

Another useful exercise may be to document shift level productivity if more trucks are available. This may highlight the proficiency of certain machine configurations in keeping up with the supply of residue for the chipper.

5. CONCLUSIONS

FPInnovations monitored a logging residue chipping operation at three sites on Vancouver Island in 2015 and 2016. Three different configurations of machine were used to supply the chipper with residue. Productivity was assessed for each configuration and basic costing performed in order to compare the configurations. The costing analysis showed a slight cost difference between the configurations used at each site. Terrain and road conditions dictate the configuration to be utilized. For example, the hayracks could only be utilized at the Buckley Bay site and the use of skidders would have increased the cost exponentially due to the distance between the chipper location and the residues.

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