Harvesting residual woody biomass in Pine Plantations in South West Western Australia

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Introduction

Previous trials conducted by the CRC for Forestry and AFORA (Ghaffariyan and Andorovski, 2011; Ghaffariyan et al. 2011) have confirmed that separate biomass harvesting systems can be expensive due to the high operating cost of the biomass technologies and low productivity. Integrated biomass harvesting can be an applicable and economically viable method for forest biomass collection. In pine plantations harvested by harvester and forwarder, any additional residue logs (conventionally called Fibre-plus in NSW) can be extracted after sawlog and chiplog recovery, to reduce the operating costs of biomass recovery (Walsh and Strandgard 2014). This study evaluated the productivity, cost, yield, machine fuel consumption and total biomass recovery.

Study area and research method

The study site was located in Baudin, a *Pinus radiata* plantation in the Sunklands, south east of Busselton – south west Western Australia. The study site was flat and even with sandy soil types. The stand had been thinned and was 32 years old with an average DBHOB of 42.1 cm (average volume of 1.53 m^3) when it was clear felled. The harvesting system consisted of a harvester/processor (Cat 541) with a Rosin RD977 processing head and a forwarder (Valmet 890.3) operating with a cut-to-length method. The study site was divided into a control plot and a Fibre-plus plot (1.1 ha and 1.2 ha). In both plots the harvester felled and processed the trees into sawlogs and chip logs to be extracted by the forwarder. In the Fibre-plus plot the harvester also produced Fibre plus material from tops or other woody waste material, which was extracted by the forwarder once the sawlogs and chiplogs had been extracted. The Fibre-plus logs were transported prior to being chipped.

A standard time study and costing method was applied to measure the productivity and cost of the machines (Magagnotti and Spinelli, 2012). Harvesting residues were estimated using the left-slash measurement approach developed by CRC Forestry/AFORA and coarse woody debris line transects to estimate the retained stem wood material.

Table 1. Product specifications

Product	Min SED (mm)	Min length (m)	Max length (m)
Sawlog	200	3.6	6.1
Chiplog	75	3.5	5.4
Fibre-plus	0	3.5	unrestricted

Results

Yield

The Fibre-plus plot treatment produced a higher yield than the control plot, which was mainly due to the additional Fibre-plus material (Table 2).

Table 2. Yield (m^3/ha) by product from each study plot

Products	Control plot (m^3/ha)	Fibre-plus plot (m^3/ha)
Sawlog	325.8	321.1
Chiplog	53.4	33.5
Fibre-plus	0	36.6
Total harvest	379.1	391.3

Machine efficiency

The study treatment (control or Fibre-plus) did not have a significant effect on harvester productivity. DBHOB was found to be the most significant factor affecting harvester cycle time (Figure 1).

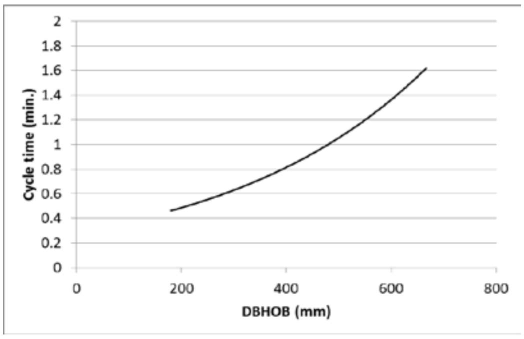

Figure 1. Impact of DBHOB on harvester cycle time

From the statistical model for predicting forwarding time (including travel unloaded, loading, moving during loading, travel loaded, unloading, moving during unloading) the extraction distance, load volume, product type and study treatment (control or Fibre plus) were found to be significant factors. For the average load volume (19.7 m^3) the forwarding time per cycle was graphed under different extraction distances for the three different product types, namely: saw-logs, chiplogs and Fibre-plus logs (Figure 2). Figure 3 presents the impact of load volume on forwarding time per cycle for the average extraction distance of 107 m. Longer extraction distance and lower volume increased time consumption. In all cases, forwarder time consumption was least for sawlogs and greatest for Fibre-plus logs and chip logs, due to the effect of piece size (Heinimann et al. 1998) and the amount of each product produced per harvested area (Nurminen et al. 2006).

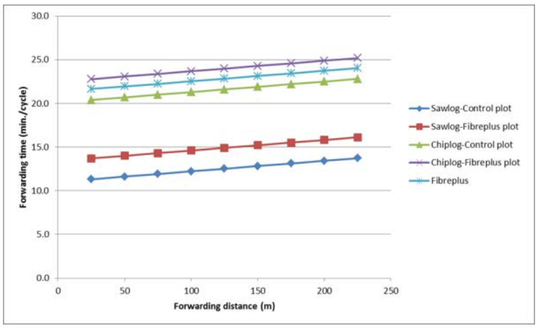

Figure 2. Effect of extraction distance on forwarding cycle time

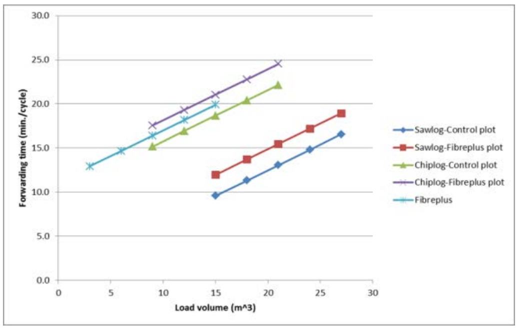

Figure 3. Effect of load volume on forwarding cycle time

Productivity and cost analysis

Unit cost was derived by dividing the hourly rate by the productivity (Table 3). There was no difference in harvesting cost between the two treatments. In contrast, forwarding cost was higher for the Fibre-plus site, due to the lower productivity.

Table 3. Productivity and cost of the harvesting machine in the two study plots

Treatment	Stems per ha	Machine	Productivity (m3/PMH0)	Machine cost ($/PMH0)	Cost ($/m3)
Control	247.3	Harvester	89.6	284.9	3.2
		Forwarder	85.9	193.1	2.2
					Total: 5.4
Fibre-plus	255.0	Harvester	88.3	284.9	3.2
		Forwarder	71.2	193.1	2.7
					Total: 5.9

The forwarder extracted each product separately in each plot, which resulted in different productivities and costs (Table 4). Fibre-plus extraction yielded the lowest productivity and the highest extraction cost. The productivity of the chiplog extraction on the Fibre-plus plot was less than that on the Control plots because the forwarder operator had to separate chiplogs and fibreplus logs while loading the chiplogs.

Table 4. Forwarder productivity and cost for each product type for both plots

Treatment	Extraction type	Productivity (m3/PMH0)	Cost ($/m3)
Control	Sawlog	91.4	2.1
	Chiplog	64.1	3.0
Fibre-plus	Sawlog	85.5	2.3
	Chiplog	33.0	5.85
	Fibre-plus	35.7	5.4

Fuel consumption

The average fuel consumption of the harvester in this case study was 51.9 l/h (0.58 l/m3) for both study sites. The forwarder's fuel consumption for the control plot was 16.4 l/h (0.19 l/m3) which was slightly less than for the Fibre-plus plot, (16.9 l/h (0.24 l/m3)).

Harvesting residues

In the control plot, there was 144.2 GMt/ha of harvesting residues (average moisture content 55%) remaining on the site, while in the Fibre-plus plot the average weight of harvesting residues was lower, 103.2 GMt/ha (average moisture content 51%) due to the additional biomass recovery from the harvesting operation. Some residue stem wood in the Fibre-plus site was collected by the forwarder, which resulted in 9.1 GMt/ha stem wood left on the Fibre-plus site after the operations, while in the control plot, the weight of the left stem wood was almost double at 18.1 GMt/ha.

Comparing results with NSW trial

Previous Fibre-plus recovery in a 34-year-old radiata pine plantation near Tumut (NSW) resulted in 14% reduction in forwarder's productivity (Walsh and Strandgard 2014) although in this case study productivity decreased by 17% in Fibre-plus recovery. Harvester's productivity was not impacted by Fibre-plus recovery in both studies. In the NSW case study, Fibre-plus provided 23 GMt/ha in additional recovery while in this case study the recovery was higher (36.6 GMt/ha).

Take-home messages

- Integrating biomass harvesting with conventional sawlog recovery resulted in higher yield per ha due to additional fibre collected and available for bioenergy use.
- Harvester productivity was unaffected by cutting the additional Fibre-plus product.
- Forwarding cost increased for integrated biomass utilisation, because of the longer working time spent collecting small logs.
- To reduce extraction cost, it may be possible to use modified forwarders, whose performance should be addressed by future research (Ghaffariyan et al. 2012).
- The high amount of left residues in this trial (> 100 GMt/ha) will probably not cause a major problem for soil fertility in the next rotation, due to low nutrient removal.

Acknowledgements

The authors acknowledge Martin Strandgard for his assistance with data preparation; the Forest Products Commission (FPC) for supporting this research by providing the plantation site, harvesting contractors, equipment and resources; and Westgen for their support with the field work.

More information

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