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Comparing the efficiency of four harvesting methods in a blue gum plantation in south-west Western Australia

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Introduction

Harvesting operations form the lion's share of plantation management costs. As a result, it is important to select the appropriate harvesting method to achieve lower total logging costs from the stump to the mill gate. This study compared the cost-productivity of four harvesting methods: cut-to-length (CTL), in-field chipping using a delimbing and debarking flail integrated with the chipper (IFC-DDC), in-field chipping using a chipper with a separate flail machine for delimbing and debarking (IFC-F/C) and whole tree to roadside (WTR).

Study area and research method

The study area was located in a *Eucalyptus globulus* plantation in south-west Western Australia, 58 km from the delivery point for all the products—the APEC chip mill. The study site covered 5.95 ha of flat terrain. Average diameter at breast height over bark (DBHOB) and tree volume were 17.8 cm and 0.207 m^3, respectively. Stocking was about 729 stems per ha. Four different harvesting methods were used to harvest the site. Table 1 describes the machine types used in each harvesting method.

Table 1. Harvesting methods and machines

Harvesting method	Type
CTL	Caterpillar harvester/processor
	Valmet forwarder (for extraction and loading trucks)
	Truck
(IFC-F/C)	Tigercat feller-buncher
	Tigercat skidder 630C and Tigercat skidder 630D
	Husky Precision flail
	Husky Precision chipper
	Truck
(IFC-DDC)	Caterpillar feller-buncher
	Caterpillar skidder
	Peterson Pacific delimber, debarker chipper (DDC)
	Truck
WTR	Timberking feller-buncher
	Caterpillar skidder
	Two Caterpillar processors
	Caterpillar loader
	Truck

A detailed time and motion study was used to evaluate machine productivity. Productivity was calculated from the delivered green metric tonnes (GMt) (derived from truck weights) and productive machine hours, excluding all delays (PMH_0). The ALPACA (Australian logging productivity and cost appraisal) model, developed by the CRC for Forestry, was used to estimate the cost of operations. The fuel consumption of each machine was also recorded during the operation. The four different harvest areas were sampled to estimate the amount of retained biomass, or 'left-slash', remaining on each site after harvesting.

Results

Production costs

Table 2 presents the productivity, cost and fuel consumption for each component of the CTL harvesting method. Harvesting and processing are the most expensive components of the CTL method. The cost of chipping the logs at the mill still needs to be investigated and should be added to the costs in Table 2.

Table 2. Productivity, cost and fuel consumption of CTL method

Machine	Productivity (GMt/PMH_0)	Cost ($/GMt)	Fuel consumption (l/GMt)
Harvester/ processor	15.47	17.35	0.95
Forwarder (extraction)	30.69	5.80	0.42
Forwarder (loading)	73.15	2.43	0.18
Truck	47.63	5.04	-
Total		**30.62**	**1.55**

Table 3 shows the productivity, cost and fuel consumption for each machine used in the IFC-F/C harvesting operation. Skidding was the most costly component of this method, with the highest fuel consumption rate per GMt. The main reason for this was that two skidders were used to extract the trees to roadside.

Table 3. Productivity, cost and fuel consumption of in-field chipping by IFC-F/C

Machine	Productivity (GMt/PMH_0)	Cost ($/GMt)	Fuel consumption (l/GMt)
Feller-buncher	97.26	2.55	0.33
Grapple skidder (two skidders)	58.17	12.02	1.58
Flail	57.80	5.98	0.77
Chipper	58.18	6.59	1.24
Truck	57.34	4.19	-
Total		**31.33**	**3.92**

The productivity, cost and fuel consumption results for the IFC-DDC harvesting operation are presented in Table 4. Using this harvest method, the feller-buncher recorded lower productivity than the other harvest methods in this trial and did not meet the feller-buncher productivity benchmark (Bulletin 12). This was attributed to the use of an inexperienced operator. Chipping was the most expensive component of this method, with an average cost of $9.50/GMt. However, this was lower than the IFC-F/C chipping cost ($12.57/GMt). The fuel consumption rate for the IFC-DDC chipper was higher than the IFC/FC chipper. But the IFC-DDC had a lower harvesting cost than the IFC-F/C and two skidders (Tables 3, 4).

Table 4. Productivity cost and fuel consumption of in-field chipping with IFC-DDC

Machine	Productivity (GMt/PMH_0)	Cost ($/GMt)	Fuel consumption (l/GMt)
Feller-buncher	61.77	4.13	0.61
Grapple skidder	38.70	5.05	0.87
Chipper	45.34	9.50	2.32
Truck	47.41	5.06	-
Total		**23.74**	**3.80**

The last method was the WTR method, producing logs with two processors (Table 5). This resulted in the highest cost and fuel rate for the processing phase of the trial. The cost of chipping the logs at the mill needs further investigation and should be added to the costs in Table 5. The skidder in the whole tree method did not clean up the debris. However, for IFC-DDC (Table 4), the skidder removed the debris, in addition to tree extraction, resulting in a longer work time and lower skidding productivity.

Grapple skidders were used in both the IFC-DDC and WTR methods. The skidder in the WTR method has been used for about 1800 hours and the skidder in the IFC-DDC had accumulated 3800 hours of use. The IFC-DDC skidder had higher fuel consumption, which could be attributed to the age of the machines (Tables 4, 5).

Table 5. Productivity cost and fuel consumption of WTR

Machine	Productivity (GMt/PMH_0)	Cost ($/GMt)	Fuel consumption (l/GMt)
Feller-buncher	86.67	3.04	0.53
Grapple skidder	58.57	3.02	0.35
Processor (two procesors)	48.79	18.39	3.42
Loader	67.42	2.19	0.31
Truck	43.81	5.48	-
Total		**32.12**	**4.61**

Sensitivity of machine productivity

Based on the statistical analysis, the longer the extraction distance, the lower the productivity (Figure1). Larger trees increase the productivity of the feller-buncher in the IFC-F/C (Figure 2), IFC-DDC and WTR methods. Larger skidding distances will reduce the productivity of the skidder (Figure 3), similar to the forwarding operation. The skidding distance significantly affected the productivity of the skidders for in-field chipping and whole tree methods. In the WTR method, the productivity of the processors was affected by tree size and the fact that two operators were needed for this operation. Larger trees resulted in higher processor productivity.

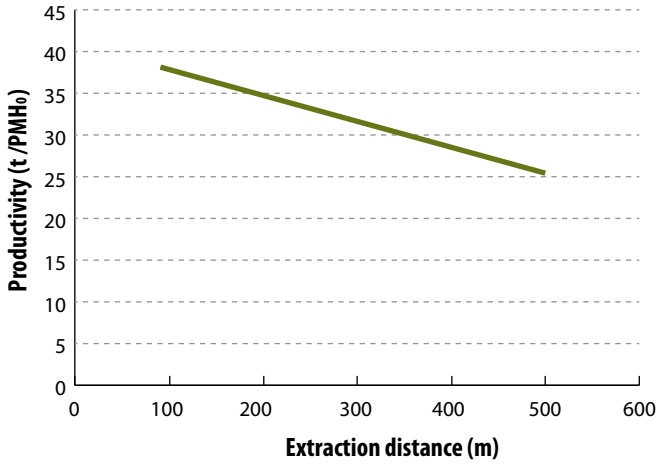

Figure 1. Impact of extraction distance on forwarding productivity (CTL method)

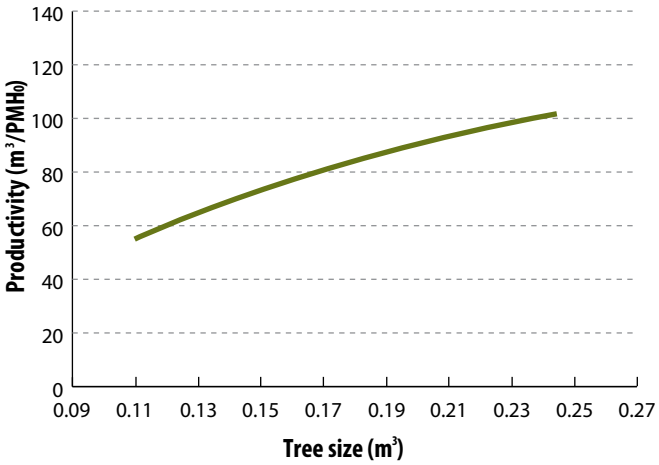

Figure 2. Impact of tree size on productivity of feller-buncher (IFC-F/C)

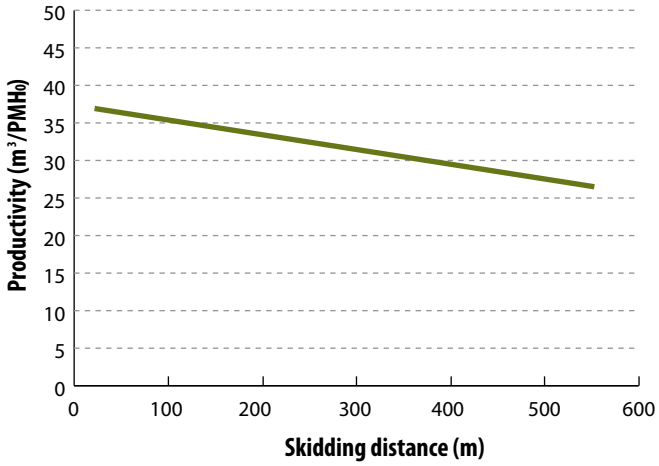

Figure 3. Impact of skidding distance on productivity of skidder (IFC-F/C)

Retained biomass after harvesting

The CTL harvest method retained higher biomass residues on the site after harvest (58.7 GMt/ha). The other methods left very small amounts of biomass at the site, as they extracted the whole trees to the roadside.

Table 6. Retained biomass after harvesting operation

Harvesting method	Retained biomass (GMt/ha)
CTL	58.7
IFC-DDC	4.2
IFC-F/C	6.5
WTR	7.7

Take-home messages

- The cheapest harvest method in this trial was in-field chipping by the chipper with a combined flail (IFC-DDC). For the WTR and CTL methods, chipping costs at the mill need to be investigated.
- The WTR method was found to be an expensive method with the highest fuel consumption.
- Transportation costs (truck costs) for log transport (CTL and WTR) are higher than transporting the chips from in-field chipping operations.
- The CTL method left the most residues at the site after harvest. The other methods left less than 8 GMt/ha. The ecological impact of biomass removal on site sustainability needs further investigation.

Organisations supporting this research

Albany Plantation Export Company (APEC) supported this research by providing its plantation, equipment and resources.

More information

CRC for Forestry website:
http://www.crcforestry.com.au/research/programme-three/index.html

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