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Evaluation of an in-field chipping operation in Western Australia

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Introduction

A large-scale set of trials investigating the main factors affecting productivity and costs of mechanised harvesting systems for varied stand conditions has been initiated in Western Australia. The trials will provide quantitative data to assist operations managers to match harvesting systems to plantation conditions in WA.

In this first trial, an in-field chipping (cold-deck) operation was studied during the clearfell of a 10-year-old *Eucalyptus globulus* plantation. The study investigated the productivity and cost of an in-forest chipping operation and also used Multidat dataloggers to obtain delay information for each machine and for the system, to determine utilisation percentages and to identify bottlenecks and system imbalances.

Harvesting machines studied

The in-field chipping system used single-grip harvesters to fell, delimb and debark full-tree-length stems at the stump and position them for subsequent extraction. From this point, a purpose-built tree-length forwarder transported the stems to roadside for stockpiling, and ultimately chipping, using a purpose-built mobile chipper. Specifically, the system consisted of two harvesters, one forwarder, two in-field trucks to shuttle chip vans and one mobile chipper (Figure 1).

Figure 1. In-field chipping system studied

Study description

- Data was collected from two 1.1 hectare plots for one in-field chipping operation. Each plot contained a total of nearly 2000 trees that were harvested and chipped. Average standing tree volume was 0.19 cubic metres.
- Time data was collected through a combination of activity sampling and detailed time studies.
- The analysis focused on time breakdown, productivity and determination of utilisation percentages for each machine in the system. Utilisation was calculated using Multidat data loggers attached to each machine. Multidats record time and duration of machine activity using a vibration sensor. Utilisation was calculated by dividing the total duration of machine activity over a period of several months by the scheduled working time for this period. Productivity models were developed for the forwarder to predict the effect of forwarding distance and payload on productivity and costs.
- Generic costs were calculated with ALPACA (Australian Logging Productivity and Cost Appraisal Model).

Results and discussion

Table 1 shows the time breakdown by machine, including productive time and short delays (less than fifteen minutes) collected during the study as well as long delays and utilisation percentages calculated from times recorded with a Multidat datalogger.

From the results obtained through a work sampling study on the 2.2 hectare area, the harvesters spent approximately 22.2 hours to harvest 1959 trees—almost 2.5 times the time spent to forward and chip the resulting tree lengths. From the time elements identified, 'processing' accounted for 58% of the harvester time and 'loading' was 42% of the productive time of the forwarder. Chipper utilisation was half that of the utilisation of the other machines in the system[1].

Figure 2 shows the productivity per productive machine hour (PMH_0 and PMH_{15})[2] and scheduled machine hour (SMH) by machine where productivity per SMH was determined using long-term utilisation percentages.

Chipper productivity on a PMH_0 basis is significantly higher than all the other machines; however, because of its lower utilisation (49%), chipper productivity drops substantially (by about 50%) when looking at productivity per SMH. The study also revealed that short delays have a significant impact on chipper productivity through the notable difference between PMH_0 and PMH_{15}.

The results show the system studied is well balanced on a SMH basis, but if chipper utilisation could be improved to a similar level as the other machines, the system would potentially require two additional harvesters, one additional forwarder and one additional in-field truck.[3] The results also reveal the importance of maintaining a rigorous control on chipper short delays as these delays can cause a dramatic drop in productivity.

Table 2 shows the cost per tonne of wood for all machines in the system. Generic machine hourly costs (on a SMH basis) were calculated as $150 for the harvester (average of two), $130 for the forwarder, $190 for the chipper, and $100 for the in-field trucks (average of two).

Given that the harvesters and the chipper are the most expensive machines in the harvesting system, increasing their utilisation is critical for the economics of the operation. As an example, increasing the utilisation of the harvesters and chipper by 15% and 30% respectively, reduces the cost of the system by about 10% (from $19.7 to $17.7 per tonne).

Finally, results from a detailed time study conducted on the forwarder show that for an average payload of 24 tonnes, the unit cost rises by 38% ($1/tonne) when the forwarding distance increases from 50 to 350 metres. Unit costs are less sensitive to payload than to forwarding distance. For an average forwarding distance of 250 metres, the unit costs obtained for average payloads of 21 tonnes, 24 tonnes and 26 tonnes were $3.4/tonne, $3.2/tonne, and $3.1/tonne, respectively.

A more detailed report comparing the productivity and cost of forwarders will be published by the CRC for Forestry during 2009.

[1] Several long delays (>1 day) were excluded from the chipper times as it was felt that their inclusion would not accurately reflect long-term chipper utilisation.
[2] PMH_0 excludes short and long delays from productive time whereas PMH_{15} considers short delays as part of the productive time. SMH includes productive time and all delays.

[3] This is the configuration that Timbercorp actually uses.

Table 1. Time breakdown (hours) and utilisation percentage of each harvesting machine

Time component	Harvesters (2)	Forwarder	Chipper	In-field trucks (2)
Productive	15.5	7.2	3.7	10.0
Short delays (< 15 min)	2.1	0.2	1.6	0.6
Long delays (> 15 min)	4.6	2.1	4.5	3.5
Total	**22.2**	**9.5**	**9.8**	**14.1**
Utilisation (%)	**70**	**76**	**49**	**71**

Figure 2. Productivity of the harvesting equipment studied

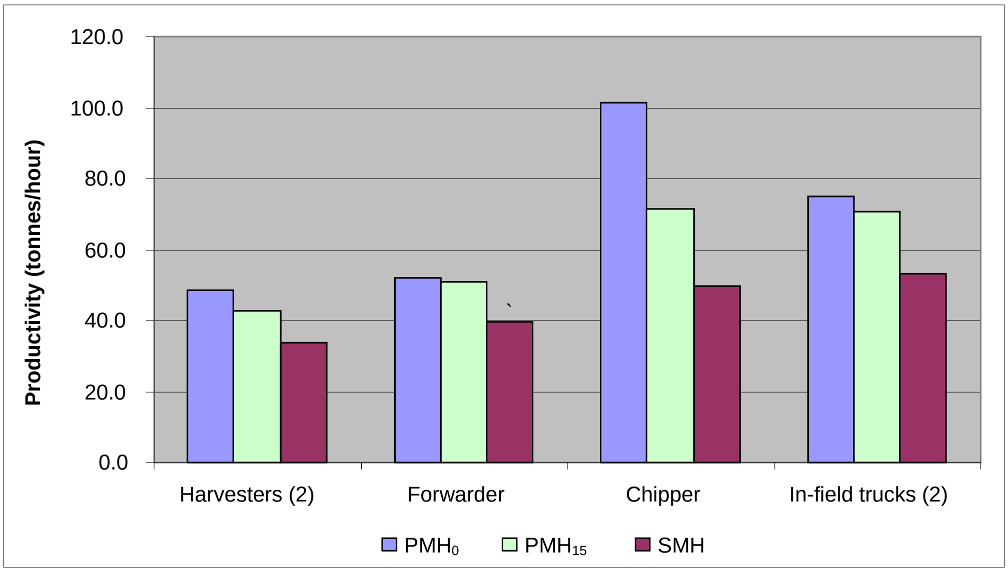

Table 2. Generic unit costs of the in-field chipping system studied

Forest machine	$/tonne	%
Harvesters (2)	8.8	44.7
Forwarder	3.3	16.8
Chipper	3.8	19.3
In-field trucks (2)	3.8	19.3
Harvesting system	**$19.7/tonne**	**100.0%**

Take-home messages

- Given that the harvesters and the chipper are the most expensive machines in the harvesting system, increasing their utilisation and reducing their short delays are critical for the economics of the operation.
- In the operation studied, chipper productivity was independent of other harvesting equipment and the harvesting system was well balanced. However, system balance would change substantially by increasing chipper utilisation, thereby allowing greater production of chips and reducing the cost per tonne of the system.
- Productivity and unit cost ($/tonne) of the forwarder are sensitive to forwarding distance. For a payload of 24 tonnes, the unit cost rises by 38% ($1/tonne) when the forwarding distance increases from 50 to 350 metres.
- The harvesters and the chipper combined contribute 64% of the production cost ($/tonne) for this system. The CRC for Forestry will conduct an exhaustive investigation of the tree-related factors (such as piece size, form and stocking) and work methods that may contribute to improving the productivity and utilisation of this high-value equipment.

Organisations supporting this research

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More information

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

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