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MECHANISED PROCESSING AND EXTRACTION OF SHORTWOOD THINNING

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Figure 1 : In-Bush processing with the Waratah Processor

ABSTRACT

A study of a fully mechanised Radiata pine thinning operation producing measured shortwood lengths was undertaken. A Waratah delimber-feller-buncher (DFB), partially delimbed, then felled and bunched the trees. A Waratah grapple processor completed the delimbing, then cut to measured length and stacked the shortwood for forwarder extraction. A Volvo 861 forwarder extracted over distances averaging 658m and loaded trucks directly from the forwarder. Productivity rates for the processor averaged 66 trees per PMH in 0.17m³ tree size (12.5 tonnes/PMH). Forwarder productivity, given payloads of 10.9 tonnes, averaged 12.7 tonnes/PMH.

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INTRODUCTION

A mechanised shortwood thinning operation commenced in Aupouri Forest in mid-1987. The system comprised mechanical felling using a Waratah delimber feller buncher (DFB) harvester, manual delimbing and processing, and extraction by forwarders converted from Clark 666C skidders (Laurenson, 1987).

Since then, the operation has developed to the stage where the manual elements of the operation have been substantially eliminated, with the introduction of a Waratah grapple processor (Duggan, 1988). A 6-wheel drive Volvo 861 forwarder has replaced the converted skidders.

The Waratah DFB delimbed, felled and bunched the trees in lines through the bush. The Waratah processor then travelled the same route processing the bunches of partially delimbed trees into 2.6 metre lengths, and stacking the processed wood for the forwarder (Figure 1). A chainsaw operator checked lengths and trimmed any malformed or heavily branched pieces that the processor could not handle.

The Volvo 861 forwarder extracted the wood through the bush, on to a sand track and then out to the truck road. Long term production prior to and during the study averaged 130 tonnes per day.

The mechanical felling phase of the operation has been previously reported (Raymond, 1989a). This Report details a study of the mechanised processing and extraction phase of the operation.

Table 1 : Stand Details

Total stocking (sph)	*830*
Crop stocking (sph)	*275*
Thinnings:	
Mean merch. length (m)	*10.1*
Mean merch. LED (cm)	*20.4*
Mean merch. volume (m^3)	*0.17*

STUDY AREA

The study was conducted in a "Board" regime stand of 12 year old Radiata pine in Aupouri Forest (Table 1). The stand had previously been thinned to waste to approximately 830 stems per hectare, of which 250 stems had been high pruned to 6.0m.

The operation consisted of thinning the stand down to approximately 275 sph. The stocking prior to thinning was such that an outrow system was not required. Instead, the DFB and processor worked through the stand roughly in the direction of the planting rows and the forwarder used an extraction track through the bush. The removal of crop trees had been minimised. Merchantable tree size was $0.17m^3$. This was calculated from the mean number of log lengths processed from each tree and the measured piece weight. This was converted to volume using a conversion factor of $0.9m^3$/tonne.

STUDY METHOD

Cycle time data was collected on the Waratah processor and the Volvo forwarder to enable calculation of machine productivity.

(1) <u>Waratah grapple processor</u>

The time to process 476 trees into 75 bunches was measured (6 to 7 trees per bunch average).

Figure 2 : Volvo 861 Forwarder loading Shortwood

The work cycle of the processor comprised the following elements:

- Pick up tree
- Process (delimb and cut to length)
- Move between bunches
- Clear slash

Operational delays such as resetting the length measuring computer, interference from the manual trimmer, and mechanical delays such as sharpening the chainsaw were recorded.

(2) Volvo 861 Forwarder

The elements of the forwarder work cycle were:

- Run empty (return to bush on sand track)
- Travel empty (in-bush travel)
- Load forwarder
- Move while loading (between bunches)
- Travel loaded (in-bush)
- Run loaded (on sand track)
- Unload (to truck)
- Delays (mechanical, operational, and personal).

The forwarder operator worked a systematic pattern, extracting each line of processed bunches before starting the next one (Figure 2). The forwarder loaded on the way into the bush. Once loaded, the forwarder turned and travelled by the most direct route to the road. The normal work method involved the forwarder unloading direct to truck or trailer. This Report details forwarder extraction productivity and further analysis of forwarder loading and unloading is given in the project report in preparation (Raymond, 1989b).

RESULTS

(1) Waratah DFB Harvester

From a previous study (Raymond, 1989a), DFB productivity was calculated at 83 trees per productive machine hour (PMH). In $0.17m^3$ tree size, this equates to 15.8 tonnes/PMH.

(2) Waratah grapple processor

Table 2 gives the results of the work cycle measurements. The total cycle time of 0.91 minutes gives hourly machine productivity of 66 trees per PMH. (12.5 tonnes per PMH). From observation, it was apparent that the DFB had delimbed almost all trees to a sufficient length to allow three 2.6 metre lengths to be cut prior to further delimbing. The average length of DFB delimbing was estimated to be 7.8 metres.

On average 3.9 processed lengths were cut from each tree (range 1-8). Bunches of processed wood averaged 25.3 pieces.

Mean delimbing speed as a function of tree length was calculated at 0.28m/sec. The mean delimbing time was predicted by linear regression:

Delimb time = 0.182 x No. of pieces - 0.104

This relationship was highly variable (r^2 = 0.35). Sources of variation in delimbing time include individual tree volume, branch size and degree of nodal swelling.

Table 2 : Waratah Processor Work Cycle

Element	*No. of Observations*	*Mean per Cycle (min)*	*$\pm$95% Confidence Limits*	*% of Total Cycle*
Pick-up tree	*476*	*0.165*	*0.005*	*18.1*
Delimb & Cut	*476*	*0.588*	*0.028*	*64.8*
Total : process	*476*	*0.753*	*0.027*	*82.9*
Move	*75*	*0.091*	*0.027*	*10.0*
Clear	*56*	*0.031*	*0.003*	*3.4*
Op. Delay	*17*	*0.034*	*0.034*	*3.7*
Total Cycle	*476*	*0.909*	*0.043*	*100.0*
Productivity :				
Trees per PMH		*66.0*		
Tonnes per PMH		*12.5*		

Table 3 : Volvo Forwarder Work Cycle

Element	No. of Observations	Mean per Cycle (min)	$\pm$95% Confidence Limits	% of Total Cycle
Return empty	7	5.76	3.41	11.2
Load	7	23.60	2.87	46.0
Move to load	7	3.29	1.64	6.4
Travel Loaded	7	3.55	1.65	6.9
Run Loaded	7	2.74	1.30	5.3
Unload	8	12.42	2.06	24.2
Total Cycle (mins)	8	51.36	7.26	100.0
Productivity : (tonnes/PMH)		12.7		
Haul Distances (metres)		**Mean**	**Range**	
Return Empty	7	575	10-916	
Move while loading	7	120	63-212	
Travel Loaded	7	235	40-458	
Run Loaded	7	386	40-816	
Total Distance (metres)	7	1316	191-1836	
Forwarder Payload				
No. of pieces		222	195-261	
Tonnes		10.9	9.7-12.3	

(3) Volvo 861 Forwarder

Forwarder work cycle measurements are given in Table 3. A mean total cycle time of 51.36 mins and mean payload of 10.9 tonnes resulted in forwarder extraction productivity of 12.7 tonnes per PMH. Average haul distance per cycle was 658 metres, with a maximum of over 900m.

Analyses of forwarder loading and forwarder movement are given in Tables 4 and 5.

(4) System Costing

Machine daily costs were calculated using the LIRA format (Wells, 1981) (Table 6.)

Given a three machine system of 1 DFB, 1 processor and 1 forwarder producing 2.6m lengths of shortwood to the existing specifications, balanced system productivity was calculated at 78 tonnes per 9.0 scheduled machine

Table 4 : Forwarder Loading Analysis

		Mean	Range
Mean Load Time (min/cycle)		23.60	19.97 - 28.78
No. of grapple loads		31.3	27 - 36
Mean grapple load (pieces)		7.2	1 - 9
Mean grapple load (tonnes)		0.35	0.32 - 0.40
Loading Productivity:	(pieces/min)	9.6	8.4 - 11.1
	(tonnes/min)	0.47	0.41 - 0.54
Unloading Productivity:	(pieces/min)	18.5	13.7 - 22.9
(onto truck)	(tonnes/min)	0.90	0.67 - 1.12

Table 5 : Forwarder Travel Speed

Element	m/min	Km/h
Run Empty (track)	149	8.9
Travel Empty (bush)	87	5.2
Move while loading	36	2.2
Travel Loaded (bush)	66	4.0
Run Loaded (track)	141	8.5
Mean Empty	100	6.0
Mean Loaded	99	5.9

hours (SMH) day. This gives a unit cost loaded on truck of $32.00/tonne on a single shift basis (Table 6).

At a production rate of 78 tonnes per day the cost of wood loaded on truck was almost equivalent to the cost of a conventional tree length manual operation. Productivity of a manual operation with 4 cutters and a double drum skidder extracting over an average haul distance of 300m, would be approximately 40 tonnes per day (single shift). This gives a wood cost (excluding loading) of approximately $31.50 per tonne.

If the requirement for measured lengths could be removed, and the operation allowed to produce random short lengths, then the processor could be eliminated from the system. This would reduce daily gang cost by $933.00. The DFB would then be the limiting factor on production and unit wood cost would fall to $17.70 per tonne (single shift).

The effect of double shifting is discussed in the full Project Report (Raymond 1989b).

Table 6 :
Operation Costing

Mechanised System	*Daily Cost ($)*
DFB	*574.00*
Processor	*610.00*
Forwarder	*472.00*
3 machine operators	*424.00*
1 manual trimmer and chainsaw	*166.00*
1 mechanic/foreman	*150.00*
Vehicle	*50.00*
Overheads	*60.00*
Total Daily Cost ($)	*2506.00*
Unit Cost ($/tonne)	*32.00*

CONCLUSIONS

Thinning a "Board" regime stand had the advantages of:

- improved access to trees for the harvester and processor.

- the lower stocking resulted in fewer trees per bunch. This resulted in shorter tree pick up times for the processor and more efficient forwarder loading (i.e. fewer grapple swings per bunch).

It was apparent given the amount of prior delimbing by the DFB, that the processor worked primarily as a merchandiser. It delimbed mostly one and sometimes two extra pieces from each tree, and measured and cut to length.

The forwarder was extracting over very long haul distances (658m). Forwarder productivity was highly sensitive to haul distance, and would have increased significantly if haul distances were reduced. The other option would be to reduce the influence of haul distance by increasing the proportion of high speed travel on the sand track. This would be achieved by spacing sand tracks at regular intervals through the bush.

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The costs stated in this Report have been derived using the procedure shown in the LIRA Costing Handbook for Logging Contractors. They are only an estimate and do not necessarily represent the actual costs for this operation.

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