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EVALUATION OF THE WARATAH PROCESSOR IN RADIATA THINNINGS

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ABSTRACT

A study of the Waratah Heavy Duty Grapple Processor working in a steep country radiata pine thinning operation indicated that 80 to 90 trees could be processed per machine hour. This rate was achieved in a piece size of 0.3 m³. Trees were extracted tree-length either to the skid or to roadside, by a John Deere 440D skidder, a Komatsu D37 tractor and a Timbermaster hauler. The processor then delimbed the wood and fleeted it for loadout.

INTRODUCTION

During the last three years several mechanised processors have been introduced into radiata thinning operations. The Waratah Heavy Duty Grapple Processor studied was a prototype of a locally manufactured model and is the first of four machines currently working in both Australia and New Zealand.

The system in which the processor operated was a steep country thinning operation. The move towards a system whereby processing (ie. delimbing, cutting-to-length and stacking) was done mechanically resulted from difficulties with manual trimming on steep slopes.

The objective of the study was to undertake a short term evaluation of the processor's productive capabilities over a range of conditions, and to determine an optimum work method.

As the processor was undergoing development during the study, no estimates of mechanical availability were calculated.

Figure 1 - The Waratah Grapple Processor working in NZFP Forests Limited Kinleith Forest

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THE MACHINE

The prototype Waratah Heavy Duty Grapple Processor was developed from experience with a Scandinavian grapple harvester and modified to achieve the robustness required when delimbing New Zealand radiata pine.

Delimbing is achieved by two wraparound knife arms and one fixed knife. The maximum tree diameter able to be delimbed is 50 cm, with a minimum of 7.5 cm.

Two spiked feed rollers and one spiked chain drive the tree through the processor with a feed speed of up to 3.5 m/s. An integral hydraulic chainsaw cuts to length with an option of an automatic length measuring device.

The processor head can be fitted to most excavators of 75 kW (or greater) engine output. The hydraulic requirement is 200 litres/min flow at 26 MPa. In this operation, the Waratah was fitted to a wheeled Hitachi 073 excavator base. The excavator is fitted with a blade to clear slash and also to act as a stabiliser in conjunction with two hydraulic outriggers. The excavator is capable of travel speeds of up to 30 kph between skids.

WORK METHOD

The processor usually works out-of-phase with the extraction machines, ie. cold deck. However, trees could be extracted to an existing stack without causing interference to either the processor or extraction machine. Due to the high productivity of the processor, hot decking alone was not a viable option. Tree preparation in the bush involved cutting off the heads at 10 cm SED for both head- and butt-pulling. For head-pulling only, the first one metre of the small end was trimmed to allow for faster hooking on times, and to give the processor's feed rollers a good grip on the tree.

The operation sequence of the processor involved starting at one end of the untrimmed stack and reversing away, usually at 2-3 metres per move.

The processed trees were stacked in line with the untrimmed stack (if possible) or alternatively were turned by the processor.

Cutting-to-length was done either with the hydraulic chainsaw (resulting in a fixed length stack of both longs and shorts), or manually (resulting in separate long and short length stacks).

The slash that accumulated between the processed and unprocessed stacks was bladed away by either one of the extraction machines or by the processor.

STUDY AREA

The production study of the Waratah processor was undertaken during February 1988 in a radiata thinning operation in Kinleith forest.

The study area was a 17 year old radiata pine stand on moderate to steep terrain. Details of the stand data were obtained from pre-thinning assessment by NZFP Forests Limited staff (Table 1).

TABLE 1

Stand Age	17 years
Total Stocking	886 sph
Yield Stocking	511 sph
Mean Yield DBH	24.5 cm
Mean Yield Volume	0.3 m^3 (range 0.03 m^3 to 0.57 m^3)

RESULTS AND DISCUSSION

A preliminary study of 105 trees was undertaken to assess the effect of length, diameter and tree volume on processing time. Results are summarised in Table 2.

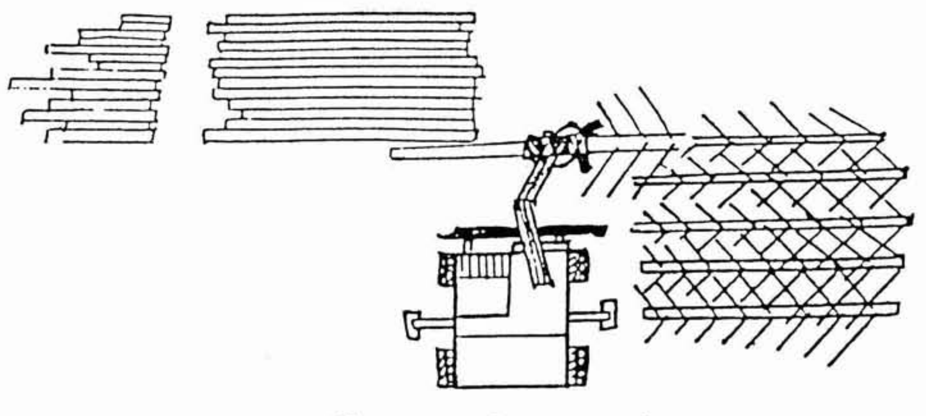


Figure 2 - Skid Layout for Waratah Processor

TABLE 2

Dependent Variable	Independent Variable	R^2
Delimb time	Tree length	.34
Delimb time	Tree diameter	.11
Delimb time	Tree volume	.29
Total Process Time	Tree volume	.19

A weak relationship was found to exist between delimbing time and tree length (R^2 = 0.34). This R^2 value was lower than expected and reflects :

(i) The effect of the "position head" component of the delimb element, (which was not recorded separately);

(ii) The longer delimb times during occasions when the processor head reversed along the tree to gain sufficient momentum to overcome either a large internodal swelling or a heavy whorl of branches.

After this preliminary study, a further 380 trees were timed during processing to determine the effect of the following factors :

(i) Operator difference
(ii) Butt-first versus head-first processing
(iii) Stack orientation
(iv) Malformation and large branches.

Effect of Operator Difference

An analysis of the work cycle for two different operators is given in Table 3:

TABLE 3 - Effect of Operator Difference

Cycle Element	Mean Time Per Cycle (min) Operator 1	Operator 2	Mean
Accumulate	0.05	0.09	
Pick Up and Return	0.14	0.15	
Position and Delimb	0.27	0.30	
Cut to Length	0.07	0.07 [1]	
Move Along Stack	0.01	0.03	
Move Along Road	0.04	0.04 [2]	
Restack	0.01	0.02	
Blade Skid	0.08	0.08	
TOTAL CYCLE	0.67	0.78	0.73
Cycles observed	248	220	-
Trees processed per PMH	90	79	84.5
Trees processed/6.5 PMH day	585	513	549
Tonnes/6.5 PMH day [3]	195	171	183

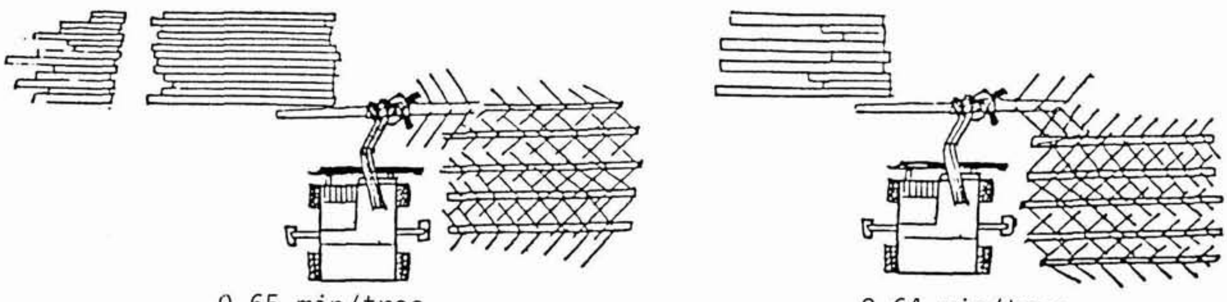
[1] - Standardised for comparison

[2] - Based on 4 km per day @ 10 kph

[3] - Piece size 0.3 m^3, conversion factor 0.9 m^3/tonne

Head First vs. Butt-First Processing

Head-first Processing | Butt-first Processing



0.65 min/tree | 0.64 min/tree

Cutting-to-length is done manually by the processor operator at intervals (usually 15-20 heads at one time). The processor chainsaw is not used. A tree of less than 11 m is stack among the long lengths.

Alignment of the butts at the far end of the processed stack is more difficult. Trees exceeding 11 m in length are cut-to-length using the processor and the short lengths are stacked among the long lengths.

Figure 3 - Work Methods

Steep country thinning generally involves head-first extraction. There are occasions however, usually on flatter country or when pulling over a ridge, when butt-first extraction is possible.

A comparison of head-first and butt-first processing was undertaken to determine the effect on processing speed and delimbing quality.

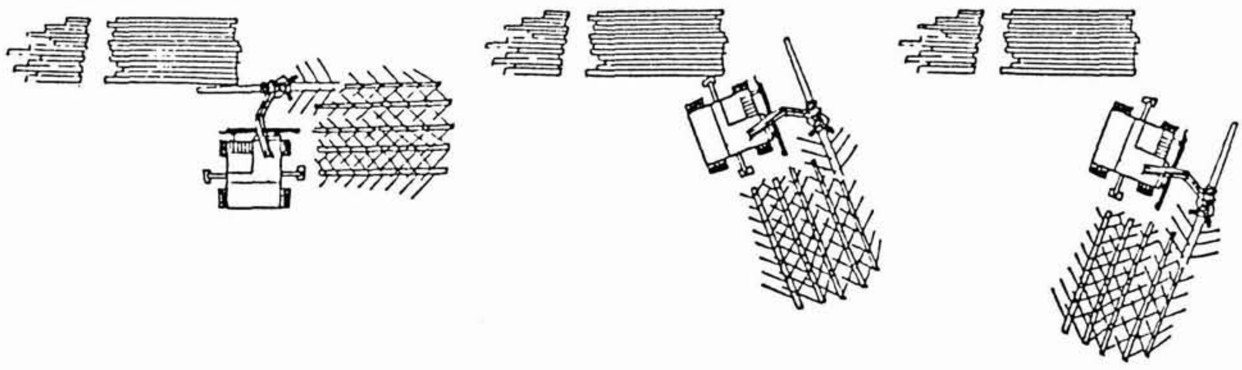
Although the cutting-to-length was reduced by 35% using the processor (ie. butt-first processing), the difference in total processing time between the two processing methods was no significant. Butt-first processing, while allowing for faster accumulation, required more frequent restacking of the processed trees. This time consuming restacking was due to the reduced ability of the processor to control direction of the processed stem with the small end in the grapple.

Because radiata pine has an average branch angle of 60% (Gleason, 1985), the quality of delimbing head-first was noticeably superior. The quality of both processing options however was acceptable to local mill standards.

Effect of Stack Orientation

Because of the ability of the processor to delimb while slewing the tree, there was no significant difference (at 95% level) in delimbing time between layout (a) and (b). Layout (c) however was significantly slower than the other layouts.

(a) 0° | (b) 60° | (c) 110°



0.78 min/tree | 0.79 min/tree | 1.09 min/tree

Figure 4 - Effect of Stack Orientation

Effect of Malformation and Large Branches

As the work method required the removal of large branches and double leaders in the bush, the frequency of malformed trees and large branches was low (6.5%). Large branch size and malformations were noted if problems in processing arose. Delimbing problems occurred only where branch diameters exceeded 4 to 5 cm. Overall, trees with large branches and malformation required 43% more processing time (1.12 min per tree).

Productivity and Cost

During the study, Operator 1 averaged 90 trees per productive machine hour (PMH) and Operator 2, 79 trees per PMH, to give a weighted mean productivity of 85 trees per PMH (refer Table 3).

Because of the difficulty in predicting the machine utilisation of a prototype, the standard estimate of 6.5 PMH/day was used.

85 trees/PMH x 6.5 x 0.3 m^3 (average tree size) - 166 m^3/day at 0.9 m^3/tonne
Production = 183 tonne/day

Costing the machine using the LIRA format (Wells, 1981) gives a total daily rate for the Waratah and operator of $850 per day and a delimbing cost of $4.77 per tonne. This compares well with other mechanised processors working in radiata pine thinnings (Raymond, 1988).

Comparison of Conventional versus Mechanised Processing

(a) Conventional System

The conventional steep country thinning operation typically consisted of 3 fallers, who also trimmed and assisted the machine operator in the breakout phase. The extraction machine was usually a small tractor (50-60 kW range) which carried 7 to 8 strops.

	$/Day
1 extraction machine	$325
3 fallers, 1 machine operator @ $120 per day	$480
Operating supplies (chainsaws, transport etc)	$154
Daily Cost	$959

- Target of 44 tonnes/day
Unit Cost $21.80/tonne

Figure 5 - Processed trees ready for loadout

(b) Mechanised System

The mechanised system required three extraction units, with one faller less in the crew. The two fallers trimmed the top metre of the tree and assisted the machine operator during the breakout phase. The 15% increase in daily production for the tractor reflected both the faster skid turnaround in the mechanised system where the fleeting requirement was minimal and the lack of "clean up" trimming in the bush after breakout was completed.

1 Waratah processor + Operator + Saw	\$ 873
3 conventional extraction units (each less one faller + saw)	
- 2 tractors (52 tonne/day) @ \$816/day	\$1,632
- 1 skidder (68 tonne/day) @ \$816/day	\$ 816
Daily Rate	\$3,321

- Daily Production 172 tonne/day
Unit Cost \$19.30/tonne

The mechanised processing system therefore compares well in terms of cost, with conventional steep country thinning operations. The fallers greatly preferred the mechanised processing work method.

Although the mechanised system required the extraction units to work in close proximity, the processor has the advantage of being able to be double shifted. This advantage will hasten the move toward mechanised processing and harvesting in New Zealand, through reducing machine costs.

CONCLUSION

The Waratah processor was found to be capable of high levels of production in radiata thinning operations. The processor was able to process both head-first and butt-first without adversely affecting productivity. Stack orientation, while important, was not found to be limiting to production unless the angle of slew exceeded 90°. This slew capability was found to be particularly useful when processing wood pulled to the roadside, by both the hauler and the ground based machines.

The piece size processed (0.3 m^3 average, with a range of 0.03 m^3 to 0.57 m^3) was considered to be approaching the upper level of the processor's capabilities.

As with any mechanised operation, the processor's ultimate acceptability will depend on the level of mechanical availability achieved and the back up service provided.

Other potential applications for the processor include processing on the landing in conjunction with a feller buncher and grapple skidder extraction.

REFERENCES

Gleason, A P; Stulen, J A (1985) : "Radiata Branch Characteristics and Delimbing Forces", LIRA Report, Vol 10 No 4.

Raymond, K A (1988) : "The Harricana Stroke Delimber in Radiata Thinnings", LIRA Report, Vol 13 No 1.

Wells, G C (1981) : "Costing Handbook for Logging Contractors", LIRA.

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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