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THINNING WITH THE WARATAH DFB

(A COMPARISON OF 5M SHORTWOOD AND WHOLE TREE SYSTEMS)

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ABSTRACT

Two mechanised thinning systems were studied in Kinleith Forest. The shortwood system used the Waratah delimber-feller-buncher (DFB) as a processor with forwarder extraction. The whole-tree system used the Waratah DFB to fell and bunch for cable skidder extraction and a Waratah heavy duty (HD) grapple processor for processing at the landing.

A shortwood system based on two DFB's and one forwarder could produce 83m^3/day at a cost of \$33.90/m^3. A whole-tree system using a DFB, one skidder and one Waratah processor could produce 100m^3/day at a cost of \$23.30/m^3. In both systems, DFB productivity was markedly reduced and costs were increased by malformation and by slopes above 15^o. In optimum conditions, using outrow systems in genetically-improved stands, with shortwood productivity levels close to those recorded in Australian studies, costs of production would be similar with both systems.

INTRODUCTION

NZFP Forests Limited recently organised a series of thinning trials in Kinleith Forest with the Waratah DFB. It was used as a processor in a shortwood system and as a feller-buncher in a whole-tree system (whole-trees are trees with branches, but not roots). This report summarises the results of these studies; details are in Project Report No. 51 (Vaughan, 1990). Previous studies on the Waratah DFB include the shortwood system at Aupouri Forest (Raymond and Moore, 1989) and in Australia (K. Raymond, 1988 and O. Raymond, 1990).

ACKNOWLEDGEMENTS

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THE STUDY AREA

The trials were undertaken in two stands in Kinleith Forest. Both were planted in the mid-1970s, waste thinned to 900 stems/ha at age six, and 250 stems/ha had been pruned to 6m. The stands were both scheduled for production thinning to 350 s/ha.

Table 1 : Stand Information

	Kakarihi Road	Antelope Road
Age (years)	12	11
Stocking (s/ha)	900	950
DBHOB (cm)	19	18
Height (m)	18	16
Standing Volume (m^3/ha)	200	190
Area thinned (ha)	40	20
Residual stocking (s/ha)	320	290
Merchantable thinnings (s/ha)	400	450
Thinning malformation	40%	20%
Recovered volume per tree (m^3)		
- shortwood system	.19	-
- whole-tree system	.21	.23
Recovered volume (m^3/ha)	80	100
Slope	0 to 25°	5 to 25°

THE SYSTEMS

Two systems were evaluated; a shortwood system and a whole tree system. The shortwood system used the Waratah DFB as a processor to fell, delimb, cut into 5m lengths and bunch for extraction by forwarder.

The whole-tree system used the DFB as a feller-buncher to delimb to 6m, fell and bunch for extraction by cable skidder. A Waratah processor was used to process the trees on the landing. The two systems are shown in Figure 1.

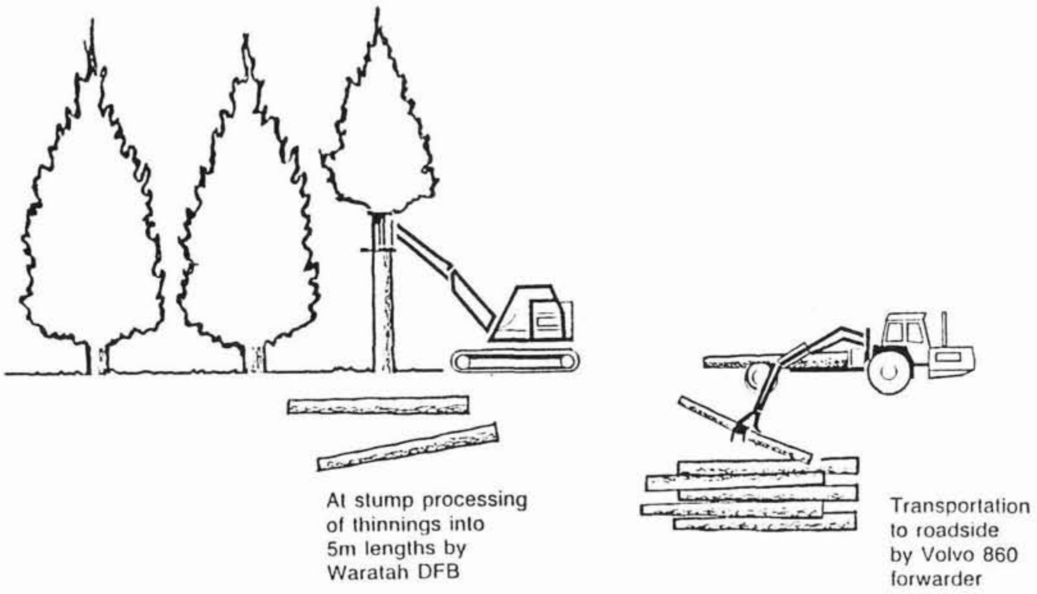

Figure 1a - Shortwood System

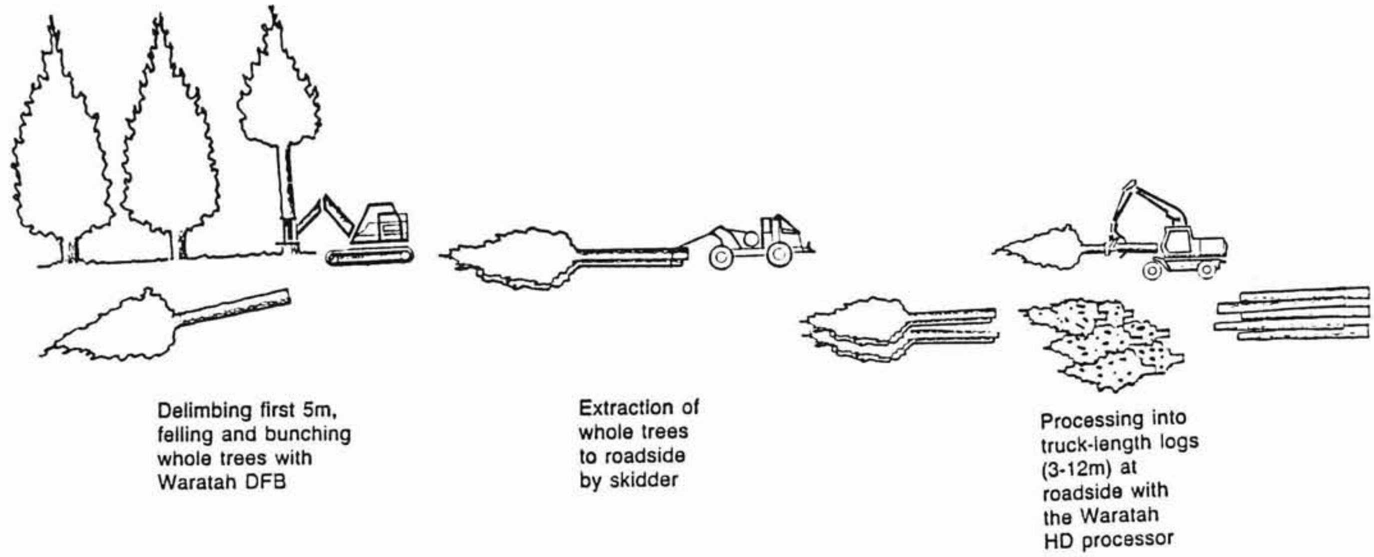

Figure 1b - Tree Length System

THE MACHINERY

Figure 2 - Waratah DFB

The DFB used in the trial was owned by a contractor in Aupouri Forest. The Waratah Mark 5B was mounted on a 15 tonne Komatsu PC 150 excavator base (Figure 2).

The forwarder was a 17-year old six-wheeled Volvo 868. The skidder was a C5D Tree Farmer and carried 5m strops for pre-stropping the bunches of whole trees. The Waratah processor was mounted on a Hitachi 073 wheeled excavator (Figure 3).

RESULTS AND DISCUSSION

Shortwood System

The DFB was used to process and bunch shortwood at the stump in a selection thinning operation. The basic work cycle involved the DFB delimbing to approximately 6m, severing the tree, pivoting to the bunch site with the tree held vertically before cutting off the bottom 5m section. It then swung back to the slash pile to delimb the second section and repeated the sequence. Up to three sections were produced from each tree.

A high level of malformation (40%) in this part of the stand affected processing time. Processing double leaders increased cycle time by 38% (from 1.66 mins/tree for single leader trees to 2.30 mins/tree for double leaders). Processing time could be estimated from a regression based on the number of pieces produced.

Figure 3 : Waratah HD Grapple Processor

Table 2 - Waratah DFB Cycle Times and Productivity - Shortwood System

Element	Mean time per tree (min)	95% confidence limits	No. of observations
Move and Select	0.38	±.07	50
Process 5m lengths	1.36	±.19	50
Operational Delays	0.08	±.07	7
Basic cycle time	1.82	±.20	50

Average piece size (m^3)	0.10	Hourly Productivity	
No. of pieces per tree	1.88	(trees/pmh)	33
Recovered volume per tree (m^3)	0.19	(m^3/pmh)	6.3
		Daily Productivity (7 pmh/day)	44m^3/day

Table 3 - Forwarder Cycle Times and Productivity - Shortwood System

Element	Mean time per Cycle (minutes)	95% Confidence Limits	No. of Observations
Travel empty	3.5	0.5	13
Load	16.2	3.2	13
Move and position	2.7	1.0	13
Travel loaded	3.1	.7	13
Unload	7.7	1.3	13
Operational Delays	4.9	5.2	13
Basic Cycle Time	38.1	5.2	13
Average haul distance	151m	Productivity:	
No. pieces loaded	75	Pieces/pmh	118
Average piece size (m^3/piece)	0.10	m^3/pmh	11.8
Payload (m^3/load)	7.5	Daily productivity (7pmh/day)	$83m^3$/day

Cycle time (min) =
*0.47 + 0.72 * no. of pieces/tree* ($r^2 = 0.63$)

The forwarder loaded the 5m pieces from the bunches (of average size of 15 pieces), extracted to the roadside, and unloaded into stockpiles. The existing road network meant travel distances were shorter than is common for a forwarder. The results are summarised in Table 3.

The selection thinning approach and the operator's lack of experience in thinning systems substantially increased the time spent by the forwarder in positioning and repositioning. The element times for "travel empty", "move and position" and "travel loaded" would be expected to be lower with an experienced operator in an outrow system.

Forwarder productivity could be estimated from the following regression:

$$Productivity\ (m^3/pmh) = 9.6 + (0.16 * nop) - (0.66 * nob) - (0.0077 * dist)\ (r^2 = 0.90)$$

where nop = no. of pieces loaded
nob = no. of pieces per bunch
dist = total distance travelled (m)

The levels of productivity achieved in this trial are considerably lower than in comparable Australian operations (Raymond, 1989). This is attributed to their use of outrow systems, easier stand conditions, greater operator experience, improved work methods and improvements in forwarder technology over the last fifteen years.

Whole-tree System

On easy terrain, the thinning system involved selection thinning with removal of additional trees to provide access for skidder extraction of the bunches of whole trees. On steeper terrain, the DFB worked an outrow system, removing all trees in its path and selection thinning up to 7m on each side. After-delimbing to approximately 6m, the thinnings were felled and bunched. In $0.22m^3$ piece size, the DFB averaged 65 trees/ productive machine hour (PMH) ($14.3m^3$/PMH). Cycle times and productivity are summarised in Table 4.

Once slopes exceeded 15^o, cycle times increased substantially as the DFB used the boom to assist climbing and time was spent clearing undergrowth, removing stumps and checking access. On these steeper slopes, fewer trees could be reached and more frequent moves were required.

Table 4 - Waratah DFB Cycle Times and Productivity - Whole Tree System

Element	Mean Time per Cycle (minutes)	±95% Confidence Limits	No. of Observations
Move and Select	0.33	0.03	455
Process	0.17	0.01	455
Travel loaded	0.29	0.02	455
Operational Delays	0.13	0.05	69
Basic Cycle Time	0.92	0.04	455
Recovered volume per tree (m^3)	0.22	Daily Productivity (7 pmh/day)	$100m^3$/day
Hourly Productivity			
(trees/pmh)	65		
(m^3/pmh)	14.3		

Table 5 - Cable Skidder Cycle Times and Productivity - Whole Tree System

Element	Mean Time per Cycle (minutes)	±95% Confidence Limits	No. of Observations
Travel empty	0.84	0.13	57
Position	0.25	0.04	43
Hook on	0.28	0.04	57
Breakout	0.27	0.06	57
Travel loaded	1.71	0.27	57
Winch	0.28	0.10	26
Unhook	0.37	0.03	57
Fleet	1.21	0.11	57
Operational delays	0.91	0.58	43
Total	6.12	.51	57
Average skid distance (m)	148	Average payload (m^3)	1.7
No. of trees per cycle	7.8	Productivity: trees/pmh	76
Recovered volume per tree (m^3)	0.22	m^3/pmh	16.8
		Daily Productivity (7 PMH/day)	$117m^3$/day

The cable skidder extracted the bunches of whole trees to the landing. All bunches were pre-stropped and hooked on by a breaker-out, and the skidder operator unhooked at the landing. Daily productivity averaged $117m^3$/day but could be increased by increasing payload size. Cycle times and productivity are summarised in Table 5.

The Waratah processor worked on the landing picking up whole trees butt first, delimbing and cutting into 12m and stockpiling. Tops were placed into the slash pile and removed by blading into the stand. The processor averaged 105 trees/hour ($23m^3$/PMH). Malformed stems and double leaders almost doubled processing time. Element times and productivity data are summarised in Table 6.

Table 6 - Waratah HD Processor Work Cycle Times and Productivity - Whole Tree System

Element	Mean Time per Cycle (minutes)	±95% Confidence Limits	No. of Observations
Position head	0.14	0.01	247
Process	0.29	0.02	247
Cut stem	0.06	0.01	195
Clear tops	0.06	0.01	190
Operational delays	0.02	0.02	9
Basic Cycle Time	0.57	0.03	247
Recovered Volume per tree (m^3)	0.22	Daily Productivity (7 pmh/day)	$162m^3$/day
Hourly Productivity			
(trees/pmh)	105		
(m^3/pmh)	23.1		

Table 7 : Daily Machine Costs

	Waratah DFB	Forwarder (FMG 1440)	Waratah HD processor	Skidder (Tree Farmer C5D)
Ownership costs ($/PMH)	50	49	43	21
Operating costs ($/PMH)	40	42	36	20
Total cost ($/PMH)	90	91	79	41
Daily cost ($/day)	630	639	552	283

Note: The use of rounded hourly costs may give daily costs that differ slightly from those shown.

SYSTEM COSTING

Daily owning and operating costs for a 7/PMH day were derived using the standard LIRA format (Wells 1981), using 1989 capital costs, a 16.5% interest rate, and a five-year life. These are summarised in Table 7.

A comparison of two systems is shown in Table 8 with productivity levels determined by the lowest-producing machine. The difference in costs is $10.60, with the whole-tree system being about 30% less than the shortwood system.

CONCLUSIONS

A shortwood system, based on two DFBs and one forwarder, could produce 83 m^3/day at a cost of $33.90/$m^3$. A whole tree system, based on one DFB, one skidder and one Waratah processor, could produce 100 m^3/day at a cost of $23.30/$m^3$.

Studies on Australian shortwood operations indicate much higher levels of productivity are being achieved by DFBs and forwarders. Contributing factors include the use of outrow systems in heavily stocked stands, improved work methods, extensive operator experience and modern forwarders. If these Australian studies are an indication of the potential levels of productivity that could be achieved in New Zealand conditions, then the differences in the costs of production between the two systems becomes minor.

Table 8 - Comparison of Production Costs for Two Systems

	Shortwood System		Whole-Tree System		
	Waratah DFB	Forwarder	Waratah DFB	Skidder	Waratah Processor
No. of machines	2	1	1	1	1
Daily cost of machines	1260	639	630	283	552
Operator	300	150	150	150	150
Travel & supplies	106	53	53	53	53
Sub total	1666	842	833	486	755
Overheads (2%)	33	17	17	10	15
Sub total	1699	859	850	496	770
Profit (10%)	170	86	85	50	77
Total	1869	945	935	545	847
Systems total	2814		2327		
Daily production (m^3)	83		100		
Costs ($\$/m^3$)	33.90		23.30		

Slopes above 15^o substantially reduced DFB productivity. Therefore , a motor-manual options would be a preferred option for steeper terrain. High levels of malformation markedly increased processing time of the DFB in the shortwood system and the Wartah processor in the whole tree system. Genetically-improved stands should provide major benefits for mechanised systems through improved tree form. They may also reduce the opportunity cost of outrow systems from the loss of final crop trees.

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

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