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THE WARATAH DFB HARVESTER

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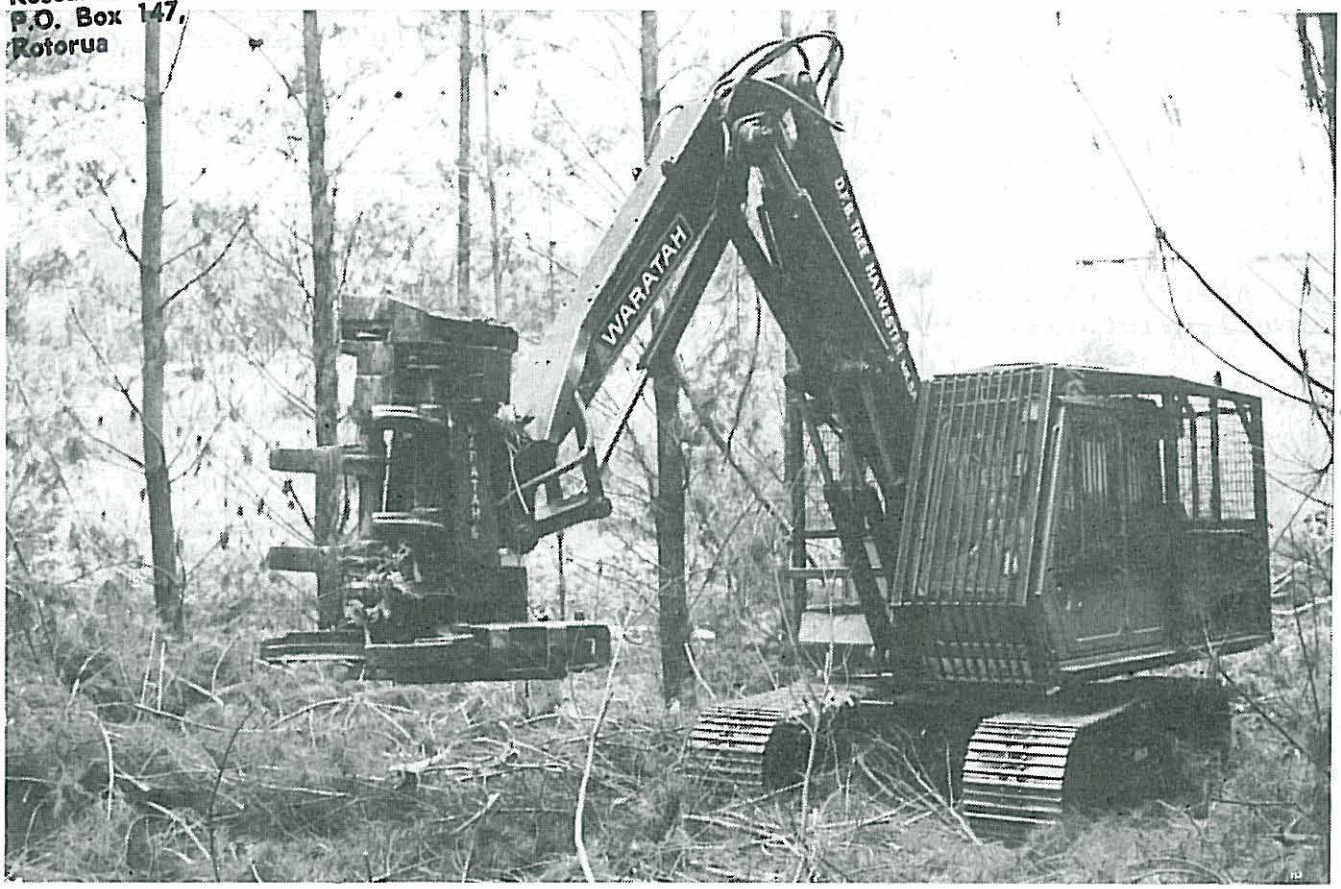

Figure 1 : Waratah Delimber Feller Buncher

ABSTRACT

Two models of Waratah delimber-feller-buncher (DFB) Harvester were evaluated in fifth row outrow Radiata thinning operations, under two different methods of operation.

In the first study, trees were delimbed standing then felled and bunched for subsequent processing by Waratah grapple processor. Productivity rates for the DFB averaged 83 trees per hour in 0.11 m³ tree size (9.2 m³ /PMH).

In the second study trees were felled, delimbed and cut to random short lengths and bunched for forwarder extraction. A slightly different work method was employed in that the tree was delimbed after it was felled. Productivity averaged 74 trees per hour in 0.23 m³ tree size (17.1 m³ /PMH).

INTRODUCTION

The Waratah DFB is a New Zealand designed and built harvester which is capable of felling and delimbing Radiata pine to a satisfactory standard for pulp-

wood. Unlike the feed roll grapple harvesters, the Waratah DFB does not have length measuring capability.

The first unit was put into operation in 1979 with further modifications to subsequent units produced in 1980-81 (Wells, 1981a). There are currently over 20 units operating throughout Australia. The opportunity arose to study a MK5A DFB in Australia, (Figure 1), and a MK5B DFB in Aupouri Forest.

ACKNOWLEDGEMENTS

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THE MACHINE

The Waratah DFB consists of a double acting shear head and four wraparound delimbing knives, mounted via a purpose-built boom to a hydraulic excavator base (Figure 2). Improvements to earlier models included the redesign of the boom from the early parallelogram-type, installation of electric over hydraulic controls, and an increase in shear capacity from 37 cm to 45 cm. The DFB head, which weighs 1500kg, can be fitted to most excavators in the 13-17 tonne weight range. The electric/hydraulic control requires only one additional hydraulic circuit, and control switches are fitted to the lever handles to operate the spool valve on the head. The minimum hydraulic requirement is 150 l/min at 175 Bar.

STUDY No. 1: FELLING AND BUNCHING FOR SHORTWOOD PROCESSING

The first DFB operation studied was McConnell Dowell's mechanised system in Aupouri Forest.

The work method involved thinning of 16 year old Radiata pine by removal of a fifth row outrow and selection thinning between outrows using a Waratah DFB, a Waratah processor mounted on a Komatsu PC 150 excavator, and forwarder extraction.

The Waratah DFB felled the outrow and then thinned the adjacent two rows from the outrow, in a single pass through the stand. The unique feature of this operation was that the Waratah delimbed the standing tree to a height of approximately 7 m prior to felling by moving the head up and down the tree to the full extension of the boom.

Felled and partially delimbed trees were bunched on the right hand edge of the outrow, to enable further processing using the Waratah grapple processor (Duggan, 1988). The elements of the DFB work cycle in the first study were:

(1) Position head on the tree

(2) Delimb the tree by moving head up and down several times

(3) Fell the tree

(4) Bunch (including move to bunch)

(5) Clear slash.

Detailed timing of the DFB operation was undertaken for one day during which time 277 work cycles were recorded. The operator had approximately six months experience on the machine and appeared to have reached a competent standard.

Delays involving mechanical breakdown or other major stoppages were not recorded due to the short term of the study. Operational delays (ie those occurring during periods of machine operation) were recorded during the study.

Details of Study Area 1 are given in Table 1. Results of measurement of the productive work cycle of the Mark 5B DFB are given

Table 1 : Stand Details

Stand Age (years)	16
Total Stocking (Sph)	1500
Crop Stocking (Sph)	370
Mean Crop Height (m)	16.8
Mean Yield DBH (cm)	17.1
Mean Merch Tree Volume (m^3)	0.11

Table 3 : Productivity : Study 1

Total Cycle Time (min)	0.719
Trees per PMH	83.4
Productivity (m^3/PMH) at 0.11 m^3/tree	9.2
Daily Production at 6.5 PMH/day (m^3)	60

in Table 2. Total cycle time, excluding mechanical delays, totalled 0.719 min or 83 trees per productive machine hour (PMH). DFB productivity is summarised in Table 3.

The harvester was capable of high quality delimbing of the bottom 7m of the trees and high felling productivity. The productivity of the DFB is higher than previous studies of earlier DFB models (Wells, 1981a).

Felled trees were accumulated into bunches averaging 13 trees per bunch (1.46 m^3) for processing into 2.6m lengths by the Waratah processor. A lot of DFB time was spent moving back and forth to build large bunches of trees that otherwise would have been spent felling and delimbing. Smaller bunches of trees (maximum of four trees per bunch) would have improved pickup times for the following processor, resulting in stacks of processed wood which better matched the capacity of the forwarder grapple (10-13 pieces).

Machine availability was not quantified in this study, although it is assumed that 6.5 PMH per day is sustainable.

STUDY No. 2: RANDOM SHORT LENGTH PROCESSING

The second operation studied was that of Venturoni Bros, Radiata pine thinning contractors for APM Forests Limited of Gippsland, Victoria. The operation consisted of 2 Waratah DFB's and 2 Osa 250 forwarders. The DFB's were mounted on Kato 550SE excavator bases. Production per DFB was 70 tonnes per day with a maximum of 100 tonnes per day (0.23 m^3 piece size).

The first thinning operation in 14 year old Radiata pine consisted of removal of every fifth row and mechanical selection thinning of the adjacent two rows (Figure 3).

Table 2 : Waratah DFB Work Cycle : Study 1

Element	No of Observations	Mean per cycle (min)	± 95% Confidence Limits	% of total cycle
Position head	277	0.173	0.009	24.1
Delimb	244	0.127	0.014	17.7
Fell	277	0.059	0.003	8.2
Bunch (incl. move)	277	0.280	0.020	38.9
Total Process	277	0.639	0.029	88.9
Clear Slash	46	0.080	0.016	11.1
Total cycle	277	0.719	0.181	100.0

Figure 2 : Close up of the DFB head

Stand details are given in Table 4. In this operation the elements of the DFB work cycle were :

(1) Position head on the tree
(2) Partially delimb on the downward stroke
(3) Fell the tree
(4) Raise the boom to full extension (7 m)
(5) Delimb the tree by opening the grapple allowing the tree to fall through the knives
(6) Lower the head to approx 5.5m above ground
(7) Cut off stem using butt shear and direct felled stem onto bunch
(8) Repeat steps 5, 6 and 7 until tree is completely processed
(9) Top off the last length using the topping shear.

A short term study of the Waratah DFB was undertaken over a 2.22 hour period, during which time 165 cycles were recorded. The operator had about two years experience and was highly skilled operating the DFB. Results of measurement of the productive work cycle are given in Table 5.

A total of 317 logs were produced during the study, giving an average of 1.93 logs per tree, (0.12m³/log). The pulpwood produced was all in random short lengths (5 to 6 m). Total cycle time excluding mechanical delays

Table 4 : Stand Details

Stand Age (years)	*14*
Total Stocking (Sph)	*1650*
Crop Stocking (Sph)	*900*
Mean Yield DBH (cm)	*19.3*
Mean Merch Tree Volume (m^3)	*0.23*

Table 5 : Waratah DFB Work Cycle : Study 2

Element	*No of Observations*	*Mean per cycle (min)*	*± 95% Confidence Limits*	*% of total cycle*
Position head	*164*	*0.094*	*0.006*	*11.7*
Fell	*164*	*0.069*	*0.003*	*8.6*
Delimb and Cut	*164*	*0.587*	*0.027*	*72.7*
Move (incl. move to bunch)	*64*	*0.043*	*0.007*	*5.3*
Total Process	*164*	*0.793*	*0.031*	*98.3*
Clear slash	*22*	*0.014*	*0.002*	*1.7*
Total cycle	*164*	*0.807*	*0.037*	*100.0*

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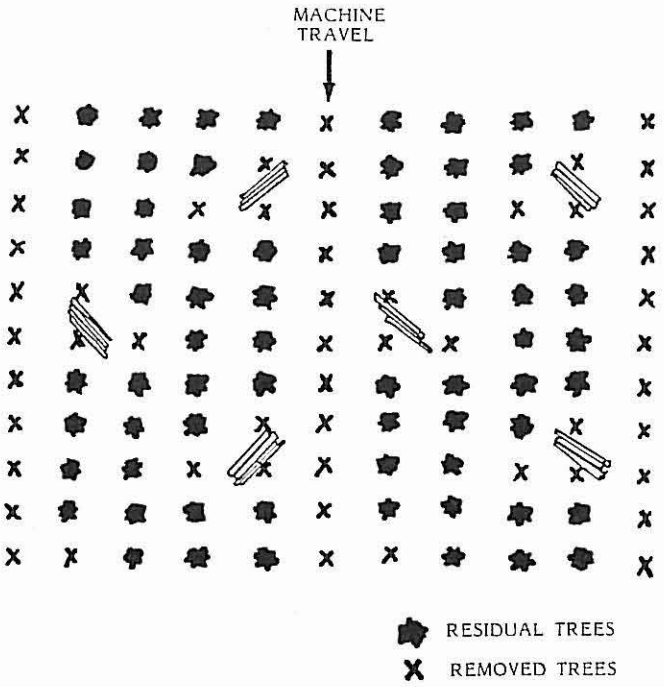

Figure 3 : DFB Felling Pattern : Study 2

totalled 0.807 min. giving productivity of 74 trees per PMH (Table 6). The apparent productivity of the DFB has improved by about 40% in first thinning operations since it was first introduced into Australia (O Raymond, pers comm). Production over the range of tree size in Study 2 was predicted by linear regression (Table 7). Long term production was calculated at 90% of measured productivity. The Waratah Mk 5B DFB Harvester was costed on both a single and double shift basis using the standard LIRA format (Wells, 1981b).

Table 6 : Productivity : Study 2

Total Cycle Time (min)	*0.807*
Trees per PMH	*74.4*
Productivity (m^3 /PMH) at 0.23 m^3 /tree	*17.1*
Daily Production at 6.5 PMH/day (m^3)	*111*

Table 7 : Estimated Productivity vs Tree Size (Study 2)

Merchantable Tree Volume (m^3)	*Production Rate (m^3 /PMH)*	*Predicted Long Term Production (m^3 /PMH)*
0.10	*10.9*	*9.8*
0.15	*13.2*	*11.9*
0.20	*15.6*	*14.0*
0.25	*18.0*	*16.2*
0.30	*20.3*	*18.3*
0.35	*22.7*	*20.4*
0.40	*25.0*	*22.5*
0.45	*27.4*	*24.6*
0.50	*29.7*	*26.8*
0.55	*32.1*	*28.9*
0.60	*34.5*	*31.0*

Prod (m^3 /PMH) = 47.2
**Tree Vol (m^3) + 6.2 (r^2 = 0.72)*

Capital cost of the boom and head is $190,000, and $120,000 for the excavator base.

Repairs and maintenance on the head and boom was estimated to be quite low due to the robustness of the construction. It was expected R & M on the base machine would be high due to the effect of in-bush travel on track maintenance and also the effect of double shifting (Table 8).

Australian estimates of long term productivity and availability suggest that an average of 70 trees per PMH and 70% utilisation is sustainable. The production rate was standardised at 70 trees per hour for comparison of costs for the two operations. In 0.11m^3 piece size, system productivity = 49m^3 /shift (based on a 9 hour work day). In 0.23m^3 piece size, system productivity was 101m^3 /shift.

Based on Table 8, costs on a single shift basis are $14.90/$m^3$ (0.11m^3) and $7.13/$m^3$ (0.23m^3). With double shifting, these costs reduce to $12.43/$m^3$ and $5.94/$m^3$ respectively. This is a 17% reduction in felling and bunching costs.

Table 8 : Costing for Single and Double Shift

	SINGLE SHIFT (6.5 PMH/day)	*DOUBLE SHIFT (13 PMH/day)*
Total Machine Cost		
($/PMH)	*90.50*	*69.85*
($/day)	*588.25*	*908.05*
Labour Cost		
($/day)	*135.30*	*297.66*
Total Cost ($/day)	*723.55*	*1205.71*
Unit Cost $/m³ : 0.11m³	*14.77*	*12.43*
: 0.23m³	*7.13*	*5.94*

Although in both studies subsequent extraction was by forwarder (due to processing into short lengths in the bush), the DFB would also be suitable in a conventional tree length skidder extraction operation. The further delimbing required (past 7m length) could be done either manually in the bush or at the landing.

CONCLUSIONS

In both studies the Waratah DFB has shown to be capable of high productivity felling, delimbing and bunching for either further processing or forwarder extraction. It has the ability to alleviate both the high cost of delimbing small diameter stems and the difficulty of accumulating suitable payloads. The Waratah harvester would not only reduce the manual labour requirements for delimbing, but would also eliminate the bunching machine from a conventional thinning system.

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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 these operations.

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