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THE BELL SUPER T FELLER-BUNCHER

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ABSTRACT

This Report compares two methods of mechanical felling using a Bell Super T Feller-Buncher in Ponderosa pine clearfelling. Felling trees out of the stand was 12% more productive than felling into the stand, due to reduced bunching times.

Operational methods, motivation and skill had a greater influence on the felling and bunching phase of the operation, than tree characteristics such as diameter or volume.

Mechanical felling and bunching was 80% more productive than manual felling. Without bunching, the Bell Super T is 150% faster than manual felling.

Figure 1 - The Bell Super T Feller-Buncher felling Ponderosa pine.

INTRODUCTION

On easy terrain, Bell Loggers have proved to be an extremely versatile and manoeuvrable machine, capable of handling both thinning and small clearfell trees (Gleason, 1985). They are commonly used on flat country for bunching and sorting.

A recent development of the Bell Logger in New Zealand has been to fit a Bell chainsaw felling head, developed from the Hultdins felling head (Raymond and Moore, 1986). This Report describes the Bell Super T Feller-Buncher in a Ponderosa clearfell operation in Kaingaroa Forest. The study objectives were to:

- compare two different techniques of clearfelling
- analyse how slash levels affected travel time and total times
- estimate machine productivity and costs.

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* Patrick Hawinkles was a third year B.For.Sc. student working at LIRA during the 1986/87 summer vacation.

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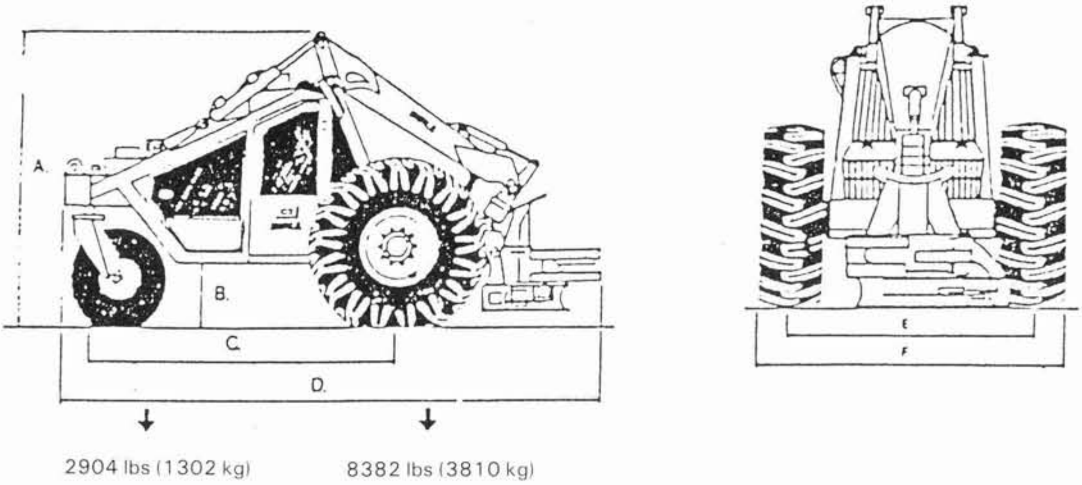
MACHINE DESCRIPTION

The Bell Super T has a 52 kW Deutz 4-cylinder air-cooled diesel engine, giving the machine a 2.2 tonne lifting capacity. It is fitted with an hydraulically operated chainsaw felling head with a 60 cm bar. Figure 2 gives dimensions of the machine.



SUPER T

Overall Height . . . . . . 1055"	(2 680mm)	
B Ground Clearance . . . . 22"	(550mm)	
C Wheel Base . . . . 114"	(2 900mm)	
D Overall Length . . . . 189"	(4 800mm)	
E Width of Axle . . . . 99" (Wheels Removed)	(2 520mm)	
F Overall Width . . . . 106"	(2700mm)	
G Weight . . . . 11280 lbs	(5130 kg)	

Figure 2 - Dimensions of the Bell Super T Feller-Buncher

PROJECT DESCRIPTION

Stand Description

The stand was 57 year old Ponderosa in the southern region of Kaingaroa Forest. The summary compiled from stand records and preharvest inventory by Tasman Forestry Limited staff is given in Table 1.

Table 1 - Stand Details

Species	- Pinus Ponderosa
Year of Planting	- 1929
Silvicultural Treatment	- Nil
Live Stocking/ha (at clearfelling)	- 418
Dead Stocking/ha (at clearfelling	- 56
Mean Merchantable Stem Volume (m^3)	- 0.4

Density of undergrowth and stand stocking varied considerably, and the topography was classified as flat. Data obtained through-out the study differed to those above primarily due to high variability in piece size and stocking throughout the compartment.

The Operation

The gang consisted of the contractor and eight men

- 4 trimmers
- 1 skiddy
- 1 loader and operator
- 1 skidder and operator
- 1 Bell feller-buncher and operator

Operational Procedure

When opening up a new block, the Bell Super T felled several corridors approximately 1.5 trees in width and 60 m apart, to provide access (Figure 3). Once the corridors were opened up, the Bell Super T worked off each face to a

Figure 3 - Felling Corridors

depth of approximately 7 m, partially bunching the trees so the butts were lined up.

Manual trimmers followed behind the Bell Super T, trimming to a 10 cm small-end diameter.

The Caterpillar 518 grapple skidder extracted approximately six pieces per cycle. Due to pre-bunching by the Bell Super T, minimum blading and pick up times were observed.

The skiddy carried out a final trim of the extracted timber, and the loader sorted, stacked and loaded trucks as required.

Study Method

A full work study was carried out on the two different types of felling:

- Felling in consisted of the machine felling the trees into the stand and then dragging them out and bunching
- Felling out comprised the machine felling outwards into the open and then bunching.

Both these two methods were analysed to observe any differences.

The felling cycle was broken into four elements: travel, position, fell and bunch.

Approximately 400 cycles for each method were recorded.

Slash and undergrowth levels and bunch distances from stumps were also recorded.

A proportion of trees felled were scaled to determine tree volume for the study area. A Servis Recorder was used to determine machine availability and utilisation and the operator classified the various delays.

RESULTS AND DISCUSSION

Table 2 - Mean Element Times for Both Felling Methods

	Felling Into Stand			Felling Out of Stand		
Element	Mean (min)		% of Total Cycle	Mean (min)		% of Total Cycle
Travel	0.194		32	0.182		33
Position	0.071		12	0.078		14
Fell	0.117		19	0.136		25
Bunch	0.221		37	0.156		28
TOTAL	**0.582**	*0.024*[1]	**100**	**0.520**	*0.022*[1]	**100**
Trees/hr	103	*1.5*[1]		115	*1.3*[1]	
Bunch Distance (m)	7.84	*0.34*[1]		3.4	*0.25*[1]	

The sum of the elemental times is longer than the mean total time due to difficulty in recording break poings of faster cycles.

NOTE [1] i.e. 95% of results should fall within this range

Cycle Time Analysis

Travel and bunch time each comprised approximately 30% of total time, with position and fell making up the remainder (Table 2).

There was no significant difference between travel time for the two felling methods. It was expected that with felling out, travel time would be lower due to the shorter bunch distances and subsequent travel to the next tree.

Effect of Tree Size on Productivity

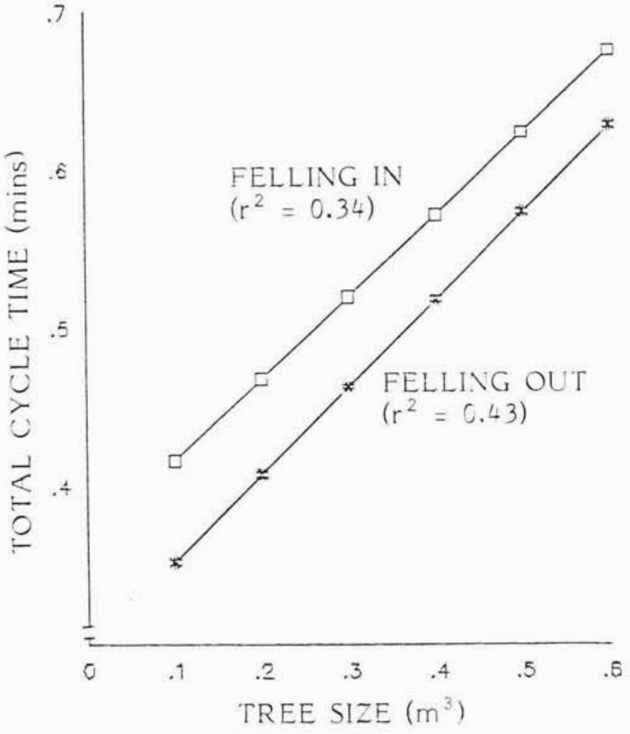


Figure 5 - Total Cycle Time vs. Tree Size

This, however, was offset by the requirement for the Bell to manoeuvre through the stand and position behind the next tree for correct felling.

The felling out method had a significantly higher fell time. This was probably due to more care being required in positioning trees where the operator frequently drove forward directing the tree as it fell, increasing felling element time but decreasing subsequent bunch time. During felling into the stand, the operator drove backwards helping to pull the trees to the ground and decreasing subsequent bunch time.

There was a significant difference between bunch times for the two methods. The bunch distance for felling in was twice that of felling out. The felling out method resulted in a significantly lower total cycle time than felling in.

The relationship between the volume of felled stems and total cycle time was plotted for both felling methods (Figure 5).

The level of skill and motivation of the Bell Super T feller-buncher operator affected all elements of the work cycle. Variation in felling time was attributable to the positioning of

Figure 4 - Bell Super T Feller-Buncher Felling Out from Stand

the head on the tree, tree lean and the directional felling of trees. Placement of the tree was a major factor influencing variation in bunch time, especially when felling outwards.

Any abnormality in felling or bunching technique affected total cycle time significantly. Hence operational methods had a greater influence on productivity than tree volume.

Effect of Slash on Travel Time and Total Time

A summary of how slash levels affected mean travel time is given in Table 3.

Within each method, travel times between each slash level were significantly different (95% level). Between felling methods there was a significant difference in travel time at the high slash level only.

Table 3 - Effect of Slash on Travel Time

	Felling into Stand		Felling Out of Stand	
Slash Level	Travel Mean (min)	95% Confidence Interval (±)	Travel Mean (min)	95% Confidence Interval (±)
Low	0.15	0.01	0.15	0.01
Medium	0.21	0.02	0.22	0.02
High	0.32	0.02	0.27	0.02

Using the mean travel time for each level of slash and adding mean times for the other elements, the effect of slash on total cycle time and hence trees per hour was calculated. From low to high slash levels, productivity reduced from 108 to 83 trees per hour (23%) for the felling in method, and from 115 to 93 trees per hour (19%) for felling out.

Delays

Servis recorder charts were obtained for a period of thirteen days, spanning through November to January. The description of delays arises from on-site observations and communication with the operator and contractor.

Total delays were not separated into mechanical and operational delays due to inability to separate some delay times and a high proportion of unknowns.

Blown hydraulic hoses (due to chafing against the felling head) were the major cause of delays. Modifications were due to be carried out to give hoses extra protection.

Table 4 - Production Delays (13-Day Period)

	Total Delays (mins)	Mean Hours/Day	% of Total Delays
Bell	215	0.28	10
Bar & Chain	258	0.33	11
Hydraulics	560	0.72	24
Tyres & Chains	108	0.14	5
Grapple	392	0.50	17
Maintenance*	273	0.35	12
Smoko	156	0.20	7
Unknown	330	0.42	14
TOTAL	**2292**	**2.94**	**100**

*Warm up, lube, clean

Total scheduled hours per day = 7.87
Productive machine hours per day = 4.93

$$\text{Machine Utilisation} = \frac{\text{PMH}}{\text{Scheduled Hours}} = 63\%$$

A large number of unknown delay times could be associated with bar, chain problems and Bell maintenance.

Smoko accounted for only 0.2 hours per day due to the operator taking smokos while maintenance was being carried out on hydraulics, bar and chain, etc. by the contractor.

Grapple delay was due to structural damage to the grapple. Modifications have been made to more recent felling heads, improving their shock resistance.

The tendency for bar bending during the early part of the study was overcome by the Bell operator through experience.

Production Estimates and Costing

Productivity calculation is based on a weight tree volume for the two felling methods over the whole study area. the weighted volume of $0.46m^3$ per tree is used to calculate production per machine hour and production per day, taking into account delays (Table 5).

Using the LIRA Costing Handbook for Logging Contractors (Wells, 1981), the daily cost of owning and operating a Bell Super T Feller-Buncher is estimated in Table 6.

Table 5 - Productivity Estimates

	Felling In	Felling Out
Trees/hour	103.0	115.0
Productivity/hour(m^3)	47.3	52.9
Productivity/day*(m^3)	233.0	261.0
Tonnes/day**	270.0	303.0

*Including delays, PMH per day = 4.93

**Conversion factor 0.86m = 1 tonne

Note: These productivity estimates are only those for the study period in which the Bell was mechanically felling and bunching trees. They do not include the productive machine hours that were spent travelling between felling corridors.

Combining Tables 5 and 6 gives a felling and bunching cost of $1.33 for the felling in method, and $1.19 per tonne for the felling out method.

Table 6 - Machine Daily Cost (March, 1987)

Bell Super T Feller Bunchers

Cost of Machine	= $118,000	Resale Value	= $40,000
Life of Machine in Years	= 5		
Prod.Hrs/Yr	= 1500	Prod.Hrs/Day	= 6.5
Rate on Investment	= 18%	Insurance	= 3%
Fuel Consumption	= 5.9 ℓ/PMH	Fuel Cost per litre	= $0.69
Oil Consumption	= 0.5 ℓ/PMH	Oil Cost per litre	= $4
R & M Factor	= 75%		
Own Cost/Hr.($)		Operating Cost/Hr.($)	
Depreciation	9.67	Fuel	4.07
Return Inv.	10.42	Oil	2.00
Insurance	1.74	Tyres	1.83
		R & M	7.25
TOTAL OWN $/HR	**21.82**	**TOTAL OPERATING $/HR**	**15.15**

MACHINE COST PER DAY = $240.32
OPERATOR COST PER DAY = $120.00

$360.32

Comparison with Manual Methods

From New Zealand Forest Service work study standards, manual felling time of approximately one minute would be required to fell each tree. This includes pre-trim and clear-slash time. To make a valid comparison, as manual felling doesn't include bunching, two methods were compared:

- Bell felling out of stand without bunching
- Bell felling out of stand with bunching

Felling into the stand without bunching would not be feasible for subsequent trimming and extraction, hence was not included in this comparison.

Table 7 - Comparison of manual and Bell felling

	Manual Felling (1 person)	Bell(Felling Out) Without Bunch	With Bunch
Trees/hour	60	151	115

Even though the productivity is lower with bunching, the advantages of bunching outweigh this reduction due to system effects such as easier and quicker trimming and greatly increased productivity of the skidder.

CONCLUSION

Bell Loggers have proven to be an extremely versatile machine. This Report documents another aspect of their versatility - felling and bunching trees.

The breakdown of cycle time has shown that "travel" and "bunch" elements contributed over 60% of total time, with "position" and "fell" making up the remainder.

High levels of slash greatly increased travel time and consequently total time per tree.

Satisfactory regression equations were calculated for total cycle time on tree volume. However, the operational method, skill and motivation of the operator had a greater effect on overall productivity.

Felling trees out from the stand proved to be significantly faster than felling in, resulting in a 12% increase in productivity. The major reason for the increased production rates was the shorter bunch time.

Machine utilisation of 63% appeared low but once planned modifications had been carried out, it was expected that machine utilisation would improve.

Comparison with manual methods shows that without bunching, the Bell Super T fells approximately 150% more trees than one manual faller and approximately 80% more trees when bunching is included. Benefits of bunching on overall gang productivity are considerable but were not quantified in this study.

LIRA NOTE

During the period of this study, equipment and work methods were in a state of development. Productivity and cost estimates are only indicative.

REFERENCES

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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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