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DOWNHILL EXTRACTION WITH A D5H GRAPPLE TRACKED SKIDDER

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Figure 1 - D5H Grapple Tracked Skidder working in Tahorakuri Forest

ABSTRACT

A study to investigate the productivity of a Caterpillar D5H Series II grapple tracked skidder working in Tahorakuri Forest was undertaken. The stand was characterised by moderate slopes up to 28° and a mean piece size of 3.1m³. The average haul distance was 223m and the average volume per drag was 7.6m³. With an average productive cycle time of 8.79 minutes, the overall productivity of the system was 52.2m³/productive machine hour.

ACKNOWLEDGEMENTS

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INTRODUCTION

The elevated sprocket design first originated in 1921 with the development of the Cletrac Model F Cleveland Tractor. The elevated sprocket was technology ahead of its time and was developed no further until Caterpillar trialled the concept on an experimental D7 tractor during the 1960s. In 1978, the first D10 high drive tractor was introduced. In 1986, the smaller, Series I, high drive tractors (D7, D6, D5 and D4) were released (Bare, 1988).

The Series I tracked skidders were initially referred to as custom skidders. The D5H custom skidders were plagued with problems associated with the flexing of the rear mainframe (Edwards, pers comm). However, these problems were often overshadowed by more favourable comments soon after their release. Many of the original problems have been addressed in the Series II machines. These machines are versatile and can be used for both road building and skidding with reported higher production rates than rubber-tyred skidders in wet terrain (Series II Tractors, 1990). The D5H tracked skidder has low ground pressure reducing soil compaction and has provided access to areas previously accessible only to FMC's (Hassen, 1989).

This study investigates the productivity of a D5H Series II grapple tracked skidder working in a clearfell operation.

THE MACHINE

This is the first grapple tracked skidder to be used in New Zealand logging operations. The grapple arch when fully extended has a reach of 2m to the rear of the machine. The Young brand grapple has a 290° rotation and a maximum opening of 2.5m which is equivalent to the width of the machine. The grapple arch unit weighs approximately one tonne. The grapple arch incorporates a fairlead so that the modified Cat 518 winch can be used to break out loads when conditions do not suit grapple skidding.

The power angle and tilt (PAT) blade gives the machine good tracking capabilities. The blade is a metre in height and has a capacity of 2.5m^3. It has a digging depth of 45cm and a ground clearance of almost one metre.

Engine (Cat 3304 Turbo Charged Diesel)	90 kw/120 hp (flywheel)
Operating Weight	15141 km (cable)
	16177 km (grapple)
Travel Speed	
1st Gear	3.6 km/hr
2nd Gear	6.4 km/hr
3rd Gear	10.9 km/hr
Ground Clearance	478mm

Table 1 - Machine specifications

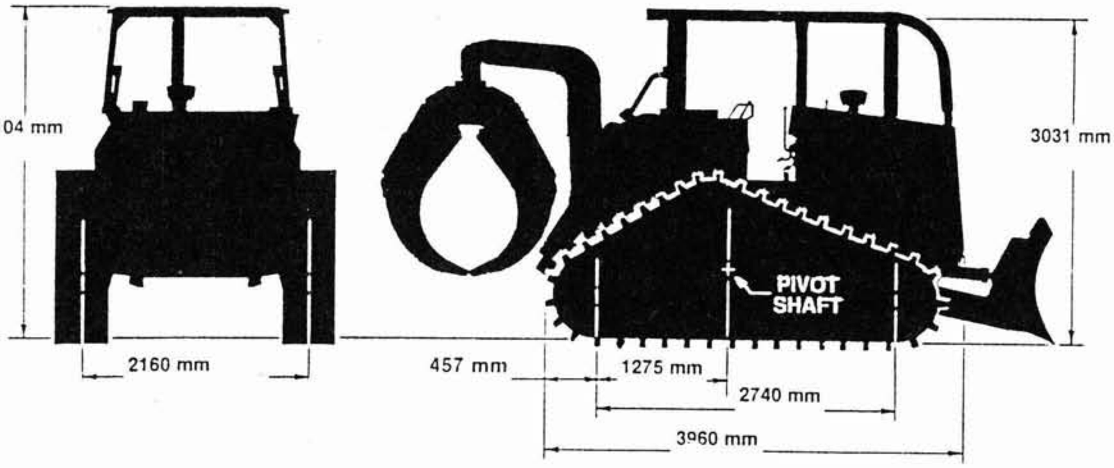


Figure 2 - Machine dimensions

STUDY SITE

The study was carried out during April, 1991 in Compartment 8381/9 of Tahorakuri Forest adjacent to the Waikato River (Table 2). The area consisted of small gully systems from which the easily accessible trees had been extracted using a skidder prior to this operation. The gullies provided access tracks which were relatively flat and stump free allowing quick travel times. The delimbed trees were extracted downhill to the landing where they were cut into log lengths and loaded out in a hot deck type operation.

Stocking (sph)	204
Piece Size (m^2)	3.1
Stand Age (yrs)	44
Stope (degrees)	0-28

Table 2 - Stand details

STUDY METHOD

Log volume calculations of an 80 stem sample were used to obtain a relationship between large end diameter to tree volume ($r^2 = 0.85$). This relationship was used to calculate individual cycle volumes.

A continuous time study method was used to collect data from 107 extraction cycles using the grapple. A small number of cycles when the winch was used to skid logs was also recorded. These cycles were not included in the grapple tracked skidder work cycle.

The work cycle elements were separated into productive and non-productive time (Table 3). The maximum ground slope of the travel loaded phase of the cycle, butt diameters of each full tree length extracted and the travel empty and travel loaded distance were measured.

RESULTS AND DISCUSSION

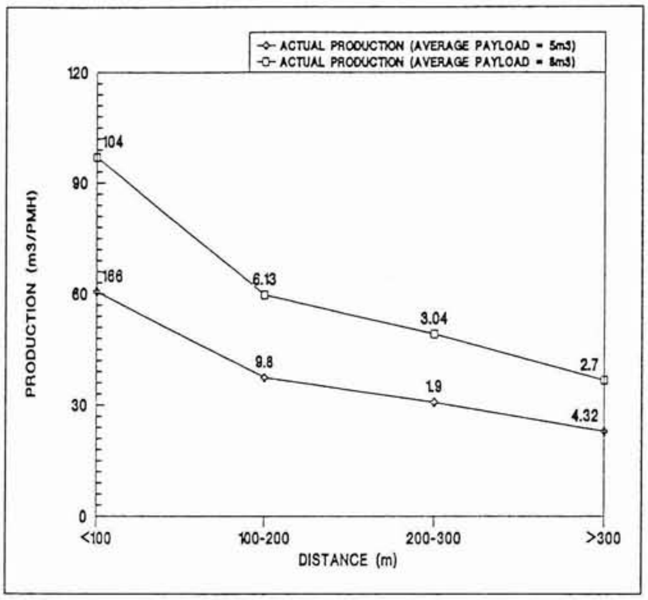
Element	Per Cycle (Mins)			Per Occasion (Mins)	
	Mean	95% Confidence Limits	Occurrence	Mean	95% Confidence Limits
Productive Time					
Travelling Empty	3.58	0.26	107	3.58	0.26
Position	1.84	0.28	105	1.62	0.24
Hook-on (includes activating grapple)	0.43	0.07	107	0.43	0.07
Travelling Loaded	2.76	0.22	107	2.76	0.22
Fleeting	0.10	0.04	23	0.44	0.58
Tracking	0.08	0.02	3	2.96	3.08
Sub Total	8.79	0.60	-	-	-
Non-Productive Time					
Personal Delays	1.43	2.80	7	21.81	12.22
Operation Delays	0.58	0.60	14	4.44	4.12
Mechanical Delays	0.08	0.15	1	8.22	-
Sub Total	2.09	1.45			
Total Cycle Time	**10.88**	**1.67**			
Stems/Cycle	2.4	0.14			
Slope (degrees)	15	1.2			
Drag Volume (m^3)	7.64	0.39			
Distance Empty (m)	246	16.3			
Distance Loaded (m)	223	15.5			

Table 3 - D5H grapple tracked skidder work cycle

The average productive cycle time was 8.8 minutes and the average drag volume was 7.6m^3. This equates to a volume productivity of 52.2m^3/PMH for the six man crew or 8.7m^3 per productive man-hour.

The 3.1m^3 piece size and the 15^0 average slope meant that grappling times were relatively quick, resulting in short cycle times and high production overall.

Figure 3 illustrates the actual production achieved from a range of haul distances.



(Note : Data labels indicate the 95% confidence interval (±) of the mean production rate (m^3/PMH))

Figure 3 - Actual D5H grapple tracked skidder production rates

The relatively high production rates associated with short hauls were attributable to:

- the reduced position time as the machine travelled in reverse from the skid to the cutover.
- the trees had slid off a steep slope adjacent to the skid site and were easily accessible using the grapple.

A large variation in mean production rates for haul distances less than 100m is attributable to the greater proportion of the cycle time accounted for by positioning and hook-on.

In an attempt to increase the payload on long hauls, the winch and four strops were used. Ten cycles using the winch rope and strops were compared with fourteen cycles using the grapple, for a constant distance. Table 4 summarises the results of the comparison.

	WINCH		GRAPPLE		
Productive	Mean	95% Confidence Interval	Mean	95% Confidence Interval	Significant Difference @ 95% Level
Cycle Time (mins)	15.89	3.09	11.55	1.41	YES
Stems per drag	3.0	0.38	2.36	0.37	YES
Volume per drag (m^3)	10.64	1.88	8.65	0.92	YES
Haul Distance (m)	307.8	31.7	315.0	22.8	NO
Productivity (m^3/PMH)	42.8	1.18	47.0	8.57	NO

Table 4 - Differences in grapple and winch systems

The difference in the productive cycle times is attributable to the time to gather loads (i.e. position and hook-on). There was no significant difference in the travel empty time or the travel loaded time for the two systems, or in hourly productivity between the two systems. The ground slope where either the hook-on and grappling was carried out was approximately 10^0. Even under these relatively flat conditions, mean production rates when using the grapple were variable.

On steep terrain grappling becomes more difficult for a number of reasons:

- the machine's tractive ability is reduced when reversing on steep slopes, making it difficult to position the machine ready for grappling.
- optimum payloads are difficult to obtain as trees already in the grapple slide downhill when the grapple is opened to accumulate subsequent trees.
- the variable piece size of this particular stand caused difficulties when trying to secure more than two stems in the grapple. Often the third stem would not be held by the grapple arms and slipped out during the travel loaded phase of the cycle. A system where a greater number of stems can be gathered quickly and secured tightly in the grapple would be benefical to overall production. It may be possible to incorporate a cable system to the grapple similar to the Hydrawrap grapple (McKenzie, 1990).

Due to the increased difficulties of securing loads in the grapple on steep country, the modified Caterpillar winch can play an important role in maintaining production levels on difficult country.

Since this study was carried out, the winch has been used more extensively to log the more difficult areas. This machine has also suffered winch problems similar to some of the other high drive machines (Hill, 1991).

CLIMBING ABILITY

Climbing ability is dependant on soil type, ground cover and the condition of the machine. The friable soils in Tahorakuri Forest are volcanic in origin (Kaharoa ash, Taupo pumice and ignimbrite bedrock). The D5H climbed slopes up to 25^0 on formed tracks but slash severely affected the machine's ability to climb adverse grades. The machine was observed pushing in tracks on adverse grades up to 22^0.

COST ANALYSIS

Estimates of the daily cost of the operation were established assuming a 6 man crew (2 skiddies, 2 fallers and 2 machine operators) using the LIRA costing format (Wells, 1981). The D5H grapple tracked skidder has a capital cost of $350,000.

	Cost ($/day)
D5H Grapple	585.00
6 Men including Saws	960.00
Work Vehicle (@ $0.60/km)	72.00
Loader (Volvo L90)	397.00
Overheads (2½%)	50.00
Profit (10%)	201.00
TOTAL DAILY COST	**$2,265.00**

Table 5 - Daily cost of D5H grapple tracked skidder operation

CONCLUSION

The study showed the D5H grapple tracked skidder is capable of producing $52m^3$/PMH given that the average piece size is $3.1m^3$, the average ground slope was 15^0 and the average haul distance was 223m. Using a 6.5/PMH day, daily production was estimated to be $338m^3$. Based on this daily production, logging costs are estimated to be $\$6.70/m^3$ on truck.

Payloads using the grapple were often limited to two trees due to the third and subsequent stems slipping out of the grapple once the machine started to move forward. A system where a greater number of stems can be gathered quickly and secured tightly in the grapple would be beneficial to overall production.

Larger payloads were accumulated using the winch rope and strops but this was no more productive than using the grapple. The winch system, however, gives the unit flexibility when conditions do not suit grapple skidding.

Payloads are obtained quickly on slopes where the trees already in the grapple are not at risk of sliding downhill when the grapple is open and where the machine still has the ability to reverse and position ready for grappling. Under these conditions, the grapple tracked skidder provides advantages over the winch systems on moderate slopes.

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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 an indicative estimate and do not necessarily represent the actual costs for this operation.

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