

of neighbouring trees. These 'growth releases' can provide insight into past forest regeneration processes. The huge variation in ring widths along different radii on the same disc identified in our study, however, indicates that an analysis of growth releases in rimu could be very misleading and of limited use in determining stand disturbance history.

Acknowledgements

We wish to thank the Lottery Grants Board for providing funds to carry out this study and Timberlands West Coast Ltd for providing the rimu discs. Drs Don Mead and Richard Duncan made many helpful comments on the manuscript.

References

- Cornere, B.M. 1992. Podocarp dynamics of a lowland terrace rimu forest, south Westland, New Zealand. M. For. Sci. thesis, University of Canterbury, Christchurch, New Zealand.
- Duncan, R.P. 1989. An evaluation of errors in tree age estimates based on increment cores in kahikatea (*Dacrycarpus dacrydioides*). New Zealand Natural Sciences 16:31-37.
- Duncan, R.P. 1991. Competition and the coexistence of species in a mixed podocarp stand. Journal of Ecology 79: 1073-1084.
- Dunwiddie, P.W. 1979. Dendrochronological studies of indigenous New Zealand trees. New Zealand Journal of Botany 17:251-266.
- Franklin, D.A. 1969. Growth rings in rimu from south Westland terrace forest. New Zealand Journal of Botany 7: 177-188.
- Franklin, D.A. 1973. Growth rates in south Westland terrace rimu forest. 1. Growing stock and increment in virgin forest. New Zealand Journal of Forestry Science 3:304-312.
- Lusk, C. and J. Ogden. 1992. Age structure and dynamics of a podocarp-broadleaf forest in Tongariro National Park, New Zealand. Journal of Ecology 80: 379-393.
- Norton, D.A. and J. Ogden. 1987. Dendrochronology: a review with New Zealand applications. New Zealand Journal of Ecology 10: 77-95.
- Norton, D.A., J.P. Palmer, and J. Ogden. 1987. Dendroecological studies in New Zealand. Part 1. An evaluation of tree age estimates based on increment cores. New Zealand Journal of Botany 25: 373-383.
- Norton, D.A., J.W. Herbert, and A.E. Beveridge. 1988. The ecology of *Dacrydium cupressinum*: a review. New Zealand Journal of Botany 26: 37-62.
- Patel, R.N. 1967. Wood anatomy of Podocarpaceae indigenous to New Zealand. New Zealand Journal of Botany 5: 171-184.
- Richards, K. 1994. Sustainable management of rimu forests – the Timberlands West Coast experience. New Zealand Forestry 39: 7-9.
- Rogers, H. 1995. Variation in the effects of disturbance along a drainage gradient for a lowland temperate rainforest, south Westland, New Zealand. Ph.D. thesis, University of Canterbury, Christchurch, New Zealand.
- Six Dijkstra, H.G., D.J. Mead, and I.L. James. 1985. Stand structure in terrace rimu forests of south Westland and its implications for management. New Zealand Journal of Forestry Science 15: 3-22.
- Stewart, G.H. and A.B. Rose. 1990. The significance of life history strategies in the developmental history of mixed beech (*Nothofagus*) forests, New Zealand. Vegetatio 87: 101-114.

Mechanical site preparation using excavators

Peter Hall*

ABSTRACT

The use of excavators for site preparation is becoming increasingly popular in New Zealand and overseas. Excavators can be fitted with a wide range of attachments and can fulfil multiple tasks within a forest.

This paper summarises recent LIRO studies of excavators used in a site preparation role in the forest industry.

Windrowing with an excavator fitted with a slash rake achieved 0.46 hectares per productive machine hour at a cost of \$240 per hectare.

Spot cultivation by ripping and mounding with an excavator cost \$434 per hectare at 0.29 hectares per productive machine hour.

The ROTREE spot cultivator-moulder working on sites with slopes of 0-15° covered 0.23-0.29 hectares per productive machine hour at a cost of \$450-\$540 per hectare.

Excavators can typically work on steeper slopes than other commonly used site preparation equipment and operate with less site impact.

Introduction

Excavators as base machines for site preparation operations are common in North America, especially Canada, where there has been a rapid increase in the number of excavators used for site preparation in the last five years (Clark, 1993).

The use of excavators as a site preparation prime mover has also gained in popularity in New Zealand in the last three years.

Windrowing of heavy slash on rolling to steep terrain with excavators fitted with slash rakes and modified tracks (Hall, 1992) as an alternative to burning or line raking with tractor is



Figure 1. Excavator with slash rake windrowing a site logged by contour tracking.

now common practice in much of the South Island (Figure 1). Cultivation of cutover soils prior to planting is a common practice, especially in the compact pumice soils in the Bay of Plenty. *Pinus radiata* root growth becomes limited when soil strength exceeds 3 megapascals (Mason and Cullen, 1986). Many of the soils in the Bay of Plenty and in much of the rest of New Zealand exceed this level below a depth of 30-40 cm. The deep cultivation provided by ripping operations reduces the incidence of severe juvenile instability and sometimes increases tree growth, depending on the soil type.

Traditionally the cultivation of these sites has been carried out with a ripper-moulder unit mounted on a 150 kW tractor. Much

* Researcher, New Zealand Logging Industry Research Organisation, Rotorua.



Figure 2. Excavator with a spot ripper-moulder.

of the development and early use of these units took place on cutovers that had been burnt and were largely clear of logging slash. There has been a marked reduction in the amount of burning being done in the last five years, both in New Zealand and overseas. The main reasons for this are the desire to retain nutrients contained in the slash and duff on site and adverse public reaction to the highly visible smoke clouds created by fires. Consequently, many cutovers now have large volumes of non-merchantable stem wood and branch material present when the cultivation operation takes place. This material can cause problems for tractor-based ripper-moulder units as it tends to accumulate around the ripper and can prevent the discs from mounding properly. The result of these slash accumulations is that many tractor-based ripping-mounding operations now require two machines, a smaller tractor (120 kW) is used with a rake or v-blade to clear a lane through the slash prior to the larger (150 kW) tractor completing the operation with the cultivation unit.

A recently developed alternative to this two pass tractor operation is the excavator-based spot ripper-moulder (Figure 2). The excavator is able to traverse the untreated cutover and remove slash from individual spots prior to making the rip-mound (Figure 3).

The excavator-based operations are also capable of working steeper slopes than tractors (Karsky, 1994) and are affected less by operational delays caused through the machine becoming stuck, as they can free themselves from stumps and holes using the boom.

Other reasons for the increasing popularity of excavators are that they are widely available, are reliable, have good service

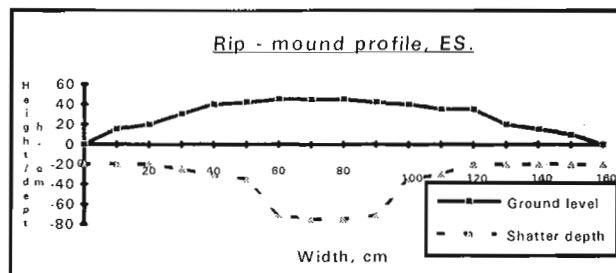


Figure 3. Rip-mound profile for excavator spot ripper moulder.

back up and are capable of performing a number of tasks within a forest. The amount of capital invested is also significantly lower than that required for a similar powered tractor (INFORME, 1994).

Apart from the traditional buckets and rippers, there is a range of more sophisticated attachments for excavators. These include the "Slash Buster" for vegetation and slash mulching on the cutover or along roadsides, the "Towtem Grapple Clam" for roading, shovel logging, and track rehabilitation, the "ROTREE" cultivator for spot cultivation and mounding on cutover and the "VH Mulcher" for spot cultivation.

LIRO have conducted a number of studies looking at excavator-based operations in the last two years. This report summarises the results of those studies.

RESULTS AND DISCUSSION

1. Excavator windrowing and tractor line raking

Table 1: Summary of study data

	Tractor line rake	Excavate windrow
Production	0.69 ha/PMH	0.46 ha/PMH
Cost	\$145 ha	\$240 ha
Slash volume	190 m ³ /ha	270 m ³ /ha
Max slope	24°	33°
Mean slope	12°	17°
Proportion of site 20° +	5%	31%
Proportion of site 30° +	0%	5%

PMH = Productive Machine Hour.

The excavator was an Hitachi EX 200 with modified tracks fitted with a 2 m wide 7 tooth slash rake. The tractor was a Liebherr 731 (110 kW) fitted with an angled bull blade. The volume of slash on both sites was very high, as the crop had not been tended and there was no pulp market for small or malformed logs.

The excavator was slower and more expensive than the tractor but left a cleaner, tidier site. It was also working on steeper terrain in heavier slash and treated a greater proportion of the total site than the tractor line raking (Table 1).

Both operations increased the amount of soil disturbance above that created by the logging operation. However there were no differences between the operations in the amount of soil disturbance created. The volume of topsoil removed from the site

was negligible in both cases. The tractor was not capable of working on the steeper sections (25° +) that the excavator treated.

2. Excavator spot ripping-mounding (ES) vs tractor two pass continuous furrow ripping-mounding (TRM). (Hall, 1994a)

Table 2: Summary of study data

	TRM	ES
Production (Spacing = rows 6m* spots 2.7m)	1.03 ha/PMH	0.29 ha/PMH
Cost	\$348/ha	\$434/ha
Stumps per hectare	475	450
No. stumps uprooted pre-treatment	7 per ha	10 per ha
No. stumps uprooted post treatment	120 per ha	30 per ha
Slash volume	56 m ³ /ha	42 m ³ /ha
Slope	0-5°	0-5°
Vol. cultivated soil/tree	1.6 m ³	1.7 m ³
Average Mound height	30 cm	45 cm
Average Rip depth	45 cm	71 cm
Spot quality acceptable	35%	94%

The excavator in this study was a Cat 320 L with tracks modified to give extra traction and was fitted with the ripper moulder shown in Figure two. The tractors used were a Komatsu D65



WILCO
PRODUCTS

Spot cultivation

The WILCO spot cultivator is a versatile unit which can be used to create spot mounding, spot ripping-mounding and slash clearing with and without fertiliser application.

It has been developed to cultivate ground with minimum environmental damage prior to the planting out of forests.

The machine, mounted on a 20-tonne excavator, creates large mounds over rips of up to 80 mm in depth.

For further information contact:



WILCO PRODUCTS, PO Box 62, Rotorua. Ph/Fax (07) 349 2527. Mobile 025 951 958.
SUPPLIERS OF FORESTRY EQUIPMENT

with a V-blade and a Cat D7H with a ripper mounder unit.

The TRM and the ES both substantially reduced the area of undisturbed soil (McMahon & Evanson, 1994), with the TRM creating more deep disturbance and uprooting more stumps than the ES. The ES cost approximately 25% more per hectare than the TRM. However it also achieved a substantially better quality result with a 40+ cm mound over a 70+ cm rip depth (Figure 3). The TRM was faster and cheaper than the ES but consistently failed to meet the requirement of a 30 cm high mound over a 60 cm deep rip (Table 2). The main reason for the failure was inadequate rip depth.

3. ROTREE spot cultivator-moulder. (Hall, 1995)

Two versions of the ROTREE spot cultivator-moulder were studied. The prototype weighs 2.6 tonnes and has 700 mm discs with cultivator tines of 920 mm and was mounted on a Cat 320L with modified tracks. The Mk II weighs 3.4 tonnes and has 900 mm discs with cultivator tines of 1250 mm. The Mk II also has a more powerful drive motor. The Mk II was mounted on a Cat 325L also with modified tracks.

Adjustments can be made to the angle of the discs, which changes the mounding height and the length of the cultivator tines, which alters the cultivation depth. The larger version has the potential to build a 40-45 cm mound over a cultivation depth of 70-75 cm. During the study in a hard, dry, rocky soil the machine produced spots with a 30+ cm mound over a 60+ cm cultivation depth (Figure 5) 89% of the time.

The data in the ROTREE studies were obtained when the machine was working in difficult conditions. In a situation more typical of New Zealand the ROTREE may be cost competitive with the ESRM operation.

Table 3: Summary of study data

	ROTREE, prototype	ROTREE, Mk II
Production	0.29 ha/PMH	0.23 ha/PMH
Cost	\$450/ha	\$540/ha
Stumps per hectare	900	515
No. stumps uprooted pre treatment	20 per ha	35 per ha
No. stumps uprooted post treatment	30 per ha	40 per ha
Slash volume	79.0 m ³ per ha	82.3 m ³ per ha
Slope	5-15°	0-10°
Vol. cultivated soil/tree	0.75 m ³	0.95 m ³
Average Mound Height	20 cm	40 cm
Average Rip depth	50 cm	65 cm
Spot quality acceptable	31 %	89%

Other Applications for Excavators

Excavators have also been used to rehabilitate skid sites and extraction tracks (Hall, 1993) when fitted with conventional rippers, buckets, slash rakes and the Towtem grapple clam. Costs for this type of operation ranged from \$600 to \$1500 per kilo-



Figure 4. The prototype ROTREE moulder working in radiata cutover, ANM Forests, Tasmania.

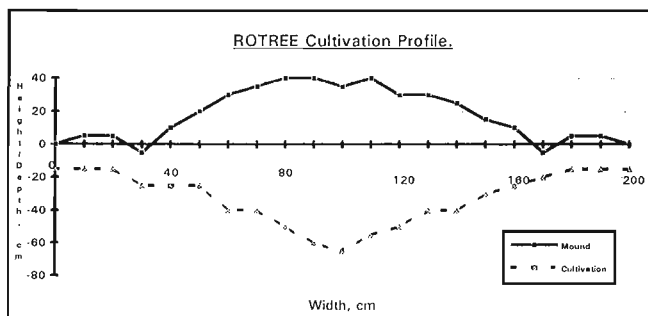


Figure 5. Cultivation profile for the Mk II ROTREE spot moulder.

metre of track to rip and return the side cast material to the track surface.

They have also been trialed spot ripping cutover as a technique for ameliorating soil damage from ground-based logging operations (Hall, 1994b) at a cost of \$420 per hectare.

A 40 tonne excavator fitted with two winches has been successfully used for roller crushing of scrub and cutover (Riddle, 1993). It achieved production rates as good as or better than those achieved by tractor operations.

CONCLUSIONS

Excavators, especially those with modified tracks, are capable of traversing and working on steeper slopes than tractors.

Production rates in ripping and mounding operations with excavators tend to be slower than those from tractor operations but the quality of the result is usually higher.

For the above reasons use of excavators for site preparation operations in New Zealand is likely to increase.

REFERENCES

- Clark C. (1992). Excavators for site preparation. Video. British Columbia Ministry of Forests.
- Forme Consulting Group Ltd (1994). INFORME – Machinery Price Survey Results, March, 1994.
- Hall P. (1992): Logging residue handling – a study of two cutover preparation techniques. LIRO Report Vol. 17 No. 14.
- Hall P. (1993): Logging extraction track rehabilitation. LIRO Report Vol. 18 No. 21.
- Hall P. (1994a): In prep. An evaluation of two site preparation operations.
- Hall P. (1994b): Spot ripping of cutover. LIRO Technical Note. TN-14.
- Hall P. (1995): In Prep. An evaluation of the ROTREE spot cultivator.
- Karsky D. (1994): Excavators for site preparation. United States Dept.. Ag. For. Serv. Publication No. 9424-2310-MTDC.
- Mason E.G. and A.W.J. Cullen. (1986): Growth of *Pinus radiata* on ripped and unripped Taupo pumice soil. New Zealand Journal of Forestry Science. 16(1): 3-18.
- McMahon S. and T.E. Evanson. 1994: Accuracy of two ground survey methods for assessing site disturbance. LIRO In Prep.
- Riddle A.C. (1993): Adding winches to Hydraulic excavators – roller crushing. LIRO Technical Note TN-11.
- Riddle A.C. (1994): Business Management for Logging. New Zealand Logging Industry Research Organisation.
- Wells G.C. (1981): Costing Handbook for Logging Contractors. LIRO Handbook. 1981.

The costs stated in this report have been derived using the procedure shown in the LIRO Business Management for Logging Handbook. They are indicative only and do not necessarily represent the actual costs for these operations.

TRIMBLE GPS THE FOREST MAPPING SOLUTION

GPS provides the forest manager with fast, accurate and cost effective solution for their mapping needs.

Trimble GPS leads the world in mapping solutions with over 1000 units in regular use with the US Forest Service as well as many of New Zealand's leading forestry organisations.

The Trimble Pro XL (illustrated) provides sub-metre accuracy on a second by second basis. Its performance under canopy is unrivaled.

The Pro XL is easy to use by the non-specialist and integrates with other field capture devices. The included software is functional, robust and integrates fully with GIS products such as ARC/INFO, MapInfo, Genamap, Intergraph, etc.

Inquire today for more information, prices, and data sheets on the Trimble Pro XL.

Contact us for friendly, knowledgeable advice and efficient service

GEO-SYSTEMS

the forest mensuration and mapping specialists.

Christchurch

Ph 0-3-343 2333

Fax 0-3-343 2444

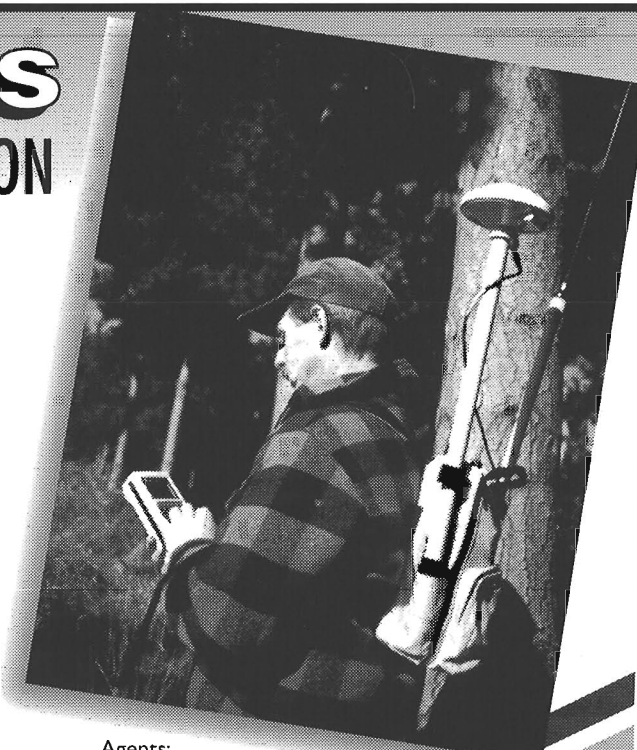
Auckland

Ph 0-9-489 2225

Fax 0-9-489 2226

**FREEPHONE
0800-555 200**

Agents for Hewlett Packard, Schonstedt, Sokkia, Laser Atlanta



Agents:



Trimble

Survey & Mapping
Products