with the less site-demanding southern pines such as *Pinus taeda* or *P. elliottii*. However, cultivation and fertilisation techniques adopted since 1970 have extended the range of sites where radiata pine can now be successfully established. On the North Auckland peninsula there are 173 000 ha of podzolised yellow-brown earths and 74 000 ha of podzols, which, if used for plantation forestry, could benefit from cultivation.

Over the past ten years, a series of cultivation trials have been established on State forests within the Kaikohe Ranger District. Some of these have been co-operative Forest Research Institute (FRI)-Auckland Conservancy trials and have been reported on in unpublished FRI reports (*e.g.*, Hunter and Thode, 1980).

This report describes the results of some local investigations, and the management prescriptions subsequently adopted.

TRIALS AND PRINCIPAL RESULTS

1972 Waitangi State Forest

Investigations commenced in 1972 at Waitangi State Forest on a strongly rolling site previously under a cover of gorse. The soil type is a Hukerenui silt-loam derived from greywacke. The structure and drainage of this strongly podzolised soil are both poor but there is no hardpan. Treatments on this site included:

(1) 100% rotary-hoeing to a minimum depth of 15 cm in a single cut.

(2) Ripping to a depth of 46 cm with trees subsequently planted in the rip.

(3) Ripping to a depth of 46 cm with trees planted approximately 15 cm to the side of the rip line.

(4) Control (no cultivation).

Trees were assessed annually for survival and height over five years. Ripping improved survivals over control treatments but no significant differences in tree height were measured. The extent to which other factors such as climate, tree handling, fertilising practices and gorse competition may have influenced results is unknown. By Northland standards, growth in tree height was very slow for the first three years after planting. The result points to the danger in assuming that cultivation automatically confers an advantage to tree growth. Results are shown in Fig 1.

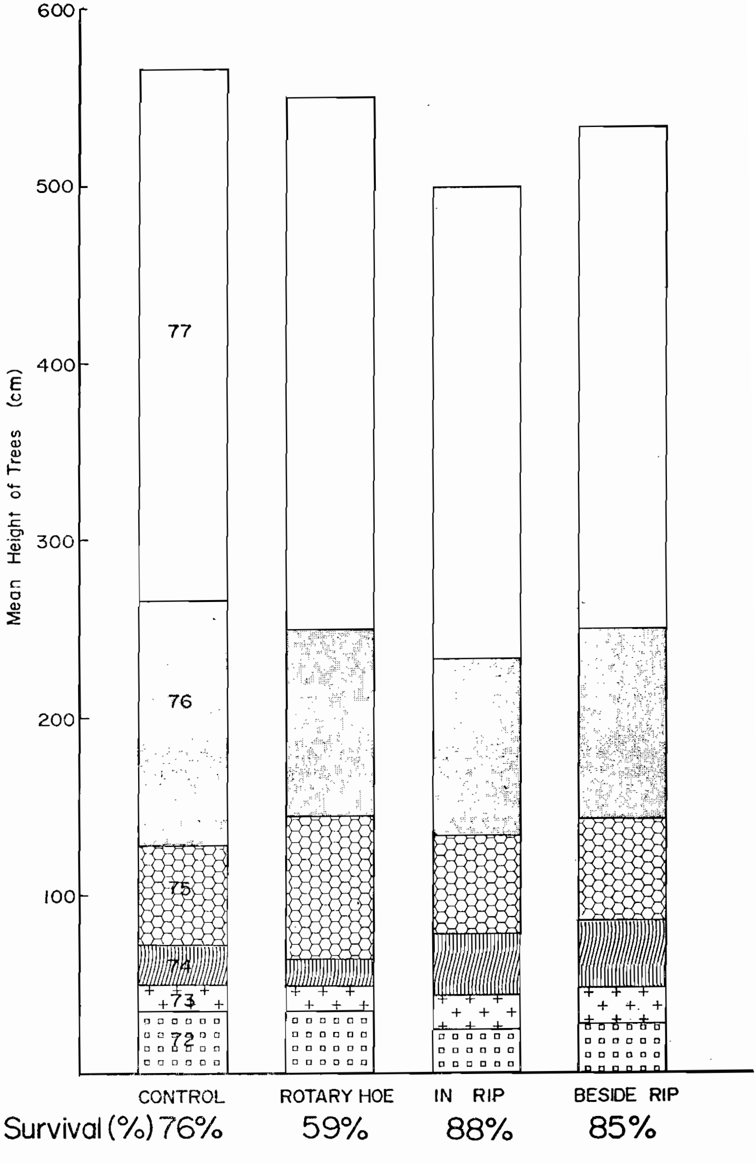

FIG. 1: *Waitangi site preparation trial A378*

1974 Waipoua State Forest : First Trial

In 1974 a cultivation trial was established at Waipoua State Forest on a strongly rolling site previously under a cover of manuka and *Hakea acicularis*. Intensive probing on a grid pattern prior to establishment revealed a hardpan varying in depth between ground level and 1.6 m (the maximum depth sampled). The average depth to the hardpan was 50 cm.

The soil type is a Te Kopuru strongly podzolised sand developed on slightly consolidated sand with the grey subsurface horizon cemented into a silica pan. The very low nutrient content together with problems of seasonably excessive moisture levels seriously restrict tree growth. The treatments investigated were:

(1) Ripping to 60 cm with planting in the rip line.

(2) Ripping to 60 cm with planting 15 cm to the side of the rip line.

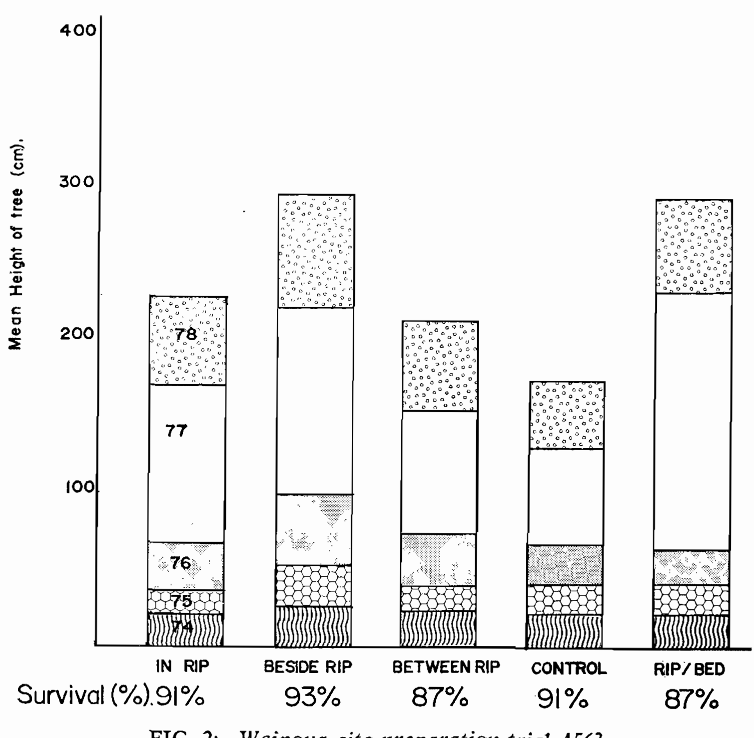

FIG. 2: *Waipoua site preparation trial A563*

(3) Ripping to 60 cm with planting midway between adjacent rip lines spaced 3.0 m apart.
(4) Ripping to 60 cm and bedding.
(5) Control (no cultivation).

Trees were assessed annually for height and survival over a four-year period, and results are shown in Fig. 2.

Four years after tree planting the main conclusions in regard to tree height growth were that:

(1) Ripping and bedding was significantly better than no treatment at the 0.05 level of confidence.
(2) Ripping and bedding was not significantly different from ripping alone and planting beside the rip.
(3) Planting beside the rip gave better height growth than planting in the rip but the difference was not significant at the 0.05 level of confidence.

1976 Waipoua State Forest : Second Trial

In 1975 a further trial was established at Waipoua Forest on a Te Kopuru podzolised sand. The site is flat to easy rolling with a strong seasonal wetness limitation to tree growth. The treatments investigated were:

(1) Deep ripping to 70 cm with planting beside the rip line.
(2) Deep ripping to 70 cm and bedding over the rip line.
(3) Bedding alone.
(4) Control (no cultivation).

The main conclusions relating to tree height after three years were:

(1) Ripping and bedding was better than ripping alone at the 0.01 level of confidence.
(2) Ripping was better than bedding at the 0.01 level of confidence.
(3) Bedding was better than control at the 0.05 level of confidence.

These results are illustrated in Fig. 3.

At age four years from planting, one tree from each treatment was excavated with a fire hose to examine rooting patterns. Major points of interest were:

(1) The tree planted on the ripped and bedded area had the most extensive root system.

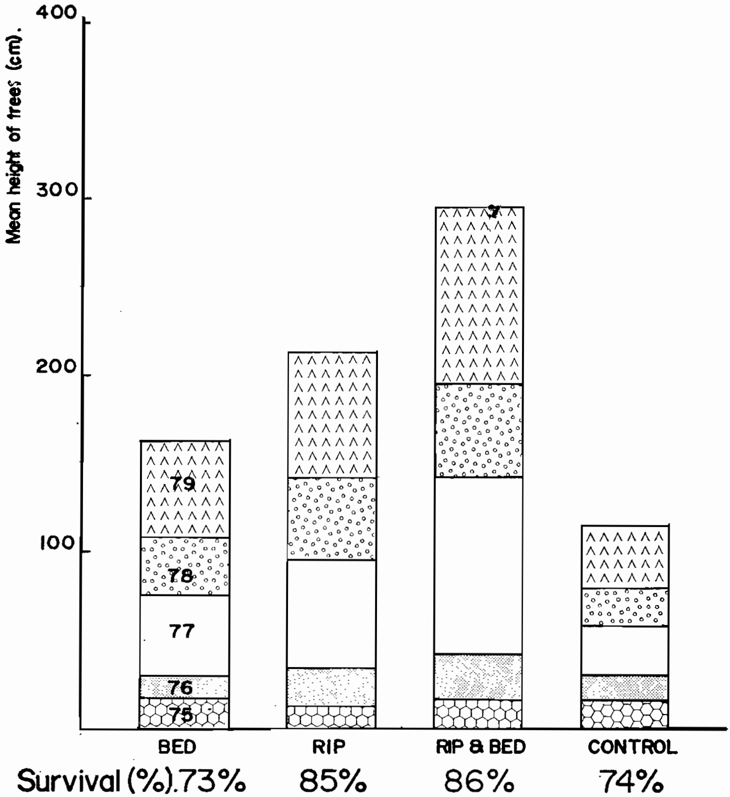

FIG 3: *Waipoua site preparation trial A479/1*

(2) The soil depth to hardpan was on average 30 cm. Without riping no root penetration of the hardpan surface was achieved.

(3) The hardpan was too thick for the ripper to break though ripping had increased effective rooting depth from 30 to 60 cm.

(4) If a tree was not planted over or very close to the rip line, tap root development may stop at the hardpan surface with lateral roots sending down sinker roots to occupy the rip line.

(5) By age four years, lateral roots from trees on ripped and ripped and bedded lines had extended to occupy adjacent rip lines spaced at 3.6 m apart.

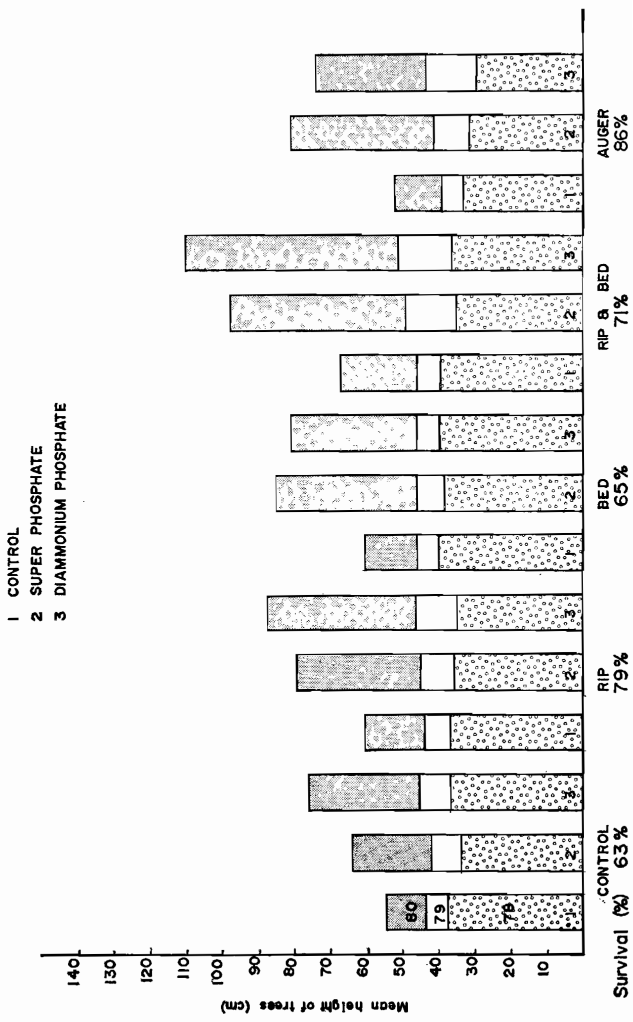

FIG 4: *Maungatapere site preparation trial A766*

1978 Glenbervie State Forest

In 1978 a cultivation trial was established at the Maungatapere block of Glenbervie State Forest. The site is a moderately rolling ridge cleared from manuka and hakea. The soil type is a Wharekohe silt loam derived from silicified claystone, very acid and strongly podzolised. Both the structure and drainage are poor and biological activity is very low. The trial was a randomised split plot design with three replicates. Major plot treatments included ripping, ripping and bedding, bedding, drilling holes with a post-hole borer and refilling them with the spoil, and control (no cultivation). Fertiliser sub-plot treatments included control (no fertiliser), 170 g/tree of superphosphate, and 85 g/tree of diammonium phosphate.

The trial was destroyed by cattle before it had run its five-year course. The main results two years after planting were:

(1) Ripping and auger treatments had significantly better survivals than controls at the 0.05 and 0.01 levels, respectively. Ripping and bedding increased survival but the difference was not significantly better than control at the 0.05 level of confidence.
(2) Ripping and bedding significantly increased height increment at the 0.05 level of confidence.
(3) Superphosphate and diammonium phosphate significantly increased height and diameter increment at the 0.01 level of confidence.
(4) Cultivation and fertiliser interaction is evident but individual contrasts tested were not significant because of the large error term involved.

These results are illustrated in Fig. 4.

1981 and 1982 : Puketi, Waitangi and Waipoua State Forests

During 1981 and 1982 cultivation trials were established at Puketi, Waitangi and Waipoua State Forests to look into the following problems:

(1) On podzolised cutover sites traditional ripping and bedding operations may not be possible because slash and stump material may prevent effective bed formation without intensive prior stumping and windrowing. Single and double pass vee-blading over single and multiple rip line trials were examined.
(2) Peaty loam and loamy peat soil types may be too soft to safely support the prime mover used in vee-blading operations. Spot mounding with a hydraulic excavator working on swamp mats

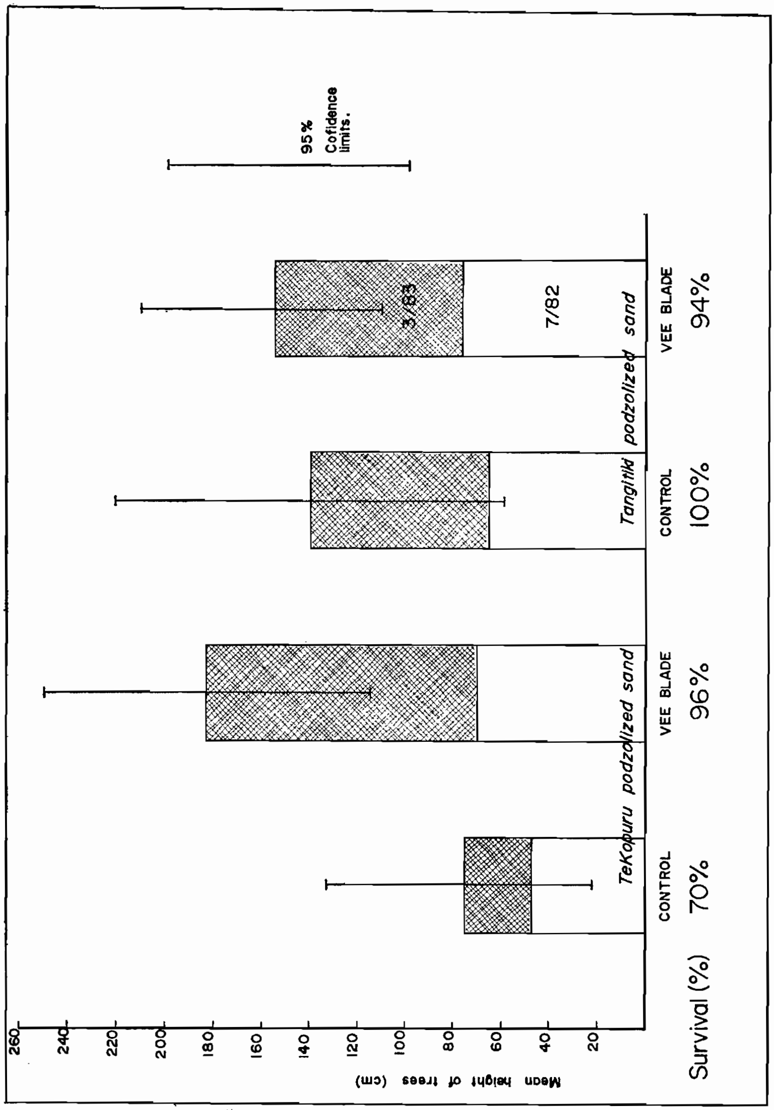

FIG 5: *Waipoua vee blading trial A901*

is practised by at least two forest companies in Northland and this was examined for blackwood establishment on swampy sites.

(3) On some podzols, the thickness of the hardpan may preclude a single ripper from achieving total shatter through the hardpan into softer rooting horizons beneath. Since the rooting depth will be limited to the maximum depth the ripper can work in these situations, multiple ripping may be expected to increase the tree rooting zone to that depth by cultivating the full site. This was examined in a further trial.

As yet it is too early to confidently draw results from all of these trials. Second-year results for vee-blading trials at Waipoua Forest on Tangitiki and Te Kopuru podzolised sands are shown in Fig. 5.

The main advantages of vee-blading have been:

1. An improvement in tree growth on hardpan sites such as the Te Kopuru podzolised sand.
2. More uniform tree height on less consolidated Tangitiki sand as shown in Fig. 5.
3. No weed release requirement to date on the Hukerenui, Hihi, Te Kopuru, Tangitiki and Waipoua clay soil sites vee-bladed over the last three years at Puketi, Waipoua and Waitangi Forests. Such sites would normally require releasing from gahnia grass, bracken or manuka.
4. The option of discarding desiccation and burning operations on tractor country. For small cutover sites in high-hazard burn situations, the combined costs of desiccation, firebreaking and burning can be in excess of $300/ha.
5. Access for planting and hand fertilising is improved. Labour costs are reduced by about 15% for these operations when compared with the traditional burn-plant regime.
6. Incorporation of slash, humus and topsoil into the rooting zone.

The Evolution of Practice

There have been changes in cultivation practice since early trials were established and the results presented here may have been improved upon in current use. Major changes have been:

(1) A trend to larger more powerful machines. Some early trials and operational work were undertaken with D6 equivalent machines. Tractors currently used for ripping and bedding are

in the D7G and D8 class. Some operational work has also been done with D8K and D9 class machines by private companies.

(2) The mounting of the bedding discs directly on the tool bar has improved manoeuvrability of the prime mover and the ability to clear build-up of sticks under the disc unit. Bedding discs used for early work were generally towed units, and clearing these of stick material is awkward and difficult on slopes. This led to the earlier prescription of ripping and bedding on flat to easy contour country, and ripping without bedding on strongly rolling slopes.

(3) Early trials did not have the benefit of winged rippers to improve soil shatter. These are now routinely used for ripping operations and take the form of a ripping shoe slipped over a standard ripper and held in place with a drift. Draught, forward speed, angle and shape of the ripping shoe affect the degree of cultivation achieved and these aspects were discussed by Page (1977).

OPERATIONAL WORK

Ripping and bedding is the most widely practised cultivation operation used for preparing sites for the establishment of radiata pine in Northland. The success of this operation is directly related to soil moisture conditions, with the January-February period the best season for this work. Outside these months, soil moisture levels are likely to increase, with clay soils tending to flow rather than shatter. It is not possible to rip and bed in all situations which slope allows and the main exceptions to this are shown in Fig. 6.

1. Ripping and Vee-blading

High stump density, heavy slash and some vegetation types may prevent good bed formation with bedding discs. On hardpan cutover sites, ripping and vee-blading as a two-pass operation has been undertaken and Fig. 5 indicates the early results achieved on sites which formerly were either restocked without cultivation or ripped only. On flat to easy rolling hardpan sites, mounding is required to overcome seasonal waterlogging and Fig. 3 indicates the desirability of mounding in association with ripping where water is a problem.

Rushes can prevent good bedding disc action. Dense interwoven rush roots are cut as continuous strips and the disc action in turning these strips may create tension in the strips causing them to

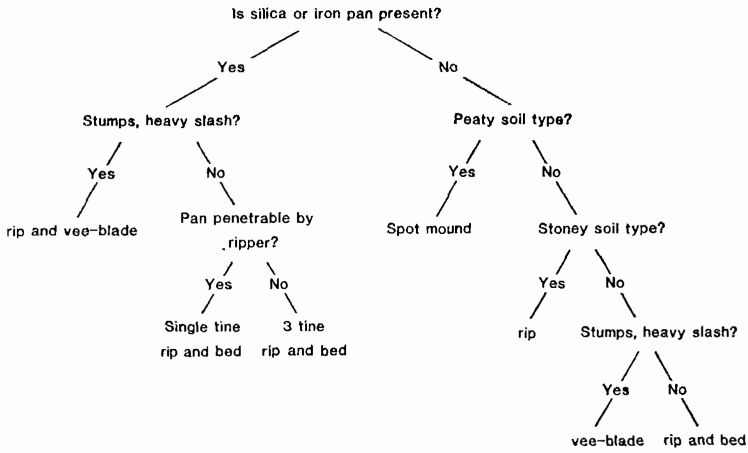

FIG 6: *Cultivation decision chart*

return to their original position in the ground after the discs have completed their pass. Multiple ripping and bedding can be effective on such sites where new planting is being undertaken and the scale of operation justifies a 220 kW machine.

Two-pass ripping and vee-blading is carried out annually at Waipoua State Forest on cutover hardpan sites. Areas are ripped with a contract HD16 and mounded with the station D65A at a total cost of about $340/ha.

2. *Single-tine Rip and Bed*

This operation is undertaken with a wide range of prime movers and disc units for new land preparation. The cost of ripping and bedding is about $140/ha for a 130 kW machine and the benefits of this work to tree growth and survival are outlined in trials discussed previously and in FRI reports. Most of this trial work has been carried out on badly podzolised soils and podzols. To date little cultivation investigation has been carried out on slightly to moderately podzolised soils and it cannot always be assumed that cultivation will automatically confer an economic response in tree growth as Fig. 1 indicates. Within a soil suite, nutrient status, biological activity and physical soil structure generally deteriorate with increasing soil maturity and the point where economic responses cease to occur from cultivation are not known within many Northland soil suites. The routine use of a soil penetrometer to measure physical soil resistance to tree roots could be advantageous in the scheduling of this operation.

One practice which does vary widely in Northland is that of recompaction of beds with an hourglass roller mounted to the rear of the bedding discs. Main advantages are improvement of soil tilth and easier planting. No significant advantage to tree growth has been demonstrated as yet in an FRI trial established at the Mt Camel block of Aupouri Forest in 1978 (J. Cullen, pers. comm.).

3. *Multiple Ripping and Bedding*

On some Northland podzols the thickness of the hardpan may preclude currently available rippers from penetrating through the hardpan. Using a large prime mover and three rippers enables the full site to be cultivated, thus increasing the soil volume available to tree roots over that made available by single-tine ripping. Penetrometer measurements have confirmed that this result has been achieved but it is as yet too early to expect significant height differences to be evident from trials established in 1982.

Contract prices for this work are about $200/ha.

4. *Spot Mounding*

On peaty-loam and loamy-peat soils, the load-bearing capacity of the soil may be insufficient to support a prime mover used for continuous mounding. Such sites have in the past been regarded as unsuitable for planting. Spot mounding with a tracked hydraulic digger operating on swamp mats is used to prepare these sites for blackwood planting in Waitangi State Forest. 45 to 60 kW diggers have been used to create aproximately 600 mounds per hectare at a cost of about $295/ha. Sites planted in blackwood without mounding have failed owing to the high water-table. With mounding, good survivals have been realised with an average tree height of one metre 18 months after planting. A private company has achieved good results with radiata pine planted on to mounds in swamp sites with an average tree height of two metres two years after planting.

5. *Ripping*

On stony or bouldery soil types, disc action and life are reduced and unsatisfactory beds can result. Forest Service practice on Okaihau and Omaiko gravelly soils encounted at the Puhipuhi block of

Glenbervie Forest was to rip without bedding. Apart from small ponding areas where survival is poor, the balance of the block was sufficiently well drained not to require perched mounds for successful tree establishment and the practice of ripping alone on bouldery or stony sites has continued. The cost of this operation is about $132/ha.

Since bedding in association with ripping is only slightly more expensive than ripping alone, usually $7–$10/ha, most forest managers undertake the two operations together on new planting sites because bedding assists in reducing scouring down the ripline, provides a better tilth for tree planting and provides a weed-free planting site. It may not always provide better tree survival and growth than ripping alone on rolling sites where waterlogging is not a problem (see Fig 2).

6. *Vee-blading*

Where hardpan is absent on clay and weakly consolidated podzolised sand, this operation is carried out within State forest on tractorable cutover without prior ripping. A 100 kW tractor is used and the operational cost is about $210/ha for a double-pass operation. Priority is given to podzolised soils, weedy areas and heavy slash areas likely to impede access for planting and fertilising operations.

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XPLOT: IMAGERY FOR PRUNED LOG SALES

A. SOMERVILLE and M. McGREGOR*

ABSTRACT

Marketing of pruned conifer logs is assisted by adequate log description, which must feature internal as well as external log characteristics. The existing cross-sectional analysis system provides very detailed log descriptions with important characteristics defined using three-dimensional co-ordinates. XPLOT is a software package that uses this information to print scale diagrams, showing (a) median longitudinal sections of a sample log, in two planes, and (b) superimposed cross-sections. Characteristics shown in these images should enable buyers to rapidly assess log quality.

INTRODUCTION

New Zealand's 1 million hectare exotic forest estate now includes significant volumes of pruned butt logs. Successful marketing of these logs, at prices satisfactory to both grower and buyer, depends on adequate log quality description. The quality of sale lots can vary greatly, due largely to variation in internal log features invisible in the intact log. Therefore, the description must consider internal, as well as external, log properties (Somerville *et al.*, 1985).

For the processes of sawing, peeling, and slicing, the quality of the pruned log is dependent on: the external shape and dimensions of the log, the location of pith, the location and dimensions of pruned branch stubs and associated occlusion scars, the presence of adventitious shoots, and the location and presence of scattered defects such as resin pockets and stem damage.

An image of a pruned log showing the incidence and location of all the above features should provide adequate information to enable a wood processor to anticipate that log's grade and conversion performance. Extending this reasoning, if the processor were supplied with imagery of a representative sample of logs from a large batch of pruned logs (*e.g.*, those in a log sale) he would be better informed as to the worth of the batch. This would eliminate some elements of risk and assist the processor in negotiating a satisfactory price.

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