PART 6

THE FUTURE

THINNING IN NEW ZEALAND RADIATA PINE PLANTATIONS — FUTURE PRACTICES AND RESEARCH NEEDS

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ABSTRACT

Tending practice, being a function of management, depends as much on the economic and physical background in New Zealand as on silvicultural objectives to produce maximum volume or value yields. The background facts relevant to plantation practice in New Zealand include a massive planting programme with a concomitant silvicultural commitment, a large involvement by non-state agencies, an urgent need to diversify export markets, often steep terrain and high labour and machinery costs.

The area of proven tending practice for radiata pine is limited. This is why many different silvicultural regimes have been proposed but few have survived. The simple plant and clearfell regime has been applied most widely. For this reason the principles to adopt in deciding how the species should be grown and harvested are most important. Suggested principles are: define the target tree taking into consideration markets, profitability and the technical requirements of wood quality; minimise growing costs; simplify management wherever possible but without sacrificing market flexibility; and reduce as much as possible biological, physical, management and market risk. The background facts and these principles suggest a sawlog final crop is logical for most New Zealand plantations and trends indicate it will normally be grown on a rotation of 20-30 years. A proportion of the resource will be pruned to 6 m and stockings will be relatively low in these stands. Steep country is unlikely to be production thinned but the practice will continue in State forests while old regimes grow through to rotation end. Some private organisations will continue to production thin because they believe it is in their interests to do so. Future developments in production thinning are likely to include a geometric approach to tree removal, a relaxation of unnecessarily rigid specifications, intensive method improvement, and adoption of skidding machinery which has high productivity in relation to its capital cost.

Research must continue to focus on overall evaluation of the growing and harvesting system. This will highlight priorities for micro-economic research by a balanced multi-disciplinary team. Principal targets in the Forest Research Institute programme have a bias towards silviculture and clearfelling but this is seen to be appropriate.

INTRODUCTION

Future thinning practices in New Zealand are difficult to predict with certainty for several reasons. Foremost is the current variety of silvicultural regimes being practised

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and the rapid evolution of silvicultural concepts; secondly the spectrum of objectives being adopted by the state and private sector; and thirdly the realisation that gorse, terrain, tree form, wind, market factors and felling strategy all impinge on how stands will be managed and harvested. This paper attempts to list the background facts and current trends relevant to thinning practice in the hope that interpretation of these will point to future practices and research priorities.

BACKGROUND

Plantation Objectives

New planting is now evenly balanced between private enterprise and the Forest Service (Table 1), and this was also true of the 1925 to 1940 period. The original target of enough plantation resource to meet domestic demand in the face of dwindling

TABLE 1—Actual and projected growth of exotic forest area and roundwood equivalent of production and exports

Period	Exotic Planting (× 1000 ha)	Percentage State	Cumulative Total Stocked Area (× 1000 ha)	Average(1) Annual Supply (M m³)	Proportion from Exotic Removals (%)	Exports (M m³)	Exports as proportion of Average Annual Supply (%)
Pre-1921	76	20	77	—	—	—	—
1921-25	14	70	91	—	—	0.2	—
1926-30	157	47	249	—	—	0.1	—
1931-35	115	54	363	—	—	0.2	—
1936-40	28	46	390	1.6	13	0.1	7
1941-45	7	93	397	—	—	—	—
1946-50	7	89	405	2.4	38	0.1	4
1951-55	15	63	416	3.2	44	0.2	7
1956-60	23	65	427	4.1	56	0.8	20
1961-65	47	65	469	5.4	67	1.1	20
1966-70	90	61	545	7.2	76	2.3	32
1971-75	168	50	686	9.9	78	3.8	38
1976-80	200(2)	—(3)	858(4)	11.4(5)	75	4.9(5)	43
1981-85	200	—	1030	12.6	76	5.2	41
1986-90	200	—	1202	14.0	76	5.8	41
1991-95	200	—	1374	15.4	77	6.3	41
1996-2000	200	—	1546	20.0	82	10.1	51
2001-2005	200	—	1718	28.8	86	18.3	64
2006-2010	200	—	1890	33.0	87	22.0	67

(1) includes indigenous, residues and waste utilised in processing.
(2) assumed new planting rate for projections is 40 000 ha/ann.
(3) no attempt made to project future role of State in planting.
(4) projected cumulative stocked area assumes 86% net gain from new planting (after Hosking 1972).
(5) based on data in Hosking (1972) and O'Neill (1974).

Sources: Yska (1970).
Forest Economics Division, N.Z. Forest Service (1974).

indigenous resources has been long since passed. More recent objectives have included an exportable surplus. In 1974, 38% of the total available supply (including residues and waste paper), was exported and this could rise to 63% in 2010. The size that this exportable surplus should be has not been planned in detail but it is generally agreed that plantation expansion should continue to a stage where forestry makes a "significant" contribution to national export earnings and reduces current dependence on agricultural products and traditional markets. The form in which the wood will be exported is largely undecided. Many alternatives are available, including export logs, sawn timber and pulp and paper products. Unlike agriculture, the availability of markets is not seen as a major constraint. The constraints are mostly internal, and relate to the availability of wood, electric power, capital, labour, and suitable locations for the resource relative to population centres, water and ports, etc., and cost/price relationships. Additional processing can be very capital intensive and does not necessarily add significant gross value/unit of wood input (Table 2). State forestry tends to be concentrated around "project" areas such as Nelson, Hawke's Bay, Otago and Northland, with the vague aim of building up a critical mass of wood. Similarly, large company plantings also tend to be planned on a project basis. As export earnings is the main production goal the criterion emphasised by the World Bank Report on the New Zealand economy (1968) is of the utmost importance. This report suggested exports from New Zealand's rather open (i.e. trade dependent) economy should develop in a way which maximised export dollars earned/import dollar used, this being the criterion which maximises *net* overseas earnings. On this criterion capital and energy intensive industries are unlikely to rank highly, while export logs compare very favourably. Thus the form of future exports is not clearcut and to a large extent will be determined by Government and large private companies' policies. It will be important to clearly identify where New Zealand's comparative advantages in world forest products trade lie, because the types of product to be exported have a marked bearing on where the forests should be

TABLE 2—Export prices of selected forest products free-on-board prices in roundwood equivalent

	($/m^3)	($/ft^3)
Logs A-grade(1)	31.94	0.91
Average all logs	23.66	0.67
Sawn timber	27.54	0.78
Refiner groundwood pulp	34.25	0.97
Chemical pulp	25.42	0.72
Newsprint	43.78	1.24
Chips(1)	9.89	0.28

(1) = current contract price

All other prices are 1973/74 averages obtained by dividing total FOB value by volume.

Source: Forest Economics Division, N.Z. Forest Service.

grown and the manner in which they should be managed. Whatever product mix is eventually exported, there is unanimity that the sooner the benefits come on stream the better from the national point of view.

This discussion suggests:

urgency in the plantation programme,

management which concentrates on planting high quality sites and adopts reasonably short rotations, and

cost efficiency in all phases of growing, harvesting and utilisation.

Concentration on Radiata pine

The trend in New Zealand is to grow more and more radiata pine. Eighty percent of the current exotic estate is this species and the proportion is rising. The risks associated with monoculture, as with agriculture, are accepted but minimised by sound management, an intensive research back-up (breeding for resistance), vigilant quarantine service and biological survey, etc. The high opportunity cost of diversification to other species and genera is seen as unacceptable, especially as the alternative species are inferior to radiata pine in terms of growth rate, profitability, market flexibility and site requirements. Foresters recognise that the best alternative species would have to be available in equal volume to radiata pine and also to have similar wood properties and end uses to be a meaningful reserve in the event of a disaster striking radiata pine. None of these requirements is met. In fact the effect of insect and disease attack on radiata pine and the minor plantation species has been to intensify attention on the former. Radiata pine is more profitable to grow and exists in relatively large uniform blocks. These combine to enable cheap and easy protection. For example, aerial spraying of copper fungicides to control *Dothistroma* needle cast disease costs only $NZ8.50/ha and is applied at most three times per rotation.

Alternative high yielding species which could be grown on short rotations, such as *Eucalyptus* spp., are included in research programmes but are unlikely to play a major role while radiata pine remains the most profitable species.

Plantation Expansion

The present surge in exotic planting (41 000 ha in 1974, of which 96% was radiata pine) is of similar magnitude to the levels achieved between 1928 and 1933 (Table 1). The main differences are that this time the high level is likely to be sustained for the next 25 years and could reach 55 000 ha/annum. Simultaneously an increasing load of exotic cutover re-establishment and tending will appear with the clearfelling of post-World War II stands. By the year 2000 the plantation resource could total about 1 550 000ha, and the volume of all silvicultural operations will be formidable. This will be a new experience for New Zealand forestry as the first short burst of planting largely escaped management. Current State tending has focussed on the relatively smaller areas planted since 1960. Only at Kaingaroa Forest have really large annual programmes of thinning been faced over a considerable period and this has not been without problems — especially with production thinning (Chandler, 1976).

Lessons from the Past

New Zealand plantations are often intensively managed at an early stage (say up to 12 m). Multiple pruning and non-commercial thinning treatments are applied widely.

Most organisations accept that the incentive for such intensive silvicultural treatments must be financial. Foresters now realise that too frequently plantations are being established with little knowledge of what the crops are being grown for, the quality requirements of the final products, the means of manipulating stands to obtain these qualities, or the costs of production. Accordingly the bases for silvicultural regimes have been closely analysed and new principles for determining silvicultural treatment have emerged.

These are:

(a) Define the target (i.e. the ideal type and dimension of tree which should be grown) taking into consideration markets, profitability and the technical requirements of wood quality.

(b) Minimise growing costs. In New Zealand this implies concentration on radiata pine, planting up large forests as quickly as possible, and planting fertile land of easy topography close to utilisation points.

(c) Simplify management wherever possible but without sacrificing market flexibility.

(d) Reduce as much as possible biological (insects and disease), physical (wind and fire), management and market risk.

Management risk includes selective pruning coupled with delayed thinning which causes suppression of the pruned element by unpruned neighbours, and planning for commercial thinning in circumstances where the absence of a market could reduce the yield, diameter and value of the final crop. Fluctuations in the fence post market and the lack of a pulpwood market have caused this in New Zealand. Thus management risk is incurred by adopting unnecessarily complicated silviculture.

Market risk is incurred by long rotations (the distant future is more difficult to predict) and by producing trees which have limited end-use potential. A pruned butt log is the most flexible product.

Biological and physical risks are reduced by having as short a rotation as possible.

The target in most State silviculture is a sawlog crop, although a high proportion (say 50%) of pulpwood is produced simultaneously if slabwood and top logs (3rd and higher) are chipped — even if commercial thinnings are not included in the regime. The mean final crop tree diameter aimed for is usually in the 40-60 cm range and the ability of radiata pine to achieve this quickly, is one comparative advantage enjoyed by New Zealand forestry. The tree may or may not be pruned to 5.4-6 m. A goal of cellulose in any form is not accepted for reasons of market risk and harvesting cost. The price stability and dominance of the sawlog and veneer log in the American market is reassuring, and trends there are expected to to be repeated in Australasia (Table 3). It

TABLE 3—Consumption of sawn timber, veneer and plywood as percentage of total wood consumption (roundwood equivalent)

Year	1950	1955	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
U.S.A.	55	56	55	56	56	58	59	58	57	57	59	58	58	60	63
Australia	78	73	66	—	—	—	—	64	—	—	—	—	62	63	63
New Zealand	86	82	77	74	74	72	71	71	74	67	65	60	52	59	61

Sources: Hair and Ulrich (1972), Hair and Phelps (1973), Wilson (1974) and Yska (1970).

is of considerable interest that the most industrialised country in the world still requires at least 60% of its wood supply in the form of saw/veneer logs and there are indications of a *rising* demand. Trends towards increasing chipwood consumption in Australasia are due to low pulp and paper consumption in the 1950s. However, this must not be allowed to mask the continuing high level of sawn timber consumption.

The sawn timber, veneer and plywood consumption trends indicated for USA have been accompanied by rising prices in real terms, a trend which is not apparent for pulpwood (Table 4). Premiums for quality have been very stable for veneer logs and sawlogs over the 22-year period. This is also reflected in sawn timber price lists where, for example, between 1958 and 1970, the highest grade of ponderosa pine has sold at eight times the lowest grade (Western Wood Producers' Association Lumber Price Lists). The widening gap between southern pine sawlogs and southern pine pulpwood provides another example of premiums for quality. Similar long term series for Australasia are not available but the trends are likely to be repeated here if the market is relatively free.

TABLE 4—Selected prices veneer logs, sawlogs and pulpwood — U.S.A., 1950-72. (Prices in 1967 values)

	Douglas Fir Veneer* (c/ft^3)			D. Fir Sawlogs* (c/ft^3)			Southern† Pine Sawlogs (c/ft^3)	Southern† Pine Pulpwood (c/ft^3)	Ratio Sawlogs Pulpwood
	No. 1	No. 3	Ratio No. 1: No. 3	No. 1	No. 3	Ratio No. 1: No. 3			
1950	62.7	45.0	1.39	34.9	23.7	1.47	—	—	—
1955	63.5	47.5	1.34	36.8	25.5	1.44	—	4.4	—
1960	62.6	45.8	1.37	36.3	26.7	1.36	15.4	5.2	3.0
1965	63.4	48.1	1.32	37.4	28.7	1.30	14.7	5.1	2.9
1970	81.7	62.0	1.32	48.4	31.5	1.54	21.6	4.7	4.6
1971	76.2	59.7	1.28	50.3	33.1	1.52	26.1	4.6	5.7
1972	86.5	62.7	1.38	58.5	38.2	1.53	28.2	4.4	6.4

* Prices for a range of price points from river dump to mill, converted from bd ft basis to cu ft basis using factor of 5.

† Stumpage prices, converted to cu ft basis, from bd ft basis in case of sawlogs and from cord basis to cu ft basis in case of pulpwood, using conversion factors of 5 and 90 respectively. Sawlog prices for sales from private lands in Louisiana; pulpwood prices for all ownerships, Louisiana.

Range of price points for D. fir sawlogs and peeler logs makes comparisons difficult. However, differential for quality is large and has been maintained over the past 20 years. Definition of grades:

(a) Douglas fir No. 1 Veneer Logs — suitable for rotary cutting and production of clear, uniform-coloured veneer. Minimum s.e.d. = 30 in. and length = 17 ft plus trim allowance. At least 90 percent surface clear.

(b) Douglas fir No. 3 Veneer Logs — suitable for rotary cutting, production of centre core, cross core and backs or better. Minimum s.e.d. 24 in., and length = 17ft plus trim allowance. Knots — limited to scattered, sound, tight knots, not to exceed 1½ in. diameter.

(c) Douglas fir No. 1 Sawlogs — suitable for the production of B and better lumber. Logs shall be 90 percent surface clear. Minimum s.e.d. = 30 in., length = 16 ft plus trim.

(d) Douglas fir No. 3 Sawlogs — suitable for the production of No. 2 common or better grades. Minimum s.e.d. = 6 in., length = 12 ft plus trim. Knots — sound, tight knots 3 in. in diameter and smaller. Larger knots must be so distributed as to permit the required amount of No. 2 common or better grades.

Sources: Prices — Hair and Ulrich (1972); Hair and Phelps (1973).

The bogey of substitution by non-wood products is often raised, but it has had remarkably small impact as the figures in Table 3 will testify. Recent and likely future increases in the cost of energy and the effect these have on wood substitutes may be significant, however. They favour the competitive position and continuing high level of consumption of timber products. For example, one study showed the cost of energy accounted for 19% of the value of cement, 7.5% of the value of iron and steel, 6.5% for plastics, 2.8% for aluminium and only 1.6% in the case of sawn timber (Carruthers and Hansom, 1974).

In the light of these data a sawlog target is reasonable and a quality sawlog target probably well worthwhile.

Trends in Silvicultural Practice

(a) Planting fewer trees and the adoption of rectanguar rather than square spacing

New Zealand establishment practice has tended to plant too many trees and these have merely introduced the added cost of removal by non-commercial thinning at a later date.

The trend has been from 1.8 m × 1.8 m and 1.8 × 2.4 m to 3 × 1.8 m, 4.3 × 1.8 m and rarely 7.3 × 1.8 m. The latter applies when planting on flat or gently rolling grassland with a view to harvesting hay or silage and subsequently grazing sheep and cattle. Studies of wastage between planting and 4.6 m crop height indicate that with current improved standards of nursery, tree handling and establishment practice, it is difficult to justify planting more than 1200-1500 stems/ha whatever the management objectives.

(b) Treating stands early and tending fewer stems (say before 12 m crop height)

Foresters now realise that the crucial decisions on silviculture must be made and implemented before a stand exceeds about 12 m height. The most important decision is whether or not to prune to control branch defects. If branch defects are controlled by pruning then there is no need to have close spacing to suppress branches and hence knot defects. The trend is to prune fewer stems and to remove culls at the same time.

Previously pruning in three stages to 5.8 m was completed before stands were non-commercially thinned at 12.2 m; however, the unpruned, reject trees from low and medium pruning tended to dominate pruned stems. So now culls are thinned at both low and high pruning to ensure growth is maximised on pruned stems. This policy favours pruning fewer trees insofar as their dominance is guaranteed. Hence pruning and thinning operations are no longer considered in isolation.

(c) Shorter rotations and no commercial thinnings

There is a trend by many, but not all, organisations to shorten sawlog rotations from about 35 years to 25 years and pulpwood rotations to 20 years or less. Some pulp and paper companies with their own forests are not necessarily following this trend. Shorter rotations are achieved by adopting heavy early thinning regimes which do not include commercial thinning. Research results indicated that, for sawlog crops at least, the value is concentrated in the bottom 11 m of final crop stems, and this is where management should focus for quality improvement.

(d) More use of grazing animals in plantation management

New Zealand has been traditionally dependent on sheep and cattle for export earnings but only very recently has farming experience been applied to forestry problems.

The prospects for using sheep and cattle to prepare land, release trees from weeds, reduce the risk of fire, improve access for silviculture and to contribute to profitability by providing intermediate yields of meat and wool are only just being realised.

(e) Second rotation establishment

For cutover re-establishment the trends are: more intensive site preparation (especially on hard sites to ameliorate frost effects); special treatment for loading areas and logging roads (ripping and fertilising) and much less dependence on natural regeneration. Future cutover re-establishment will be by planting rather than by natural regeneration or airsowing. The advantages of uniform, planted stands become increasingly important with intensive silviculture and the availability of seed orchard seed is a key factor in the changeover.

(f) Special regimes for particular situations

There is now general recognition that the intensity of management should be varied with local conditions. For example gorse sites are now frequently given a plant and clearfell regime because access for tending is so expensive. Similarly wind in Canterbury and Nelson will set close physical limits for tree stability and force the adoption of short rotations.

(g) Better tree form

The extent to which the rising yield of seed orchard seed will have on thinning to waste practice is not yet clear. A better ratio of acceptable stems is anticipated from improved stock and for this reason spacing will probably go wider. However, malformation derived from the combination of windy climate and long growing season can be expected to continue.

(h) Some steep terrain

The present planting effort is reported to be evenly split between tractorable and non-tractorable terrain. A survey of planting areas for the next 15 years showed a high proportion of future planting will be on steep and very steep country (Table 5).

TABLE 5—Future planting by slope category

Period	Slope category			
	Less than 20° %	20° to 30° %	More than 30° %	Total %
1976-80	54	36	10	100
1981-90	61	28	11	100

Apart from experimental gangs production thinning of radiata pine on steep country has not been implemented. State policy is to avoid the problem by growing the crops without this operation.

Labour and Machinery Costs

Labour is in short supply in New Zealand and the position is unlikely to change as both political parties favour policies which generate full employment. Forestry does not enjoy wide appeal with the work force. The main disadvantages are monotonous, sometimes dirty work, difficult outdoor conditions, poor safety record, high labour turnover (100% or more) and frequently a rather isolated location. The advantages include cheap accommodation, good hunting and fishing opportunities, and negligible industrial strife. The trend is towards contract rather than wages labour and this is seen as important if large establishment and silvicultural programmes are to be completed on time, with minimum cost and supervision. Pruning and thinning to waste operations are constantly being refined to reduce costs — mainly through earlier, more timely treatment and a reduction in the number of stems treated/unit area, but forest management has not been sufficiently positive in attracting and retaining a skilled labour force. Management has tended to compare present conditions with the past rather than with current conditions in other industries. Thinning is not a preferred logging operation with the current labour force. In comparison with large-piece-size, clear-felling operations the work in production thinning is hard and brings less status. Consequently labour turnover is high, affecting production levels. In some cases a situation exists where the hardest work returns the smallest reward and many personnel use the thinning operation as a training ground before moving into other more rewarding and less demanding logging operations. This continued movement makes it difficult for organisations to introduce comprehensive training programmes to increase production rates in an operation where every movement must count if the workers, many of whom are on a piece rate, are to achieve an adequate financial reward. The labour requirements for various forest operations are shown in Table 6. These emphasise the very high labour input required to carry out an early production thinning. If labour is a genuine limitation on forestry expansion then this area warrants investigation with a view to either eliminating the operation altogether or mechanising the labour intensive components.

Typical gross (before tax) daily wage rates for New Zealand forestry workers, as at March 1975 are:

	Rate per 8-hour day $NZ
General silvicultural worker	14.70*†
Logger (i.e. bushman)	16.24-17.08*†
Driver and machine operator	15.62-16.42*

* Bonuses can increase these

† Plus daily power saw allowance of $NZ6.00 where worker supplies own saw. (The capital cost of power saws ranges from $NZ230 to $NZ360)

A competent bushman, with saw, expects to gross $25 or more per day. Absenteeism is reported to be more prevalent where higher rates are paid. Attendance bonuses are not paid but may be considered in the future.

New Zealand imports the bulk of its logging machinery. It is faced with a limited selection and is at the mercy of cost-price escalations in the manufacturing countries. Excluding duty, machinery from USA and Japan costs 20-50% more than the factory door price. Wharfage and transport costs are the major components. Import duty widens the margin even more. In the last 18 months machinery costs have accelerated much more rapidly than local wage rates. Typical costs of imported rubber-tyred skidders as at January 1975, fully rigged and ready to work in the plantation (with safety canopy, winch, wire rope and blade) are as shown below.

Maximum HP	Estimated Capital Value $NZ
	$
400 +	122 000 +
240 to 250	69 000
135 to 200	46 000
125 to 130	37 000
100 to 125	31 000
25 to 100	22 000

These figures indicate current prices, but the situation is fluid. In the current inflationary climate a considerable rise in price can be experienced between the placing of an order and delivery. For example, the price of an 83 hp conventional skidder increased by $8000 over a 12-month period.

Thus both labour and machinery are expensive in New Zealand and the efficient use of both is essential if low cost-structures are to be achieved. Pressures to fully mechanise are not great except in a few areas where circumstances are exceptional. Highly mechanised systems have not been introduced into New Zealand thinning operations and the industry appears to be adopting a "wait and see" attitude. This is reasonable, as a machine capable of carrying out a selection thinning operation at current rates is either not available or not proven in field conditions. Local machinery development has been minimal. The main limitations are fragmented effort, lack of finance and a very small home market for equipment geared to local conditions.

Current and Future Practices

Summary of the background facts:

- a rapid and sustained radiata pine plantation programme with a concomitant large silvicultural commitment
- a large involvement by non-State agencies
- the need for cost efficiency in all phases of export oriented production
- an element of urgency to meet regional development and national export diversification goals
- a sawlog objective for most regimes and a significant proportion of intensive tending in the expectation of reasonable premiums for quality
- better tree form, wider initial spacing and shorter rotations, especially for regimes which include pruning
- steepness of terrain and/or gorse will impinge on management on say 40-50% of new areas
- labour and machinery will both be expensive
- a possibility that the labour supply will be limited
- deliberate shortening of rotations in some areas to reduce the risk of windthrow.

Current Thinning Practice

Thinning (for production or to waste) practice in New Zealand is still evolving. The number of production thinnings planned (if any) is usually only one (Fig. 1). Many organisations plan to avoid production thinning altogether but include one waste operation. Figure 2 shows the wide range of first thinning treatments currently prescribed by New Zealand State and private organisations. Representative Australian

FIG. 1 NUMBER OF COMMERCIAL THINNINGS IN CURRENT RADIATA PINE MANAGEMENT

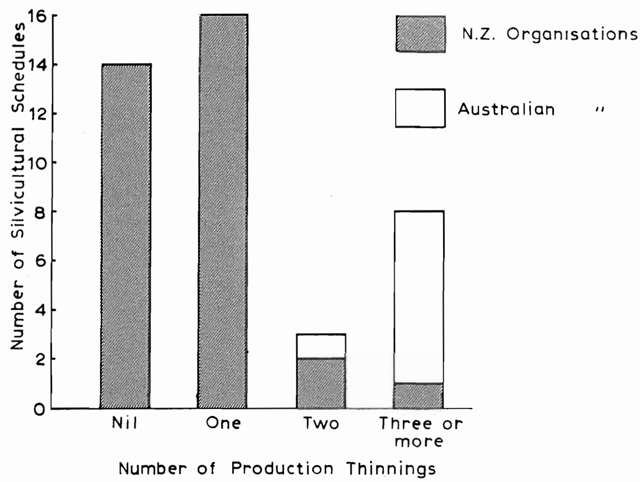
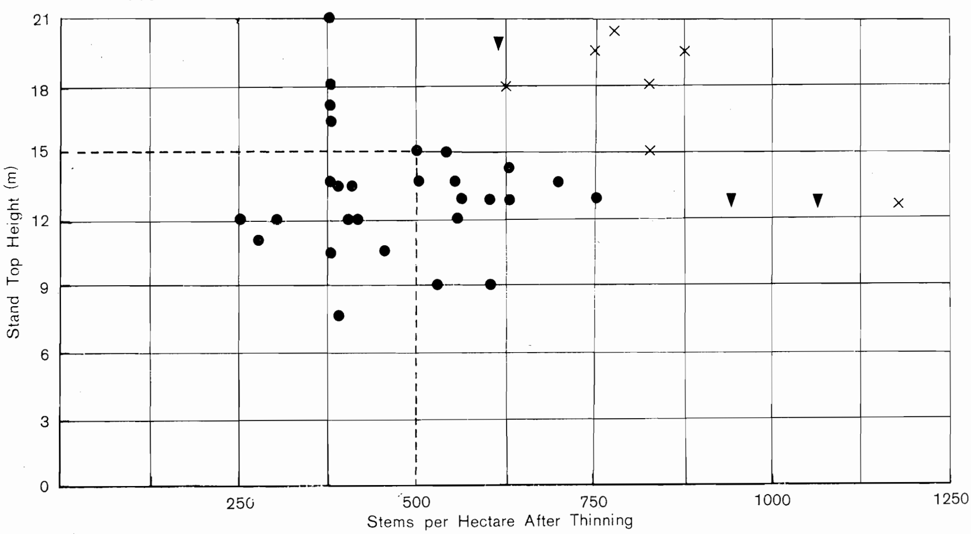


FIG. 2 SUMMARY OF FIRST THINNING SCHEDULES FOR RADIATA PINE



prescriptions are also shown. Those organisations which plan to thin before 15 m height and to less than 500 stems/ha have generally adopted financial objectives and would expect this thinning to be non-commercial. Organisations outside the dotted line tend to be volume oriented. They delay their first thinning and make it a production operation. This group includes pulp and paper companies with their own plantation resource and Australian organisations.

Consideration of the background facts and the spectrum of current regimes suggests that both production and waste thinning will continue in New Zealand. The extent of production thinning in State forests in the medium to long term future is difficult to predict but it may be fairly small. In the short term, crops which have been half grown on relatively "high stocking" regimes will provide opportunities for production thinning. This lag while "old regimes" are worked through will always be evident until there is sustained unanimity on how crops should be grown and harvested. It is likely that steep country will not be production thinned by either State or private organisations. Some private organisations will continue to production thin flat and rolling country because they believe it is in their interests to do so. The rigour with which these practices are justified in the future will be of considrable interest to Australasian foresters. Developments which may accompany a production thinning objective are discussed in the next three sections.

Crop Factors

Tree size has a marked influence on man-hour production and cost/cubic metre delivered to the landing (Table 6). Studies have also shown that the time taken to accumulate a load of small trees has a major effect on tractor cycle times and therefore on the production rate and unit cost. A large part of the problem is the random distribution of the thinning element in the stand. There is also the loss of pruned stems arising from a regular tracking pattern and the felling of badly damaged stems.

TABLE 6—Estimated labour requirements for planting, tending and harvesting radiata pine

Operation	Man-days/ha	m^3/man-day (8 hrs)	m^3/ha
Planting: 1482 stems/ha	2.0		
Slasher Releasing	1.7		
Pruning 0-2.2 m 590 stems/ha	2.8		
Pruning 2.2-4.0 m 370 stems/ha	2.5		
Pruning 4.0-5.8 m 350 stems/ha	2.5		
Thinning to Waste at height approx. 13 m	2.6		
	14.1		
Production Thinning of 0.1 m^3 tree size	21.0	4.7	104
Production Thinning of 0.3 m^3 tree size	13.5	10.6	143
Production Thinning of 0.6 m^3 tree size	12.0	17.7	210
Clearfelling of 3.0 m^3 tree size	27.0	22.7(1)	600

(1) One well documented gang produced at a rate of 49 m^3/man-day.

Note: These data are only indicative and demonstrate relativity between operations and tree sizes. Gang numbers vary between operations.

If production thinning using current motor-manual systems is to continue and costs are to be minimised the essential ingredients are low capital input and high productivity. The latter is greatly facilitated if the stand is designed to improve access for machinery and the thinning element to be extracted is grouped or concentrated. This implies that a mechanical or geometric thinning approach must be adopted. Future developments are seen to be along these lines but always with the proviso that final crop values are safeguarded.

Methods and Specifications

Tree length logging is the normal practice in both production thinning and clear-felling, and is likely to remain so. Logging, transport and mill infeed systems are designed to handle this type of produce, and it is difficult to see major changes in these spheres to allow wide adoption of the shortwood system, so popular and highly developed in the Northern Hemisphere. Current thinning work methods involve an integrated unit often made up of 4-5 men: 2-3 men felling and trimming, 1 machine operator and 1 man carrying out the manufacturing on the landing. A small "fleeting" machine is used to stack logs on the landing, and this machine normally services a number of units to minimise the cost. The system is already highly developed but can be further improved by the use of method study.

Logging machines and methods currently used in thinning operations (where tree sizes ranging from 0.1-0.6 m^3) are scaled down versions of the machinery and methods used in clearfellings. Most studies show that the horsepower of the tractor is usually under utilised because of the scattered layout of the stems which prevents or makes difficult the accumulation of a large load. The single winch and mainline aggravate this situation. Grapples have been used but have invariably been discarded, again, partly because of the problem of gathering together a payload and partly because of excessive down-time. They may, however, have a role to play where pre-bunching is part of the system or where one or two tree lengths is a payload.

Many processing plants in New Zealand demand a very high standard of log preparation, accurate length measurements and flush debranching. These high standards are reflected in logging costs. The adoption of random tree lengths, especially where private roads exist, and "rough" trimming would increase man-hour productivity (for trimming occupies as much as 50% of the bush cycle in small piece size thinnings) and reduce the cost of wood delivered to mill or port.

Lightweight power saws of around 8 kg will be the main felling and trimming tool for some time. Any relaxation of trimming specifications will ease the work load in an operation that is not popular with the work force because of the high work content and constant work pressure. There is a tendency to squeeze the piece rate in radiata pine thinning, because of its high delivered cost and low value, and a much higher work rate is often necessary to make an acceptable wage compared with other logging operations such as the thinning of Douglas fir and the clearfelling of mature radiata pine. In these operations trimming is a much smaller proportion of the bush cycle. Future developments will probably focus on relaxing unnecessarily rigid specifications, evaluation of small but important ancillary gear such as polypropylene ropes, spring loaded tapes, radio controlled winches, etc.; achieving a better balance between trees size, manpower and horsepower, and raising the productivity of below average gangs to that of the best. There is sometimes a 25% productivity difference between apparently identical gangs working in similar conditions.

Machinery Trends

Production thinning operations in New Zealand, being tree length, are usually built around the small articulated rubber-tyred skidder, or track laying machines of the Komatsu D21A size, or modified agricultural tractors such as the Same 70, Massey-Fergusson 135, etc. Land preparation and establishment standards must be very high if agricultural type tractors are to be competitive in New Zealand plantations. Although in some areas the terrain is suitable for their use, the presence of large logs and stumps together with vigorous undergrowth, limits their performance and leads to high "down time" and maintenance costs. It is now apparent that this form of low capital investment has not necessarily led to low costs. The only significant local machinery development has been by a private contractor who modified a standard agricultural tractor by removing the front wheels and attaching a rear section containing trailer wheels, butt plate, fair lead and winch, etc. The machine is similar in appearance to the conventional skidder and has similar steering characteristics but no blade and only two wheel drive. Although the concept is good, the machines have met with limited success because of excessive breakdowns and traction problems and again operating costs are higher than expected.

Overseas developments such as the British Hydrostatic Forest Tractor seem well worth evaluating locally with a view to minimising costs. To maximise the potential of the tractor a mechanical line thinning has been adopted by the British Forestry Commission; complete outrow, with the thinning element between the outrows felled into the outrow tip first This presentation allows the maximum number of stems to be picked up with the minimum of effort, and allows more complete utilisation of the two radio controlled winches characteristic of this particular machine.

Further developments arising from method improvements are the use of coloured lightweight polypropylene rope strops to speed the stropping process. The tractor cycle time has further been reduced by using two 23 cm steel pins which serve as a quick release for the load (18-20 stems) on reaching the landing. This development is claimed to reduce terminal time by up to 25%. A second set of strops from the previous load plus the two steel pins are hung on the rear of the tractor by the man carrying out the manufacturing on the landing and the tractor returns to the felling face to repeat the cycle without undue delay. It is difficult to understand why conventional small rubber tyred skidders fitted with two winches and fair leads, radio controlled, have not been introduced before in New Zealand logging operations. These developments, primarily methods improvements around a potentially highly suitable machine, offer the best prospects in the immediate future. The role of highly sophisticated multi-function processing machinery in the New Zealand environment is not clear at this stage. The gains rrom these new concepts must be compared with fully evolved current systems, if the comparison is to be meaningful.

RESEARCH NEEDS AND PRIORITIES

Effective research does not automatically flow from a list of research topics. The most essential ingredient is a motivated team with the right blend of expertise — for harvesting research this means foresters, mensurationists, work study specialists, cost accountants, economists and possibly one tame engineer. Such groups exist, or could exist, in the private companies, large State forests, and the forest research institute — all appropriate venues for the many aspects of thinning research. New Zealand will soon have a new research organisation — N.Z. Logging Industry Research Association — which will implement and co-ordinate harvesting research. This association is to be jointly funded by Government and industry. It is likely that the research programme funded by the association will largely concentrate on short-term, quick return investigations until it becomes established and has assured long term backing from industry. The extent to which aspects of thinning will be tackled is not yet clear.

Investigations currently underway at the Forest Research Institute and the priorities established are outlined below. Other organisations may set different priorities but these will usually be attributable to their viewpoint.

At the Forest Research Institute the overall aim of the Economics of Silviculture group is "To identify the most efficient means of growing and harvesting radiata pine for both domestic wood requirements and export".

Preliminary work by this group suggested that the harvesting cost structure is largely in the hands of silviculturists who determine initial espacement, thinning policy, final crop tree size and branchiness and rotation. These factors also influence the net volume recovered. Obviously overall evaluation must precede concentrated investigation of individual operations and the former is facilitated where silvicultural and harvesting research are integrated in one programme and implemented by one research group. This is seen as the strength of New Zealand research organisation. Considerable use has been made of forest budgets (i.e. cost models of plantation projects) to identify knowledge gaps and priorities. These have shown the most important weak points in physical or cost data and hence highlighted priorities for micro-economic research. Principal silvicultural targets in the current 3-year research programme are:

Identify the minimum ratio of number of trees planted to the number harvested for the main site types and the main end products.

Quantify the transfer of growth from pruned to unpruned elements in selectively pruned stands, including treatments where crop rows are distinguished from thinning rows at the outset.

Quantify green pruning effects on growth in stands where unpruned competitors are removed as they are rejected.

Evaluate the yields and size assortments from pulpwood regimes and minimum tending sawlog regimes.

Evaluate well-pruned logs of various diameters to further quantify grade improvement by tending.

Determine the acceptability of top logs from open grown stands for sawlog and alternative products.

Refine yield data for very wide spaced crops.

Measure grass yields under stands of varying age and stocking relative to the open paddock situation to quantify intermediate yields from livestock.

The emphasis on silviculture is heavy but this is deliberate as the biggest economies in harvesting are expected to come from the planning of the production system from establishment to mill door. The strength of the current research effort is probably that the system is being tackled in this way. Other essential ingredients are a willingness to test extreme treatments and the use of considerable imagination in drawing up the research programme.

On the harvesting side the research objectives are:

(a) To reduce the cost of moving wood from stump to mill door.

(b) To improve the profitability of the growing plus harvesting phase.

(c) To identify the capital and manpower required to harvest specific crop types on easy and difficult topography.

Principal targets in the current programme are:

The establishment of long-term silvicultural trials; the object of which is to tailor stands for cheap harvesting by manipulating spatial arrangement, tree size and stem uniformity.

Case study documentation of the best gangs available to provide an index of the productivity levels achievable at current levels of mechanisation, with well motivated gangs and sound work methods.

Investigation of operations which are currently rare but likely to be important in the future. For example, clearfelling of young tended stands (15-25 year age range), production thinning stands of approximately 14 m and salvage of cutover wood.

Collection of comprehensive time standards to enable synthesis of operations which are not at present being carried out; and also to test the effect of stand, terrain and gang structure interactions in a computer simulation program (currently being prepared);

Collation of data on effect of tree size, form and pruned state on bushman productivity.

Investigation of management restraints on productivity and costs — including training, methods of payment, contracts, turnover, accidents and scale of operation.

Collection of tree and branch data of importance to highly mechanised systems, and evaluation of the implications of whole tree harvesting.

Investigation (with Mensuration group) of methods for fast measurement of haul sizes, assessment of cutover waste, breakage and recoverable yield and the use of photography for volume assessment.

Preparation of a booklet to assist small contractors and accountants with estimating and planning logging operations.

Many of these targets do not necessarily relate to production thinning or clearfelling alone, but they represent the FRI viewpoint of current priorities. The emphasis is always likely to be weighted towards clearfelling because this is where the bulk of future wood will be derived.

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