REVIEW OF THINNING PRACTICE IN NEW ZEALAND 1974 TO 1981

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ABSTRACT

The limited extent of the remaining "old crop" resource planted in the 1920s and 1930s, and the low level of planting between 1935 and 1955, will lead to a period of wood supply constraint in the 1980s. This will be followed by a substantial increase in production from the mid-1990s. The resulting constraints on industrial expansion, and the large age-class which might supply commercial thinnings have led to a review of silvicultural practice. There is a wide range of thinning and pruning regimes currently being practised in New Zealand, as exemplified by those of the four major growers in the Rotorua region.

Other significant developments have been the application of fertilisers after commercial thinning, and the establishment of the Radiata Pine Task Force to study the effect of management regimes on value outturn in relation to a range of processing options.

INTRODUCTION

In his background paper presented at the 1974 IUFRO Conference, Kirkland (1976) reviewed the history of thinning in New Zealand and contrasted that history and its influence on thinning practice with the Australian situation.

In summary, thinning contributed little to the annual harvest from the plantation resource in New Zealand. At present (1981) it is around 17% of total plantation production (Elliott & Levack 1981). A major reason for this small contribution from thinnings has been the long period during which supply exceeded demand, and clearfelling represented a plentiful (and much cheaper) source of small roundwood.

Even though the original "old crop" resource, planted in the 1920s and 1930s, is now almost gone it still represents the main source of supply for the forest industries which have expanded rapidly since the early 1950s. The logging industry has developed its expertise in clearfelling operations and has tended to apply these techniques to commercial thinning. While two or more commercial thinnings were prescribed in most management regimes in the late 1950s and early 1960s, it was not until the 1960s that post-war stands were extensive enough for the introduction of extraction thinning as a general practice.

Where common ownership of forest and industrial plant led to a priority commitment to the uplift of thinning yields, regulated regimes were developed and successfully implemented. In many forests, however, the commercial thinning operations became the first victim of any downturn in demand, programmes regularly fell behind schedule, delayed operations led to wind damage, and lack of effective control led to poor selection and damage to residual stems.

In the late 1960s the economic studies of R. Fenton and other Forest Research Institute scientists had a profound influence on thinning practice in State forests. The short-rotation sawlog regimes prescribed by FRI for high-quality sites abandoned commercial thinning on the grounds that intermediate produce was of relatively low value and was obtained at the expense of the final crop. Three pruning lifts and two waste thinnings before 15 m mean tree height were prescribed to obtain maximum value increment on the pruned butt log which comprised over 30% of stand volume and 60% of stand value at an age-25 clearfelling.

By 1974, the short-rotation sawlog regimes and variations of them had become widely adopted by the State and some private organisations; the two major private forest companies, N.Z. Forest Products Ltd and Tasman Pulp and Paper Co., had persisted with more conventional regimes based on at least one commercial thinning and, for N.Z. Forest Products Ltd, on longer rotations.

CHANGES 1974 TO 1981

The Change in Age of the Resource

One of the most important changes since 1974 is the diminished area of the "old crop" resource, which has sustained the steadily increasing production of the forest industries since the early 1950s. In contrast the 1–20 years age-class, which represents the area requiring thinning treatment, has increased dramatically (Fig. 1). In 1981, 59% of the resource is less than 11 years of age and only 15% is over 25 years.

Within the next 5 years most of the "old crop" planted in the 1920s and 1930s will have been removed and the clearfelling cut will have to be sustained by the small-scale plantings of the immediate post-war period. The 1–10 years age-class is 97% radiata pine (*Pinus radiata* D. Don) while the 25+ age-class comprises only 56% radiata pine. There are also large areas of minor species, many of poor quality.

The logging and sawmilling industry in New Zealand will face a substantial drop in tree size during the next 10 years as the average age of clearfelling drops from over 50 to less than 30 years. In the Rotorua region mean tree volume at clearfelling will drop from 2.6 to 1.6 m^3 between 1983 and 1993. This change in tree size will coincide with a period of wood supply constraint which can only be relieved by a substantial increase in the area commercially thinned. In New Zealand this will represent a significant change in management practice as most forest growers have implemented regimes which prescribe early thinning-to-waste to final-crop stocking.

The forecast of production (Fig. 2) based on current management intentions shows that there will be virtually no expansion until 1990, a modest increase in 1991 to 1995, and then a dramatic increase beyond 1996.

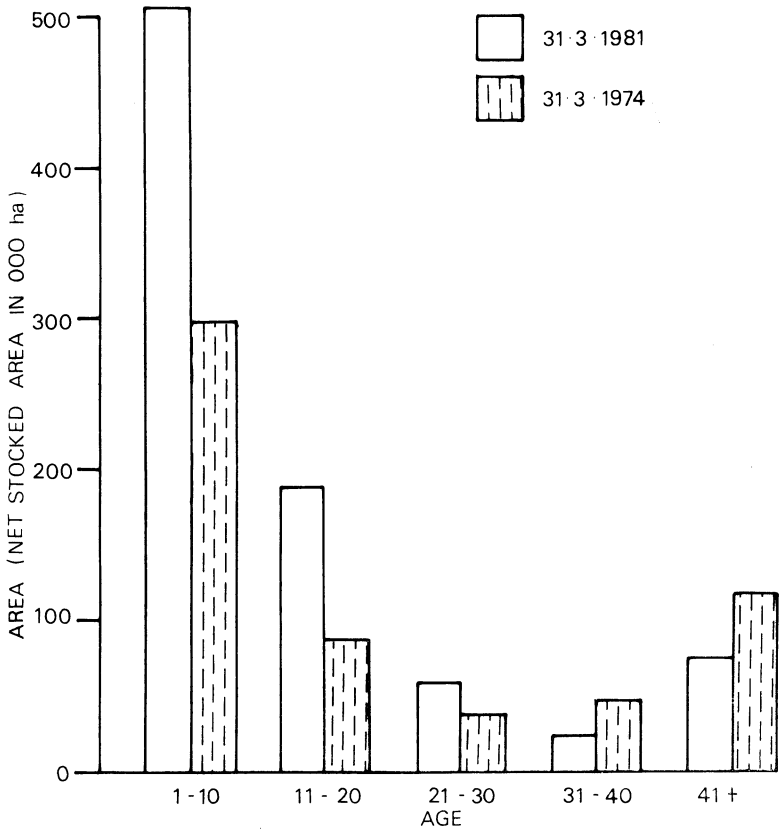

FIG. 1—New Zealand's plantation resource 1974 and 1981.

Pressure for Increased Commercial Thinning

The dilemma facing the forestry sector in New Zealand is a period of minimal growth followed by the need to double production in a period of 10 years. If there is a recovery in the economy within the next 10 years which results in a building boom, the domestic demand for timber will grow at the expense of the export trade, which should be maintained to hold markets for the boom ahead.

This unpalatable situation has resulted in pressure from industry for increased wood supply in the 1980s. As the State is the major forest grower, owning 52% of the plantation resource, this pressure has fallen on the N.Z. Forest Service which has been forced to review its management practice and to consider the feasibility of commercial thinning and/or early clearfelling.

The demand for increased wood supplies is from the existing pulp and paper industry, and from both New Zealand and overseas interests wishing to establish a toehold in industries using reconstituted wood. It is only such smallwood users who could take advantage of an increase in commercial thinning or early clearfelling. As the regimes implemented in the State forests are aimed at shortening rotations without

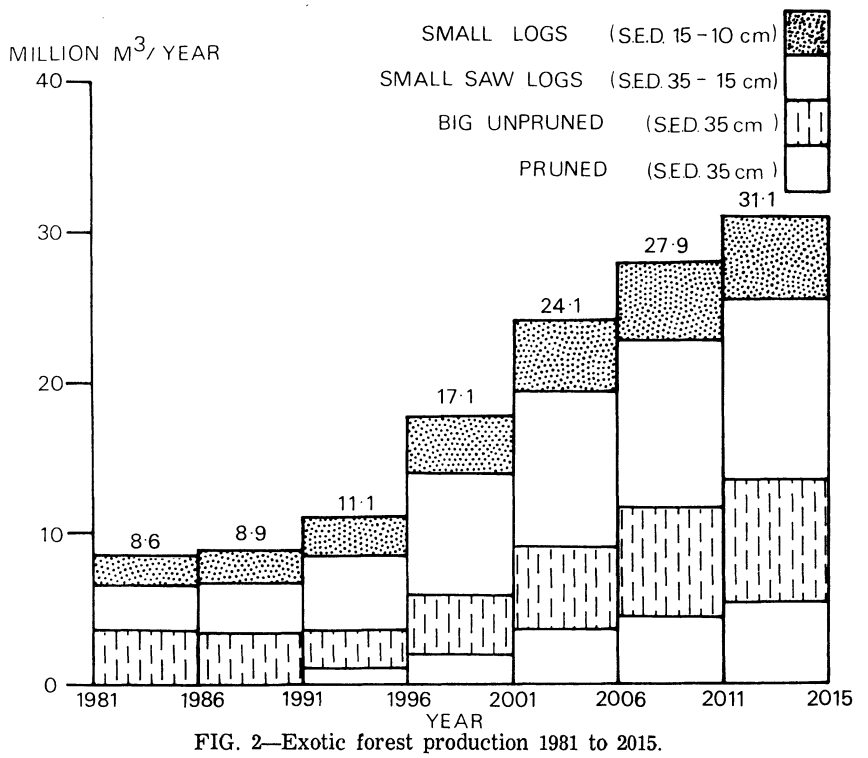

FIG. 2—Exotic forest production 1981 to 2015.

sacrificing final tree size, they provide for the earliest opportunity for expansion of the sawmilling and plywood industries. Unless commercial thinning is restricted to the very small yields of wood currently thinned to waste, an increase of smallwood supply in the next 10 years will only support the reconstituted-wood industries at the expense of the early expansion of solid-wood industries. However, with a royalty differential of almost 1 : 5 in favour of sawlogs, and an even greater difference in favour of plywood logs, there is little financial incentive to implement substantial management changes.

Nevertheless, some compromise to support early harvesting in those areas with little or no industrial base to expand from is justifiable. It will ensure that an expertise in utilisation is developed locally in preparation for an accelerating production beyond the early 1990s.

Fertiliser Application after Thinning

Since 1974 the application of nitrogenous fertiliser after commercial thinning has become a well-established forest operation in radiata pine stands on pumice soils. Until recently N.Z. Forest Products Ltd applied fertiliser after every thinning operation, and Fletcher Forests Ltd have introduced the operation after their final thinning-to-waste at age 8 years.

Fertiliser trials in forests on pumice soils were pioneered by N.Z. Forest Products Ltd, and led to a co-ordinated series of experiments in several forests in the central

North Island. A "fertiliser action group" comprising representatives of major growers and the Forest Research Institute was involved in this programme which confirmed the early results obtained by N.Z. Forest Products Ltd.

On high-quality sites an 8–10% increase in volume production over 10 years can be achieved from a single application of 200 kg N after a thinning at age 14, and most of this response is in the first 5 years. In practice, N.Z. Forest Products Ltd anticipate an increased yield of 36 m^3/ha. Evidence from trials indicates that response is directly related to site quality and tree age at thinning, and is achieved only if the fertiliser is applied within 2 years of a thinning. However, more recent evidence from large-scale operations has suggested that this response is not achieved in second (18- to 20-year-old) thinnings, and N.Z. Forest Products Ltd no longer apply fertiliser after this operation.

The tight wood-supply situation has provided the incentive to apply fertiliser as a means to increase total forest yield. N.Z. Forest Products Ltd's multiple thinning regime could provide the opportunity for a double boost in growth, while the early thinning-to-waste regimes practised by the N.Z. Forest Service and Fletcher Forests Ltd minimise the opportunity to benefit from the application of fertilisers.

It remains to be seen whether fertiliser application becomes standard practice, rather than a means to relieve a temporary wood-supply deficit, but it adds a further element in the debate over the relative merits of alternative regimes.

The Radiata Pine Task Force

In 1976 the Forest Service established the Mensuration Project Team to develop a set of computer systems for mensuration and management planning of exotic plantations. By 1979 the team had completed its assignment and had disbanded. The success of this concept of a small multi-disciplinary team, dedicated to a single comprehensive assignment, led to the establishment of the Radiata Pine Task Force in 1980. Like the Mensuration Project Team, the Task Force drew staff from research and management. While the Mensuration Team concentrated on the means to predict current and future forest yield in terms of log assortments, the Radiata Pine Task Force has concentrated on the quality of radiata pine relative to a range of manufacturing processes. It is developing the means to relate log size and defects to processing cost and the value of outturn, and to relate silvicultural treatment to log quality. The effects of log defects, such as sweep, branch size, and resin pockets, are being studied in a range of primary and secondary manufactured products. The results of the studies will be presented in the form of a set of predictive computer models which will allow forest managers to explore the relative merits of silvicultural regimes, and the managers of processing industries to efficiently allocate a log mix to a range of processing plants.

CURRENT PRACTICE IN NEW ZEALAND

National Output of Thinning Operations

The extent of commercial thinning operations in New Zealand has been studied recently by the Logging Industry Research Association (LIRA 1980). This survey of forest owners sought an estimate of the production of smallwood from commercial thinning operations in the period 1981 to 1985. It excluded the thinning of "old crop"

radiata pine and Douglas fir (*Pseudotsuga menziesii* (Mirb.) Franco) stands and concentrated on operations in immature stands representative of current management intentions for stands planted since 1960.

The results of the survey (Tables 1 and 2) suggest that 1.45 million m^3/year will be produced and that this yield represents 17% of the total annual production from radiata pine plantations in the 5-year period. Of the total thinning yield only 5.5% will be obtained from hauler terrain, 80% will be obtained using conventional logging skidders, and 73% will be extracted as tree lengths. There have been few serious attempts to introduce fully mechanised logging methods.

TABLE 1—Estimated annual exotic roundwood removals, New Zealand, 1981–85

	Million m^3	Percentage
From clearfelling operations	7.18	83
From thinning operations*	1.45	17
Total†	8.63	100

* LIRA 1980

† Elliott & Levack (1981)

Total minus thinning gives clearfelling figure.

TABLE 2—Thinning volumes by method of extraction

Extraction method	Units*	Shortwood (m^3)	Tree length (m^3)	Total (m^3)	Percentage of all thinning
Skyline	8	—	56 000	56 000	4
Chutes	7	20 000	—	20 000	1.5
Agricultural tractors	35	88 000	35 000	123 000	8
Forwarders	1	28 000	—	28 000	2
Crawler tractors	3	7 000	14 000	21 000	1.5
Skidders (cables)	70–80	250 000	952 000	1 202 000	83
TOTAL		393 000	1 057 000	1 450 000	100

* All known units 1981

This survey represents forest owners' intentions, and LIRA staff regard the results as an upper limit. In the past many attempts to obtain such low-value wood from thinnings have failed to be commercially viable and the abandonment of operations has not been uncommon. The consequent delay in the silvicultural thinning-to-waste and its increased cost have been a major disincentive to the commitment of forest managers to regimes which produce an intermediate yield.

The breakdown into extraction methods (Table 2) is based on current practice in 1981, but a major revolution in methods is not expected during the next 5 years. This lack of interest in modern mechanised operations is one of the major differences between Australia and New Zealand.

Silvicultural Regimes in New Zealand

While commercial thinning is not a prominent feature of management regimes in New Zealand, there are few plantation stands which are not thinned. Most thinning operations are carried out early in the life of a stand as a thinning-to-waste operation, and a dominant influence on thinning practice is the pruning regime.

One of the first tasks undertaken by the Radiata Pine Task Force was a survey of silvicultural regimes in New Zealand (Williams 1982) which revealed a wide range of practice and identified nearly 70 silvicultural schedules. There appeared to be a general lack of clear objectives for the development of optimum schedules, and even for schedules with similar objectives there was wide variation in most elements from initial spacing to timing and intensity of the final thinning.

In spite of this apparent diversity of practice, two major groups of regimes were apparent: namely, a "clearwood" group which embraces pruning regimes, and a "structural" group which does not. Furthermore, the major changes since 1970, when a similar survey was carried out, were identified:

> "Initial stockings used in most schedules appear to have decreased significantly since 1970 . . . due to improvements in . . . forest establishment techniques as well as the improved genetic quality of tree stocks. [For structural regimes average planting stocking has been reduced by 20% from 2040 stems/ha to 1670 stems/ha.] Thinning practice for clearwood schedules has become more uniform in the last decade with a clear trend toward two thinning operations, earlier thinning and a higher final-crop stocking. . . . Production thinning intentions appear to be much less frequent now than in 1970 [in both structural and clearwood regimes] . . . Earlier thinning is also a feature of structural schedules . . . Pruning practice and intended rotation length have changed rather less than thinning in the [last] 10 years" (Williams 1982).

The report provided two examples of "typical" tending schedules which are reproduced here in Table 3 (from Table 3 of Williams 1982).

TABLE 3—Typical New Zealand tending regimes

Schedule type	Thinning		Pruning		
	Ht (m)	Stems/ha	Ht (m)	Stems/ha	Lift (m)
Clearwood	6	740	6	600	2.2
			9	350	4.0
	12	300	12	300	6.0
Structural	12	370	No pruning		

The report was critical of the large number of regimes and implied that such wide variation in practice was unacceptable. This is perhaps unreasonable; in my opinion, the author did not adequately differentiate between the environmental factors which must lead to wide variation in practice and the basic principles upon which the regimes are based. Site productivity, soil stability, weed infestation, disease risk, and susceptibility to wind damage vary widely in New Zealand and must be allowed for in silvicultural practice. As far as silvicultural principles are concerned, there are significant points of agreement and disagreement which explain variation in practice.

The clearwood regime aims to obtain maximum growth of final-crop stems by releasing them from competition as soon as possible. Control of branch size in the bottom log is achieved by pruning which concentrates quality and value in this log at the expense of increased branch size in the rest of the tree.

The structural regime constrains branch size in the bottom log by retaining higher stockings either at the expense of final tree size or longer rotations.

The debate between the protagonists of these two approaches centres on four factors:

(1) The effect of intensive pruning and heavy early thinning on volume production;
(2) The value and future price differential for clearwood and log size;
(3) The importance of rotation length for profitability;
(4) The risks associated with, on the one hand, a commitment to prune, and to prune on time; and on the other hand a commitment to a market for low-value, high-cost wood which will support a delayed thinning.

It is a combination of environmental influences and the approach taken to these four factors which determines an organisation's silvicultural regimes.

Radiata Pine Regimes Adopted by Four Major Growers

To explore the rationale for the development of alternative silvicultural regimes, senior management staff of the four major growers in New Zealand were asked about their approach to the management of radiata pine on the pumice soils in the Rotorua region.

The four organisations are: N.Z. Forest Service; N.Z. Forest Products Ltd; Tasman Pulp and Paper Company; and Fletcher Forests Ltd. (The last two organisations are now part of the same corporate body but their approach to forest management has been quite different.) All four organisations have plantations in the Rotorua region in excess of 25 000 ha. Two of the organisations, N.Z. Forest Products Ltd and Tasman, own both the forest and a large integrated industry, while the other two are exclusively forest growers.

Fletcher Forests Ltd

This is an independent company which is required to establish, manage, and harvest a forest resource as a commercial venture. The company must compete for investment funds with other companies of the Fletcher Holdings group which are involved in a wide range of enterprises such as steel manufacturing and heavy construction. Fletcher Forests' management objectives are admirably simple – to maximise market opportunity and return on investment.

The clearwood regime has been adopted to obtain large tree size as soon as possible. The timing of thinning is regarded as critical, and pruning is seen as a means of avoiding serious degrade in the bottom log rather than of obtaining maximum clearwood content. While the management have an open mind on the value of clearwood, they regard short rotations and large final-tree size as critical factors. Fertiliser application at time of planting is standard practice and has recently been introduced after thinning at age 8 years. Silvicultural treatment has priority over new establishment in use of investment funds. There is a single thinning regime (Table 4) for all sites, with only minor variations to pruning practice on pasture sites.

TABLE 4—Silvicultural regime of Fletcher Forests Ltd

Age (years)	Operation
4–5	Thin to 500 stems/ha; prune to 2 m
6–7	Prune to 4 m
8	Prune to 6 m; thin to 250 stems/ha; apply 200 kg N/ha
25	Clearfell

N.Z. Forest Service

The short-rotation sawlog regime was recommended by the Forest Research Institute as a means to achieve a return of 7% (and later 10%) compound interest on the cost of establishing and managing each stand of radiata pine. It was relevant to high-quality sites on which the cost of pruning could be covered by a rotation of 25 years (site index 27 m or better). The regime was proposed in 1969 but the philosophy behind it is still advocated by Research Institute staff. Recent work of the Radiata Pine Task Force has highlighted the importance of restricting the diameter of the defect core (Park 1980), and suggested that the timing of pruning is critical to the value of the final crop. In its uncompromising form the clearwood regime embraces a combination of early thinning and severe pruning to achieve a maximum diameter-over-stubs of 16 cm on 200 stems/ha, so as to produce a final-tree size of 50 cm diameter as soon as possible. It is based on a perceived need to reduce rotations and on a future price differential for both large logs and defect-free wood, and aims at maximum value at the expense of volume production.

The State forests of the Rotorua region support the integrated mill owned by Tasman, a second integrated sawmill/pulpmill at Napier, a large State-owned sawmill, and 20 smaller sawmills. The current rate of production is in excess of the allowable cut and will have to be reduced as the production in Tasman's own forest resources expands, and as short-term commitments are terminated. The forest faces a very tight supply situation, pressures of supply commitment being exacerbated by the poor health of a minor species resource which had been regarded as a "bridge" supply between the exhaustion of the "old crop" radiata pine resource and the maturity of the young crops.

The main regime (Table 5) adopted in Kaingaroa, the major State forest, is a variant of the clearwood regime which has been modified to reduce loss in volume production at the expense of early attainment of large tree size. It is applied on sites with a site index of 27 m and has the objective of obtaining a mean tree size of at least 45 cm diameter at age 30 without significant loss of the growth potential of the site. Because of the tight supply situation, and the commitment to a large supply of pulpwood, crop rotation cannot be extended, and volume production must be maximised. Two waste thinnings have been included to meet the objectives set, and the control of these operations and three pruning lifts are entirely under the control of the forest's management.

On higher altitude sites with site indices below 27 m, only the first thinning to 600 stems/ha and the low pruning are applied. The final-crop stocking will achieve an average tree diameter of 35 cm at age 30 or a later commercial thinning could be introduced.

TABLE 5—N.Z. Forest Service silvicultural regime

Age (years)	Ht (m)	Operation
4–5	6	Thin to 600 stems/ha; prune to 2.2 m
	9	Prune to 4 m
9–10	12	Prune to 6 m; thin to 350 stems/ha
30		Clearfell

N.Z. Forest Products Ltd

This Company's radiata pine regimes include one or more commercial thinnings, considered to be essential to maximum volume production and to the improved size and quality of clearfelling harvests. The company's standard for profitability is not based on the net discounted return from individual stands but on the balance between expenditure, revenue, and capital value of the total forest resource. This places less constraint on rotation length and more emphasis on obtaining optimum value increment from the forest.

Nevertheless, the recent expansion of the kraft pulp mill has placed severe pressure on the forest resources and the current regimes (Table 6) have been developed in response to this pressure. The sawlog regime on flat country involves two commercial thinnings which reduce basal areas to the threshold below which volume production is considered to be sacrificed. This maximises early yield. On country that is steep but with slopes less than 18° a single commercial thinning to 300 stems/ha is carried out at age 17, and on slopes greater than 18° chutes are used for thinning to 300 stems/ha at age 13. The plywood regime, which is considered to sacrifice volume production to obtain a large pruned butt log in 30 years, delays thinning after final pruning at age 9 years until age 11 in order to obtain a viable yield.

TABLE 6—N.Z. Forest Products Ltd silvicultural regimes

Age (years)	Plywood 0–10° slopes	Sawlog regimes		
		0–10° slopes	10–18° slopes	>18° slopes
Pruning				
5	500 stems/ha to 2.2 m	500 stems/ha to 2.2 m	No pruning	No pruning
7	500 stems/ha to 4 m	500 stems/ha to 4 m		
9	500 stems/ha to 6 m	500 stems/ha to 6 m		
Thinning				
11	To 350 stems/ha			
12–14		To 500 stems/ha		To 300 stems/ha
16–18			To 300 stems/ha	
18–20		To 300 stems/ha		

These commercial thinnings produce 22% of the total cut and 38% of the supply to the pulpmill.

The company regards pruning as a justifiable operation, but considers there is insufficient evidence to warrant giving the return to pruning investment priority over total production, in the present situation of supply constraint. Pruning was abandoned, briefly, during a period when planting had a clear priority call on available funds but is currently applied on all tractor-negotiable country (0–10° slope). Unlike operations in State forests and in Fletcher's forests, selection pruning is carried out and pruned trees are not released until the first commercial thinning.

After most thinning operations N.Z. Forest Products Ltd apply fertiliser at a rate of 230 kg N/ha.

Tasman Pulp and Paper Company Ltd

Tasman obtains the bulk of its wood supply from State forests but by 1990 its own forests will be capable of supplying between 25 and 30% of its industrial capacity. The company's major resource, Tarawera Forest, is on one of the most productive plantation sites in New Zealand, and is situated on the doorstep of the mill at Kawerau.

In 1962, when the forest was acquired, the supply of material for groundwood refining was regarded as a constraint while the supply of sawlogs and kraft pulp logs from clearfelling operations in State forests was considered to be secure. The company set as a management objective the production of high-quality groundwood crops with an average tree size between 15 and 30 cm d.b.h.o.b. and with minimum heartwood content. A short rotation of around 18 years was envisaged. Since then changes in management practice have led to a lengthening of rotation. While this has resulted in increased mean annual production, the main reasons for change were the timing of industrial demand, and the need to build in flexibility of management for the log product mix.

The forest resource will be critical to the company's industrial expansion of its newsprint capacity. This will place more emphasis on early production than on maximum production and the current regimes have been developed in response to this priority.

Two environmental factors have a dominant influence on thinning practice in Tarawera Forest. The first is the serious incidence of terminal die-back caused by *Diplodia pinea* (Desm.) Kickx. The effect of this fungal pathogen is most serious in young stands with a mean top height of less than 10 m. The selection of final-crop stems cannot be made until this height is reached and this has set the timing of the first thinning.

The second factor is wind damage which is much more of a constraint than in the forests of N.Z. Forest Products Ltd. Attempts to thin stands from a live stocking of around 1700 stems/ha to 400–450 stems/ha at age 9–10 have resulted in serious wind damage, and for this reason the early thinning to 900 stems/ha at a top height of 10–12 m (which had been abandoned as a cost saving) has been re-introduced (age 5–6 years) on land with 0–15° slopes. Stands are then thinned to 450 stems/ha at age 8–10 and clearfelled at age 21–22 (average d.b.h.o.b. 40–43 cm). Stands on slopes $\geq 15°$ receive one thinning to 400 stems/ha at age 6 years.

Pruning is not included in either of these regimes. Tasman was the first forest organisation to abandon pruning, but the coastal Bay of Plenty sites represent some of the best opportunities in New Zealand to grow large pruned butt logs on short rotations. Tasman Pulp and Paper Company has acquired other forests in this region which have been managed under clearwood regimes. It has recently implemented, as Company policy, the maintenance of intensive tending regimes on 25% of its total forest resource each year.

CONCLUSIONS

In 1974 there was fierce debate in New Zealand over the management of radiata pine. In 1981 this debate is less heated but there still exist a wide range of practice and a division into two major philosophies. The New Zealand situation in 1981 is more similar to that in Australia in 1974 in that the demand for smallwood now exceeds supply for the first time in our history. It is unlikely, however, that New Zealand practice will move toward the multiple commercial thinning that has been commonly adopted in Australia.

It is notable that there is much more in common between the silvicultural practices of the four large forest organisations in New Zealand than there was in 1974, and it is more than likely that the information being made available by the Radiata Pine Task Force will lead to further coincidence of approach.

One area of dispute still to be resolved is the effect of pruning and thinning on total forest yield. It is to be hoped that the new generation of growth models being developed by the Forest Research Institute will put this dispute to rest once and for all.

There will remain the difference of approach to forest accounting, the question of compound interest rates, the relative value of pulpwood to sawlogs and plywood logs,

and the eventual price differential for clearwood. These, together with local environmental factors, and an organisation's supply/demand balance, will influence thinning and pruning practice in New Zealand.

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