REVIEW OF NEW ZEALAND THINNING PRACTICES

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PREAMBLE

This review attempts to cover past, present and future objectives of thinning and to outline current practices with the emphasis on why and how they have evolved.

First, to point out the obvious—thinning is only one of a number of devices available in New Zealand or elsewhere to shape production forests to particular end purposes. Others include choice of sites, rates of planting, initial spacing, pruning, tree breeding, and the approach to regulating cut. In attempting to achieve whatever end use objectives are laid down none of these means of manipulating the crop operates independently of the rest.

Thus, one will not observe any uniform approach to current thinning practice in New Zealand. Sites range widely from nitrogen deficient coastal sands supporting radiata pine of fine branch and stem form to fertile pumicelands with a more malformed but swiftly growing crop. Superimposed on these physical differences there are, even in State forests, widely varying management objectives from region to region and a large measure of local autonomy in how they are achieved. Moreover, except in the few areas where plantings are starting from scratch the forester inherits past planting rates, often in the form of a markedly abnormal set of age classes, the results good or bad of past fashions in tending, and commitments of varying length and complexity to supply particular products to industry. He is thus commonly constrained, to a considerable degree, in his choice of management strategies. His task is usually to effect a transition from the existing forest to that which he conceives as the ideal. In so doing he must meet existing commitments as efficiently as he can and create the most favourable opportunities for additional future market outlets. He seldom has sufficient mensurational data to predict with precision the quantitative and qualitative consequences of his choice of thinning and silvicultural schedules and even if the physical outcome were forecast with certainty he would still be faced with uncertainty of markets and hence of the relative return to be expected for various products, raw or processed, export or domestic, 20 years or more hence.

The inevitable consequence of uncertainty is that, when all that can be has been made explicit, there remain various choices which are essentially value judgments and for this reason alone there will be no uniformity of approach in thinning practice unless decision making is completely centralised.

Finally, despite the many constraints which he commonly faces, the forester can exert a major, lasting influence by the way he manipulates, through thinning or other practices, the younger age classes in his care.

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REVIEW OF THINNING PRACTICE

Both the theory and practice of thinning New Zealand plantations have been subject to continual change and have seldom been completely in harness. Probably this will continue to be the case. It is, therefore, not easy to trace objectively the manner in which thinning practices have evolved even if one has been on the spot. It is even more difficult to succinctly convey the reasoning to those who have not periodically visited New Zealand.

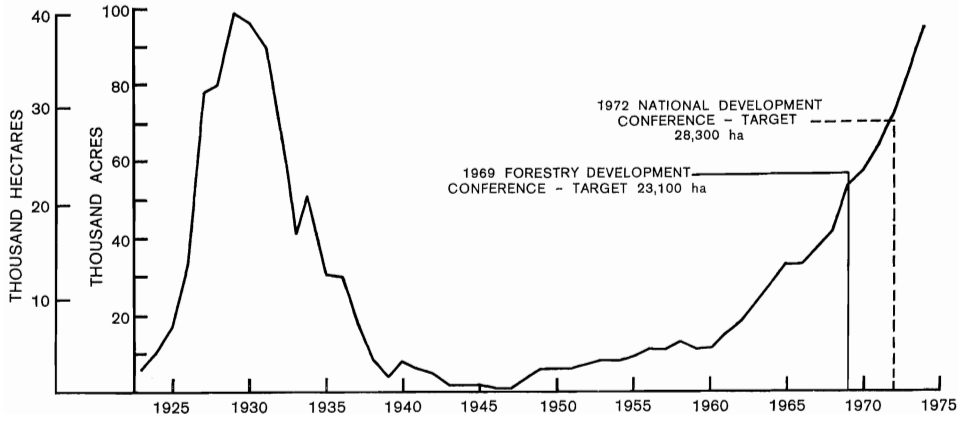
Perhaps the dominant underlying influence throughout has been the size and nature of the market in relation to the age class distribution of the forests. In the 1920-35 period massive plantations had been established (Fig. 1) for which markets were virtually non-existent, a situation hardly conducive to bold silvicultural innovation. The exotic forest-based sawmills and kraft pulpmills set up in the 1940s and 1950s allowed, for the first time, a clearer appreciation of the desirable attributes of the raw material. The introduction of panel board plants, the Japanese log trade and refiner groundwood outlets progressively added new possibilities. As the market has evolved and diversified so have the silvicultural practices. Initially the vast volume of wood accumulated in the old crop stands dominated management strategies. It is still of great importance but within the near future the relatively sharp and traumatic change from utilisation of predominantly pre-war crops to utilisation of only post-war crops faces us and the methods of tending the latter will then no longer be of academic interest.

To simplify the review I shall consider pre-war and post-war crops separately and within convenient time periods. Thinning of other than radiata pine in post-war crops has been negligible and I shall deal only with that species in the section concerned. The review will be necessarily selective and incomplete and indicative only of changes and their reasons. It will be biased toward State forest practices which are more fully documented than those of the private sector. Information on earlier practices has been obtained from departmental annual reports.

Thinning of Pre-war Crops (old crop)

1897-1919. The need for some thinning in earliest State plantations of the late 1800s and early 1900s became evident about 1910-11. The general philosophy for

FIG. 1 NEW PLANTING FROM 1925



tending the wide range of conifers that had been planted was to maintain stands in a dense condition and thus obtain close-ringed, knot-free timber. The impossibility of doing so because of the persistent nature of branches under New Zealand conditions was apparently not fully appreciated until the mid-1930s. For some species which were considered to be more "light-demanding", for example larch, the need for thinning to give crown space was recognised but only the dead and suppressed were removed and thinned stands were usually under-planted to lessen "the action of air currents and direct sunlight on surface humus". After an inspection of British and American experience in 1914 it was conceded that initial spacings in State forests should be as wide as possible to lessen the labour needed in thinning and defer that which would be required until the 20th year or later but otherwise the approach was similar. The only markets at the time were for firewood, mining timber and fencing and these ceased during World War I.

1920-50. The urgency of thinning the increasing area of plantations was much discussed from the end of World War I but little work took place until 1929 due to lack of markets and the anticipated cost of waste thinning. Following the Empire Forestry Conference's visit in 1928 some thinning, partial thinning, cleaning and underscrubbing was undertaken in most older State forest stands using relief labour. The nature of these operations which established the New Zealand practice of thinning to waste was not well recorded. They were doubtless very light thinnings by current standards. Up until 1937 some 70,000 acres had been treated and it was then proposed to deal with a further 336,000 acres resulting from the boom plantings.*

The massive thinning programme anticipated in 1937 was not achieved. Only a few thousand acres more were thinned up until 1942 when silvicultural operations were placed on a maintenance-only basis for the rest of World War II.

1951 Onwards. From the early 1950s the establishment of pulp and paper industries in the central North Island and the post-war expansion of exotic sawmilling both in that region and in other parts of New Zealand, coupled with the advancing age and size of the pre-war stands, at last created the conditions needed for widespread extraction thinning on a meaningful scale. In State forests most of the extraction thinning of pre-war stands was in species other than radiata pine and was located in the central North Island. The principal species involved were Corsican and ponderosa pines and Douglas fir and most extraction thinning in the 1950s and 60s was in 30- to 50-year old stands. Such stands were thinned rather than clearfelled because:

(a) Rotations as long as 100 years were envisaged as necessary to produce the maximum quantity of high quality timber in these relatively slow growing species.

(b) There were massive areas of forest falling within a narrow range of age classes, in a heavily overstocked condition and ripe for mortality of potentially epidemic proportions.

Rigid analysis of the economics of the alternatives of clearfelling and thinning would probably have made little difference to the course of action initiated in the early

* Extraction thinning for box-making began on a small scale in Dusky Forest, Southland, in 1934. Pruning of dead branches following thinning began in State forests in the mid-1930s and persisted for over 20 years, whenever labour was available, before its futility for improving sawlog quality was recognised. Green pruning commenced operationally in 1935 as a counter to snowbend of branches in Southland radiata pine.

1950s because markets were still limited and prevention of mortality was the uppermost consideration.

Clearfelling of pre-war Corsican and ponderosa pine stands in the central North Island region did not replace thinning until the late 1960s the decision to change resulting from

(a) wind damage after the increasingly late thinning involved;
(b) increasing severity of attack by *Dothistroma pini*;
(c) some appreciation of the opportunity cost of very long rotations; and
(d) export log markets.

Thinning of pre-war Douglas fir is still practised in combination with clearfelling but is currently being reviewed in the light of increasing severity of defoliation by the Swiss needle cast fungus.

Extraction thinning of pre-war stands of species other than radiata pine in areas outside the central North Island was, in the absence of pulpmills, limited by the outlet for the small roundwood arising from sawlog production.

Extraction thinning of pre-war radiata pine was not widely practised in State forests. In the South Island and at higher altitudes in the central North Island the dense stocking of tall (relative to other species of similar age) trees predisposed such stands to post-thinning windthrow. The largest area of old crop radiata pine was thinned by N.Z. Forest Products Limited in low altitude central North Island stands which had already been reduced in stocking by the 1948-55 sirex (*Sirex noctilio* F.) epidemic. Similar stands in nearby State forest were also thinned until windthrow losses became excessively high. Among the objectives of thinning old crop radiata pine was the maintenance of vigour in stands which would not be felled until the late 1980s, i.e., it was also induced by the age-class imbalance.

The thinning of pre-war stands while it has been an important source of wood has been discussed here largely because this is a review and the work has contributed to later thought. Such operations were invariably belated, as was any earlier silviculture in the same stands and few positive lessons for future practice emerged.

Thinning of Post-war Crops

From 1946 to 1963 (1st Symposium on Pruning and Thinning Practice).

The development of thinning practice in radiata pine in State forests over this period is probably best illustrated by reference to the so-called "Rotorua" schedule which originated in Kaingaroa State Forest. I will trace this in some detail as it illustrates much of the thinking of the time. Although little or no planting had taken place in the forest during the war period clearfelling of radiata pine to supply the State sawmill had commenced in 1939 and by 1948 regeneration on the clearfelled areas was in obvious need of attention. At the time there were no State forest growth plots and hence no data which could be used as a basis for silvicultural proposals. The pre-war radiata pine stands were entering into a period of severe reduction in stocking ostensibly as a result of an epidemic of sirex. There were quite limited markets, mainly for radiata pine sawlogs.

The desirability of tending young stands was far from self-evident but pruning and thinning were advocated on the grounds of soil and crop health, an anticipated demand for quality wood (hence pruning) and fullest use of the land (i.e. maximum volume

production). The first formal schedule was set out in 1949 after trials of "slasher thinning." It proposed a thinning of regeneration to 6 ft × 6 ft at age 3, one further thinning to waste, a pulpwood thinning at about 15 years (56-70 ft mean top height, M.T.H.) and clearfelling at 30 years of the final crop of 80 s.p.a. (mean d.b.h. 25 in.). The schedule was derived from a study of the growth of unthinned stands, the size of marginal trees and recommended *Pinus sylvestris* schedules. Its main elements were:

(a) A 6 ft × 6 ft initial spacing—regarded as the widest allowable if a coarse crop was to be avoided but close enough to give an adequate selection of crop trees.

(b) A pulpwood thinning, the timing of which it was recognised would depend on the economics of logging.

(c) A final crop of 80 s.p.a. with quality, pruned buttlogs of sawlog size.

Given these elements the possible variants were limited and after further trial the schedule shook down as:

Mean Height	Approximate Age	Treatment
25 ft-30 ft	6- 7	Prune 1 in 3 to 10 ft
40 ft-45 ft	8-10	Prune 100-150 s.p.a. to 20 ft Thin to 240 s.p.a.
90 ft	19	Thin to 80 s.p.a. for sawlogs and pulp
	35-40	Clearfell

The need for and timing of the thinning to waste at 40-45 ft was reasoned as follows:

(a) Significant mortality was observed to commence at 8 years of age or 30-40 ft in height and to affect codominant or even dominant stems during peak sirex attack.

(b) An extraction thinning was not considered to be economically practicable until stand height had reached 80-90 ft.

(c) It was reasoned that the first waste thinning should be heavy enough to arrest the observed mortality right up to the time of this second thinning.

(d) Under the sirex mortality regimes then in evidence the average number of live stems per acre in untended stands was reckoned to be only 300 at 70 ft and 200 at 90 ft. Hence a reduction of 250 s.p.a. approximately, in the first thinning would satisfy (c) and allow healthy growth.

(e) This was reinforced by the fact that at 40-45 ft the stocking of vigorous trees of good form was only 200-300 s.p.a. and to leave any more required "padding".

(f) The slight delay in 1st thinning (after the initial onset of mortality) was to allow high pruning to be carried out at the same time as thinning or a little earlier without the necessity of removing what was considered an excessive amount of green crown. In the words of the author of the schedule, John Ure, "there is a strong body of opinion—and I subscribe thereto—which believes that radiata pine should be crowded in its youth, at least until the 20 ft pruning has been completed".

The "Rotorua" schedule was notable for the effective use made of the scanty basic data and the consideration its author gave to most of the factors subsequently debated whenever silvicultural schedules have been discussed, e.g. relationships of stocking and log quality, stocking and final crop diameters, pruning and thinning, etc.

Inevitably with outlets for pulp commencing in the early 1950s the question of

reducing the age at which the extraction thinning was envisaged cropped up. By advancing the first thinning to 25-30 ft and retaining 350-400 s.p.a. it was hoped to obtain pulpwood 4-5 years earlier, from 60-70 ft high stands. This schedule was tried in Kaingaroa Forest but fell into disrepute largely because the first thinning was not well controlled (in any event the actual timing of the later extraction thinning has almost invariably been late). The result was a return in the 1960s to a schedule much the same as Ure's original except that a thinning to waste associated with low pruning was retained, 2 bites at waste thinning replaced 1 and pruning to 20 ft was prescribed in 3 rather than 2 stages. The utility of the schedule in the light of the knowledge then available may be judged from the similarity of the schedules advocated for wind firm stands on tractor country by a small "brains trust" at the 1963 Symposium. These had regard to all of the evidence—physical, economic, mensurational and practical, produced by the Symposium's deliberations and were:

Height	No pulp markets	Pulp markets
45 ft	Thin to 180 s.p.a.	Thin to 220 s.p.a.
80 ft		Thin to 110 s.p.a.
90 ft	Thin to 80 s.p.a.	
110 ft		Thin to 60 s.p.a.
130 ft	Clearfell 30-40 years	
140 ft		Clearfell 35-45 years (Mean d.b.h. 26 in.)

The problem of extracting thinnings from steep hill country was discussed at length at the same symposium. It was argued, for example, that even if thinning were conducted at a loss on steep hill country it was nonetheless desirable if it resulted in a net gain over the rotation by enhancing the value of the final crop. This reasoning was valid but ironically was later used to demonstrate the undesirability of belated extraction thinning in any circumstances because of the *adverse* effect on the final crop. The authors of the tractor country schedules shown above foreshadowed later conclusions in suggesting that the problem of hill country thinning could be circumvented by not thinning pulpwood crops at all and by a single heavy early thinning (to waste to 180 s.p.a. at 45 ft) where sawlogs were required.

The schedules for State (and smaller private) forests presented at the 1963 Symposium generally prescribed a thinning to waste to 200-250 s.p.a. at 35-45 ft m.t.h. followed by two extraction thinnings to arrive at a final crop of 80-100 s.p.a. clearfelled at about 40 years of age. The extraction thinnings had no basis of experience and were thus theoretical. Industry was supplied almost entirely from clearfelling pre-war stands or from thinning of species other than radiata pine. Doubt was expressed that the relatively low volumes predicted for "two extraction thinning" regimes were consistent with economic operations.

In summary, up to 1963 most thinning in post-war radiata pine in State forests was "to waste" in young stands and disposed them to extraction thinning of an uncertain timing and intensity at some later stage.

The schedule postulated by the major private forestry company required seven thinnings over a 50-year rotation in an endeavour to capture the full growth potential of the species. Like the State schedules it was largely theoretical although the earliest thinnings had been tried.

From 1963 to 1970 (2nd Symposium on Pruning and Thinning Practice).

During this period the age classes of radiata pine resulting from the surge in utilisation and regeneration in the 1950s and from the resurgence of major new planting programmes by State and private owners reached the age of intensive early tending. Programmes of tending, particularly in the Bay of Plenty grew rapidly and much of the foresters' work was concerned with devising satisfactory administrative and control procedures for their implementation. Simultaneously extraction thinning moved from the realms of theory to practice.

To begin with extraction thinnings took place more or less at the scheduled times and costs were satisfactory or at least well within agreed formulae. However, whenever there was a slowdown in overall wood requirements thinnings generally suffered first and the tendency was thus to fall consistently behind schedule. Problems of proper control were highlighted by the difficulty of obtaining a pruned residual crop after extraction thinning and of preventing "over-thinning" in some situations. The first problem was the result of faulty selection at the time of pruning some years beforehand and immediate steps were taken to tighten up the standard of pruning and associated thinning to waste with considerable success.

Despite some disenchantment with the results of extraction thinning the schedules advocated at the 1970 Symposium nevertheless persisted with it. The main changes from 1963 were a general move in the theoretical schedules to a single extraction thinning, some differentiation of regimes for particular end products (framing timber, boards or mixed products) and a general reduction in suggested rotations to 25-35 years.

Time does not allow analysis of the many factors influencing the changes even if they were in all cases readily apparent. Two examples may suffice. At Woodhill in Auckland Conservancy a fairly standard regime for pruned stands had involved thinning (with pulpwood extraction) to 200-250 s.p.a. at 45 ft and to 120 s.p.a. at 80 ft. The inevitable delays in the first extraction thinning (market downturns, desire for higher unit volumes) resulted in its timing at 55 ft or more. Dominance of pruned stems tended to be lost. The position was rationalised in 1970 three years after thinnings began by formally adopting 55 ft as the height for first thinning reducing the stocking at that height to 150 s.p.a. to avoid further thinning and abandoning pruning. Thus a "framing" regime evolved from a "board" regime. Its objects were to obtain framing timber by controlling branches to 40 ft, without pruning, to obtain a pulpwood yield and thus satisfy contractual obligations and to produce an 18 in. average d.b.h. sawlog at 30 years.

In Canterbury, as a direct result of disastrous windthrow, a schedule was adopted which dispensed with extraction thinning entirely. The Eyrewell State Forest windthrow not only disrupted the planned extraction thinning operation on other forests but highlighted the windthrow risk associated with any delay in thinning. Hence a reduction to a final crop of 120 s.p.a. at 40 ft height was prescribed — an unprecedently early and drastic treatment designed to overcome a special problem.

The major changes in thinking on silvicultural schedules during this period were advanced by the economics group at the Forest Research Institute. The proposals of Fenton and Sutton (1968) for silviculture of radiata pine on high site qualities were in effect the culmination of a variety of important basic studies. The economics, manpower requirements, etc., of a radiata pine forest managed on a modified "Rotorua"

regime had been thoroughly and systematically analysed for a notional pumiceland forest. The same systematic approach was evident in studies of the sawlog quality of both old crop and second crop stands in Kaingaroa State Forest (the same second crop stands that gave rise to the "Rotorua" schedule hitherto described). The grade out-turn from various log height classes, the origin and nature of defects, etc., were all carefully documented.

Fenton and Sutton reasoned that while production thinning was designed to increase yields, to obtain intermediate returns and to allow greater final crop selection under New Zealand conditions (generally only one extraction thinning in 1968)—increased yields were unlikely; — intermediate produce was of relatively low value and was obtained at the expense of damage to or reduced values of the final crop; selection of the final crop should be concerned with the butt and second logs in which most value was concentrated and could therefore be done at 35-40 ft top height. Accordingly the schedule which they advocated dispensed with extraction thinning as follows:

Age	Mean top height	Operation
4- 5	16 ft-18 ft	Prune 2 trees in 4 ft to 8 ft
6	28 ft	Prune 150 s.p.a. to 14 ft
8- 9	34 ft-36 ft	Prune 80-90 s.p.a. to 18-20 ft
		Thin to 150 s.p.a.
11-12	55 ft	Thin to final crop 80 s.p.a.
25-26	118 ft-120 ft	Clearfell 9-9500 cubic feet

The calculated effects of the schedule were to cut down manpower requirements, significantly reduce rotations, and to increase profitability as assessed by most of the standard indices. The calculated reduction in rotation was the direct result of being able to obtain the desirable depth of butt-log clearwood 10 years earlier than the conventional regime on the same site. The results were not immediately accepted in the field because they represented a radical change in thought, because problems of control associated with conventional regimes were considered surmountable and because there were some doubts about the mensurational basis. The caution was evident in the schedules presented at the 1970 Symposium which, as already stated, generally involved an extraction thinning. An attempt to obtain a consensus at the symposium was not entirely successful but most conceded that on non-tractorable country, thinning to final crop should take place as soon as possible after high pruning was completed, i.e., avoidance of extraction thinning was accepted as desirable on steep hill country.

1970-Present

The first national planning model for New Zealand forestry was prepared for the Forestry Development Conference in 1969 and was based on 35-40 year rotations of radiata pine (Hosking, this journal) with commercial thinnings. It was used to set a national new planting target. In 1972 this model was revised by assuming 25-30 year rotations, generally without commercial thinnings, and building the shorter (25 year) rotations into the model as an addition to the earlier planting target. The 1969 target aimed for domestic self-sufficiency with a surplus for export. The 1972 target aimed to maintain the relativity of forest products exports with total exports.

Although the 1969 and 1972 models were based on regional data at no time has there been approval or endorsement for other than a national planting target. As an

objective a national new planting target is too broad to help the forester define his management aims. Hence during the period a series of indicative regional forest development plans embracing all tenures has been commenced in the hope that these will aggregate to a more precise national goal. Simultaneously the Forest Service has changed from working plans for individual forests to regional forest management plans with the aim, *inter alia,* of more clearly defining regional objectives. Progress in both fields of planning has been disappointingly slow due to inadequate staffing and higher priorities for operational work.

In those regional management plans prepared to date profitability has been an object of forest management—variously profitability of the forest or of the forest and associated forest industry. Generally two silvicultural schedules have been envisaged—one approximating the short rotation sawlog regime advocated by Fenton and Sutton in 1968 and the other a minimum tending ("framing") regime with no pruning and a single relatively early thinning, if necessary to waste. Implicit in this approach is the recognition that labour and finance may be limited for the intensive tending needed under the first regime and that diversification of available produce even at the forest level is highly desirable. The intensively tended regime is capable of yielding a variety of products including clear timber and the minimum tending regime will yield the type of log so keenly sought by the Japanese since 1964 as well as small roundwood sawlogs in proportions that are readily manipulated. At one extreme felling early for pulpwood only is possible.

The desirability of diverse market outlets for any large forest has been amply displayed during the period under discussion by the major fluctuations in demand for export sawlogs and pulp logs, domestic sawn timber and export pulp. As long as troughs and peaks of demand for each product do not coincide absolutely, diversity gives some buffer to the inevitable market cycles and hence some stability to the logging and transport industry.

During the period a series of profitability studies on alternative regimes for radiata pine on a range of sites was published by the forest economics group at the Forest Research Institute (Fenton, *et al.,* 1972). These demonstrated that if a forest were grown for the log export trade under existing costs and returns the better sites would be more profitable by most commonly used ranking indices. They also demonstrated the importance of location, the relative importance of forest and utilisation costs, and the sensitivity of profit expectations to yields and to realisations. Similar studies of sawlog regimes with and without production thinnings indicated that under existing costs and returns the former would prove less profitable than the latter which would be comparable with log export regimes in profitability as measured by LEV and IRR. It was concluded that pulpwood commitments could be met more cheaply by growing a combination of specific pulp crops and non-production thinning sawlog regimes than by sawlog regimes with extraction thinning.

Some progress was made in applying the conclusions of these nominative afforestation models to models of existing forest situations but, as in planning generally, progress was not spectacular.

Future Objectives

Future objectives in thinning and in silvicultural schedules generally will obviously

depend on the general objectives of New Zealand forestry. The dominant influence will be the rapidly increasing volumes available as the plantings of the early 1960s, and later, reach maturity. Planning at both the national and the regional level must be concerned with the timing and nature of major new developments which the expanded resource will allow as well as maintenance of existing industry. Much of the new development will be export oriented and continuing market research is thus an obvious requirement of such planning.

Production forest planning, like planning generally, is a process of continuous revision in the following steps:

1. Definition of objectives.
2. Identification and analysis of internal and external constraints and opportunities.
3. Identification and analysis of alternative strategies which these constraints and opportunities permit.
4. Selection and implementation of the alternatives most likely to accomplish the objectives.
5. Continued feedback to reassess 1 to 4.

Ideally each of these steps should be followed at the national, regional and forest level with the conclusions at one level helping to define the objectives of that below.

To date national objectives have not been defined in other than the most general terms, i.e. annual new planting targets, establishment of a surplus for export; and the range of alternatives examined at national, regional and forest level has probably been unduly restricted. The reasons are to be found in the very large amount of detailed work that such planning requires.

Planning at the various levels is a two-way process and it is virtually impossible to effectively link national and regional planning while the latter is fragmentary as at present.

Some of the present difficulties encountered in planning may be seen by examining the forest as the most basic unit. The constraints and opportunities facing the forester at this level were discussed at the beginning of this paper and it was suggested that planning should seek to achieve a practical and efficient transition from the forest as it exists to that conceived as ideal to meet future opportunities and commitments. With the rather laborious methods available for developing planting/tending/cutting strategies in the past there has been an understandable tendency to curtail the number of options considered and in fact many cutting plans, prepared as a basis for sales, have been merely the volumetric expression of quite circumscribed courses of action, i.e. alternatives have not been effectively tested. This is also due in part to lack of mensurational and other data for regimes not conforming to current standard practices. The use of the computer while allowing increasing simulation of alternatives demands much better basic data if the real differences between them are to show up. For example it is unlikely that either absolute maximum volume production or attainment of maximum diameter of crop stems would stand up as practical objectives, but the choice of a thinning regime giving a satisfactory trade-off between volume and size requires *inter alia,* much better mensurational data than hitherto used to show up the rather gross differences between widely differing schedules. Simulations ideally require growth models applicable to the forest or region and able to provide good estimates of expected out-turn

volumes by tree and log size assortments for the various "strata" which result from the interaction of site and past silviculture or lack of it. Such growth models are only beginning to be developed. Given sound projections of alternatives in quantitative and qualitative terms it is possible to make broad predictions of costs of production and with less certainty of revenues. With a great deal of effort the alternatives may thus be analysed and that which best meets the objectives may be selected. I would expect future thinning practice to be guided increasingly by such analysis but its usefulness will depend on precision in the input and the clear definition of objectives at the regional and national level.

The major difficulty likely to be encountered in such definition is that within most regions in the future there will be three interrelated sources of wood—from the State, the small private owner and the large company. The objectives of the three are not identical. That of the small private grower is presumably to obtain the greatest return on his investment, in the form of stumpage. For company forests the objectives will conform with the wider processing, marketing and profit aims of the company. The economic objectives of the State in growing forests lie somewhere between. Stumpages are, for example, only one of the criteria taken into account in making major sales, others being full employment of otherwise idle resources, environmental effects, stimulation of related industries, added demands on Government-financed services, flexibility in meeting market change, development of new export markets, net earnings or savings of foreign exchange, financial soundness and profitability.

Despite these differing objectives Government is in a position to greatly influence the timing and nature of new developments, and hence regional and national forestry objectives because State forests form a high proportion of the plantation area in most regions.

In summary, future silvicultural schedules should be related to the broad marketing strategy for exotic forests as determined by linked regional and national development plans. These indicative all-sector plans should examine the widest range of alternatives in terms of the timing and nature of new developments. The results should guide the prescriptive regional planning of the State resource, sales from which will have a major influence on the New Zealand forest industry of the future.

REFERENCES

FENTON, R. and SUTTON, W. R. J. 1968: Silvicultural proposals for radiata pine on high quality sites. **N.Z. J. For. 13(2):** 220-8.

FENTON, R. **et al. 1972:** Special Economics Issues (collected papers). **N.Z. J. For. Sci. 2(1);** and **2(3).**

NEW ZEALAND FOREST SERVICE, 1963: Pruning and thinning practice in New Zealand. **For. Res. Inst., Symposium 3** (unpubl.).

NEW ZEALAND FOREST SERVICE 1970: Pruning and thinning practice. **For. Res. Inst., Symposium 12: Vol. 1, Proceedings; Vol. 2, Papers** (unpubl.).

NEW ZEALAND FOREST SERVICE: Working Plans and Working Plan Reports (unpubl.).