

GROWING RADIATA PINE FOR POLES

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ABSTRACT

The mainstay of New Zealand's supply of softwood poles is disappearing with the utilisation of existing stands of Corsican pine. Attention is now being focused on alternative sources to satisfy the pole market — particularly the market for stress-rated poles such as building poles.

Using stand assessments and simulation, a specialised pole regime is developed for radiata pine on low quality sites. This regime involves two waste thinnings, the second to a final stocking of 1000 stems/ha at top height 13 to 14 m. Clearfelling at about top height 30 m is proposed.

Preliminary economic analysis reveals growing costs for the pole regime of about \$15 to \$20/m³. As this is an average growing cost for all wood in the stand, the pole element will generally have to earn considerably in excess of it for the pole regime to be profitable for the grower. The risks associated with the proposed regime are identified.

INTRODUCTION

Corsican pine, Douglas fir, and European larch have been important for the production of softwood poles in New Zealand over the last 40 years, with Corsican pine having become the predominant pole-producing species. However, the bulk of this supply of poles is disappearing with the utilisation of existing stands of Corsican pine. The poor growth performance of this species relative to radiata pine and its susceptibility to the needle-cast fungus *Dothistroma pini* have essentially eliminated it from the planting programme in New Zealand. Any attempt to reproduce the existing Corsican pine resource faces severe biological and economic problems.

Attention must be focused on suitable alternative species to satisfy the future demand for poles and posts. Radiata pine, which dominates New Zealand plantation forestry and which has proven so versatile in many uses, is an obvious candidate. This paper attempts to develop a suitable regime for the production of poles using radiata pine.

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Round produce (*i.e.*, poles and posts) includes a wide spectrum of products differing in size and quality. Greatest demand, in terms of both numbers and volume, is for relatively small agricultural and horticultural posts. However, it is the stress-rated products (*e.g.*, overhead line poles, building poles and piles, shelter-fence poles) that pose the grower most problems because they must be produced to meet a more restrictive set of specifications. This paper therefore concentrates on the production of stress-rated poles.

Diameter requirements generally depend on stress and applied load so a wide range of sizes is required to cover the range of end uses. At present, demand is greatest for poles with a butt diameter of 15 to 30 cm and a length of 6 to 9 m, and piles with a small end diameter of 14 to 16 cm and a length of 0.6 to 3.6 m.

SPECIFICATIONS

Published specifications exist for building poles (see SANZ, 1977) and a preliminary draft has been prepared for overhead line poles. These documents outline requirements for aspects of log quality such as straightness, nodal swelling, knot size, taper, and maturity. The maturity requirement is expressed as the number of rings at either the butt or small end of the log. For example, building poles with a small end diameter greater than 175 mm must have a minimum of 15 growth rings at the small end. For line poles, when not produced from a special-purpose pole stand, the draft calls for trees at least 25 years old and a minimum of 22 annual growth rings at the butt end to justify present stress ratings of radiata pine.

The mechanical properties of poles (*e.g.*, strength and stiffness) are closely related to the density of wood in the outer 20% of the radius (Hellowell, 1965). In addition, wood density increases with increasing ring number from the pith (see Cown and McConchie, 1982). Maturity specifications take these factors into account and are aimed at ensuring that the outer-wood is relatively dense for the region in which the produce is grown.

Knots are an important defect. In building poles over 3 m long, all knots are required to be less than 1/15 of the circumference and the sum of the diameters of all knots in any 300 mm length cannot exceed 1/4 of the circumference (SANZ, 1977). These requirements have not generally been a problem with

Corsican pine and suppressed radiata pine but could be severe constraints on faster grown produce.

When the regional variation in inherent wood qualities is considered (*e.g.*, Cown and McConchie, 1982) the existing maturity specifications can be considered discriminatory against regions in which high density wood is grown. Separate stress ratings were established for "mature" radiata pine poles for four regions on the basis of outer-wood density (Walford and Hellowell, 1972). However, in the subsequent development of the Code of Practice for Timber Design (SANZ, 1981) and the associated pole specifications (SANZ, 1977) a single intermediate rating is used for the whole country. This may be reversed in the near future. It is possible that a set of strength/size classes will be developed which would give, for species/density region/age class combinations, the diameter required for a given pole length to meet different strength class requirements (C. R. Hellowell, pers. comm.). Such a development would shift pole specifications from the present descriptive basis to a performance basis similar to that currently used in the U.S.A. (Walford, 1982).

In addition, scope exists for the stress grading of poles into strength classes using an instrument such as the Pilodyn penetrometer to estimate outer-wood density directly rather than using number of rings as an indirect measure (Cown and Hutchison, in prep.).

DEMAND

The desirability of a specialised pole regime depends on the projected demand for poles. Supplies of radiata pine poles are potentially available, at least in the short term, from such sources as untended or conservatively treated new-crop stands. However, questions must be asked about how enduring this type of supply will be in view of the trend, in many forests, toward thinning to low final stockings at early ages.

The current framing-type regime practised on low quality and steep sites at Kaingaroa Forest is an example of this trend with stands being thinned to 600 stems/ha at top height 6 m. This early thinning means that relatively little branch control will be achieved while trees grow faster than is desirable for pole production. Consequently there must be some doubt about the quantities of poles that will be available in the future, even from this type of regime which has a higher final stocking than most regimes currently being implemented in New Zealand.

Despite the advent of early heavy thinning regimes, forest management practice in New Zealand is far from homogeneous (see Williams, 1982). Thus, some supplies of poles will be available in the future, as at present, from stands that have been kept at relatively high stockings either by design or by default.

At the 1982 Roundwood Workshop* the current annual usage for building, line, wharf, and export was estimated to be 145 000 poles with a volume of 31 000 m³. In addition, annual usage of short poles was estimated to be 100 000 units, with a volume of 3000 m³.

Future demand was estimated to be fairly static for most types of poles apart from building poles and piles for which an increasing demand was forecast. A scenario was outlined (J. C. F. Walker, pers. comm.) which estimated the annual demand for residential, agricultural, and commercial buildings to be about 170 000 poles and 240 000 piles by 1985.

Some doubt exists about the export opportunities for poles. The lack of suitable shipping and high transportation costs are problems that will have to be overcome if New Zealand is to export poles outside the Pacific Island markets currently supplied (I. J. Bourke and P. H. B. Aldwell, in prep.).

With the Post Office increasingly using radio circuits and underground cable, the demand for telephone poles will reduce from 15-20 000 to about 9000 poles per year by 1985 (R. McIntosh, pers. comm.). The market for power poles could increase from the present 10 000 per year if poles of suitable quality are available at competitive prices and the product is promoted to potential users (K. D. McLeod, pers. comm.).

The current usage of artificial-shelter poles was estimated to be 5000 m³ per year (M. Robinson, pers. comm.). There has been a continuing demand for this type of pole.

If future pole requirements cannot be satisfied from various other existing or future regimes, either because pole material is not produced within these regimes or because the price or quantities available do not warrant its segregation, a special-purpose pole regime may be appropriate. The economic advantages of using specialised regimes to produce a specific end product have been discussed by Grant (1976).

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SPECIAL-PURPOSE POLE REGIME

The fundamental problem in pole production from radiata pine is checking tree growth sufficiently so that when a tree is old enough to meet a designer's pole strength and stiffness requirements it is still small enough to be economic to process and aesthetic to market. Size has an important impact on processing costs, affecting such things as unit raw material cost, handling and transportation costs, and the amount of preservative used per pole.

Consequently, tree growth must be controlled by site and silviculture. Potential pole-producing stands in forests in Rotorua and Auckland Conservancies were assessed to help determine the site and silviculture necessary for pole production.

Site

Earlier work (S. S. Calderon and G. R. Watt, pers. comm.) showed the general unsuitability of stands grown on high site index land in the Bay of Plenty for producing poles. The superiority of phosphate-deficient Auckland clay sites was also noted. Assessments carried out in the course of the present study indicate that poles can be produced in stands with low site index, at least in Rotorua and Auckland Conservancies.

Recent work by Cown and McConchie (1982), describing the regional variation in basic wood density of radiata pine throughout New Zealand, is relevant to the growing of poles. Auckland, coastal Nelson, and coastal Rotorua conservancies are regions where high density wood is grown. This fact, together with the relatively slow growth rates of trees in two of these regions, identifies Auckland and coastal Nelson as areas especially suited to high quality pole production.

Forests in the vicinity of Auckland have a considerable advantage in terms of their proximity to a large, diversified pole market and also to a port.

Silviculture

Growing radiata pine for poles involves a compromise between maintaining very high stockings to suppress individual tree growth and control branch development on the one hand, while avoiding the onset of serious competitive mortality on the other.

To illustrate the effect of final crop stocking, simulations of a stand with site index 27 planted at 2000 stems/ha and thinned at top height 15 m to stockings of 600, 800, 1000, 1200, and 1400 stems/ha were carried out using the Kaingaroa growth

model (Elliott and Goulding, 1976). Figure 1 shows the diameter distributions for each stocking at the age when mean tree diameter at breast height (d.b.h.) was about 27.5 cm. These were derived using PROD (Goulding and Shirley, 1979). Note how this age varies, with the stand at 600 stems/ha attaining this mean d.b.h. at age 20 years while the 1400 stems/ha stand takes until age 24 years. This indicates one of the problems associated with framing-type regimes as far as pole-production is concerned. The stand with 600 stems/ha has trees growing so fast that by the time they are mature enough for poles most are undesirably large — the size-for-age problem.

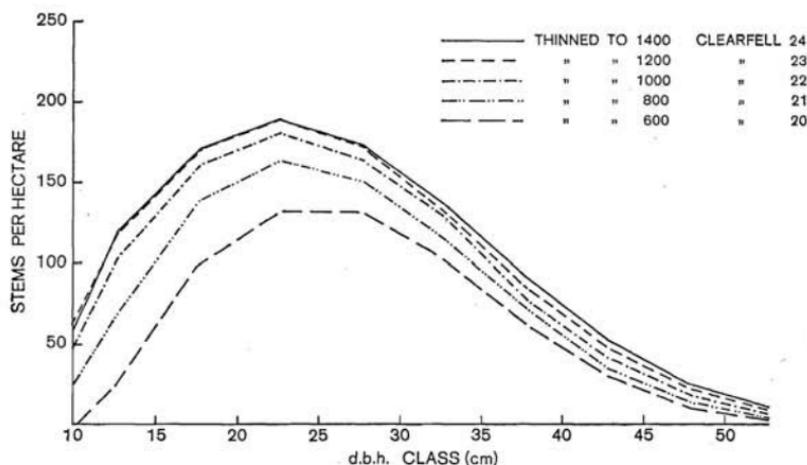


FIG. 1: Stand table for a pole regime — Kaingaroa Forest SI 27 m.

Figure 1 also reveals the effect of mortality. Note how similar the stand tables are for 1000, 1200, and 1400 stems/ha. Although the latter two simulated stands are more mature and may have slightly better branch control they are both suffering serious mortality.

A regime with a final crop stocking of 1400 to 1500 stems/ha was previously proposed (S. S. Calderon and G. R. Watt, pers. comm.). It is now considered that this stocking is higher than required and that considerable competitive mortality would occur. On the other hand, stands assessed in the course of this study with a stocking in the range 480 to 700 stems/ha had insufficient stocking to inhibit both tree and branch growth. A final stocking of about 1000 stems/ha represents a suitable compromise.

Proposed pole regime

For land with site index less than about 27 m the following regime is proposed.

<i>Top Height (m)</i>	
—	Plant 2500 stems/ha (2.0 × 2.0 m)
5-6	Waste thin to 1700 stems/ha
13-14	Waste thin to 1000 stems/ha
30	Clearfell

This regime is not presented as an absolute rule. Rather it is intended as an indication of how radiata pine can be managed to produce poles. The appropriate regime for a stand depends on both the region and the end product desired. Greater scope exists in high density wood regions in choosing a regime for the production of poles.

Note that 1700 stems/ha are held until top height 13 m to achieve branch control. The two thinnings are designed to create a uniform stand. Both thinnings have the removal of malformed trees as their principal goal, but conditional on this they should be thinnings from above (*i.e.*, removal of largest trees).

The second thinning was not considered viable as a production thinning because of the small tree size and the relatively small volume of material (about 30 m³/ha) available. In addition, the high residual stocking virtually precludes a commercial operation.

Economics

An example of the costs of production associated with the proposed pole regime are in Table 1. This particular analysis

TABLE 1: GROWING COSTS FOR POLE REGIME

<i>Year</i>	<i>Operation</i>	<i>Cost (\$/ha)</i>	<i>Cost compounded at 10% to year 22 (\$/ha)</i>
0	Land preparation	130	1058.24
0	Plant	240	1953.67
1	Release	80	592.02
5	<i>Dothistroma</i> control	30	151.63
6	Thin to 1700 stems/ha	60	275.70
10	<i>Dothistroma</i> control	30	94.15
11	Thin to 1000 stems/ha	90	256.78
1-22	Annual costs (including land rent)	30	2142.08
	Total compounded growing cost		6524.27
	Total volume = 509 m ³ /ha		
	Recoverable volume = 432.6 m ³ /ha (85% recovery)		
	Growing cost = \$15.08/m ³		

assumes land of site index 27 m on the Volcanic Plateau and a rotation of 22 years. A real discount rate of 10% is used.

Annual costs make a substantial contribution to total growing costs. They include an annual land rental of 6% of the land value. A \$10 change in annual costs changes average growing costs by \$1.65/m³.

The predicted stand table for the regime is given in Table 2. Note that 508 of the surviving 891 stems/ha at age 22 years have d.b.h. in the range 15 to 30 cm and 731 stems have d.b.h. less than 35 cm. This is desirable for marketing.

TABLE 2: STAND TABLE FOR PROPOSED REGIME AT AGE 22 YEARS ON VOLCANIC PLATEAU SITE INDEX 27 m

<i>d.b.h. (cm)</i>	<i>Stems/ha</i>
10-15	93
15-20	158
20-25	182
25-30	168
30-35	130
35-40	84
40-45	45
45-50	20
50-55	8
55-60	2
> 60	1

Average growing cost is estimated to be \$15.08 per recoverable cubic metre. Similar analyses for rotation lengths of 22 to 25 years on the Volcanic Plateau and on an Auckland sand site indicated growing costs in the range of \$15 to \$20/m³. These average growing costs are still considerably lower than those that might be expected for a regime involving more intensive management. In considering these average growing costs it must be remembered that a range of products will come out of any pole regime stand and that not all the wood harvested in a stand will be pole material. It is difficult to estimate accurately the likely content of poles produced in the proposed regime as this depends on the sizes (diameter and length) required. However, at least 500 poles/ha should be produced with about 40 to 50% of the recoverable volume being pole material. The balance of the outturn will largely be suitable for posts or smallwood. In many instances the pole element will have to earn well in excess of the average growing cost for the pole regime to be profitable to the grower. Current returns for poles vary widely throughout

New Zealand between about \$8/m³ stumpage for some Corsican pine stands and about \$40/m³ stumpage equivalent for some log sales of segregated poles.

Pruning

Pruning is a means of controlling branch and nodal swelling defects. Low pruning in particular controls these defects in the groundline or critical zone provided poles are cut from the butt. Pruning in the proposed regime would improve pole quality and visual appearance but as branch control is already achieved by high stockings it is unlikely to provide many additional poles.

For the proposed regime 100% low pruning would cost about \$500/ha, adding \$5.31/m³ to growing costs. A selective pruning of 1000 stems/ha would cost about \$300/ha and add \$3.19/m³ to growing costs.

For a pole regime one-lift pruning might be considered more appropriate than the conventional three-lift approach because overall it will cost less but yet might sufficiently control branch and nodal swelling defects for pole, as opposed to sawlog, production. Such an operation would probably cost between \$800 and \$1000 per hectare and add between \$5.80 and \$7.25 per cubic metre to growing costs. (A. R. Koehler, pers. comm.). This compares with \$9.75/m³ for three-lift pruning to 6 m with selective low pruning and \$11.87/m³ for three-lift pruning with 100% low pruning.

Pruning is an expensive way of improving tree quality for pole production, since the increase in average growing costs will have to be borne by the pole element of the stand. The fact that many poles are over 6 m long is another consideration in assessing the desirability of pruning.

It has been suggested (C. R. Hellawell, pers. comm.) that, by using growing stock of high wood density, and pruning for grade and appearance to trade-off against immaturity, it may be possible to produce poles more quickly and in regimes with lower final crop stockings than 1000 stems/ha. More work is required by the timber engineers to quantify possible trade-offs but regimes would still have relatively high final stockings and therefore be dedicated to the production of poles.

Tree Improvement

The establishment of a special tree-breeding programme with emphasis placed on density, as well as stem straightness and branching habit, would help ensure that pole stands had relatively high wood density for the region in which they were grown.

Harris and Wilcox (1976) suggested using rooted cuttings as planting stock for pole stands because trees grown in this way have small butt swelling, slight stem taper, and more controllable branch diameter than trees grown from seedlings. However, it was found (Wilcox *et al.*, 1976) that trees grown from cuttings had lower wood density than their ortets which had been grown from seed. This indicates the necessity of using cuttings of high density parent stock for pole production. Trials have been established by FRI since 1979 to compare cuttings with seedlings for pole production.

Risk

The management of radiata pine for poles involves risk. Stands must be thinned to their final stocking late enough to achieve branch control but early enough to prevent severe mortality from competition and windthrow. The timing of this thinning is therefore important.

The regime developed is very specific to the production of poles. Should the market for poles not be present, then the stand will be suitable mainly for posts or pulp. The proposed regime has some flexibility in the timing of clearfelling in that trees are growing slowly enough to remain suitably sized for pole production without suffering undue mortality around this time.

CONCLUSIONS

1. Moderate supplies of poles are available from radiata pine stands not specifically established for pole production. However, because of restrictive pole specifications and the trend in New Zealand silvicultural practice towards heavy early thinning, this supply will probably diminish.

A detailed assessment of regional resources and projected pole demand is required to describe the future status of the pole market in terms of quality, quantity, and locality. Such information would indicate to the grower the need for, and desirability of, implementing a special-purpose pole regime.

2. The fast growth of radiata pine presents a problem for the production of poles. A special-purpose pole regime with a final crop stocking of about 1000 stems/ha on low quality sites is advocated to slow sufficiently the growth of individual trees without causing excess stand mortality.

3. Phosphate-deficient clay and nitrogen-deficient sand sites in Auckland Conservancy have inherent advantages for pole production. In particular, radiata pine growth on these sites is relatively slow and trees have a high wood density. Coastal Nelson sites have the same advantages.
4. Economic analysis, using a real discount rate of 10%, suggests a growing cost of about \$15 to \$20/m³ for wood produced using the proposed pole regime. Because only a proportion of recoverable volume will be suitable for poles, a return considerably greater than this average growing cost will probably be required for the pole component of a stand if the regime is to be profitable to the grower.
5. Pruning is an expensive means of improving tree quality for pole production.
6. Implementing a pole regime involves risk because of the specialised end-product.
7. The maturity (number of growth rings) requirement in current pole specifications presents a particular obstacle to pole production using radiata pine and this needs attention. The development of strength/size classes based on density regions and age classes, and the stress grading of poles could help rationalise the existing situation and should particularly assist growers in areas where relatively high density wood is grown.

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