SILVICULTURE AND MANAGEMENT OF *PINUS RADIATA* FOR FRAMING TIMBER PRODUCTION

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ABSTRACT

The major requirements for framing timber are restriction of knot diameter to under 1.33in., straight grain, minimal distortion, and lengths of 16ft to 18ft. Silvilculture to ensure these requirements over two 18ft log lengths, if logs are not pruned, needs close (8ft × 5ft or 6ft × 6ft) initial spacing to be maintained until stand height is at least 60ft. Current framing production is from stands grown without thinning, but No. 1 Framing grade out-turn rarely exceeds 40%. On site indices of 95ft, about 850 bd ft of No. 1 Framing grade can be produced per acre per year from either a "framing regime" of 8ft × 5ft spacing, thinning to 150 s.p.a. at 60ft, and clear-felling at 19in. d.b.h., age 34yr; or from finger-jointing clearwood from a board regime. As with Douglas fir, the suppressed growth rate of the "framing regime", that accompanies restriction of branch size reduces final log size, with concomitant increases in logging and sawing costs. A rational solution would be to concentrate framing timber production on sites where branch size is naturally limited. The best framing grade potential appears to be in Northland.

The apparent reluctance of industry to season framing is considered to account for the negligible volume (200,000 bd ft) exported annually. Present supplies of framing timber from the 500,000 acres plus of first rotation stands of all species are abundant.

The future cost of production and proportion of framing timber required remain to be evaluated. Different methods of building construction may be a more favourable alternative for second rotation plantation utilisation.

INTRODUCTION

The abundance of timber supplies available from the earliest days of settlement in New Zealand has led to a general use of softwood-framed construction in domestic buildings. Ability of timber framing to withstand earthquakes has helped sustain its use. The transition from heart kauri, through the podocarp species, to exotic softwoods has followed in framing, as in finishing, uses. Minor quantities of predominantly North American softwoods have been used for special purposes, but for general uses, ample supplies of locally grown softwoods have been available. General acceptance of radiata pine (*Pinus radiata* D. Don) followed its grading on national standards (NZ Standards Institute, 1970), and its preservative treatment, largely against house borer *(Anobium punctatum* L.). The grading is enforced only by the interplay of competition, but the

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less essential preservative treatment is efficiently policed centrally by the statutorily empowered Timber Preservation Authority. Use of radiata pine framing has increased rapidly since the 1950s but, in contrast to finishing quality timber, there have been adequate supplies available from the first rotation stands of untended plantations. Imports are of little significance. An earlier estimate of the proportion of "Building Timber" required was 47% (Williams and Yska, 1963), the same as current consumption; this figure may be amended in future forecasts.

The specifications for framing timber are given below, followed by data on past grade results. The silvicultural alternatives for production of good framing grades are then discussed with relation to locality; economic considerations are not evaluated in detail in this paper.

SPECIFICATIONS FOR FRAMING TIMBER

Framing timber is largely used in New Zealand in an unseasoned condition, partly because of the easier manual nailing of the softer green wood. The subsequent distortion during seasoning *in situ,* is reduced by built-in restraints in the frame. There is no large domestic demand for seasoned framing, and little desire apparent by industry to generate one.

The piece size required most frequently is a nominal 4in. × 2in. cross section, which comprises about three-quarters of the demand. Length specification is important; most houses have an 8ft stud, and 8ft and 16ft lengths (plus an allowance for tolerance in manufacture) are required wherever possible. For some larger cross sections (5in. × 2in., 6in × 2in. and 8in. × 2in.), which are used as joists (beams), the lengths are equally important as spans of less than 10ft are little used.

The grading rules have been devised on the basis that 4 × 2s are components of a composite structure, *viz.* a timber wall which is cross braced by three lines of horizontal noggings; pith is allowed in 4 × 2s if little is on the nailing (2in.) surface. The question of density is thus allowed for to some extent. The low density wood associated with pith is allowed in pieces which form components of a wall, but the nailing face provision generally excludes the quarter-sawn pieces which would have the most pronounced density gradient (as would the severe provisions limiting crook). Pith is not allowed in the light beam sizes of 5in. × 2in., 6in. × 2in. and 4in. × 3in. cross section, though such pieces may be cut very close to the pith itself.

The major considerations in visual grading of domestic framing timber for No. 1 Framing grade (1F hereafter) are that: not more than one-third of the cross section in pieces up to 6in. wide may be occupied by defects; maximum sloping grain is 1 in 8; cross grain is not allowed, and the straightness provision against crook is more severe than for bow or twist. Large cross sections over 12 sq in. can include larger individual defects, including pith. There are no provisions for amount of heartwood or for variations in rings per inch.

Therefore silvicultural requirements to fulfill these timber specifications are for straight logs which will minimise cross grain and produce the maximum length per piece (as well as conversion benefits), and for the restriction of knot size to a maximum of 1.33in. (viz., about a third of a 4in. × 2in. cross section). Pith is unavoidable in the tree, but the relative proportion and even the absolute volume of the low density core is controllable by influencing log size and possibly knotty core size. Spiral grain is difficult to detect in standing trees but bark patterns give some indication of excessive spirality.

The advent of stress grading machines will enable more accurate quantitative grading to be done. Visual grading is naturally more accurate for boards which are graded on appearance, than for framing, where cross-sectional defects and allowances for grain deviation have to be estimated. Density considerations are largely excluded from the visual grading rules but are tested in stress grading. The general omission of stress grading in commercial production contrasts with its partial adoption in New South Wales and elsewhere. As grade studies can have appreciable long-term effects on management, it is desirable that visual results in research studies be checked by a stress grading machine.

PAST FRAMING GRADE RESULTS

First Rotation Stands

New Zealand exotic forestry is conveniently divided into "first rotation" or old crop stands planted prior to 1939, which consist largely of the untended areas of the planting boom of the 1920s, and the post-war, largely post-1950 stands, where some tending has been done. Present supplies of framing are almost exclusively from "first rotation" stands in all regions; crops were generally planted at spacings up to 8ft × 8ft, left untended; some areas were attacked by *Sirex* in 1946-56, which reduced stockings to 70-150 stems per acre (s.p.a.), and are now almost all over 35 years old. Framing grade out-turns from the large mills cutting this first rotation material are given in Table 1, and grade study results from young (up to age 20yr) second rotation stands

TABLE 1—Grade out-turns from major mills cutting first rotation crops

Location	Type of mill	Grades — % Out-turn				
		Box	Merch.	Dressing Factory	Framing	
					1F	2F
		1in. & 2in.	1in.	1in.	2in.	2in.
Bay of Plenty	Integrated	51	4	7	30	8
,,	,,	25	12	15	34	14
,,	,,	39	32	14	19	5
,,	Non-integrated	49	7	7	27	9
Canterbury	,,	16	31	5	39	9
Southland	,,	20	34	14	28	4

in Table 2. Grade study results of second log out-turns of old first rotation stands are given in Table 3. Generally about a third of the out-turn is now of 1F. Spacing appears critical, and 6ft × 6ft stands unthinned until 70ft can yield 55% of the timber of the second-log-height class as 1F grade.

Second Rotation Stands

The merchantability of production thinnings is a major preoccupation of local management; two grade-study results based on thinnings of material 15yr-20yr old

TABLE 2—Grade out-turns from second rotation thinnings

Forest	Spacing	Thinning		Grades — % Out-turn					
					1in.		2in Framing		
	ft	to s.p.a.	at ft	Box	Merch.	Dressing Factory	IF	2F	Box
Ngaumu*	8 × 5	500	40	—	6	8	37	16	33†
Patunamu‡	6 × 6	170	60	1	7	7	35	15	35
Ashley‡	8 × 8	—	—	3	8	7	14	20	48

* W. R. J. Sutton pers comm. † 1in. and 2in. Box. ‡ J. R. Tustin pers. comm.

are given in Table 2. These thinnings were extracted from stands at 6ft × 6ft and 8ft × 5ft initial spacing, reduced to 170 and to 500 s.p.a. at 60ft and 40ft by previous thinning to waste, *viz.* the poorest two-thirds of the crop being already removed. Although many of the extracted stems had been pruned, the small stem diameters allied to generally late pruning have resulted in negligible upgrade. The grade results in Table 2 have to be balanced against small piece size and concomitantly high logging and sawing costs. Framing out-turns from clear-felling dominant 20-yr-old trees from 8ft × 8ft spacing are also shown in Table 2; results are poor, with less than 20% 1F produced.

SILVICULTURAL ALTERNATIVES FOR PRODUCTION OF GOOD FRAMING GRADES

The basic question in framing production is how fast can logs be grown, while maintaining a reasonable grade out-turn? Because 20% to 30% of the sawn out-turn from the log sizes produced in plantations is unavoidably of 1in.-thick timber, a total 1F out-turn of 50% (*viz.* 30%-40% of the total volume) has been taken as a "good" out-turn. However, this proportion is arbitrary.

Four major alternatives exist—the first is an unpruned regime of the traditional type, with silviculture parallel to that for Douglas fir (*Pseudotsuga menziesii* (Mirb.) Franco) (Fenton, 1967a). The second approach is to aim at versatility of end products (boards + framing) within the one regime. A third alternative is the board regime (Fenton and Sutton, 1968) with remanufacturing for framing. A fourth solution is to repeat the first rotation. These four alternatives are discussed below, and more remote methods enumerated.

A SPECIFIC "FRAMING REGIME"

Initial and subsequent stocking must be sufficiently dense to suppress branch diameter development and preferably to kill the branches early. As volumes and values are concentrated in sharply decreasing order up the tree, control of characteristics in the butt and second logs is more important than in higher logs (Fenton and Sutton, 1968).

Results from sawing trials indicate that the critical initial spacing, for the pumice and east-coast North Island areas at least, is not wider than 6ft × 6ft. Two-inch sawing results of second logs of three old Kaingaroa stands (either not or belatedly thinned) are given in Table 3. The increase in spacing from 6ft × 6ft to 8ft × 8ft has apparently been sufficient to reduce the 1F yield by about 55% to 60%. The more acceptable rectangular spacing (Fenton and Sutton, 1968) of 8ft × 5ft is expected to give similar results to the 6ft × 6ft.

TABLE 3—Grade study results for the second log height class*

Kaingaroa	Spacing	2in. Grades			Thinning	
Cpt No.	ft	Box	1F	2F	at ft	to s.p.a.
1045	6 × 6	23	57	21	75	430
1125	6 × 6	36	50	14		†
1061	8 × 8	42	23	35	None	

* Percent of only the 2in. material sawn. † Not before 80ft, stocking not known.

Comparatively little is known yet about the branch diameter response (in terms of branch diameter increase) after thinning, but results from one trial suggest that the larger branches in at least the upper 25ft of crown will respond (Sutton 1968). Another study established responses on the upper 35ft of crown (James and Tustin 1970).

Assuming only 25ft of crown will respond to release, then thinning must be delayed until about this height above the second log to ensure continued branch size restriction within the bottom two logs. For 16ft log lengths this would mean holding the stands to a height of 57ft (say 60ft to allow for stump and over-cutting) before thinning. For control over 2½- and 3-log lengths, the thinning would have to be delayed until heights of 68.5ft and 77ft respectively were reached.

Regimes for a site index (Lewis, 1954) of 95ft for a final crop of 150 s.p.a. (assuming only one thinning) and mean d.b.h. of 19.0in. have been developed by W. R. J. Sutton and given in Table 4. These assume an initial spacing of 8ft × 5ft, growth trends, excluding mortality, based on yield tables (Beekhuis, 1966) and extrapolations, where necessary, similar to those used for the short rotation sawlog regime (Appendix 1 of Fenton, Grainger, Sutton, and Tustin, 1968). The exclusion of mortality means the volumes will almost certainly be over-estimates. When the taper tables for Rotorua unthinned stands (Duff, 1954) are applied with the appropriate stem diameter distribution (Beekhuis, 1966), the log size distribution for the final crop at 137ft is as given in Table 5. (The taper tables for unthinned stands have to be used in the absence of more directly applicable data).

TABLE 4—Alternative framing regimes

For crown control over log-height classes	Thin to 150 s.p.a. at ft	Ht at clearfelling for mean tree 19in. d.b.h. ft	Total volume/acre (max.) cu ft/acre
2 log lengths	60	137*	13,000†
2½ log lengths	68.5	147	13,800†
3 log lengths	77	158	14,900†

* Age 34 (from Lewis, 1954). † Excludes mortality.

TABLE 5—Effect of silvicultural regime on log size (s.e.d.) distribution (% per acre)

	Framing Regime		Board Regime†		Douglas Fir‡
Rotation (years)	34		26		50
Logs/tree	3	5	3	5	5
Log s.e.d. (in.)					
6		4.0			18.1
7		3.8			19.0
8	0.7	9.0		20	12.4
9	4.3	10.6			8.6
10	11.3	16.6			5.0
11	9.3	9.0			9.2
12	18.0	12.2		20	7.5
13	18.3	11.4			3.6
14	14.3	8.8	33.3	20	3.6
15	11.3	6.8			4.5
16	6.0	3.6	33.3	20	4.0
17	3.7	2.2			1.7
18	1.7	1.0	33.3	20	1.2
19	0.7	0.4			0.9
20	0.3	0.2			0.3
21					0.2
21					0.2
Mean s.e.d. (in.)	13	11.5	16	14	10

* Adjusted for the same site index of 95 (Lewis, 1954).

† Fenton and Sutton, 1968; tree d.b.h. distribution data are not available for such stands and these diameters are for mean trees.

‡ Fenton, 1967b.

The effect of spacing on branch size is shown by data from spacing trials in Table 6. The interaction of branch size on framing grade results is pronounced, but the cost of good framing grown by this "framing regime" is considerable, as a high percentage of small logs are produced in a long rotation (Table 5); Douglas fir presents the same problem. The results from the Patunamu study show the grades of thinnings from this schedule (Table 2) can be indifferent.

TABLE 6—Effect of spacing and site on branch size

Forest	Spacing (square)	Site Index*	Diameter (in.) Largest Branch at (ft)							
	ft		0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40
Woodhill†	6	101	1.16	1.17	1.09	1.15	1.20	1.23	0.95	1.15
	8	101	1.23	1.55	1.35	1.35	1.18	1.25	1.03	1.25
	10	||	1.50	1.45	1.49	1.58	1.50	1.43	1.45	1.48
	12	101	1.55	2.10	1.90	1.78	1.60	1.68	1.58	1.65
Eyrewell‡	6	64	—	1.71	1.25	1.17	1.18	1.32	1.18	1.21
	8	66	—	1.52	1.16	1.38	1.32	1.42	1.34	1.23
	10	71	—	1.28	1.68	1.53	1.55	1.17	1.50	1.69
	12	67	—	1.28	1.56	1.71	1.71	1.66	1.61	1.74
Ashley§	8	75	0.91	1.33	1.51	1.50	1.37	1.47	1.63	1.72
	10	80	1.44	1.58	1.78	1.72	1.64	1.65	1.63	1.75
	12	92	1.18	1.76	1.78	1.80	1.87	1.95	1.93	2.07

* Lewis, 1954. † Sutton, 1967. ‡ Sutton, 1969. § J. R. Tustin pers. comm.

|| Not measured, probably 100.

VERSATILITY IN SAWN OUT-TURN FROM ONE REGIME

The second approach to growing framing is to attempt to gain versatility of end produce within the same regime. Recent and current Kaingaroa tending schedules aim at this, with clear wood production from the butt log, and framing production from the second and third logs (with presumably the fourth and higher logs being pulped). The schedule is shown in Table 7. Specifications for the regime on tractor country include:

TABLE 7—1969 Kaingaroa schedule*. Initial spacing, 6ft × 6ft in planted stands. 1,000-1,500 s.p.a. in naturally regenerated areas

Pruning				
	0- 8ft	300 s.p.a.	top height 20ft	
	8-14ft	150 s.p.a.	top height 30ft	
	14-20ft	150 s.p.a.	top height 40ft	
Thinning		Residual stocking	at top height	
Regenerated areas		600 s.p.a.	20ft	To attain uniformity
Both planted and regenerated areas				
On steep sites, to waste		150-220 s.p.a.	40ft	Final crop
On Tractor country, to waste		200-300 s.p.a.	40-50ft	
production		80- 90 s.p.a.	90ft	Final crop

* As at November 1969.

1. Ensuring pruning is on time — common to all board regimes.
2. Ensuring pruned trees survive — common to all board regimes; achieved here by pruning a comparatively large number of stems, and thinning to allow no tree to be within 8ft of a pruned stem.
3. A production thinning, which is the major reason for the longer rotation.

The main drawbacks are:

1. A lengthened rotation.
2. Smaller final crop trees than from the board schedule (Fenton and Sutton, 1968); mean log small end diameter (s.e.d.) is around 13in. if three log lengths are sawn.
3. Attainment of the required framing yields from the second log has yet to be demonstrated: the thinning to 200 to 300 s.p.a. (usually 220 to 240 stems) at 40ft, combined with the unavoidable green pruning, will produce somewhat larger branches than from 6ft × 6ft stands unthinned till 60ft.
4. An overall higher cost of forest production, an inevitable accompaniment of versatility.
5. Greater risks due to longer rotations and the extraction thinning necessitating a further guarantee of survival of sufficient, undamaged, pruned final-crop trees.

The Kaingaroa hill country regime avoids the production thinning, but produces still smaller final-crop trees, with reduced yields of clear wood plus some uncertain mortality as the rotation is extended.

FRAMING BY REMANUFACTURE, AND CLEAR WOOD PRODUCTION

A third method of obtaining acceptable framing is by quite different means—by direct adoption of the board regime (Fenton and Sutton, 1968), using clear framing and finger-jointing the butt and second log factory and dressing grades. The grade out-turns of this regime and of the framing regime are compared in Table 8. If anything, the 26-year rotation produces a higher yield of framing per acre per year. The material would be on average 8 years younger than from the framing regime outlined; annual ring curvature would be less because of the greater log diameters. All framing from the butt log would be 3in. to 6in. away from the pith, and at least 2in. away in the second log with some increase in density. The strength of the full-length clear framing would be increased but not its stiffness (Sunley, 1962). Length specifications would be excellent as material would be fingerjointed; the larger logs in any case would give good lengths. The final gain would be dried timber from the finger-jointed material. Finger-jointed framing would be adequate for studs (used as columns) but full-length clears may have to be used for beams. Nevertheless, the bulk of the current framing demand could be met this way.

The figures given in Table 8 are probably conservative, being based on the clear-shorts recovery of wide boards. If sawing patterns to produce 4in.-wide cants are used, clear-cuttings recovery is improved. For example, results from the untended Cpt 1061, Kaingaroa Forest (Fenton, 1967c, table 38) showed flat sawing yielded 4,273 bd ft of

TABLE 8—Relative framing grade yields

A. 26-year rotations—pruned trees*

23.4in. d.b.h., 120ft; 43 cu ft butt logs; 30+ cu ft second logs; 80 s.p.a.

Butts—43 cu. ft. × 6.6 conversion factor = 284 bd. ft. per log.

% Grade		% Clear	Finger-jointing length (mean ft)	Correction %	Bd ft/ tree	Bd ft/ acre
BUTT LOGS						
45	clear	100	—	—	127.8	10,224
23.5	factory	85.2	4.54	–5	54.0	4,320
10.7	dressing	91.9	5.02	–5	26.5	2,120
SECOND LOGS 30+ cu ft × 6.45 conversion factor = 193.5 bd ft per log						
34	factory	81.7	2.60	–6	50.0	4,040
12.7	dressing	71.0	2.29	–6½	16.3	1,304
3.5	framing				6.8	544
3.5	framing†				6.8	544
						22,552
						= 867 bd ft/acre/year

B. 34-year-rotations—unpruned trees

19.0in. d.b.h.; 137ft

Log Height class	cu ft‡	s.e.d.‡ in.	Conversion factor	% 1F	Bd ft/tree 1F	Bd ft/acre 150 stems
Butt	25.3	15	6.4	65	105.3	15,795
Second	20	14	6.3	55	69.3	10,395
Third	17.5	12	5.9	40	41.3	6,195
						32,285
Less area loss in production thinning 10% before mortality						29,147
						= 857 bd ft/acre/year

* Data from Fenton, Sutton and Tustin, 1970. † A higher proportion could be cut.
‡ From taper tables, Duff, 1954.

clears from butt logs—50% of sawn out-turn, while quarter sawing yielded 4,528 bd ft—60% of sawn out-turn—despite a lower conversion factor. The net gain is about 5% in this case.

The relative costs of production of the framing regime and the "versatile" regime need to be calculated; that of the board regime is around 10c to 11c per cu. ft. (Fenton and Tustin, 1968) on sites of 95ft index (Lewis, 1954).

OTHER METHODS

A fourth alternative is to repeat the "first rotation" crop regime by planting at up to 8ft × 8ft spacing and leaving it largely untended, though the cost of a thinning to waste to remove at least the malformed trees is not very high. Natural mortality in one form or another would reduce final stocking; given a sufficiently long rotation (of 35 years or more), enhanced log size would ensure a grade out-turn similar to that being currently obtained. This would avoid risks and investments from pruning and production thinning, at a high cost of production due to prolonged rotations, giving an undistinguished grade yield. A variation would be to plant at an initially wider spacing than 8ft × 8ft and to prune to control branch size in the 16ft to 18ft butt log.

Other, more uncertain, possibilities remain. The "framing regime" given on page 63 may be unduly conservative if branch diameters do not increase much after thinning; the reduction of final crop stem basal area increment by retaining dense stands until 60ft may be less if stocking is reduced earlier. The recovery of some acceptable framing from large diameter logs which have 2in. to 3in. diameter branches is not inconsiderable, as the individual 4 × 2s may well be cut between the branches (Fenton, 1967c). The diagrammatic representation (Fig. 6 of Fenton, 1967c) of framing grade/log size/piece position should be amplified—a certain proportion of framing cut from close to the pith is of good visual grade, as knot sizes have not attained those of the branch maxima. For example, the fourth and fifth logs of the Cpt 28 Waiotapu study (Fenton, *et al.*, 1970) had branches between 2in. and 3in. in diameter, yet 1F recovery on visual grading totalled 40% of the limited 2in. material cut, as the knots in the timber sawn were formed by the early years of the branches' growth. There is some doubt about the value of visual grading of such material on account of the subsequent rejection of a fifth of the 1F grade of the Patunamu study when stress graded (J. R. Tustin pers. comm.). As only a small sample has been stress graded, it is uncertain if this result is a reliable indication of the quality of this class of material.

Further alternatives are to induce branch death other than by pruning or stocking control. A level of 30% or more of *Dothistroma* infection may be an acceptable method of branch diameter control as infection spreads upwards through the crown. The use of methods of biological control in silviculture is not widespread, because of difficulties of control. It is at least arguable whether the low thinning so beneficially imposed by *Sirex* has been any less erratic than more deliberate production-thinning operations (Fenton *et. al.*, 1965). *Dothistroma* control is positive with current spraying techniques and a designated level of infection could be tolerated. The relative loss of final crop increment obtained by controlling branch growth by dense stocking as against

Dothistroma branch control would then have to be quantified. There are other more remote possibilities which should be mentioned, if only for rebuttal. These include the hormone spraying of lower crowns of accessible stands, but the degree of vertical spray control probably rules this out. Semi-abandoned stands in dense gorse or scrub where individual trees have emerged may yield good framing up to 10ft to 25ft up the tree depending on the vigour of the surrounding vegetation; this method of branch control is not advocated. Too little is known of fire behaviour to consider ground fires in New Zealand plantations at present.

LOCATION OF FRAMING GRADE STANDS

One New Zealand solution to domestic production of framing is to concentrate on areas where branch size is naturally small. With a few exceptions due to peculiarities of the Auckland and Northland soils, this generally means on sites of lower growth potential, Site Index 80 or less (Lewis, 1954). The natural converse is to concentrate board production and pruning on high quality sites for the dual reasons of concentration of clearwood increment and the innate difficulty of restraining branch diameter on such areas.

There are appreciable areas which, because of low site quality or of other restraints, are less suitable for clearwood production. The Canterbury plains have low site indices of around 60ft, together with relatively higher fire hazards and with a wind risk which virtually sets a physical rotation of about 90ft (just over 30 years). The flat topography, lack of weeds, proximity to markets, and good tree form allow a case for afforestation. A spacing trial at Eyrewell shows that 6ft × 6ft and 8ft × 8ft spacings result in very small trees by age 20; 16ft and 20ft spacings result in branches which are too big for production of good framing; and the best possibilities here may be 10ft or 12ft spacing. Branch diameter control by stocking can only be afforded for about three 8ft stud lengths, say 25ft, and thinning (usually to waste) would necessarily have to be early if stands are to be wind stable. Silviculture on the Canterbury plains has clear-cut constraints, as thinning must be done early and physical rotations are set by wind. Stand marginal trees, whose branches exceed the desirable size, should be pruned, a prescription which should apply almost universally in New Zealand.

The other major areas in Canterbury are in the foothills where the site indices are between 70 and 85, typified by Ashley where the high incidence of resin pockets (Clifton, 1969) negates much pruning for clearwood production and dictates an end use of framing; the "framing regime" outlined here may be appropriate. Alternatively, as grade study results of 20-yr-old trees from 8ft, 10ft, and 12ft spacings of a spacing trial at Ashley yielded less than 20% 1F timber from any of these spacings (J. R. Tustin, pers. comm.), it may be necessary to prune and thin these, as in the "board" regime, to produce partly clear framing timber.

Sand dune areas in Wellington and Auckland (Waitarere, Santoft, Woodhill, and Aupouri Forests) are another classification where management is determined partly by the wind risks as, almost by definition, these areas are exposed. Long rotations are undesirable, site indices are often mediocre (70-80), and a further technical limitation of low stem cones is present. Bannister (1962) reported no difference in height of occurrence of these first stem cones between the four sites (231 trees) studied, but these studies excluded sand dune areas where observation suggests (Woodhill sand apart) that stem cones occur unusually low down. Board timber regimes are difficult to prescribe and a regime set to control branch size on $1\frac{1}{2}$-log lengths *(ca.* 25ft) is suggested as the compromise solution on these sites. Hanmer Forest in North Canterbury, though not remotely connected with sand, has comparable low stem cones and moderate site index, and could be included in this category.

The clays of Maramarua, parts of Riverhead, Tairua and the Coromandel Peninsula, Athenree, Glenbervie, and Waipoua have considerable advantages for framing production as branch diameters are reasonably small and wood density is high. Grade recoveries of both framing and boards from Maramarua (Whiteside, 1964) are outstanding. The site indices are not above 80, but the complex mosaic of the soils includes areas of higher site qualities which are identifiable and excluded from the framing management considered here. In the past, there has been no undue wind hazard on these sites. The "framing regime" given here may be conservative for these sites (wider spacings being possible) but as branch diameter measurements are not available, no firm suggestion can be made at this stage.

The use of the sites of high volume production (the Bay of Plenty pumice areas, papa sites of Te Wera and almost all the North Island east coast where site indices are between 90 and 120) for framing production from radiata pine demands a tight espacement regime. Diameter increment potential is high and provides a fundamental reason to adopt pruning. Country which is too steep for tractor extraction is not at present designated for production thinning in State Forests. Two technical possibilities for such sites appear to be the board regime outlined (Fenton and Sutton 1968) on high site quality areas of, say, 90+ or the "framing regime" given here. As half the sites now being acquired for afforestation are on this steep country, rationalisation of silviculture and management is urgent.

The comments given apply to future planned production; current supplies of framing timber are extensive. These comprise the remaining first rotation stands of radiata pine (over 300,000 acres); 80,000 acres of *P. ponderosa* of generally low quality; 60,000 acres of *P. nigra,* close planted (4ft × 4ft and 6ft × 6ft) stands, at least, will yield good framing grades on low site indices (Fenton, 1960); over 60,000 acres of Douglas fir, and the untended stands of other species. The sawmilling industry is now concentrating on cutting framing grade timber from these resources, though exports of pine framing are less than a quarter of a million bd ft annually. The decision to sustain the current proportion of the cut as framing timber in the future was not a simple extrapolation of current conditions (Williams and Yska, 1963), whereas the sawmilling industry's current attitude is partly an oversimplified reaction to the intrinsic quality of the log supplies now available. Framing timber production requires an equally careful direction of silviculture as board timber production.

COSTS OF PRODUCTION

Technical silvicultural prescriptions have been given for production of framing timber from Douglas fir (Fenton, 1967a), for which the economics of 50-year rotations have been evaluated within the limits of the management data available (Fenton, 1967b). Radiata pine framing timber production has not yet been evaluated, but obviously the cost of production is going to be increased, as in Douglas fir, by the long rotations and smaller log sizes produced. If the "board regime" (Fenton and Sutton, 1968) is used, these costs are replaced by those of finger-jointing. The lower site quality areas inappropriate for pruning and technically suitable for framing production naturally require longer rotations and incur higher costs.

DISCUSSION

The cost of producing framing timber by branch control, as against the production of clear lengths by pruning and finger-jointing has yet to be calculated. The most immediate needs are the differential sawing costs of different log diameters (as ever), the grade yields from different framing regimes and finger-jointing costs. The log sizes produced from radiata pine framing regimes or from Douglas fir are markedly smaller than those from the board regime, with a higher proportion of small logs (Table 5). The facts now required are: (a) the costs of production of radiata pine framing from the possible technical alternatives, (b) the cost of production of Douglas fir framing, and (c) the proportion of the framing timber demand that should be met with New Zealand-grown timber.

The present domestic demand for framing is in part a reflection of the primary suitability of the first rotation for this use (Fenton, 1967c), though even in Canterbury, where knot sizes are possibly smallest, the yield of 1F from 34-yr-old stands is still less than 40%. The continuing poor export record of pine framing is due, presumably, to industry's reluctance to dry it; in 1968, Douglas fir exports increased sharply to 18 million bd ft.

Future demands for framing are as uncertain as for other products. Substitutes are available—steel framed houses are being produced in Australia; reinforced concrete block construction is increasing in New Zealand. Concrete floors displace both framing and board uses.

One concept of plantations that is being formulated is of the direct manipulation of the crop to gain the required end product. The alternative approach of maintaining versatility of end products in the stand is inherently expensive; rotations are prolonged by the necessity to control branch diameter, hence value increment on pruned logs is restricted. Fundamentally, the problem is to accommodate marketing risks; silviculture aimed at specific end products has lowered costs of production but with possibly reduced chances of profit if the particular end product is not required. Thus the board regime proposals (Fenton and Sutton, 1968) aim at clearwood production primarily for boards. But they can obviously produce face-quality veneer if necessary and, more indirectly, can be adapted to produce framing timber of high quality; the relative costs of producing framing from alternative regimes has still to be assessed. The "framing regime" can also produce clear boards if necessary by finger-jointing but in smaller amounts than a board regime and at substantially greater costs. Whatever decision is taken, the longer the rotation, the greater the biological, managerial, and marketing risks become.

The major questions to be answered are: how much framing timber should be produced in New Zealand and when should it be grown? The answers should depend on the relative earning power of alternatives such as Japanese log trade production and the cost and availability of imports. It is unsatisfactory that the potential Australian framing timber market remains unexploited. The 1F timber produced from the old "first rotation" stands is technically good framing, and the continued failure to build up exports on this base reduces future framing export prospects.

The technical difficulties in producing 1F are such, it is contended, that framing timber production will be relatively expensive. The cost of production of 23-year-old unpruned crops is at least 8 cents (c) per cu ft on SI 95 (Fenton and Tustin, 1968) whereas the board regime (Fenton and Sutton, 1968) costs 10.2 c/cu. ft. to produce (Fenton and Tustin, 1968). The approaches discussed here have been those required to produce by plantation practice a currently saleable product, 4in. × 2in. 1F, which has reasonable prospects of future demand (if the price is acceptable?). A radically different approach to costly production of 4in. × 2in. 1F from plantations is to find alternative building methods which can utilise the material that is more readily available from plantations. In sawn timber terms, this is Box or Merchantable grades — pine sapwood containing numerous knots of 2in.+ in diameter, with many small (0.5in. or less) holes and/or dead knots. Structural plywood is one possibility. Such possibilities are indicated here, though the innate conservatism of the trades and financial institutions concerned will be slow to change. One method of sawn timber construction whereby no framing is used, has been successfully established on the local domestic house market and exports started, and the increase of such methods of construction may amend estimates of future framing grade requirements.

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