TIMBER-GRADE STUDIES ON CORSICAN PINE IN THE TAPANUI DISTRICT AND THEIR SILVICULTURAL IMPLICATIONS

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SYNOPSIS

Logs from a random selection of final-crop 52-year-old Pinus nigra *(laricio) Arn. trees were sawn to 1 in. boards and 2 in. framing timber. Grade recovery from sawing to framing was fairly good, but, owing to early encasement of knots, board grades were poor. Maintenance of a deep green crown improves recovery of board grades; acute branch angles and butt sweep accentuate degrade due to knot encasement.*

A practical division at a sawmill is to cut logs 8 in. or less in small-end diameter, to boards, and larger logs predominantly to framing timber. Further tending of these old stands is not justified

Investigation of younger stands confirmed that the timing of pruning is vital, and that wider initial spacing up to 8 x 8 ft results in deeper green crowns and gives greater latitude in timing tending.

The maximum-top-height limits deduced for the timing of pruning to 6 ft before timber degrade through knot encasement occurs are 14 ft for 4 x 4 ft, 16 ft for 6 x 6 ft, and 20 ft for 8 x 8 ft spacing. Comparable limits for pruning to 16 ft are 32 ft for 4 x 4 ft and 40–44 ft for 8 x 8 ft spacing.

INTRODUCTION

Corsican pine, *Pinus nigra* (laricio) Arn., is an important species in New Zealand exotic forests, more than 61,000 acres having been established in State forests up to 1957. The Tapanui district in Otago contains some of the oldest stands in the country, including areas of 50-year and older trees. Timber-grade studies were carried out on older stands, and these were supplemented by knot studies on younger stands. The major study, henceforth called study I, was done to determine the grades that would be recovered now and in the future from milling the oldest stands, and to assess the effects of tending. The facts discovered stimulated supplementary work, which included study II – a grade study of old trees that possessed exceptionally deep green crowns – and study III, whorl studies of younger stands.

All sawing necessary in studies I and II was done on the frame-saw line at Conical Hill sawmill. This saw line is of a conventional frame type – a log frame feeding a cant frame and a double edger. Practical considerations caused the work to be carried out mainly in the course of normal forest and mill operations, and details of sampling and

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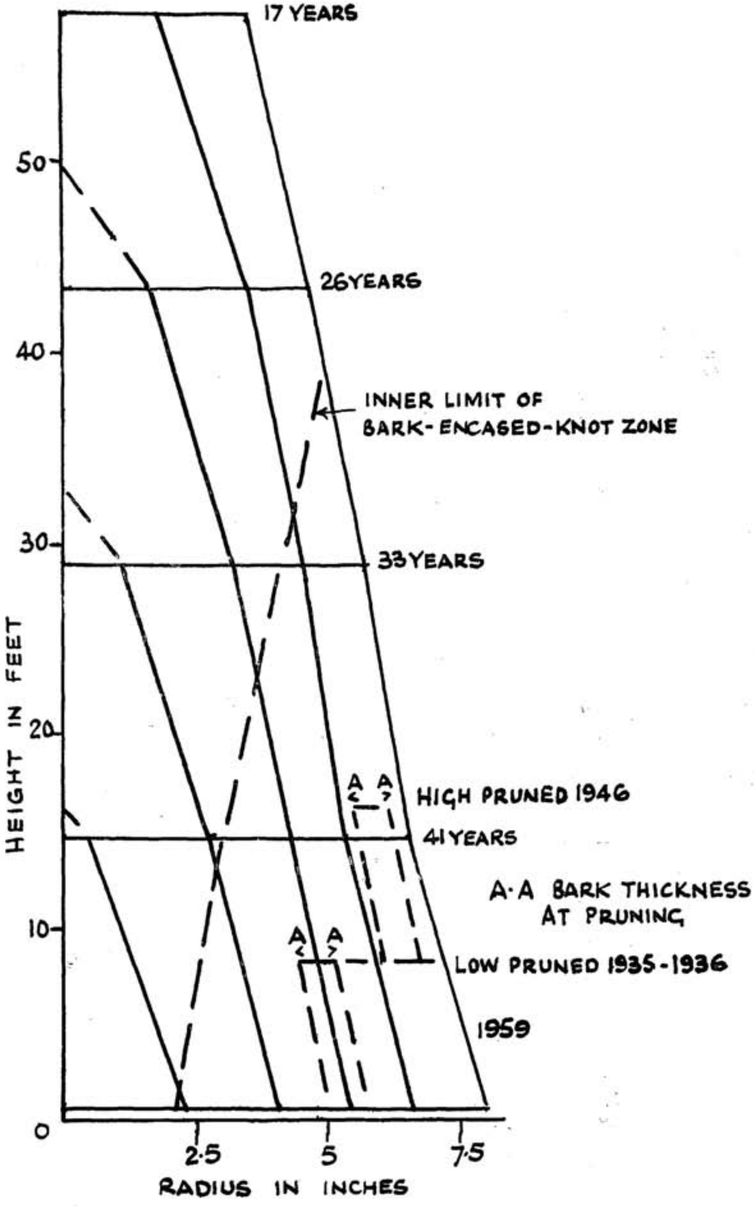

Study I. Development of trees (average of 14) showing 10-year growth intervals inside bark and extent of bark-encased knots.

TABLE 1: DETAILS OF STANDS STUDIED

	Study I	Study II	Study III				
Forest	Dusky	Dusky	Conical Hill	Tapanui	Conical Hill	Conical Hill	
Compartment	3a	1a	4a	12a	25	26	26
Year planted	1908	1907	1929	1926	1947	1948	1949
Spacing	4×4 ft	4×4 ft	8×8 ft	8×8 ft	6×6 ft	6×6 ft	6×6 ft
Blanking	Not recorded*	Not recorded*	1930†	1927, 15%	None	None	None
Low pruned	To 6 ft, 1935–6	To 6 ft, 1930, all trees	To 4 ft, 1937; to 8 ft, 1940, all trees	To 10 ft, 1939–40, all trees	To 6 ft, 1959, 1 tree in 4	To 6 ft, 1959, 1 tree in 4	—
High pruned	To 16 ft, 1946, all trees	To 16 ft, 1946–7, all trees	To 14 ft, 1948, 200 trees per ac	To 14 ft, 1948–9, 200 trees per ac	—	—	—
Thinned 1	4th line, 1929–30	4th line, 1929–30	None in part studied	To 350 per ac, 1953–4‡	—	—	—
2	To 520 per ac, 1935–6	To 300 per ac, 1947–8	—	—	—	—	—
3	Salvage, 1938–9	—	—	—	—	—	—
4	To 300 per ac, 1944–6	—	—	—	—	—	—
Mean top height	72 ft	65 ft¶	50 ft¶	58 ft¶	18 ft	18 ft	12 ft
Site index § (at 30 years)	44 ft	40 ft	46 ft	52 ft	46 ft	50 ft	40 ft
Mean d.b.h., 100 biggest trees per ac	14.8 in.	12.8 in.¶	12.4 in.¶	14.5 in.¶	—	—	—
Vol. per ac to 6 in. top	6,200 cu. ft.	5,930 cu. ft¶	2,900 cu. ft.¶	5,000 cu. ft.¶	—	—	—
Ht. to base green crown	40 ft	Special trees chosen	27 ft	24 ft	0–4 ft	0–4 ft	0

*Full stocking was the aim of establishment at that time. It can be assumed that the stands were at least 90% stocked.
† This blanking was confined to a small area that was not studied. The stand elsewhere is at least 90% stocked.
‡ This is evidently wrong. Stocking is now about 420 per acre.
§ Duff, 1956.
¶ Figures from district assessment plots, 1959.

measurement vary considerably with each study; for convenience both the methods and results of each study are described separately. Details of stands investigated, derived primarily from compartment history registers, are given in table 1.

METHOD AND RESULTS, STUDY I

A one-acre block was selected at random for logging, and within it 14 dominant or co-dominant trees were selected at random for study. Because of variation in the height of high pruning, butt logs of 14 ft were cut, and to facilitate comparison between log classes, all other logs were also cut to 14 ft. Five trees yielded three logs each and nine trees four logs each. To facilitate comparisons, two logs from the fourth log-height class were disregarded, leaving seven logs in each log-height class to be sawn to 1 in. timber and seven to be sawn to 2 in. timber. Details of the sawing patterns and log sizes are given in table 2.

TABLE 2: SAWING PATTERNS AND LOG SIZES (STUDY I)

Log-height Class ft	Log Small-end Diameters in.	Cant Cut in.	Timber Cut 1 in. %	Timber Cut 2 in. %
0.5–14.5 (Butt logs)	11, 11, 13	8	100	—
	11, 12, 13, 13	6	100	—
	11, 11, 12, 13, 13, 13, 14	Two of 4	26	74
14.5–28.5 (2nd logs)	10, 10, 11, 12	8	100	—
	10, 10, 10	6	100	—
	10, 10, 11, 11, 12, 12, 12	Two of 4	25½	74½
28.5–42.5 (3rd logs)	9, 10, 10	8	100	—
	8, 8, 9, 10	6	100	—
	8	4		
	8, 8, 8, 9, 9	5	29	71
	10	6		
42.5–56.5 (4th logs)	6, 6, 6, 6, 6, 7, 7	4 & 5	28	72

A photograph of the northern end of this area has been published (Weston, 1957). The trees photographed are actually outside the area randomly selected, but are characteristic of the older age classes.

All timber sawn was graded according to specification (New Zealand Standard Specification 169) with the exception of Dressing grade. The latter was graded according to the limits prescribed in the Appendix. The size and grade of each piece, the nature of the critical defects, and the upgrade due to pruning were recorded. The position of each piece within the log and annual-ring measurements at each log end were recorded. Results are given in tables 3 and 4, and in the graph.

TABLE 3: GRADE RECOVERY, OLDEST STANDS, 1 IN. SAWING (STUDY I)*

Log-height Class	Degraded to Box†	Total Box	Merchantable	Dressing	Factory & Clear	Percentages Timber Recovered
Butt	73	75	20.5	2.5	2	40
Second	47	53	33	14	—	32
Third	9	15.5	19	65.5	—	28
Overall	47	52.5	24.5	23	—	100

* Based on 1,376 bd. ft from seven logs in each class.

† Degraded to box grade because of bark-encased knots.

TABLE 4: GRADE RECOVERY, OLDEST STANDS, 2 IN. SAWING (STUDY I)*

Log-height Class	Degraded to Box†	Total Box 1 in. & 2 in.	Merchantable 1 in.	Dressing 1 in.	Clear 1 in.	No. 1 F 2 in.	No. 2 F 2 in.	Percentages Timber Recovered 3 logs	Percentages Timber Recovered 4 logs
Butt	13.5	21	2.5	—	2.5	66	8	43	38
Second	17	25	—	—	—	67.5	7.5	36	31.5
Third	17	17	4	22	—	53	4	21	18.5
Fourth	0	1	8	19	—	72	—	—	12
Overall	14	19	2.5	6.5	1	65	6	—	100
Overall, fourth omitted	15.5	21.5	2	15.5	1	64	7	100	—
‡	—	21	5.5	4.5	1	51	6	100	—

* Sawing predominantly 2 in. Figures based on 1,691 bd. ft from seven logs per class.

† Degraded to box grade because of bark-encased knots.

‡ Recovery if butt and second logs are sawn mainly to 2 in. timber and third logs to 1 in. timber.

METHOD AND RESULTS, STUDY II

Very few old trees possessed deep green crowns. Four trees were selected because they had green crowns down to the high-pruned level. The reasons for the development of these deeper crowns were not apparent, but fortuitous wider spacing was the most likely. Higher pruning in this stand (cf. study I) allowed the cutting of 16 ft logs, which is the usual commercial length. The branch nodes above the butt logs were removed, the knots were split, and the onset of encasement was measured. Details of log sizes and sawing patterns are given in table 5.

TABLE 5: LOG SIZES AND SAWING PATTERNS; OLD TREES, DEEP CROWNS (STUDY II)

Log-height Class	Log Diameters, Small End in.	Width of Cant in.
Butt (0.5–16.5 ft)	11, 12, 14	8
	9	6
Second (17.5–33.5 ft)	11	8
	7, 9, 10	6
Third (33.5–49.5 ft)	4, 6, 7, 7	4

All logs were sawn into 1 in. boards.

Timber was graded as in study I, and similar data were recorded. Results are given in table 6.

TABLE 6: GRADE RECOVERY, OLD TREES WITH DEEP CROWNS, 1 IN. SAWING (STUDY II)*

Percentages

Class	to Box†	Total Box	Merchantable	Dressing	Timber Recovered
Butt	42.5	48.5	42.5	9	53
Second	2	3	3	94	35
Third	1	21	16.5	62.5	12
Overall	—	29.5	25.5	45	100

* Based on 4 logs per height class.

† Degraded to box grade because of bark-encased knots.

METHOD AND RESULTS, STUDY III

Two stands of the 30–35-year age class of 8 x 8 ft spacing were sampled. A 0.1 acre plot was positioned at random in each stand and five normal trees were chosen from each plot. Nodes were cut nearest to the 6 ft and 16 ft levels and immediately below the green crown. The Conical Hill stand had received three-stage pruning, and a further node was cut at the 2 ft level. All knots in the whorls cut were sawn along their long axes, and their diameter, depth, and age of encasement were measured. The depth of clearwood and growth-rate data were

TABLE 7: KNOTS IN TREES 30–35 YEAR CLASS (STUDY III)*

Forest	Height	Knot Sizes in inches 0–0.5 %	0.6–1.0 %	1.1–1.5 %	1.6–2.0 %	2.0 %	Average No. of Knots
Conical Hill	2 ft	75	25	—	—	—	4.8
	6 ft	33.3	63.3	3.3	—	—	6.0
	16 ft	12	57	27	3	—	6.6
	below green crown	27	51	12	9	—	6.6
Tapanui	6 ft	58	39	3	—	—	7.2
	16 ft	15	60	12	9	3	6.6
	below green crown	35	46	16	3	—	7.3

* Knots from five nodes nearest each level.

TABLE 8: EXTENT OF ENCASEMENT AND CLEAR WOOD, TREES 30–35 YEAR CLASS (STUDY III)*

Forest	Height	Mean Encasement in.	Mean Encasement Years before Felling	Clear Wood in.	Clear Wood Years before Felling
Conical Hill	2 ft	0.05	20	2.1	19.4
	6 ft	0.3	18	1.2†	13.6
	16 ft	0.3	4.3	—	—
	below green crown	0.04	—	—	—
Tapanui	6 ft	0.15	19	1.7	17.0
	16 ft	0.9	6	—	—
	below green crown	0.3	2	—	—

* Based on results from five whorls nearest each level.

† Many trees had evidently been pruned to 6 ft in 1937, but were already slightly encased.

TABLE 9: AVERAGE RADIAL GROWTH, TREES 30–35 YEAR CLASS (STUDY III)

Forest	Height ft	Last 5 years in.	5–10 years before felling in.	10–15 years before felling in.
Conical Hill	2	0.24	0.43	0.73
	6	0.27	0.49	0.72
	16	0.32	0.66	1.06
Tapanui	6	0.46	0.58	0.72
	16	0.74	0.88	1.08

TABLE 10: EARLY BARK ENCASEMENT*, TREES 30–35 YEAR CLASS (STUDY III)

Forest	Branch 45° from vertical %	Branch 50° from vertical %
Conical Hill	50	2
Tapanui	42	2½

* Encasement within three years of branch formation.

also recorded. Branch angles (those made by the branches with the vertical) were measured.

Results are given in tables 7 to 10.

There, are, unfortunately, no Corsican pine stands between the 1929 and 1947 plantings. All stands of 1947–49 planting were sampled on a systematic basis. The number of dead branch whorls on each sample tree was noted, and one sample tree in 20 was examined to determine the extent of encasement. Any variation in spacing to give the equivalent of 5 x 5 ft or 7 x 7 ft spacing (instead of 6 x 6 ft) had a marked effect on the condition of the lowest branches, closer spacing resulting in earlier death of the branches. The effect of slope, as could be expected through all of this work, was to maintain a lower green crown on the downhill side, and a higher one on the uphill side of stems. Results are given in table 11.

TABLE 11: DEAD WHORLS, TREES 11–13 YEAR CLASS (STUDY III)

Age Class	Trees Examined	Total Height (ft)	Average No. of Dead Whorls	Range in No. of Dead Whorls	Encasement at 2 ft Level (Range of Years)
13	350	14–18	1.8	0–4	0–2
12	190	13–18	1.0	0–3	0–2
11	75	10–14	0.0	0	0

DISCUSSION OF RESULTS

The writer is aware that the degree of reliability of the sampling methods employed in these studies is not known; only in the latter part of study III was the sampling extensive. The large number of variables in studies that involve sawing and grade returns tend to reduce the value of results from small-scale samples. There is also considerable variation in the type or strain, or possibly the variety of the species present in the younger stands; this is less marked in the thinned older stand of studies I and II. There are some differences in site qualities in the stands investigated. Thus discussion is confined to the results that are consistent and clear cut.

Current Forest and Mill Implications

The major results of study I indicate that, in future, grades from these old stands of Corsican pine will, if sawn to 1 in. timber, be initially Factory grade and then, as all knot stubs become occluded, Clears from the outer part of the butt logs, and Box grade from the second and third logs. Varying the sawing patterns by cutting 2 in. or thicker framing timber will reduce the incidence of Box grade. (It is relevant to consider markets for framing predominantly in terms of pieces of 4 x 2 in. which is the size most in demand.) The extensive zone of dead branches, and hence of bark-encased knots, is the significant fact in determining the future of these old stands; the pruned butt section will eventually produce good grades, but only over a knotty core of 10–12 in. diameter. These stands are subject to wind throw in exposed areas, and current volume increment is low. Thus the logical solution is to clear fell them, and this is the course being adopted.

The sawmill cannot segregate logs into height classes, but only into 1 in. small-end diameter (s.e.d.) classes. An empirical division at the 8 in. s.e.d. limit would divide most of the green-crown third or fourth logs from the butt and second logs, in which most of the knots are encased. All logs larger than 8 in. s.e.d. would give a reasonable grade return if sawn to 2 in. timber; logs 8 in. s.e.d. and under could be sawn to 1 in. timber with good grade recoveries. The 8in. s.e.d. limit would vary with the average tree size in the stand; if the average tree size is smaller than that of the study I stand, then the limit would be reduced to 7 in. s.e.d. These limits were adopted by the mill. The grade recovery in framing dimensions increases as the cross section of the framing increases, owing to the relatively small diameter of the bark-encased knots. Thus sawing to 5 x 2 in. timber gives higher grade recovery than sawing similar logs to 3 x 2 in. timber. Within the limits of market demand, this course has also been adopted, although demand is primarily for 4 x 2 in. timber.

The 30–35-year-old classes have been established mainly at 8 x 8 ft spacing and in some areas have been thinned once. It would be necessary to carry out whorl studies, similar to those of Study III, to determine in each stand how deeply the dead branches are bark encased. Further pruning and heavy thinning would not give the maximum return on these stands, as the timber has already been degraded to some extent; the knotty core of the largest butt logs would be about 9 in. in diameter. The most difficult problem is the timber between the 16 ft level and the base of the green crown. If the stands are to remain for an 80-year rotation it will be difficult to maintain a green crown down to, say, 25 ft, and there is a case for accepting the degrade present in second logs and sawing them to framing when the stands are eventually felled. This regime would give some clear timber in the butt logs, a predominantly good recovery of framing grades from the second logs and good 1 in. timber grades from the third logs. Alternatively, extra-high pruning may be justified on some stands.

General Silvicultural Considerations

A general observation made in the studies was that any degree of butt sweep or log curvature increases the chances that timber will contain bark-encased knots. Such curvature also reduces mill conversion factors. Similarly sweep would reduce the incidence of Clears even in well pruned stems, as the potentially clear board would run into the knotty zone.

A further general observation was that any branch that lay at an acute angle to the stem was much more likely to contain a bark pocket along its upper edge, than a more obtuse-angled branch. Table 10 confirms this to some extent.

Studies I and II demonstrated that by far the most important defect in these old stands of Corsican pine is bark encasement of the knots, due to early death of the branches. Where the branches are green, good grade recoveries can be anticipated. This was shown by the results obtained in sawing the second and third logs of study II, and from fourth, and to a lesser extent, third logs of study I. Hence grade recovery, in the old stands, improves from butt to top log. This is in contrast to radiata pine *(Pinus radiata* D. Don) where the decreasing incidence of branch encasement from butt to top log can be largely nullified, as far as 1 in. timber grades are concerned, by the increasing effect of cone-stem holes on the trunks (New Zealand Forest Service, 1959). Unfortunately, the shortness of the internodes of Corsican pine in the Tapanui district prevents any appreciable outlet through Factory grade, whereas this grade improves recovery from logs of radiata pine with bark-encased knots. In radiata pine pith can be an important cause of degrade, whilst it is of comparatively little significance in Corsican pine.

It is characteristic of Corsican pine that branch size is relatively even, and that nodes are very regular. Thus the problem of the early death of the small secondary branches which occur frequently in radiata pine, is of much less importance in Corsican pine. This means that encasement at any one height generally begins at the same age, plus or minus two years, and this relative constancy simplifies tending.

Thus the improvement of timber quality in Corsican pine lies in both preventing the occurrence of dead branches and in producing clear timber.

Low Pruning

Throughout the ensuing discussion of pruning, top heights, and stem diameters are derived from yield tables (Duff, 1956).

Encasement in study I trees (4 x 4 ft spacing) began at 10–12 years of age, in the first 6 ft of trunk. This is at a top height of 12–15 ft. Judging from the incidence and depth of encasement recorded from the timber in study I, death of lateral branches must have progressed rapidly up the trunk, approximately keeping pace with height growth. Low pruning at 11 years of age would have resulted in an intergrown knotty core of 3–4 in. diameter.

Encasement in study III trees (8 x 8 ft spacing) was negligible up to the 6 ft level at the time of low pruning. The only encasement was due to the actual bark thickness present at the time of pruning. The top heights at the age of low pruning were 22 ft in the Tapanui stand, and 17 ft (4 ft pruning) and 22 ft (8 ft pruning) in the Conical Hill stand. This low pruning was well timed, at 12–14 years of age, to prevent encasement. Pruning at this age has produced an intergrown knotty core of about 5 in. diameter at breast height. This may be considered too large; low pruning at a top height of 15 ft would reduce the diameter of the knotty core to about 3½ in. at breast height.

The trees of the study III young stands (6 x 6 ft spacing) were beginning to develop bark-encased knots at their lowest branch whorls at about age 11 (equivalent to a top height of about 16 ft). Thus, at 6 x 6 ft spacing, the pruning necessary to prevent the knots from becoming encased produces a knotty core 3 in. in diameter at breast height.

It is evident that 8 x 8 ft spacing allows more latitude in timing low pruning than 4 x 4 ft or 6 x 6 ft spacing. From table 7 it is evident that the wider spacing does not cause any significant increase in branch diameter; less than 5% of knots were even as large as 1.5 in. If, however, the knotty core is to be kept down to 4 in. in diameter, it is necessary to low prune trees spaced at either 6 x 6 ft or 8 x 8 ft by the time a top height of about 15 ft is reached.

High Pruning and Thinning

Encasement at the 16 ft level in study I trees (4 x 4 ft spacing) had begun at about 18 years of age, at a top height of about 32 ft. If trees had been high pruned at that time, the resultant knotty core would have been predominantly intergrown, and about 5 in. in diameter. The high pruning was done about 20 years late.

Study III trees (8 x 8 ft spacing) in both the Tapanui and Conical Hill stands had begun to produce bark encased knots at the 16 ft level at about 26 to 27 years of age. High pruning then, at top heights of 42 ft and 46ft, would have resulted in a predominantly intergrown knotty core of about 6 in. diameter. Thus compared with 4 x 4 ft spacing, there appears to be about nine years' latitude available in timing high pruning. Earlier pruning would reduce the diameter of the knotty core; earlier thinning would increase it. The Tapanui trees had deeper green crowns and larger diameters than the Conical Hill trees (8 x 8 ft spacing), and this was probably due to the 1953 thinning. The figures deduced here are for maximum, not optimum top heights for timing of high pruning. It appears that the current Southland prescription for thinning with intermediate 6–12 ft pruning at 25 ft top height (Brown, 1959) will produce logs of very good grade, with a knotty core of about 3½ in. diameter at the 10 ft level. It is intended (Brown, 1959) to thin to 300 s.p.a. at top height 25 ft. The Tapanui stand of Study III had been thinned at 27 years of age at a top height of about 42 ft, and this thinning lessened the reduction in increment recorded in table 9. The new prescriptions will probably avoid any reduction of the diameter increment rate.

Further definition of future thinning regimes cannot be made from these studies, apart from stressing the general aim of maintaining deep green crowns.

Limits of Discussion

This discussion has been concerned almost exclusively with growing trees to recover the highest possible grades of timber, and has not considered biological aspects. Pruning of green branches, called for in this paper, has on occasion led to pathological troubles overseas. So far, in Tapanui district, no deleterious effects due to green pruning have been noticed. Occlusion over pruned stubs has not been mentioned here, but general observation shows that, in Corsican pine, occlusion is particularly clean. The annual-ring pattern suggests that green-pruned branches occlude very rapidly, the rings projecting outwards towards the bark. Around dead branches the annual rings project inwards towards the pith, and occlusion is thought to be delayed. Further work on these points is necessary.

Attack by *Sirex noctilio* has not been significant in Tapanui district, and it is not anticipated that green pruning, or heavy early thinning will result in an increased incidence of attack.

CONCLUSIONS

The oldest stands of Corsican pine (pre-1914 planting) in the Tapanui district can yield a reasonable grade return if sawn predominantly to timber of framing size.

Below a small-end-diameter limit of 7 or 8 in., a good grade of 1 in. timber can be expected from these old stands.

Further tending of these old stands is not worth while, and the logical course is to eventually clear fell them.

There is a case for establishing new stands at wider spacing, probably 8 x 8 ft, in order to give some flexibility in timing tending without bringing about any significant increase in branch size.

Pruning to 6 ft should be carried out by the time a top height of 14 ft is reached in stands planted at 4 x 4 ft spacing, 16 ft at 6 x 6 ft and 20 ft at 8 x 8 ft, if deterioration of the knotty core through bark encasement is not to occur.

High pruning to 16 ft should not be delayed beyond the development of a maximum top height of 40–44 ft in 8 x 8 ft unthinned stands.

Maintaining the green crown at the lowest possible level is an important factor in grade recovery.

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APPENDIX

Amended grading rule used for dressing grade of Corsican pine

Specifications as for radiata pine dressing grade except:

1. Knots, intergrown, sound: singly or in groups	Sum of diameters not greater than two-thirds the width of the piece, but no single knot greater than 2 in.
2. Knots, spike, intergrown, sound	Up to $\frac{3}{4}$ in. in width on face, projected length of single spike or sum of lengths of double spike shall not be over two-thirds the width of the piece, and on edges depths of double spike shall not be more than two-thirds the thickness of the piece.
3. Knots, partially intergrown, sound	Up to one-third width but no single knot greater than $1\frac{1}{2}$ in.
4. Bark pockets and crescents associated with partially intergrown knots	Up to $\frac{1}{8}$ in. wide and one-quarter width of piece.

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