SILVICULTURAL CHARACTERISTICS OF RADIATA PINE IN TAPANUI DISTRICT

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SYNOPSIS

Various growth characteristics of radiata pine (P. radiata D.Don) in the Tapanui District that are considered to be of some silvicultural significance were investigated.

It was found that for all purposes of practical management maximum green crown depth is dependent solely on stand stocking. The relationship between stocking and maximum green crown depth was established, and thinning schedules to maintain the green crowns at any particular desired height level can now be devised.

Branch development throughout the crown in young unthinned stands is described. Also illustrated are the effects of initial spacing and thinning on the branch diameters encountered and knotty core diameters obtained in pruning according to various pruning schedules. Wider initial spacing or thinning prior to pruning are shown to cause considerable increases in branch and knotty core diameters, and the conclusion is reached that first thinning should be delayed until pruning to 18 feet is completed.

The relationship between the diameter of the largest branch in a whorl and the knotty core diameter resulting from pruning the whorl is demonstrated.

Finally the effects of green pruning on increment are illustrated. With low pruning from 0–6 ft, a knotty core diameter of 5 in. can be obtained without excessive depression in diameter or height growth. However, for pruning from 6–12 feet, a core of 6 inches in diameter is the smallest that can be expected.

INTRODUCTION

At the present time there is an ever increasing emphasis on producing timber of the highest possible quality from P. radiata by correctly timed and applied tending. To devise optimum pruning and thinning schedules for radiata pine it is considered necessary

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to understand first something of the nature and development of certain key growth characteristics, of which green crown depth and branch size are two of the more important.

The importance of retaining deep green crowns to maintain good growth, and to produce timber free of bark-encased knots, is now fully realised, while the significance of branch and consequently knot size in the grading of timber, particularly framing timber, is also recognised. What possibly is less fully understood is the way crown depth and branch size develop in unthinned stands, and the effects of thinning on these characteristics. Also little information is evidently available on the significance of the size of the branches encountered in pruning, both in regard to pruning costs and knotty core size obtainable.

The effect of green pruning on diameter and height growth is another factor on which there is some information available but generally in a form that cannot be translated into current practice.

In this paper studies carried out on certain growth characteristics of radiata pine are described, with particular emphasis on young stands in the age range where most of the key silvicultural practices take place. The effects of certain pruning and thinning practices on growth characteristics are given, and conclusions are drawn as to the optimum timing of first thinning and of the various stages of pruning.

GREEN CROWN DEPTH

Study Methods and Results

In the Tapanui District there are radiata pine stands of nearly all ages from 1 to 50 years, planted at various spacings, and subjected to numerous pruning and thinning regimes. In an endeavour to find out the factors influencing green crown depth the following procedure was adopted:

(1) The total heights and green crown depths were measured for 10 dominant trees from each of a considerable number of stands aged between 3 and 50 years, and which were either unthinned or had not been thinned for at least 5 years. In each stand the measured trees were contained in an area of 0.4ac. and the stocking on each area was determined. Stands in Beaumont Forest were excluded. Some information was also obtained from sample plot and assessment plot data. Green crown depth is defined as the distance between the top of the tree and a point midway between the lowest green branch and lowest green whorl. For each stand the mean height of the 10 measured dominants was defined by the writer as stand top height. This is not the same
as the formal definition of stand top height, but was considered to be accurate enough for this study of green crown depth. The mean crown depth of the 10 dominants was defined as stand green crown depth.

(2) Stand top height is generally considered a more satisfactory reference index than stand age for the timing of silvicultural schedules, and so will be used in this paper. Excluding the higher altitude stands on Beaumont Forest, the relationship between stand top height and stand age is fairly uniform in this district where there are no marked variations in site quality. The relationship is shown in fig. 1.

(3) The second relationship established was that between top height and stocking for unthinned stands planted at 6ft × 6ft and 8ft × 6ft spacing. The relationship is shown in fig. 2.

The decrease of stocking with increasing top height is due to natural mortality, caused predominantly by suppression. Mortality due to Sirex attack is nearly absent from forests in Tapanui
Fig. 2. Relationship between Top Height and Stocking of Unthinned Stands.

Fig. 3. Relationship between Top Height and Green Crown Depth of Unthinned Stands.
District. It will be noted that the most rapid reduction in stocking is between 40ft and 100ft top heights when competition is most intense.

(4) The third relationship established was that between stand top height and green crown depth for unthinned stands planted at 6ft × 6ft and 8ft × 6ft spacing. The relationship is shown in figure 3. It will be noted that green crown depth increases regularly as top height increases. It will be noted also that for top heights of 70ft or less the crown depths are greater for 8ft × 6ft planting, but that for top heights exceeding 80ft crown depths are identical for both initial spacings.

A comparison of figs. 2 and 3 clearly indicates that the increase of green crown depth in unthinned stands, as top height increases, is closely correlated with decreasing stocking.

(5) The next step was to examine all stands, both thinned and unthinned, to see if any definite correlation exists between stand stocking and stand green crown depth. It was found that such a correlation does exist, and that for all practical purposes all stands of the same stocking, regardless of their top heights, have

![Diagram](image-url)

Fig. 4. Relationship between Stocking and Maximum Green Crown Depth for all Stands.
the same green crown depth provided that:
(a) Top height is sufficiently great for the base level of the green
crowns to have risen above the ground-level. This applies
particularly to young stands.
(b) In the case of thinned stands the green crowns have increased
in depth to their full extent since the last thinning took place.

Thus if a stand of 900 stems per acre (s.p.a.) is thinned to
300 s.p.a. the green crown depth immediately after thinning
will be only 21 ft and will not be 41 ft, which is the crown depth
corresponding to 300 s.p.a., until the stand has grown another
20 ft in top height. Thereafter as long as the stocking remains at
300 s.p.a. the green crown depth will remain at 41 ft. Therefore
it is the maximum green crown depth that can be correlated with
stocking, and for any stocking it must be ensured that the crowns
have indeed reached their maximum depth. The relationship
between stocking and maximum green crown depth is shown in
fig. 4.

Significance of Relationship Between Stocking and Maximum Green
Crown Depth

There appears to be no reason why a distinct relationship
between stocking and maximum green crown depth should not exist
for all pine species. The writer has already determined the relation­
ship for corsican pine, as well as for radiata pine. Once the
relationship is determined for a particular species in a particular
locality, the way the green crown will ascend throughout the life
of the stand with various thinning regimes can be accurately pre­
determined. If necessary, thinnings can be planned to maintain
the base level of green crowns at certain desired heights. For
example, for first thinning at say 35 ft top height, it may be desired
to maintain the base level of green crowns at the high pruned level
of 18 ft from the ground until second thinning at 70 ft top height.
Thus when the stand is at 70 ft top height the green crown depth
must be (70 – 18) ft or 52 ft. The stocking corresponding to a green
crown depth of 52 ft is 170 s.p.a. and so first thinning must reduce
the stocking to this figure.

Thus for any particular thinning, the height to which the green
crowns will have risen by the next thinning can be found. As even
one whorl of dead branches is sufficient to degrade a complete log
length this knowledge is of considerable importance. In addition
the information in fig. 4 can be used in planning pruning schedules.
If bark encasement in the knotty core is to be avoided, green pruning
is necessary; thus each stage of pruning must be at least to that
height level which the green crowns will have attained by the next
pruning stage. Reference to fig. 4 will give this height level.

An example of a thinning schedule that will retain the base level
of the green crowns at 32 ft from the ground is shown in table 1.
TABLE 1: THINNING SCHEDULE TO RETAIN GREEN CROWN LEVEL AT 32 FEET

<table>
<thead>
<tr>
<th>Top Height (ft)</th>
<th>Thin to (Stems/acre)</th>
<th>Crown Measurements at Time of Thinning</th>
<th>Crown Depth (ft)</th>
<th>Green Level (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>36</td>
<td>250</td>
<td>22</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>76</td>
<td>110</td>
<td>45</td>
<td>31</td>
<td></td>
</tr>
<tr>
<td>105</td>
<td>70</td>
<td>73</td>
<td>32</td>
<td></td>
</tr>
<tr>
<td>125</td>
<td>50</td>
<td>93</td>
<td>32</td>
<td></td>
</tr>
<tr>
<td>140</td>
<td>Clearfell</td>
<td>108</td>
<td>32</td>
<td></td>
</tr>
</tbody>
</table>

This schedule, in which there is a 10 year thinning interval, maintains a mean relative spacing of between 22 and 23 percent. The green crown level at 32 ft has been selected for an example as it is to this height that extra high pruning is commonly carried out.

BRANCH DEVELOPMENT

Branch Development in Young Unthinned Stands

In Tapanui District radiata pine is now planted entirely at 8 X 6 ft spacing, and so only stands planted at this spacing were studied for branch development throughout the crown. Three unthinned stands with top heights of 15, 25 and 35 ft respectively were selected, and then from each stand 20 trees, representative of those which would be left after a first thinning to 300 s.p.a., were randomly selected.

Branch diameters were taken for each tree from those whorls nearest to 3 ft height intervals up the stem from the ground to the growing tip. The largest, middle-sized and smallest branch in each

TABLE 2: AVERAGE BRANCH DIAMETERS AT THREE-FOOT HEIGHT INTERVALS ON RADIATA PINE STEMS

<table>
<thead>
<tr>
<th>Height of Whorl</th>
<th>15 ft Top Height</th>
<th>25 ft Top Height</th>
<th>35 ft Top Height</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 in.</td>
<td>0.40</td>
<td>0.40</td>
<td>0.40</td>
</tr>
<tr>
<td>3 ft</td>
<td>0.77</td>
<td>0.97</td>
<td>0.97</td>
</tr>
<tr>
<td>6 ft</td>
<td>0.82</td>
<td>1.02</td>
<td>1.05</td>
</tr>
<tr>
<td>9 ft</td>
<td>0.61</td>
<td>0.96</td>
<td>1.07</td>
</tr>
<tr>
<td>12 ft</td>
<td>0.39</td>
<td>0.89</td>
<td>1.08</td>
</tr>
<tr>
<td>15 ft</td>
<td>—</td>
<td>0.80</td>
<td>1.07</td>
</tr>
<tr>
<td>18 ft</td>
<td>—</td>
<td>0.69</td>
<td>1.05</td>
</tr>
<tr>
<td>21 ft</td>
<td>—</td>
<td>0.52</td>
<td>1.01</td>
</tr>
<tr>
<td>24 ft</td>
<td>—</td>
<td>0.22</td>
<td>0.94</td>
</tr>
<tr>
<td>27 ft</td>
<td>—</td>
<td>—</td>
<td>0.83</td>
</tr>
<tr>
<td>30 ft</td>
<td>—</td>
<td>—</td>
<td>0.66</td>
</tr>
<tr>
<td>33 ft</td>
<td>—</td>
<td>—</td>
<td>0.37</td>
</tr>
</tbody>
</table>
selected whorl were measured. The three diameters were averaged to give the mean branch diameter for each whorl. Results from the 20 trees in each stand were then averaged. The results are shown in table 2.

The following points are illustrated by table 2 –

(a) Branch size increases most rapidly near the growing tip, and near-maximum branch size is reached very quickly. Ten feet below the growing tip a branch has attained 80–90 percent of its ultimate diameter.

(b) Except for the stand of 15 ft top height, below 10 ft from the growing tip there is a quite considerable stem length over which branch diameters are fairly uniform and increase in size at only a slow rate.

(c) In 8 × 6 ft unthinned stands the average branch diameter per whorl stays below 1.1 in. for all top heights studied. Less detailed study of older unthinned stands reveals that the average branch diameter per whorl remains fairly constant at a value between 1.0 and 1.1 in. for a considerable time in the life of the stand, and that an average branch size larger than this will develop only after thinning takes place.

(d) Branch size is very small from ground-level up to 2 ft, and branches at this level die very readily.

With three stage pruning from 0–6 ft, 6–12 ft and 12–18 ft at top heights of 15 ft, 25 ft and 35 ft respectively, it will be noted in each case that, although the branches to be pruned have reached almost their full diameter, they are not excessively large. The largest branches will be encountered at high pruning; but, even here, the average-sized branch per whorl is less than 1.1 in., and the largest branch per whorl would not exceed 1.5 in. Thus the conclusion can be drawn that stands planted at 8 × 6 ft spacing will not result in excessively large branches being encountered in pruning to 18 ft, provided that no thinning is carried out in the interim.

The Effects of Initial Spacing and Thinning on Branch and Knotty Core Sizes

The size of the branches encountered in pruning is of considerable significance for two reasons:

(a) Branch size strongly affects pruning costs.

(b) Branch size has a considerable influence on the knotty core diameter obtained with pruning.
It is obvious that pruning costs must bear a direct relationship to the cross-sectional area of the branch to be pruned. Thus it is economically desirable to keep branch size to a minimum.

The effect of branch size on knotty core size is threefold, because larger branches result in greater stem swelling at the nodes; greater stub length after pruning; and protracted rates of occlusion following pruning.

All these factors contribute to the production of a large knotty core. In addition, if the larger branches are a result of thinning, then the average stem diameter at pruning level will be greater than if the stand had been left unthinned. Thus knotty core size will be further increased.

Branch size above the pruned level is also of considerable importance, but in this paper branch size in the 0–18 ft pruned zone only is considered.

Branch sizes encountered in three stage pruning to 18 ft were determined for 11 different stands, some of which were unthinned and others that had received various thinning treatments prior to the pruning stage under consideration. In each of the 11 stands ten trees were selected. In the case of the unthinned stands, these were trees that would be left after a thinning to 300 s.p.a. Apart from this the choice of trees was entirely random. The trees selected in the four stands of 25 ft top height had already been low pruned to 6 ft, and the trees selected in the four stands of 35 ft top height had already been pruned to 12 ft. For each of the trees selected in each stand the largest branch and that of average size in every whorl at the appropriate height-zone were measured. Thus, in stands of 15 ft top height, measurements were taken of the whorls from 0–6 ft; in stands of 25 ft top height, from 6–12 ft; and in stands of 35 ft top height, from 12–18 ft. The d.b.h. of each tree was recorded.

After the branch measurements had been taken, the branches in the appropriate height zone were pruned off with a pruning saw, and a count was taken of the total number of branches pruned off each tree. Knotty core diameter was determined by measuring the diameter over the stubs of each pruned whorl with a diameter tape. The largest diameter recorded was taken as the knotty core diameter.

The maximum and average branch diameters recorded for each whorl were first averaged for each tree, and then for the 10 trees in each stand. The knotty core diameters obtained, and also the total sectional areas of pruned branches were also averaged for the 10 trees in each stand. The data obtained are shown in table 3.
### TABLE 3: AVERAGE MEASUREMENTS FOR TEN SAMPLE TREES IN EACH STAND

<table>
<thead>
<tr>
<th>Spacing, Pruning and Thinning Regime of Stand</th>
<th>Mean d.b.h. in.</th>
<th>Knotty Core Diameter in.</th>
<th>Mean Diameters of Sectional and Largest Branches</th>
<th>Total Area of Branches sq. in.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>1. Low Pruning 0–6 ft, at 15 ft Top Height</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 X 6 ft Unthinned</td>
<td>3.55</td>
<td>5.12</td>
<td>0.57</td>
<td>0.82</td>
</tr>
<tr>
<td>8 X 6 ft Unthinned</td>
<td>3.96</td>
<td>5.56</td>
<td>0.69</td>
<td>1.00</td>
</tr>
<tr>
<td>Regeneration Thinned to 10 X 10 ft at 8 ft Top Height</td>
<td>4.37</td>
<td>6.08</td>
<td>0.84</td>
<td>1.24</td>
</tr>
<tr>
<td><strong>2. Intermediate Pruning 6–12 ft, at 25 ft Top Height</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 X 6 ft Unthinned</td>
<td>4.91</td>
<td>5.68</td>
<td>0.68</td>
<td>0.94</td>
</tr>
<tr>
<td>8 X 6 ft Unthinned</td>
<td>5.69</td>
<td>6.54</td>
<td>0.97</td>
<td>1.30</td>
</tr>
<tr>
<td>Regeneration Thinned to 10 X 10 ft at 8 ft Top Height</td>
<td>6.60</td>
<td>7.82</td>
<td>1.18</td>
<td>1.61</td>
</tr>
<tr>
<td>8 X 6 ft Thinned to 300 s.p.a, at 15 ft Top Height</td>
<td>6.78</td>
<td>8.08</td>
<td>1.23</td>
<td>1.68</td>
</tr>
<tr>
<td><strong>3. High Pruning 12–18 ft, at 35 ft Top Height</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 X 6 ft Unthinned</td>
<td>5.90</td>
<td>5.52</td>
<td>0.65</td>
<td>0.92</td>
</tr>
<tr>
<td>8 X 6 ft Thinned to 300 s.p.a, at 15 ft Top Height</td>
<td>6.77</td>
<td>6.65</td>
<td>1.07</td>
<td>1.47</td>
</tr>
<tr>
<td>8 X 6 ft Thinned to 300 s.p.a, at 25 ft Top Height</td>
<td>8.50</td>
<td>8.37</td>
<td>1.38</td>
<td>1.86</td>
</tr>
</tbody>
</table>

The figures in table 3 illustrate the following points:

(1) Branch size and knotty core size are appreciably larger in unthinned stands planted at 8 X 6 ft spacing than in those planted at 6 X 6 ft spacing. Therefore pruning costs will be considerably lower with 6 X 6 ft planting, and the timber grades obtained from pruned trees will be slightly better. Whether these factors are of more than sufficient importance to offset the higher establishment and thinning costs resulting from planting at the closer spacing is clearly a matter worthy of close study.

(2) All thinning treatments carried out prior to pruning have resulted in marked increases in branch size at the pruning level and hence in branch sectional area to be pruned, and also in considerable enlargements in knotty core diameters. Branch
sectional area increased by as much as 67% in some cases, while knotty core diameters are increased by nearly 2 inches.

(3) In all stands planted at 8 X 6 ft spacing, even if unthinned, larger branches are encountered and larger knotty core diameters are obtained from intermediate and high pruning than from low pruning. In unthinned stands this could be avoided to some extent by advancing the times of intermediate and high pruning to, say, 22 ft top height and 30 ft top height respectively. However, in stands thinned before intermediate or high pruning it would be impossible to keep branch size or knotty core size uniform throughout the three pruning stages.

The conclusion from these findings is that, to avoid excessive pruning costs and to keep knotty core size down to about six inches, it is necessary to delay thinning of a stand planted at 8 X 6 ft spacing until pruning to 18 ft has been concluded. No degrade due to bark encased knots will occur by delaying thinning until this time, as pruning will be entirely of green branches and the natural base level of the green crown will still be only 12 or 13 ft from the ground.

If pruning is to be carried up higher than 18 ft then there may be a case for delaying thinning even later on the same grounds as before, namely small branch size and small knotty core diameter. Provided that the pruned height keeps ahead of the natural ascent of green crown level no bark encasement will occur in the knotty core. However, it is the writer's opinion that delaying thinning much later than 35 ft top height is not justified even if extra high pruning to 35 ft is to be carried out. The reasons for this opinion are:

(1) Severe competition will be occurring in the unthinned stand from the time it reaches 35 ft top height, and if the stand is left unthinned there will be considerable loss of increment on the high pruned stems and also those other stems which would be left after thinning.

(2) With any considerable delay in thinning, mortality due to suppression will start occurring with increasing frequency. The pruned stems may be particularly affected as their diameter and height growth may already have been slowed down appreciably by the green pruning.

(3) Only a limited number of stems per acre are likely to be pruned higher than 18 ft, and those which are not will very soon be degraded due to branches dying above the 18 ft level.

If no pruning higher than 18 ft is contemplated, then certainly thinning cannot be delayed much later than 35 ft top height. When the stand passes 40 ft top height the branches above the pruned level will start to die, with consequent degrade of the second log.
Relationship Between Largest Branch Diameter and Knotty Core Diameter

To determine the relationship between the diameter of the largest branch in a whorl and the knotty core diameter resulting from pruning that whorl the following procedure was adopted:

1. Three unthinned stands of 15 ft, 25 ft and 35 ft top height respectively were selected.
2. In each stand ten trees were randomly selected, and the following measurements made on a whorl representative of each six-foot zone up to 18 ft –
   a) Stem diameter adjacent to the whorl.
   b) Largest branch diameter.
   c) Knotty core diameter after pruning. (This was measured with a diameter tape over the stubs.)

The largest branch diameter was plotted against knotty core diameter minus stem diameter. A linear relationship was found to exist. The relationship is shown in fig. 5.

\[
\text{Knotty Core Diameter} - \text{Stem Diameter in inches}
\]

Fig. 5. Relationship between Maximum Branch Diameter and Knotty Core Diameter minus Stem Diameter.
This figure illustrates that maximum branch size has a considerable effect on the size of knotty core obtained in pruning. For stems of the same diameter the knotty core diameter is increased by 0.35 in. for each increase of 0.5 inches in the diameter of the largest branch. The importance of selecting, for pruning, trees with small branches in the pruned zone is therefore not only to keep pruning costs down, but also to keep the knotty core diameter to a minimum.

EFFECT OF GREEN PRUNING ON GROWTH RATES

With the present emphasis on green pruning, its effects on tree growth should be clearly understood lest the depression to diameter and height growth caused by the pruning be over-severe.

Investigations of these effects were carried out by the writer for the following pruning schedules of unthinned stands:

1. Low pruning from 0-6 ft with stand top height of 11 ft.
2. Low pruning from 0-9 ft with stand top height of 15 ft.
3. Low pruning from 0-6 ft with stand top height of 15 ft.
4. Intermediate pruning from 6-12 ft with stand top height of 20 ft.
5. Intermediate pruning from 6-12 ft with stand top height of 25 ft.

Stands (4) and (5) had previously been low pruned from 0-6 ft at 15 ft top height.

In the case of the first three stands mentioned above, the growth rates of pruned stems were compared with the growth rates of stems in unpruned control plots. In the case of the last two stands, growth rates of the intermediate pruned stems were compared with the growth rates of low pruned stems which did not receive intermediate pruning. Breast height diameters and total heights were recorded at the time of pruning and twelve months after pruning. Knotty core diameters were also recorded. Results are shown in table 4 below.

<table>
<thead>
<tr>
<th>Pruning Regime</th>
<th>Knotty Core Diameter in.</th>
<th>Depression of Increment D.b.h.</th>
<th>Total Height</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) L.P. 0-6 ft at 11 ft Top Ht.</td>
<td>4.2</td>
<td>0.3 in.</td>
<td>1 ft</td>
</tr>
<tr>
<td>(2) L.P. 0-9 ft at 15 ft Top Ht.</td>
<td>5.4</td>
<td>0.2 in.</td>
<td>Negligible</td>
</tr>
<tr>
<td>(3) L.P. 0-6 ft at 15 ft Top Ht.</td>
<td>5.3</td>
<td>0.1 in.</td>
<td>Negligible</td>
</tr>
<tr>
<td>(4) I.P. 6-12 ft at 20 ft Top Ht.</td>
<td>5.6</td>
<td>0.2 in.</td>
<td>1 ft</td>
</tr>
<tr>
<td>(5) I.P. 6-12 ft at 25 ft Top Ht.</td>
<td>6.4</td>
<td>Negligible</td>
<td>Negligible</td>
</tr>
</tbody>
</table>
Epicormic growth was promoted by all pruning schedules, being particularly heavy with the first two treatments.

The results show that the third and fifth schedules do not cause any appreciable depression of either diameter or height growth, but that the other more severe schedules do cause quite appreciable depression of growth. Low pruning from 0–6 ft could probably be done at 13–14 ft top height to give a knotty core diameter of 5 in. without very severe growth depression resulting, while the schedule for intermediate pruning from 6–12 ft could similarly be advanced to 22 ft top height to give a six inch diameter core. It is considered that these are the smallest knotty cores that can reasonably be expected. Earlier pruning to reduce pruning costs and knotty core diameters might well result in suppression of the pruned stems by those left unpruned.

CONCLUSION

The aim of this paper has been to demonstrate some of the growth characteristics of radiata pine which are of significance to the silviculturist; to show how these growth characteristics are affected by various silvicultural practices; and consequently to help determine which silvicultural practices are the most desirable to implement in routine operations. The emphasis has been almost entirely on young stands in the range 5 to 15 years of age, as it is during this period that most of the silvicultural practices that either make or ruin a stand take place. Grade studies have fully demonstrated this fact.

An attempt has been made to regard and understand radiata pine as a living organism, which, once its mode of growth in certain key characteristics is fully understood, can be modified and improved by the hands of the silviculturist. Much more investigation is yet needed, particularly into a number of economic aspects of silvicultural practice, but it is to be hoped that any economic considerations will not necessitate silvicultural requirements of growth taking second place or being neglected.

REFERENCES