A manual for selecting crop trees when pruning and thinning radiata pine

Piers Maclaren

FRI BULLETIN No. 133
FOREST RESEARCH INSTITUTE
A MANUAL FOR SELECTING CROP TREES WHEN PRUNING AND THINNING RADIATA PINE

Piers Maclaren

This FRI Bulletin is of particular relevance to forest managers and farm foresters.
## CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PREFACE</strong></td>
<td>1</td>
</tr>
<tr>
<td><strong>ABSTRACT</strong></td>
<td>2</td>
</tr>
<tr>
<td><strong>PRUNING</strong></td>
<td>3</td>
</tr>
<tr>
<td>Why prune?</td>
<td>3</td>
</tr>
<tr>
<td>How hard should a tree be pruned?</td>
<td>4</td>
</tr>
<tr>
<td>Using stem calipers</td>
<td>4</td>
</tr>
<tr>
<td>When to prune</td>
<td>5</td>
</tr>
<tr>
<td>How long should the pruned log be?</td>
<td>6</td>
</tr>
<tr>
<td>Use of FRI Integrated Modelling System</td>
<td>7</td>
</tr>
<tr>
<td><strong>THINNING</strong></td>
<td>8</td>
</tr>
<tr>
<td>Why thin?</td>
<td>8</td>
</tr>
<tr>
<td>When to thin a stand</td>
<td>8</td>
</tr>
<tr>
<td>When is a site not fully stocked?</td>
<td>9</td>
</tr>
<tr>
<td><strong>SELECTION</strong></td>
<td>10</td>
</tr>
<tr>
<td>How early can a crop tree be selected?</td>
<td>10</td>
</tr>
<tr>
<td>Defects in the butt log at low pruning</td>
<td>10</td>
</tr>
<tr>
<td>Selection criteria at low pruning</td>
<td>13</td>
</tr>
<tr>
<td>Selection criteria at medium or high pruning</td>
<td>14</td>
</tr>
<tr>
<td><strong>SUMMARY</strong></td>
<td>15</td>
</tr>
<tr>
<td>Pruning</td>
<td>15</td>
</tr>
<tr>
<td>Thinning</td>
<td>15</td>
</tr>
<tr>
<td>Selection</td>
<td>15</td>
</tr>
<tr>
<td><strong>ACKNOWLEDGEMENTS</strong></td>
<td>16</td>
</tr>
<tr>
<td><strong>FURTHER READING</strong></td>
<td>16</td>
</tr>
</tbody>
</table>
PREFACE

This publication is in accord with the draft "1985 NZFS Plantation Management Policy for Radiata Pine", and is designed to replace the booklet produced by R.E.J. Wylie (1968) "Radiata pine — a basis for selection of trees for pruning and thinning". It is also designed to update parts of the Logging and Forest Industry Training Board leaflets on pruning, thinning, and selection. Since details of this manual are intended only as a guide, they will not apply in every circumstance.
ABSTRACT

This booklet describes: the reasons for pruning and thinning radiata pine in New Zealand; how to determine the timing and intensity of pruning and thinning; and the criteria for selecting crop trees.

KEYWORDS: selection, selection criteria, pruning, thinning, caliper, Pinus radiata
PRUNING

Why prune?

(a) To produce knot-free wood ("clearwood") (Fig. 1). We prune because most of our timber will be exported, and many growers predict that New Zealand's best opportunities and greatest profits probably lie in clearwood. For example, a pruned butt log contains only one-third of the volume of a tree, but is as much as two-thirds of the value.

(b) To avoid large branches in the lower part of trees in agroforestry regimes. These trees tend to be wide-spaced and in soils with high fertility levels, conditions which can result in large low branches. Large branches produce large knots and therefore low timber values. Pruning has the added benefit of increasing sunlight available for pasture growth.

(c) Other reasons for pruning include pruning for disease control, access, fire control, and appearance. Pruning green branches (even if too late to produce much knot-free wood) stops the formation of bark-encased knots, which are a serious defect in sawn timber.

FIG. 1 — Cross- and longitudinal-sections of an unpruned tree (left) showing knotty wood and a pruned tree (right) showing clearwood sheath around defect core
How hard should a tree be pruned?

Stand variability, combined with traditional fixed lift pruning, is currently causing over-pruning of small trees and under-pruning of large trees. This generates an undesirably large variation in the defect core size and subsequent growth rates. Variable lift pruning, where a tree is pruned in relation to its height or diameter, avoids over- and under-pruning and is a practical and effective means of controlling the size and variation of the defect core. This approach is recommended. Fixed lift pruning is discouraged.

Pruning should aim to leave 3-4 m of green crown on each tree (Fig. 2). This crown length has been determined as an optimum trade-off between removing too much crown (and thus slowing tree growth too much) and removing too little crown (and thus obtaining too large a defect core).

![Pruning examples](image)

**FIG. 2** — Correct and incorrect pruning of an 8-m tree. Only the middle tree has been pruned correctly.

Using stem calipers

In practice, it is very difficult to judge a 3-4 m length of green crown accurately. A caliper, made from a piece of plywood with a slot of specified width cut in it, can help (Fig. 3). The pruners prune up a tree and stop when the caliper can be slipped over the stem at the thinnest point below the lowest (unpruned) whorl.

The caliper “size” (i.e., the width of the caliper slot) varies between 7 and 12 cm, but is usually 9-10 cm. It can be determined two ways. First, it can be predicted by the computer program EARLY, which uses the formula: d.b.h. \( (\text{crown length} + 0.3 \text{ m})/(\text{height} - 1.4 \text{ m}) \), where d.b.h. is diameter at breast height in centimetres and crown length and height are in metres. Alternatively, caliper size can be calculated by measuring the average stem diameter 3-4 m below the green crown for a sample of trees.
When to prune a tree

If the interval between pruning lifts is too great, both stem size and branch size will be large, resulting in a large diameter over stubs (DOS) and, therefore, a large defect core. Consequently there will be less clearwood (Fig. 4). Also, pruning will be more expensive, since large branches mean greater pruning costs. On the other hand, it is also expensive to prune trees too frequently since it costs money every time a stand is visited.
Studies indicate that at DOS of 13–19 cm is the optimum. This will give a defect core of 19–25 cm in a straight log. A 13-cm DOS is achievable on low fertility sites where growth is slower and branches smaller, or where trees have little taper. A DOS of 19 cm is a more realistic target for high fertility sites or where trees have strong taper. An average forest site should achieve a 16-cm DOS.

Because the largest DOS determines the log quality, every regime should aim to maintain a uniform DOS over the whole length of the pruned log.

The stand must be pruned when the average stem diameter at the lowest whorl reaches the target DOS. This critical time can be predicted by computer models and verified by field measurements. Two pruning lifts per tree for a pruned, 6-m butt log are adequate on many forest sites of medium fertility and site index (Fig. 5), but four or five lifts may be necessary on more fertile farm sites or where site index is low.

How long should the pruned log be?

It is common practice in New Zealand to prune to between 4.5 m and 6.0 m. These measurements correspond to traditional log lengths, for which transport and sawmilling equipment have been constructed. They are also such that many forests can be adequately pruned in two or three lifts.

Ideally, pruned length should not only be convenient for growers, but should also fit predicted market requirements, thus ensuring maximum profitability. However, there is little market information available at present. Neither is it clear how branching habit (long internodes versus short inter-
nodes) affects the economics of pruning. Fortunately, the effects of certain other factors are known. Heavy hindrance (such as in dense gorse) may mean that only one or two lifts are economic. Low pruning costs less per tree than subsequent lifts, and lower pruning lifts make it easier to obtain a small DOS. Diameter growth is better for trees that have been only low pruned, because the trees have suffered less green crown removal.

Use of FRI Integrated Modelling System

The FRI Integrated Modelling system can help decision-making about pruning. This computer package includes STANDMOD, SAWMOD, and SECMOD and replaces SILMOD. In particular, the system can:

(a) Determine the appropriate target DOS. This will depend on growth rates, anticipated prices, and silvicultural costs. Cashflow, therefore, is also a consideration.

(b) Determine the optimum trade-off point between leaving too little and too much green crown per tree. As previously stated, this trade-off point is obtained, in most cases by leaving about 3–4 m of green crown.

(c) Predict the caliper size for a stand that will ensure that the required length of green crown is left.

(d) Predict the timing of the pruning (to the nearest month) so that the target DOS is achieved. This may need to be confirmed by actual measurements nearer the time.

(e) Determine the optimum length of the pruned log, in so far as this is possible with limited market information.
THINNING

Why thin?

(a) To enable some selection for larger and straighter trees. Selection for disease resistance and branching habit are also possible.

(b) To concentrate the growth potential of the site on the crop trees in order to increase their size and/or decrease the time taken to reach a marketable size.

(c) To obtain an intermediate yield of timber.

When to thin a stand

For most stands, thinning should occur at the time of pruning. Delayed thinning can mean that unpruned or partially pruned trees will compete strongly against, and reduce the diameter growth of, the pruned crop trees. It is also more costly to waste-thin larger trees, and delayed thinning encourages wind-throw of the remaining stems. Furthermore, in agroforestry regimes the greater quantity of slash produced by delayed thinning (early thinning minimises slash) reduces the area available for pasture. Obviously malformed or unthrifty trees should therefore be removed as early as possible.

For simplicity regimes are described here that have two thinnings. Under certain circumstances, one to four thinnings may be more appropriate.

First thinning is best carried out at the time of first pruning. The second (and final) thinning is best carried out at the time of medium or high pruning (which, as previously stated, is determined by the target DOS). On the other hand, the final thinning can be delayed if:

(a) “Cull” trees are required to control the branch size in the second log of the crop trees. Delayed thinning for this reason, however, is usually not recommended because its advantages are outweighed by the disadvantages of a reduced size in the crop trees, and by the increased cost of delayed thinning.

(b) The “cull” trees are to be production thinned. Production thinning reduces the costs of final thinning, or may even generate a small profit. Again, the delayed thinning is at the expense of the crop trees and is not to be recommended unless the grower is confident that there will be a market for thinnings, and that the loss of growth and damage to the crop trees is outweighed by the cashflow advantages.

(c) Extreme weed problems (such as with gorse) are present. Delayed thinning may suppress the gorse and enable cheaper final pruning and thinning.
When is a site not fully stocked?

It is the ground area available to each tree that influences its growth, not the shape of that area (unless taken to extremes). Regimes are calculated on a stocking per hectare basis, and thinning should be carried out without concern for maintaining even distances between trees. Nevertheless, no tree should be closer than c. 2.5 m to another; otherwise competition will restrict the growth of both trees. On the other hand, tree spacings greater than c. 12 m are likely to under-use the available area.
SELECTION

Some managers find advantages in thinning stands first, then pruning them. Others do the opposite: prune then thin. Crop trees usually will be selected by the workforce that performs the first of these operations. The basis of selection should not depend on the person performing the selection. For example, a contract pruning gang should prune the best trees, even though the workers might prefer to prune small trees with small branches.

How early can a crop tree be selected?

The quality of the butt log can be assessed with confidence when the tree is about 6 m tall. The quality of the second log can be seen in a 12-m tree. It is not necessary to delay selection until the characteristics of the third and subsequent logs can be determined, as the bottom two logs contain almost all a tree's profit. In practice, little is lost by completing selection long before a tree reaches 12 m. Final selection, as already stated, could occur at the time of medium pruning (i.e., when tree height is c. 8 m).

Defects in the butt log at low pruning

The first selection usually takes place at low pruning, when the trees are 5–6 m high. At this height most of the characteristics of the butt log have been determined. There are three types of defects in butt logs: (1) Defects which will definitely reduce the value of the crop tree; (2) Defects which might, or might not, correct themselves; (3) Defects which can be corrected by subsequent pruning.

1) Defects which will reduce the value of the crop tree
Reject trees with these defects, if at all possible.
Malformations such as wobble, kink, or sweep. It is essential that the chosen trees are straight. If the malformation is so severe that the stem veers off an imaginary line from the middle of the base to the leader, reject the tree (Fig. 6).

![Fig. 6 - Stem sinuosity. A centre line, from tree top to base, must stay within the stem boundaries for a tree to be acceptable.](image-url)
Lean. Any tree, even a straight one, with a lean of greater than five degrees from the vertical should be rejected. The tree is likely to correct itself later and end up with sweep and associated compression wood. The extent of lean can be checked by placing a 1.4-m stick vertically against a tree near its base. If the top of the stick is less than 12 cm from the tree, the tree is acceptable; otherwise it must be rejected (Fig. 7).

FIG. 7 — Determining whether lean is acceptable or not. For acceptable lean, the distance between the centre of a stem and the stick must not exceed 12 cm.

(2) Defects which might, or might not, correct themselves

Reject trees with these defects unless they are required to make up the specified number.

Dead or broken tops, multiple leaders. If the leader is damaged, another leader will often take over. In half of such cases the tree will completely overcome the defect. Where the leader has been damaged low down, however, the result may be a kinked stem (Fig. 8). Such trees should be rejected.

FIG. 8 — Double and multiple leaders. The stem on the left will probably correct itself, as may the middle stem. The stem on the right, however, will probably result in unacceptable kink.
(3) Defects which can be corrected by subsequent pruning

Accept trees with these defects unless there is doubt as to whether pruning will overcome the problem.

**Multiple stems, multiple leaders, ramicorn branches** (Fig. 9). A tree with a multiple stem should be rejected only if subsequent pruning will not overcome the fault. The remaining stem must be straight (see above for definition) and any irregularity caused by the defect must be contained within the defect core (which, for a straight tree, is the target DOS plus 6 cm).

It is important to remember that, although the bottom 2.2 m will be pruned immediately after selection, it will be at least 1 year before the next 2 m is pruned, and at least 2 years before the top 2 m is pruned. Although the defects in these upper parts of the log may be corrected with pruning, they may well grow worse over 1–2 years (Fig. 8 and 9).

---

**FIG. 9** — Defects that cannot be corrected at subsequent pruning — (a) and (b) — and those that can — (c)
Having decided which trees are acceptable, the correct number of stems must be chosen from them. Select according to the following criteria (listed in descending order of importance):

1) Vigour. This is a combination of d.b.h., height of tree, and healthy appearance. If trees have equal vigour then look at

2) Straightness. Any tree which is unacceptably crooked has already been rejected. If there is any detectable difference in straightness select the straightest tree. If the trees are equally vigorous and equally straight then look at

3) Branch habit. Coarse branching and basket whorls (Fig. 10) are expensive to prune, and trees with these should be rejected. Finally consider

4) Spacing. This is the least important criterion. Select so as to ensure the most even spread of trees.

---

**Fig. 10 — Defects in branching habit above 6 m (upper row). Only the bottom illustration, light and flat branching, is acceptable.**
Selection criteria at medium or high pruning

The second thinning usually occurs when mean top height is 8–12 m. All stems present should have been low or medium pruned. The characteristics of the butt log are obvious, and some of the second log is present. Criteria for second selection are largely the same as those for low pruning, with some differences. They are, in descending order of importance:

(1) Malformation. All trees should be of acceptable straightness (as for first selection). Most crooked trees, however, will already have been removed.

(2) Lean. Some trees could have developed a lean since first selection. If this lean is greater than five degrees, reject the tree.

(3) Multiple stems, multiple leaders, and/or ramicorn branches in the bottom 6 m. If these problems can be solved in subsequent pruning, then ignore them; otherwise reject the tree.

(4) Vigour. Select the correct number of stems from the most vigorous of the acceptable trees. If trees are equally vigorous, then look closely at

(5) Straightness. Any unacceptably crooked tree has already been rejected. The straightness of trees should be compared and only the straightest trees accepted. If trees are equally vigorous and straight, then consider

(6) Branching habit above 6 m. Defects that could lead to rejection of the tree are multiple leaders, ramicorn branches (Fig. 8 and 9); and basket whorls, heavy branching, and steep branching (Fig. 10). Some managers will prefer long internode trees, while others will prefer short internode trees.

(7) Spacing. Spacing has been overemphasised in the past, and it is necessary to repeat that this is the least important criterion for selection. The stocking has been determined by the prescription, and as long as there are the correct number of trees in, for example, 0.04 ha, then spacing is unimportant so long as no tree is more than 12 m away from another tree, and so long as no tree is closer than c. 2.5 m to another. For example, at 200 stems/ha, a 20 m x 20-m square (0.04 ha) should contain eight trees (Fig. 11).

FIG. 11 — Spacing. Each square is 20 m x 20 m [i.e., 0.4 ha]. The planting pattern was 2.5 m x 5.0 m (left). The final pattern (right) may look uneven, but the spacing is quite acceptable.
SUMMARY

Pruning

In order to get the best price for timber, the bottom log(s) of our trees must be pruned. Good pruning involves:

(1) Keeping the defect core small, by pruning on time. The time can be predicted by computer models and confirmed by field measurements. On an “average” site, a stand should be pruned when pruning of the lowest whorl of a sample of trees will result in a mean DOS of 16 cm.

(2) Variable height pruning with calipers. Thus enough crown is left on the tree so as not to slow down diameter growth unnecessarily. A common caliper size is 9–10 cm, which usually leaves a 3- to 4-m-long green crown.

(3) A pruned log length based on anticipated maximum profitability rather than on tradition.

Thinning

It is desirable to plant more trees than are required for a final crop. The remainder are thinned out. In most situations:

(1) It pays to thin simultaneously with pruning;

(2) It pays to complete thinning as soon as crop trees can be selected.

Selection

It is wasteful and uneconomic to prune defective trees. If at all possible, any defective trees should be removed as soon as they are identified.

Defective trees have malformed or leaning stems or lack good single leaders. Minor defects in the leader may correct themselves. Some defects may be corrected by subsequent pruning. Defects in the bottom log (e.g., up to 6 m above the base) are critically important; defects in the second log (e.g., 6–12 m above the base) are of lesser importance; defects in the top logs (e.g., above 12 m high) are of minor importance.

The correct number of acceptable trees are selected from the non-defective trees, according to the following criteria, listed in descending order of importance:

(a) Vigour.

(b) Straightness.

(c) Branching habit. Select against coarse branching and basket whorls.

(d) Spacing. This is the least important criterion. Try to ensure that no tree is more than c. 12 m away from another, or closer than c. 2.5 m to another.
ACKNOWLEDGEMENTS

This bulletin is based on the work of R.L. Knowles, G.G. West, I.D. Whiteside, A.R. Koehler, and many others who contributed to the FRI Integrated Modelling System.

FURTHER READING


