SILVICULTURE OF *PINUS RADIATA* STAND EDGE TREES AT WOODHILL FOREST

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SYNOPSIS

In Pinus radiata *stands at Woodhill Forest, Northland, comparison of stand edge trees with those growing within the stand reveals a considerable clearwood potential from the edge trees. Removal of branches from these, before excessive development occurs, prevents degrade of an otherwise valuable sawlog, enhances stand appearance, and prevents the encroachment of trees on forest roads and tracks.*

INTRODUCTION

Purposeful and controlled pruning of radiata pine stand edge trees (*i.e.*, those along roads, tracks, firebreaks and forest edges) is seldom undertaken in stands managed for the production of framing timber. At Woodhill Forest radiata pine stands are managed under one or the other of two regimes depending on potential productivity. Areas with a site index exceeding 27.5 m at 20 years are managed to produce sawlogs suitable for clearwood boards. This involves pruning the 6 m bottom log in three lifts and two thinnings to give a final crop stocking of 200 stems/ha by mean top height 23 m. Clearfelling is planned for age 30 years, when the stand will have achieved a mean top height of 37 to 40 m and a mean dbh of 50 cm. Areas of lower site index are managed under a framing sawlog regime, involving no pruning and a single thinning at a mean top height of 18 m to 400 stems/ha. Clearfelling is scheduled for age 30 to 33 years when the stand will have reached 33 to 36 m mean top height and a mean dbh between 40 and 45 cm. It is estimated that 85% of Woodhill Forest will be managed under this latter regime.

Edge trees of stands managed under the board regime are pruned as part of the scheduled operations, but in many cases edge trees of stands managed under the framing regime are not pruned or, if pruned, the operation has often been delayed to the point where benefits are minimal. Removal of overhanging branches to encourage drying of clayed roads, and the removal of branches blocking other roads and firebreaks, have been the principal reasons for such pruning.

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TABLE 1: COMPARISON OF STAND-EDGE AND WITHIN-STAND TREE GROWTH

				Stand Edge Trees				*Within-stand Trees*			
Site Index (m)	*Stand Age (yr)*	*Mean Top Height (m)*	*Stems/ha*	*Mean dbh (cm)*	*Mean 400*[1] *(cm)*	*Mean Branch diam.*[2] *(cm)*	*Radial Stem growth*[3] *(cm)*	*Mean dbh (cm)*	*Mean dbh 400*[1] *(cm)*	*Mean Mean Branch diam.*[2] *(cm)*	*Radial Radial Stem growth*[3] *(cm)*
17.1	35	25.3	300	39.1	—	7.6	3.0	25.9	—	2.8	3.0
19.5	33	25.6	700	42.4	49.0	8.6	3.0	27.4	32.0	2.8	2.5
20.4	31	26.2	666	46.0	51.1	7.9	4.3	28.4	32.8	3.0	2.5
23.1	34	32.0	598	48.3	53.4	5.3	4.6	31.2	35.3	2.5	3.6
23.4	33	32.0	524	46.0	50.3	6.8	4.6	34.0	36.6	2.8	3.0
23.8	30	31.1	578	48.0	52.3	5.1	4.6	29.7	34.0	3.0	3.3
25.0	28	31.7	356	47.8	—	—	—	36.6	—	—	—
25.6	27	32.0	247	51.8	—	—	—	41.1	—	—	—
27.1	28	34.7	459	50.0	52.6	—	—	37.1	39.4	—	—
28.3	27	36.0	548	49.5	53.1	6.6	5.1	34.8	37.6	3.6	3.8
29.2	26	36.3	706	54.1	60.2	9.4	5.8	34.3	38.1	3.6	4.1

[1] Mean diameter of the largest 400 stems/ha — final crop stocking for the framing regime.
[2] Mean diameter of the four largest branches on the 0 to 6 metre bottom section of the tree.
[3] Mean radius of the last ten annual growth rings of the tree, measured at breast height.

STAND EDGE TREE DEVELOPMENT

Collection of data from within-stand and from stand edge radiata pine on a variety of sites and at several ages has been carried out at Woodhill Forest, from which the following information has been derived.

Effect of Gap Size on Edge Tree Development

The rapid growth of stand edge trees as compared with growth of trees within the stand is a response to the greater light source at the opening. The physical expression of this response is greater branch development on the side of the tree facing the gap. Gap size varies from two or three failed trees, to tracks where the equivalent of one or more rows of trees may be missing, to firebreaks 50 to 100 m wide, and to forest edges with no opposing stand of trees. Within this range of gap sizes growth response also varied in terms of branch and stem diameter growth. Diameters of trees in stands of similar age (30 to 32 years), stocking (550 to 600 stems/ha), and site index are plotted in Fig. 1 for a number of gap sizes, showing that the larger the gap the larger the mean diameter of edge trees.

In a 35-year-old stand carrying 600 stems/ha the mean dbh of within-stand trees was found to be 30.2 cm, while the mean dbh of edge trees was 48.3 cm adjoining a firebreak 100 m wide. The mean dbh of the largest 400 stems/ha (the final crop element) was 52.0 cm.

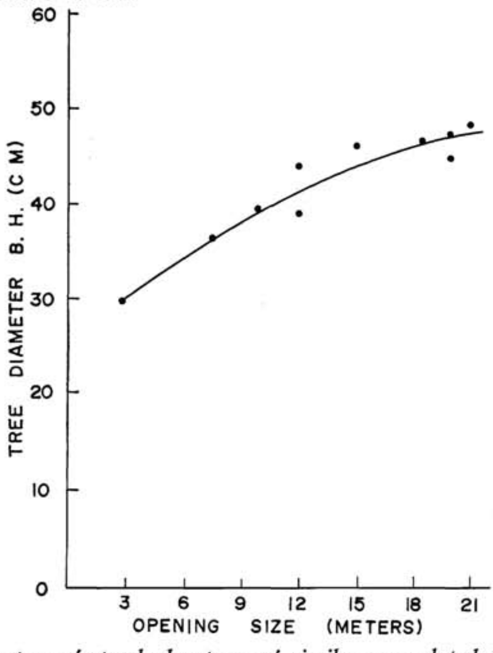

FIG. 1: *Diameters of stand-edge trees of similar age related to size of gap.*

Effect of Site Index on Edge Tree Development

Data for stand-edge and within-stand breast height diameters for crops with similar age and stocking are given in Fig. 2 and Table 1.

At all site indices examined, the stand-edge trees have a marked advantage compared with trees within the stand. An indication of the diameters the edge trees might have attained had the stand been thinned according to the framing regime schedule is indicated by the measurement of the largest 400 stems/ha.

Effect of Age on Edge Tree Development

Until branch development is restricted at the beginning of canopy closure (at about five years at Woodhill Forest) there is no difference in diameter development of edge and within-stand trees. From this time onwards, edge trees benefit from greater crown development, the accompanying greater tree diameter growth being illustrated for stands of similar site index in Fig. 3.

By age 30, on sites of average productivity, the difference between the two is 15 cm. This indicates the added growth

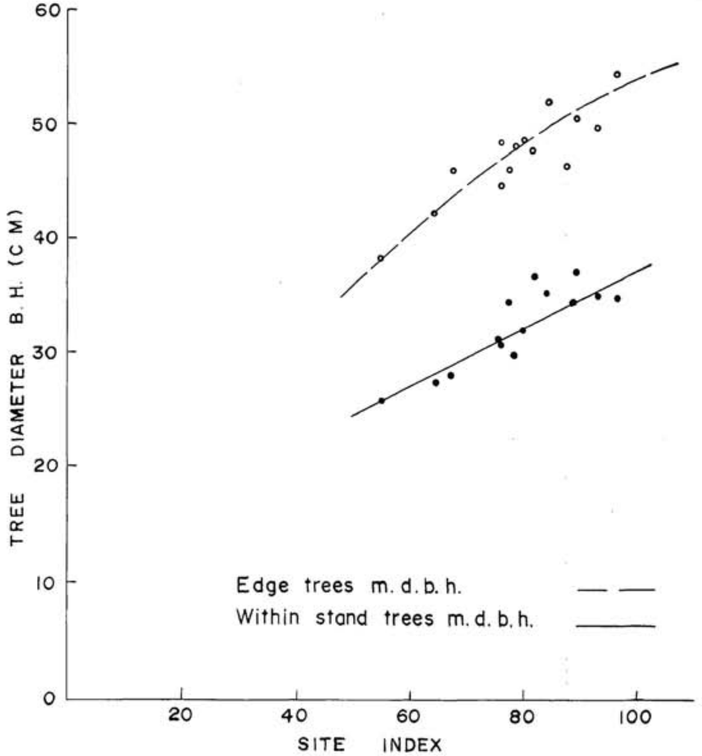

FIG. 2: *Comparison of diameters of stand edge and within-stand trees, for stands of similar age and stocking.*

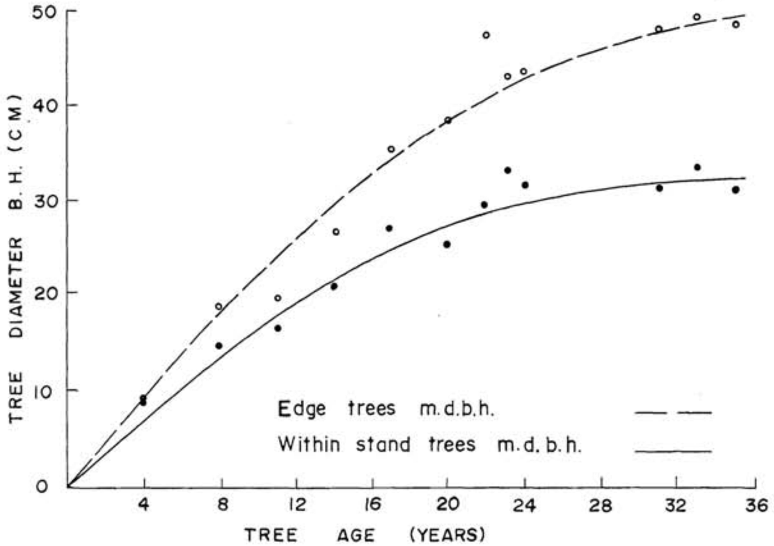

FIG. 3: *Diameter growth of stand edge and within-stand trees for stands with similar site index and stocking.*

possible with regimes involving heavy thinnings to maximize growth on crop trees.

Branch Size of Edge Trees

Branch sizes over the bottom 6 m of both edge and within-stand trees is shown in Table 1. The large branch diameters of edge trees, if occurring frequently in the same log, cause framing timber sawn from such logs to be of a low grade. As 85% of the stands at Woodhill Forest are on sites considered most suitable for the production of framing grade sawlogs, branch defects associated with edge trees are of some consequence.

Stem Form of Edge Trees

The presence of large branches down one side of the edge trees could be expected to induce one-sided tree growth and lead to elliptical growth of the bole. Measurements of ten years' radial growth by increment borings on four quartiles of the tree (facing the gap, facing the stand, and two parallel to the edge) show that little variation in growth occurs around the tree at breast height. The small differences that are found can most probably be attributed to branch base swellings.

Where stems have been pruned over at least part of the bottom log (up to 6 m), branch base swellings are absent, and no significant differences in growth can be detected around the tree at breast height. Radial growth on each of the three aspects of the tree is shown in Table 2 for both pruned and unpruned trees.

TABLE 2: RADIAL GROWTH OF EDGE TREES[1]

Site Index (m)	*Radial Growth at Breast Height (cm)*[2] *Unpruned Trees* *Outward*	*Inward*	*Sides*	*Pruned Trees* *Outward*	*Inward*	*Sides*
19.5	—	—	—	3.0	3.0	3.0
20.4	4.3	4.1	3.8	—	—	—
23.1	—	—	—	4.8	5.3	5.3
23.8	4.8	4.1	4.6	4.6	4.3	4.6
28.3	5.6	4.8	4.8	—	—	—
Mean	4.9	4.3	4.4	4.1	4.2	4.3

[1] Sample of 140 trees.
[2] Measurements were made on four quartiles — facing the gap (outward), facing into the stand (inward), and two measurements parallel to the stand edge (sides).

The taper of the bottom log of edge trees also differs from that of within-stand trees as shown in Table 3. Taper has been measured between 1.5 and 6 m above the ground. Edge trees carrying branches more or less from ground level have greater taper than within-stand trees, whilst pruned trees of both classes have similar taper.

TABLE 3: STEM FORM OF EDGE TREES

Site Index (m)	*Taper (in cm/m) from 1.5 to 6.0 m* *Unpruned Trees* *Stand Edge*	*Within-stand*	*Pruned Trees* *Stand Edge*	*Within-stand*
16.8	2.50	1.54	—	1.61
23.8	—	1.88	2.10	1.98
25.6	2.39	1.84	—	1.73
28.3	2.54	1.73	1.88	1.78
Mean	2.48	1.75	1.99	1.78

The improvement in form associated with the pruning of edge trees should result in a higher utilizable volume being produced in the more valuable bottom sawlog. Reduction in taper after pruning has also been illustrated by Adlard (1969) for *Pinus patula*.

DISCUSSION OF RESULTS

Table 1 shows that diameters of the best 400 stand edge trees per hectare, even at site indices as low as 19.5 m at 20 years, approach the mean dbh of 50 cm considered desirable for the clearwood regime at clearfelling. As almost all the stands managed for framing sawlog production have site indices between 20 and 28 m, the timely pruning of all edge trees in these stands could yield a large volume of clearwood in addition to that obtained from stands managed under the board sawlog regime. The average site index for framing sawlog stands at Woodhill Forest is about 24 m. At this site index, and with a final crop stocking of 400 stems/ha at 30 years, edge trees would achieve a mean dbh of 53 cm, whilst within-stand trees would have a mean dbh of about 38 cm. Such stands carry a volume of about 560 m^3/ha. The mean edge tree volume at a mean top height of 33 m (taken from the Woodhill tree volume table) in such a stand is 2.46 m^3, and there is one edge tree about every seven metres of stand edge. Thus, in a hypothetical square stand of 40 ha about 2.4% of all trees would be stand edge stems but, because of their relatively large size, the volume component of edge trees is 4.5%. If the edge trees were pruned to 6 m, and if a 15 cm knotty core is obtained, clearwood volume would be 2.1% of total stand volume. However, because of the long narrow shape of Woodhill Forest, stands are not regular in shape and edge tree yields are estimated at 10% of total volume.

Although stands of lower site index may not show sufficient diameter response to warrant pruning in terms of clearwood yield, the removal of branches before massive development occurs prevents degrade of an otherwise valuable log. For example, where a second thinning is practised at Woodhill, stands yield approximately 50% sawlogs and 50% pulpwood; up to half the sawlog material is produced from edge trees. Timber grade studies of radiata pine sawlogs from thinnings with a high edge tree component (Compartment 109) and clearfellings from within stands (Compartment 30) yielded the following percentage grade outturns.

Grade	*Thinning* (%)	*Clearfelling* (%)
No. 1 framing	55.2	69.8
No. 2 framing	9.5	13.0
Box	13.4	5.7
Dressing	4.8	4.8
Merchantable	17.1	6.7

To some extent the lower yield of framing timber from thinnings is due to the smaller average log diameter. However, the proportion of box, No. 2 framing and merchantable grades from thinnings is also due to the greater knot size in the edge tree portion of the sample; 40.0% as compared with 25.4% for clearfelling. As the principal cause of degrade in both studies was large branch diameter or branch-associated defect (such as bark pockets), a 5% edge tree element in any stand could be responsible for significant degrade. This is particularly true at Woodhill Forest, where Whiteside (1964) noted that very small average branch size (excluding edge trees) gave rise to high yields of framing grades. The reason for this is that the soils — recent coastal sand deposits — are deficient in nitrogen (Will, 1965; James *et al.*, 1970).

Pruning of edge trees is variously cited as having several intangible benefits. Jolliffe (1956), British Forestry Commission (1964), and Taylor (1967), consider pruning as a fire protection measure to be very valuable, particularly on the margins of conifer stands. Fires starting in scrub and grass on stand margins may otherwise quickly climb into the crowns of adjacent trees. New Zealand experience indicates that failure to prune edge trees in conjunction with pruning and thinning operations within the stand increases susceptibility to windthrow and breakage (N.Z.F.S., 1965). This is probably because of development of vertical wind turbulence and eddies behind the densely branched edge tree barrier. However, in Britain side branches down to ground level can be beneficial on exposed sites (British Forestry Commission, 1964) since opening stand edges exposes interior trees not adapted to withstanding strong winds.

It is also widely acknowledged that pruning of edge trees and within-stand trees improves access for further selective pruning, for marking for thinning, for utilization and for fire protection. Jolliffe (1956) also considered that pruning improves access for farm purposes, such as where the stand is used as shelter or grazing for stock. However, grazing is less likely to be practised in more lightly thinned stands for framing timber production.

In areas where weed control is difficult, tree canopy closure may effectively shade out and eradicate various species. Barr (1968) considers that afforestation gives good control of gorse (*Ulex europaeus*). In such situations, raising of the crown around the stand edge may permit growth of undesirable species within the stand in perpetuity. Other weeds may be beneficial; for example tree lupin (*Lupinus arboreus*) growing in stand margins at Woodhill may promote growth of edge trees by releasing significant quantities of nitrogen (Gadgil, 1971).

The encroachment of branches along the margins of forest roads and tracks, forming both an obstacle to vehicle movement and an impediment to drying out of tracks in winter conditions, is also justification for edge tree pruning. Such treatment is also considered to have aesthetic appeal.

CONCLUSIONS

Pruning of stand edge trees has a number of tangible benefits, including high potential clearwood yields at relatively low site index, and improved timber grades, especially in stands subjected to utilization thinnings for sawlog material.

There are also a number of indirect benefits. These include: improved fire protection; increased wind stability in pruned and thinned stands; better access into the stand for marking, utilization, grazing and fire protection; removal of roadway obstacles; and enhanced appearance.

There are also disadvantages, including the invasion of stands by undesirable weed species, and increasing the hazard of windthrow by exposing within-stand trees.

The findings have relevance to current ideas on growing radiata pine sawlogs on short rotations for the production of high grade boards, under an intensive tending regime.

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