CHANGES IN TREE DOMINANCE AND FORM IN A YOUNG RADIATA PINE STAND

W. R. J. SUTTON

Forest Research Institute, New Zealand Forest Service, Rotorua

(Received for publication 20 March 1973)

ABSTRACT

In a low-stocked, unpruned and unthinned radiata pine (**Pinus radiata** D. Don) stand on malformation-prone scoria soils, the proportion of dominants increased from 35% at height 5 m to 50% at 9.5 m, but had decreased to 37% by 12.5 m. There was some interchange of dominance; only 68% of the final dominants were dominant at all assessments. Some trees dropped in status to regain it later.

Of trees of acceptable form at 5 m only 49% were still of the same form and dominance by 12.5 m, yet the total number of such trees at 12.5 m was the same as at 5 m. This anomaly is explained by the unexpected result that half of the original terminally defective stems outgrew their malformation.

Experienced officers differed in their opinions of the best 400 stems/ha at height 5 m. Despite this and the subsequent interchanges of both dominance and malformation status, 35-40% of the selected stems were still of good form by height 12.5 m. This suggests that these stands can be reduced to 500-600 stems/ha at the time of first pruning and still provide adequate selection for a final crop of 200 stems/ha.

These results suggest that current priorities in pruning selection are not correctly based. Dominance can be maintained by adequate thinning; leader malformation has an even chance of recovery; therefore, stem malformation, as it is permanent, should be the primary basis for selection. The condition of the leader should be the second basis and relative dominance the third.

INTRODUCTION AND OBJECTIVES

Past pruning in New Zealand radiata pine (*Pinus radiata* D. Don) has rarely achieved the objective of a fully-stocked final crop of pruned stems. There are many possible explanations for the loss of pruned stems. This study investigates three aspects which may influence stem losses or may be important in early tree selection. These are:

(a) the changes in individual tree dominance between the time of an early pruning selection (assumed to be at height 5 m) and the time of a late, final, butt log pruning lift (assumed to be at 12.5 m);

(b) the incidence and possible changes in malformation occurring between assessments;

(c) the feasibility of selecting potential final crop trees at the time of the first selection (5 m).

STUDY AREA AND METHODS

The area selected for the study was on the volcanic scoria soils of the northern boundary of Kaingaroa Forest. This area is noted for the high incidence of malformation, especially terminal dieback, much of which occurs when the trees are between about 6 and 11 m high. In the area selected, only 22% of the trees were of good form by height 12.5 m, compared with over 60% for similar stockings on the Woodhill sands (Sutton, 1967).

The area selected had a low stocking (1600 stems/ha) and would be representative of that obtained from an initial spacing of 3 m × 2 m.

Within a 0.2 ha plot all trees were permanently numbered. Dominance and malformation were assessed when the mean height of the crop trees (MCH), i.e., dominants, was 5, 9.5 and 12.5 m. Malformation was not assessed at the 9.5 m assessment. All three assessments were made by the same officers.

At the first assessment (5 m), five experienced research officers individually selected the equivalent best 200 stems/ha and 400 stems/ha in the plot.

RESULTS AND DISCUSSION

Changes in Dominance between Assessments

The assignment of dominance status must be subjective as there are no measurable criteria for assessment. In this study, however, borderline trees were uncommon and were never more than 2% of the total stocking. This suggests that differences between assessments would be significant when only about 1%.

The proportion of trees by crown classes at each assessment is given in Table 1.

TABLE 1—Crown classification

Percentages at the three assessments

Assessment	Dom. ht. at assessment m	Total stems/ ha	Crown class Dom. %	Co-dom. %	Subdom.* %	Dead %
1	5	1600	35	40	25	0
2	9.5	1600	50	28	22	0
3	12.5	1595	37	37	26	(0.3)

* includes suppressed trees

The percentage of dominants increased from 35% (554 stems/ha) at 5 m to 50% (806 stems/ha) at 9.5 m, but dropped back to 37% (590 stems/ha) by height 12.5 m.

An increase of about 250 stems/ha in the number of dominants between the first and second assessment was unexpected. It suggests that not all potential dominants are apparent by MCH 5 m. The decrease in the number of dominants between the second and third assessments was expected with the increase in stand competition.

As the basis for many selection systems is dominance it is important to know the dominance development of individual trees. Table 2 shows the earlier dominance development of the trees which were dominants and co-dominants at the third assessment.

TABLE 2—Interchange of dominance between the three assessments

A. Of the 590 stems/ha which were dominant at the third assessment:		
68%	(400 stems/ha)	were dominant at all three assessments
23%	(135 stems/ha)	were co-dominant at the first; dominant at the second
7½%	(45 stems/ha)	were co-dominant at both the first and second
1½%	(10 stems/ha)	were dominant at the first; co-dominant at the second
B. Of the 590 stems/ha which were co-dominant at the third assessment:		
40½%	(237 stems/ha)	were co-dominant at all three assessments
4%	(25 stems/ha)	were dominant at the first; co-dominant at the second
18½%	(109 stems/ha)	were dominant at both first and second
23%	(134 stems/ha)	were co-dominant at the first, dominant at the second
4%	(25 stems/ha)	were subdominant at the first, co-dominant at the second
10%	(60 stems/ha)	were subdominant at both first and second

Interchange in dominance has taken place between assessments even to the extent of 1.5% of initially dominant trees dropping in status and then regaining their original dominant status. However, despite these interchanges 68% of the dominants at the 12.5 m assessment (25% of the total stocking) remained dominant at all three assessments. In theory, therefore, a selection system based on pruning the best tree in four should include most of the potential future dominants up to the time of the first thinning (rarely later than 12-13.5 m for radiata pine for most areas in New Zealand—James *et al.*, 1970). This aspect is discussed later under the selection results.

Changes in Malformation

Classification by normal and malformation classes was attempted at the first and third assessments. The standard of acceptability for normal trees was very similar to that proposed in the Selection Manual (NZFS 1968; 1971) which is in current use on many New Zealand forests. Within the co-dominants there was some emphasis on size as well as form; small co-dominants, for example, could be regarded as malforms although they had no serious malformation. Summarised results by dominance classes are given in Table 3.

TABLE 3—Stem acceptability by dominance classes at first and third assessments

Dominance class	Stand ht. at assessment (m)	Stocking/ha (% of total stocking) Acceptable form	Malformed	Total
Dom.	5	282 (18)	272 (17)	554 (35)
	12.5	278 (17)	312 (20)	590 (37)
Co-dom.	5	277 (17)	372 (23)	649 (40)
	12.5	80 (5)	510 (32)	590 (37)
Subdom.*	5	204 (13)	193 (12)	397 (25)
	12.5	NA†	NA	415 (26)
TOTAL	5	763 (48)	837 (52)	1600 (100)
	12.5			1595 (100)

* includes suppressed
† not assessed

Table 3 shows that for the dominants the number of well formed trees is almost the same at both assessments, but for co-dominants such trees decrease to about a third. This result is surprising because dominants are generally regarded as being more prone to malformation than co-dominants. It suggests that there must either be very little malformation occurring within the dominants between heights 5 and 12.5 m or that the co-dominants recruited to dominant status were almost all of good form. The other possible explanation is that some trees first classified as malformed later become acceptable.

Analysis of these aspects is given in Tables 4, 5 and 6.

TABLE 4—Development of initially acceptable trees between first and third assessment

Crown class of acceptable stems at 5 m		Form at 12.5 m Acceptable form Dom.	Co-dom.	Malformed total*	TOTALS
Dominant	stems/ha	124	15	143	282
	%	44	5	51	100
Co-dominant	stems/ha	59	15	203	277
	%	21	6	73	100

* Includes subdominant and suppressed stems which may be of good form but which are too small to be acceptable

Table 4 shows that of the initial 282 dominants/ha acceptable at height 5 m only 139 stems/ha (or 49%) are still of acceptable form by height 12.5 m. For the 277 initially acceptable co-dominants the loss due to subsequent malformation is even greater; only 74 stems/ha (or 27%) remained acceptable. This result suggests, and Table 5 confirms, that the co-dominants are more prone to malformation than the dominants.

TABLE 5—Primary reason for non-acceptability at third assessment of acceptable stems at first assessment

Malformation type	Originally aceptable form Dominants Stems/ha	%	Co-dominants Stems/ha	%
Double or multiple leader	34	12	64	24
Dead top (terminal dieback)	25	9	44	16
Stem distortion (kinks) 2nd log	15	5	25	9
Too small to be acceptable*	—	—	20	7
Total now unacceptable	74	26	153	56
Acceptable stems	208	74	124	44
Totals	282	100	277	100

* trees only recorded as being too small if no malformation present

The presence of dead tops equivalent to terminal dieback is generally regarded as a feature of trees on the scoria soils of the northern boundary of Kaingaroa Forest. Incidence of dead tops in this trial was, however, limited to only 9% of the initial dominants and 16% of the co-dominants. It is reasonable to assume though that stem distortions or kinks in the second log are almost always the result of a dead leader. Malformation caused by dead top or terminal dieback should, therefore, be the combined result of dead top and stem distortions. This makes terminal dieback the most important cause of between-assessment malformation, accounting for the loss of 14% of the dominants and 25% of the co-dominants. It is, therefore, a slightly more important cause of malformation than double or multiple leader (some of these could also be the result of leader dieback). It is of interest to note that *no* leader or terminal dieback was observed at the 5 m assessment, which suggests that this malformation type is unlikely to occur before this height.

The results in Table 4 indicate that the continuation of a more or less constant number of acceptable dominants cannot be explained by a relative absence of malformation in trees which have either remained dominant or been recruited from a co-dominant status. The only explanation is that trees once regarded as unacceptable have outgrown their malformation and become acceptable. That this has happened is shown in Table 6. Of the 356 stems/ha currently regarded as acceptable, 118 stems/ha (or 33%) were originally regarded as malformed. Considering the dominance classes separately the dominants appear to have a greater chance of outgrowing malformation than the co-dominants, recoveries being 24% for dominants and 9% for co-dominants.

TABLE 6—Malformation status at first assessment of stems acceptable at third assessment

Current dominance status		Always acceptable	Originally malformed	Totals
Dominant	stems/ha	193	84	277
	%	54	24	78
Co-dominant	stems/ha	45	34	79
	%	13	9	22
Total	stems/ha	238	118	356
	%	67	33	100

An analysis of the initial (5 m) assessment showed that there was a total of 243 stems/ha which were dominant or co-dominant and for which the major malformation was a double or multiple leader occurring in the upper portion of the tree. As the criteria for acceptability were the same in both assessments, it follows that the 119 stems/ha which were once malformed but are now of good form must have been originally included in these 243 stems/ha. This represents an improvement in form of 49% of the dominant and co-dominant trees. This result suggests that to eliminate trees solely because of the present condition of the tree terminal is wrong. It could also explain why some well-formed trees have apparently been missed in earlier pruning and why stands of young, badly-formed trees often eventually become acceptable. Interchange of malform status may be as important as the interchange of dominance status. The implications for management are discussed later.

Assessments of malformation in adjacent stands thinned to the final crop stocking at the completion of butt log pruning indicate that malformation in stands above 10.5 m tall is comparatively rare; a maximum of about 5% of the stems had any malformation between heights of 10-17 m. This result suggests that even on these sites malformation is not important after crop selection at the time of final butt log pruning.

The Feasibility of Selecting Potential Final Crop Trees at 5 m

At 5 m stand height, five experienced research officers selected those trees which they considered were the best 200 and 400 stems/ha. There was no restriction on time but some problems were experienced in selecting exactly the specified number of stems.

Because of the choice available, there were differences in selections between individual officers. In the 200 stems/ha selection, only 54 trees (or 27%) were chosen by four or more officers; in the 400 selection, 158 trees (or 40%) were chosen by four or more. What is of more practical interest, however, is how successful individuals were in selecting currently acceptable stems. Results for the individual officers are given in Table 7.

TABLE 7—Stocking of stems selected at first assessment acceptable at third assessment

Officer	Trees of initial selections remaining acceptable			
	200 stems/ha selection		400 stems/ha selection	
	stems/ha	%	stems/ha	%
A	69	35	153	39
B	94	47	144	36
C	84	43	146	37
D	79	40	158	40
E	89	45	153	39

The results indicate that, even with the known interchange of dominance and malformation status, the individual officers were moderately successful in selecting crop trees. The least successful 200 stems/ha selection (officer A) still had 69 stems/ha (35%) of acceptable trees remaining at height 12.5 m. Similarly, the worst 400 stems/ha selection (officer B) still had 144 (36%) stems/ha of acceptable trees remaining at height 12.5 m. This suggests that even on these malformation-prone sites we could expect 35-40% of stems selected at height about 5 m to be still acceptable by height 12.5 m. This means that the stand could be reduced to about 600 stems/ha at about 5 m and still have enough stems to provide an adequate selection of an acceptable final crop (assuming 200 stems/ha will be required) at around 10-12 m height.

GENERAL DISCUSSION AND IMPLICATIONS FOR MANAGEMENT

The observed interchange of dominance status suggests that the emphasis placed on dominance in early selection for pruning is unnecessary. Further support for this view comes from two other sources:

1. In the Forest Research Institute (FRI) Economics Group's demonstration thinning

trial at Kaingaroa, co-dominant and subdominant trees were released by thinning at a stand height of 9 m. These trees showed an obvious capacity to respond to the thinning; the response, however, was not so apparent where the thinning was delayed.
2. The co-dominant pruning treatment in the FRI pruning trials at Kaingaroa demonstrated that very severely pruned co-dominants are capable of sustaining growth, even in unthinned stands (Sutton and Crowe, 1972).

With the current trend towards early thinning of stands at the time of first pruning, any chance of trees losing dominance through competition is almost eliminated. The implication for management is that dominance is not necessarily of major importance in pruning selection; preference should be given to dominants only when tree form is equal.

The unexpected result of this study is the improvement in malformation status. Half of the stems considered unacceptable at 5 m because of leader malformation had sufficiently outgrown this defect to be acceptable again by height 12.5 m. This result provides a satisfactory explanation of at least some of the failures of early selection to ensure that every acceptable stem is pruned. It also implies that leader malformation is less important than malformation of the lower stem as the latter is permanent and results in an increase in the size of the knotty core, which reduces both clearwood and overall sawn yields.

However, despite the problems of interchange of dominance and malformation status, the relatively low stocking (equivalent to 3 × 2 m initial spacing), and the relatively high incidence of malformation, it is possible for conscientious operators to select crop stems at about 5 m and be reasonably certain that at least 35% of them will have acceptable form by height 12.5 m. These stands could be reduced to 500-600 stems/ha at height 5 m and still have enough stems to provide adequate selection of a final crop of 200 stems/ha at 10-12 m. Very little malformation can be expected for stand heights above this.

THE PRUNING AND THINNING SELECTION MANUAL

The pruning and thinning selection manual (NZFS, 1971) is now the standard on which most forests base their selection.

The booklet states that the order of importance in tree selection should be:
1. Relative dominance and vigour.
2. Condition of leader (top 5 ft or 1.5 m).
3. Straightness of first 20 ft (6 m).

Since dominance can be maintained by adequate thinning, and leader malformation has at least some chance of recovery, stem malformation, as it is permanent, must be regarded as the primary basis for selection. Thus, the order of priority in pruning selection should be:
1. Straightness of the stem.
2. Condition of the leader (top 1.5 m).
3. Relative dominance and vigour.

ACKNOWLEDGMENTS

The writer wishes to acknowledge the assistance of Mr J. B. Crowe who did all the assessments and selections as well as the basic calculations, and Messrs J. O. Drewitt, J. R. Tustin and G. R. Whiteside who carried out the early selections. The helpful comments of Mr G. Duff are also gratefully acknowledged.

REFERENCES

JAMES, R. N., TUSTIN, J. R. and SUTTON, W. R. J. 1970: Forest Research Institute Symposium on Pruning and Thinning. **New Zealand Journal of Forestry 15 (1):** 25-6.

NEW ZEALAND FOREST SERVICE 1968: Radiata pine—A Basis for Selection of Trees for Pruning and Thinning. First Edition (R. E. J. Wylie).

——— 1971: Radiata pine—A Basis for Selection of Trees for Pruning and Thinning. Third Edition (I. A. Frost).

SUTTON, W. R. J. 1967: Effects of initial spacing on branch size and the incidence, type and severity of malformation in **Pinus radiata** on the coastal sands at Woodhill. **New Zealand Forest Service, Forest Research Institute, Silviculture Branch Report No. 89** (unpublished).

SUTTON, W. R. J. and CROWE, J. B. 1972: Pruning of **Pinus radiata** dominants. Part IV. Effects of pruning on dominance, growth and stem characteristics. **New Zealand Forest Service, Forest Research Institute, Economics of Silviculture Branch Report No. 53** (unpublished).