EVALUATION OF DIAMETER DISTRIBUTION AS A CRITERION FOR SELECTING CROP TREES IN A PULPWOOD REGIME

R. N. JAMES

Department of Forestry, Australian National University,
Canberra, A.C.T. 0200, Australia

and S. O. HONG

New Zealand Forest Research Institute,
Private Bag 3020, Rotorua, New Zealand

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ABSTRACT

An attempt was made to create a crop of plantation-grown *Pinus radiata* D.Don with more uniform diameter dimensions by selecting residual crop trees at age 8 from co-dominants with diameters close to the stand mean ("uniformity" thinning). A crop selected at age 7 by the conventional "from below" method was used for comparison. In both crops stocking rate was reduced from 2500 to 500 stems/ha to simulate a pulpwood thinning regime. The diameter range was reduced by uniformity thinning to the point where stands carried almost the same basal areas despite the difference in age of 1 year. After uniformity thinning, growth in basal area was slower for the first 3 years; it then increased to equal that of the conventionally thinned plots. By age 28 there was no significant difference in diameter distribution of crop trees selected by either method. It is unlikely that the final distribution of stem diameters in plantation-grown *P. radiata* can be altered for more than a few years by thinning to a restricted diameter range.

Keywords: thinning; pulpwood; plantation silviculture; *Pinus radiata*.

INTRODUCTION

This paper presents results from a study aimed at production of crop trees of uniform dimensions for industrial pulpwood processing. The Tarawera Valley Regimes Trial, of which this study formed a part, was located in a forest managed by Tasman Forestry Ltd near the town of Kawerau, New Zealand. The trial, in stands planted in 1963 with *Pinus radiata* from an unimproved seedlot, was established in 1969 at the invitation of Tasman Forestry Ltd. It was designed to compare 24 regimes applied to adjacent stands planted at 1.3, 1.8, 2.1, and 2.7 m square spacing. The trial objective was to obtain data on stand growth and quality which would aid the design of regimes for a number of wood product objectives. A full description of the treatments and earlier results has been presented previously (James 1976).

Various regime options for the production of pulpwood for the stone groundwood process were tested. This process differs from the currently more common refiner groundwood process in that it uses billets (or small logs) which are forced against a revolving grindstone. Power requirements and the shape of the grindstone impose limits on the size of the billet and the process operates most efficiently if piece size is uniform with a maximum diameter about 35 cm.

Choice of regimes aimed at definition of appropriate silvicultural treatment for pulpwood crops involved testing a range of final-crop stockings derived from four initial stocking rates. It was thought that variation in timing of thinning was less important than variation in final-crop stocking rate because thinning for pulpwood crops included early reduction or elimination of malformed and less productive trees and the transfer of the growth potential of the site on to the crop trees. Final-crop stocking rates tested for pulpwood regimes ranged between 500 and 1000 stems/ha, although the range over the whole trial was 380 to 5900 stems/ha (unthinned controls). Growth in basal area and development of stand diameter distributions were monitored by annual measurement.

The objective of this study was to ascertain whether restriction of the tree diameter range at time of thinning would reduce stem diameter variability at time of harvest.

METHODS

Stand Selection

The study was carried out in stands planted at 2.1 m spacing (2500 stems/ha). Only plots at the highest and lowest final stocking rates were measured for height. In unthinned control plots and plots thinned to 380 stems/ha, average plot mean top height increased from 13.5 m at age 7 to 44.5 m at age 28 years.

Diameter at breast height (1.4 m) of each tree was measured annually. Stand basal area and within-stand diameter distribution were calculated for each year between 1970 and 1990.

Plot Layout

Individual plots were hexagonal in shape and were laid out in a honeycomb arrangement. Although originally surveyed in imperial units, each was almost exactly 0.06 ha in area and was surrounded by a 10-m-wide buffer (0.12 ha) receiving identical treatment. Measurements were made in the inner plot only. Standing basal area was assessed in all plots before treatment. Plots were then ranked in order of basal area and allocated to high, medium, and low categories. Each treatment was applied to one plot selected at random from each of these groups. Hexagonal plots can be divided radially by line-of-sight into six triangles of equal area. During thinning, the same number of residual crop trees was allocated to each triangle.

Thinning for Uniformity

Two treatments designed to restrict the range of diameters in crop trees were compared. In 1970 one set of plots was thinned to 500 stems/ha using the "from below" selection method (Treatment 1—"conventional" thinning). In 1971 a second set of plots was thinned by selecting 500 stems/ha that had diameters closest to the mean diameter calculated for the stand as a whole. This "uniformity" thinning (Treatment 2) involved identification of all trees in the 6- and 7-inch (14- to 19-cm) diameter classes, and selection from them of evenly spaced individuals that were free from malformation.

Statistical Analysis

Effects of the two treatments on mean diameter were compared immediately after thinning and at age 28 years. Unpaired t tests were used to compare plot means and coefficients of variation. The shapes of the diameter distributions were compared by application of the three-parameter Weibull function, which has been widely used for predicting and quantifying diameter distributions of forest trees (Bailey & Dell 1973; Lee 1990). The Weibull function for probability density is:

$$F(X) = \left(\frac{C}{B}\right) \left(\frac{X-A}{B}\right)^{C-1} e^{-\left(\frac{X-A}{B}\right)^{C}}$$

where A, B, and C are the parameters for location, scale, and shape of the distribution, respectively. All statistical analyses were carried out using the statistical software package Genstat 5 (1995).

RESULTS

Basal areas of the residual crops were very similar even though the thinnings had been carried out 1 year apart (Table 1). As expected, Treatment 2 (uniformity thinning) resulted in reduction of the range of diameters present, reduction in the numbers of stems in the smallest- and largest-diameter classes, and an increase in the number of stems in the class nearest the mean value (Table 2). By age 28, mean basal area resulting from each treatment was also similar. Six trees had died in Treatment 1 and seven in Treatment 2.

TABLE 1–Basal area resulting from conventional or uniformity thinning (m^2/ha)

	Aged 7	Aged 8	Aged 28
Treatment 1: 500 stems/ha—conventional	12.09	16.51	76.73
	10.70	14.78	62.44
	10.30	14.43	66.34
Mean	11.03	15.24	68.50
Treatment 2: 500 stems/ha—uniformity		11.33	66.23
		11.85	73.13
		11.47	57.80
Mean		11.55	65.72

Stand basal area growth between ages 7–8 and 28 years was slower after uniformity thinning than after conventional thinning during the first 3 years (Fig. 1). From 1973, growth rate increase in the uniformity plots was relatively greater, and by age 28 the mean plot values were similar.

Unpaired t-tests used to compare plot means immediately after thinning (ages 7 and 8) and at age 28 showed that neither diameter nor the coefficient of variation of diameter was significantly different at the 5% level (Table 3).

TABLE 2–Diameter frequency distribution resulting from conventional or uniformity thinning

Size class (cm)	Treatment 1: conventional at 7 years	Treatment 2: uniformity at 8 years
12	2	
14	19	9
16	31	27
18	25	43
20	8	10
22	4	1
24	1	
Total	90	90

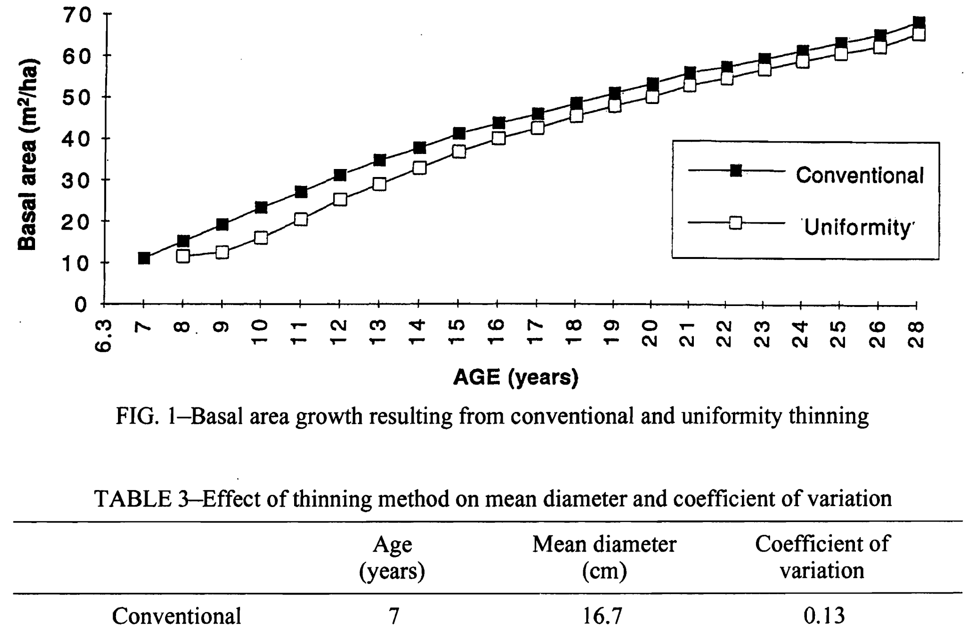

FIG. 1–Basal area growth resulting from conventional and uniformity thinning

TABLE 3–Effect of thinning method on mean diameter and coefficient of variation

	Age (years)	Mean diameter (cm)	Coefficient of variation
Conventional	7	16.7	0.13
Uniformity	8	17.2	0.10
Conventional	28	42.8	0.19
Uniformity	28	42.1	0.19

Fitting the three-parameter Weibull function (Table 4; Fig. 2 and 3) indicated that the fitted distributions for data collected after thinning (ages 7 and 8) had different shapes. After uniformity thinning trees showed an approximately normal distribution (shape parameter 3.30), whereas the conventionally selected crop showed a skewed distribution (shape parameter 2.27). By age 28 the fitted distributions were very similar, both conforming approximately to the shape of a normal curve (shape parameters 3.10 and 3.93 for the uniformity and conventional crop respectively). Shape parameters were within the range of

TABLE 4–Parameter estimates and standard errors for fitted Weibull functions

Thinning treatment	Age	Values of Weibull parameters					
		A	s.e.	B	s.e.	C	s.e.
Conventional	7	11.88	0.72	5.44	0.91	2.27	0.49
Uniformity	8	12.32	1.51	5.41	1.62	3.30	1.16
Conventional	28	13.95	7.06	31.79	7.54	3.93	1.07
Uniformity	28	20.79	6.26	23.86	6.93	3.10	1.06

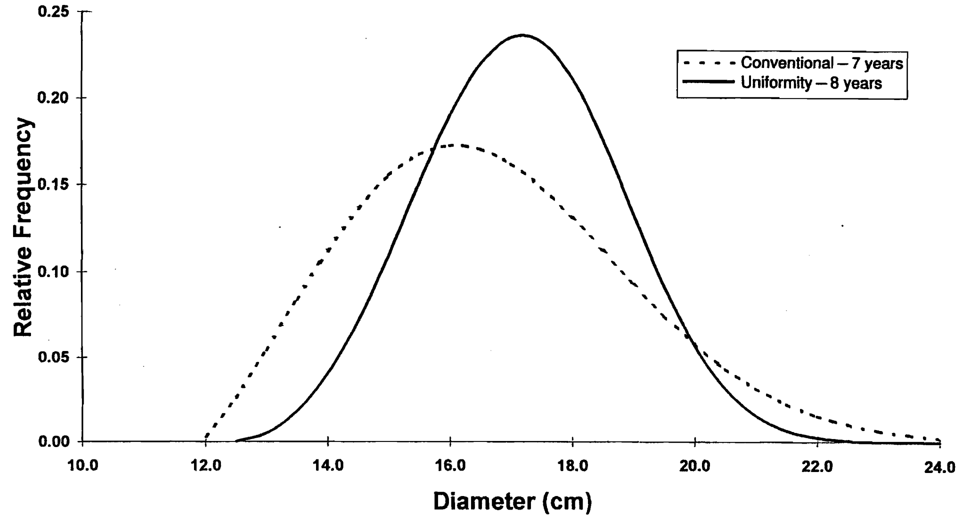

FIG. 2–Initial diameter distribution fitted to Weibull model

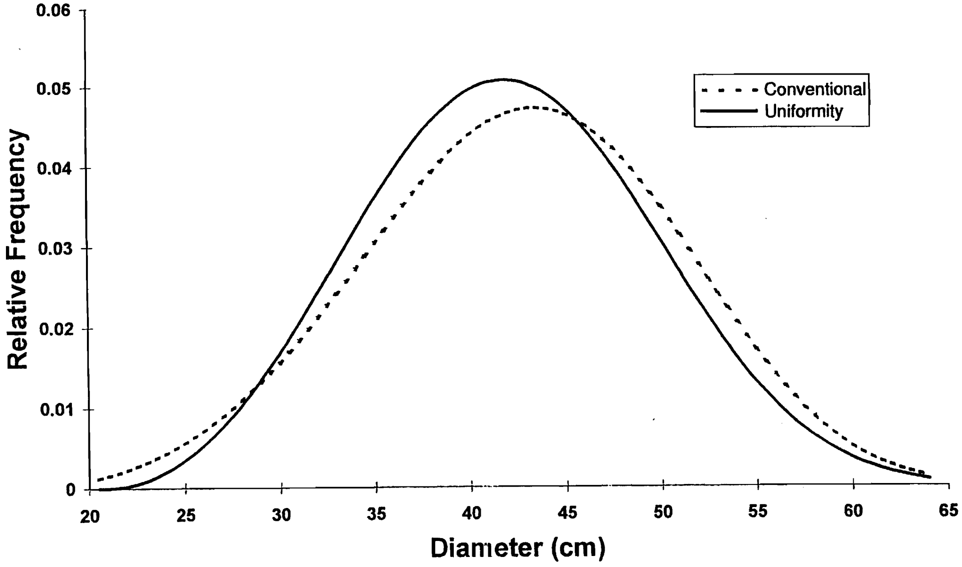

FIG. 3–Diameter distribution at 28 years fitted to Weibull model

their standard errors, indicating that there was no significant difference between the shapes of the distributions resulting from the two treatments.

Actual diameter distributions (all plots within treatments combined) at ages 7–8 and 28 years are shown in Fig. 4.

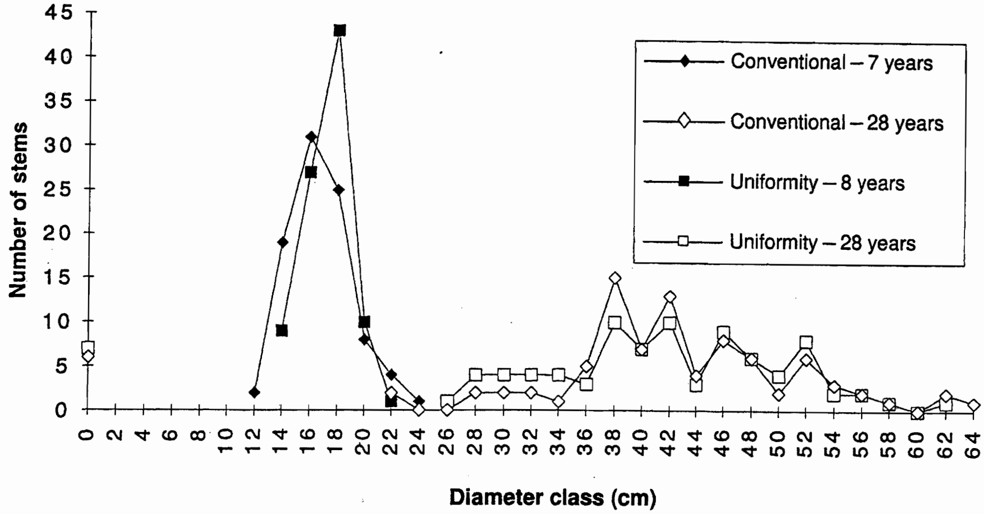

FIG. 4—Actual diameter class distributions

DISCUSSION

One of us (RNJ) clearly recalls that the trees remaining after the uniformity thinning were exclusively co-dominants. Conventionally selected crop trees were a mixture of dominants and co-dominants. Uniformity thinning had effectively "set back" stand basal area growth by 1 year since, although numbers of stems per hectare and stand basal areas were the same immediately after treatment, the plots thinned for uniformity were 1 year older.

The study showed that use of diameter distribution as the major criterion for crop selection did not increase diameter uniformity at time of harvest. At age 28 the crop derived from uniformity thinning had virtually the same diameter distribution as that derived from conventional thinning. Uniformity thinning did have an early effect; initial increment in basal area was reduced for about 3 years (Fig. 1). This was to be expected. Trees in lower dominance classes have a lower leaf area than dominants, a lower rate of photosynthate production, and hence a slower growth rate. Resumption of normal growth after 3 years can be attributed to increase in crown size that follows thinning. These effects were discussed by Oliver & Larson (1990, p.223) who claimed that among relatively tall trees those with deep crowns of medium size use growing space more efficiently than trees with larger crowns. Co-dominants left after uniformity thinning would have had medium size crowns which probably deepened in response to increased light availability after thinning. The effect of crown size on growth has been noted in other species. O'Hara (1988) found that after thinning the rate of growth of *Pseudotsuga menziesii* (Mirb.) Franco increased in the order suppressed→ intermediate→co-dominant trees.

Although data are available from only one trial, the results make it clear that little confidence can be placed in any attempt to control stand diameter distribution in *Pinus radiata* by varying the method of crop selection. The technique might be successful for pine species which can be described as non-differentiating (e.g., those in the southern pines group). It might be amenable to manipulation by genetic means such as the use of clones. The evidence presented here confirms that *P. radiata* has a strong tendency to differentiate into dominance classes and suggests that this can only be temporarily delayed by selecting a crop on the basis of uniform diameter.

CONCLUSION

An attempt to manipulate final stand diameter distribution in plantation-grown *P. radiata* by selecting crop trees from the middle of the diameter range during thinning at age 8 was unsuccessful. At maturity, both mean diameter and diameter distribution in the crop resulting from uniformity thinning were similar to those of trees selected by conventional means. This was despite temporary reduction in stand basal area growth rate immediately after uniformity thinning.

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