DIAMETER GROWTH OF A SLASH PINE SPACING STUDY FIVE YEARS AFTER BEING THINNED TO A CONSTANT STAND DENSITY INDEX

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Abstract—In 1994, a 17-year old, slash pine (*Pinus elliottii* var. *elliottii*) spacing study was thinned to evaluate the influence of prethinning stand conditions on diameter growth after thinning. Diameter growth and crown dimensions measured just prior to thinning showed that diameter growth was positively related to both initial spacing and average crown dimensions. After thinning, these relationships almost immediately disappeared. The first year after thinning, diameter growth was significantly affected by only the initial 8 x 8-foot spacing treatment and was unrelated to prethinning crown dimensions. From the second to the fifth year after thinning, neither initial spacing nor prethinning canopy dimensions significantly influenced diameter growth. Within the fourth and fifth years after thinning, diameter growth appeared to become inversely related to prethinning crown dimensions, but the pattern was not statistically significant.

INTRODUCTION

Stand density is a major factor that a forester can manipulate in developing a stand. Foresters attempt to maintain stand density in a range that fully utilizes the site for maximum production of desirable, usable volume. By controlling stand density, silviculturists are able to influence species establishment, modify stem quality, rate of diameter growth, and volume production during stand development (Daniel and others 1979). In plantations, density is controlled through initial spacing of seedlings and with thinning. Silviculturists must make a compromise between individual tree growth and total stand growth when choosing appropriate planting spacing. At relatively close initial spacings, stand yields are usually highest, whereas individual tree growth is normally best at relatively wide spacings (Long 1985). Thinning is an important silvicultural practice for improving tree growth by redistributing growth and increasing the growth rates of residual trees. It also allows forest managers to select trees to which additional growth will be allocated.

Many stand density measures are considered expressions of the average area occupied or average area available per tree relative to some standard condition (Curtis 1970). Reineke's stand density index (SDI) (Reineke 1933) expresses stand density in terms of the equivalent number of trees in a stand at a standard diameter of 10 inches ($SDI = TPA (QMD/10)^{1.6}$ where TPA = number of trees per acre and QMD = quadratic mean diameter (inches) at breast height). Advantages of using SDI as a measure of stand density are that it is independent of site, age, and species and is easily calculated.

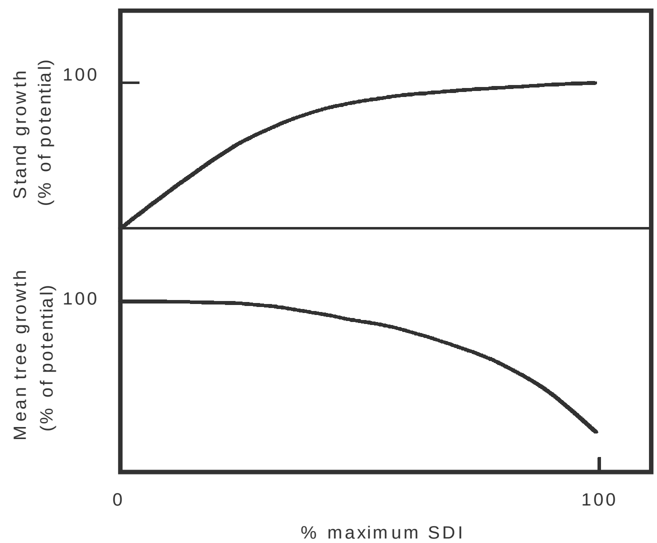

Figure 1—Hypothetical relationship between current annual growth and level of growing stock

Long (1985) illustrated the general relationship between current annual stand and individual tree growth as related to growing stock (figure 1). Relative SDI expresses growing stock relative to the species maximum SDI. The maximum SDI for slash pine is 450 (Dean and Jokela 1992). Since both stand and tree growths are functions of growing stock, stands of the same age and growing on the same site should have equal growth rates. When thinning is involved, however, potential tree growth is probably more strongly related to stand density prior to thinning for some time after thinning.

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The overall purpose of this research is to analyze the magnitude and the duration of the effects of prethinning stand conditions on diameter growth after thinning. With the expectation that plots thinned to a common SDI should exhibit the same growth rate, any differences in growth should be due to stand conditions prior to thinning.

METHODS

The study area is located about 1 mile east of Woodworth, LA, on the Alexander State Forest, which is managed by the Louisiana Office of Forestry. The soil is a Kolin silt loam with a clayey lower subsoil that restricts internal drainage. However, a slight slope in topography allows adequate surface runoff. This study was installed in the winter of 1976-1977 with planting stock from a single seed orchard of genetically improved parents. Seven spacing treatments (4 x 4, 4 x 6, 6 x 6, 6 x 8, 8 x 8, 10 x 10, and 14 x 14 feet) were randomly assigned to plots within five blocks. Each measurement plot consisted of 8 rows of 8 trees. A one-half chain (33 feet) isolation strip surrounded each measurement plot with trees of the same spacing.

At age 17, all plots within three of the blocks were thinned to 35 percent of the maximum SDI. Three of the spacing treatments were not included in this study. An ice storm shortly after thinning eliminated the 4 x 4 and 4 x 6 spacings from the study, and the 14 x 14 spacing was not used because the average stand density was too low for it to be thinned when the thinning treatments were applied. Additional information about the plots and the original study can be found in Ferguson and Baldwin (1995) and Baldwin and others (1995).

Trees were measured at age 15 years and before and after thinning at age 17 years. The trees were measured annually after thinning until age 22 years for five growth intervals after thinning. Field measurements consisted of diameter at breast height, height to live crown, total height, crown width in two directions at right angles, and crown class was also noted.

Diameter growth was analyzed for each age with a randomized complete block design. Correlation analyses were used to analyze the effect of initial spacing and prethinning crown dimensions on diameter growth after thinning using the simple correlation coefficient. Prethinning crown dimensions consisted of crown width (C_{W0}), crown length (C_{L0}), and crown ratio (C_{R0}). Crown width represents the span of the crown of a tree. Crown length represents the average length of the individual live crown. Crown ratio is the average ratio of crown length and total tree height per plot and is important in maintaining diameter growth and is related to stand density. All significant differences were tested at the 10percent significance level.

RESULTS

Average stand diameter growth of the trees for the different spacings at each age were compared (figure 2). Prior to thinning, diameter growth was strongly and negatively related to stand density. Initial spacing ceased to have any systematic effect on diameter growth the first year after thinning. While initial spacing significantly affected diameter growth one year after thinning, the effect was due to the diameter growth in the 8 x 8-foot spacing. There was no significant difference in diameter growth between the 6 x 6, 6 x 8, and the 10 x 10-foot spacings the first year after thinning (figure 2). The influence of initial spacing on diameter growth diminished each year after thinning as evidenced by the increasing probability of a greater F value from age 19 to 22 years.

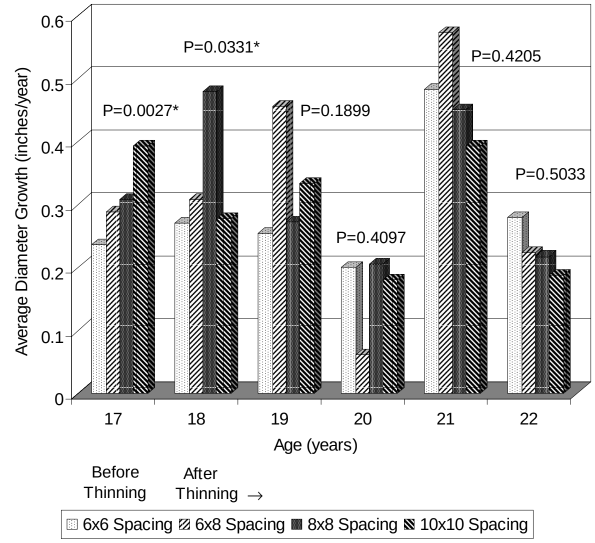

Figure 2—Average diameter growth for each spacing at age 17 before thinning and ages 18-22 after thinning for slash pine near Woodworth, LA

In addition to initial spacing, diameter growth before thinning was strongly related with crown size. Simple correlation coefficients between diameter growth and crown width, crown length, and crown ratio ranged from 0.81 to 0.86 (table 1). One year after thinning and thereafter, however, no correlation existed between diameter growth and crown size prior to thinning. Between the ages of 18 and 20 years, the simple correlation coefficients did not exceed 0.12 (table 1). Four and 5 years after thinning, the correlation

Table 1—Correlation coefficients relating initial spacing and prethinning crown width, crown length, and crown ratio to average mean diameter growth at age 17 (before thinning) and ages 18-22 (after thinning) for slash pine near Woodworth, LA

Correlation Coefficients (r)						
Age	17	18	19	20	21	22 p
C_{W0}	0.81	0.12	0.05	0.07	-0.37	-0.35
C_{L0}	0.86	0.01	-0.02	0.11	-0.33	-0.26
C_{R0}	0.84	0.12	0.06	0.07	-0.36	-0.39

coefficient became increasingly negative suggesting that diameter growth was becoming inversely related to initial spacing; however, the coefficients were not statistically significant ($P > 0.20$).

DISCUSSION

In general, results support the hypothesis that diameter growth is a function of growing stock and that stands thinned to a common level of stand density will have equal rates of diameter growth. Prior to thinning, average diameter growth was highest for the lowest stand density and decreased systematically with increasing density (figure 2). This trend is supported by the correlations between diameter growth and crown size for age 17 (table 1). The strong correlation between diameter growth, initial spacing, and crown size prior to thinning agrees with previous results (e.g., Curtin 1964, Smith and Bailey 1964, Hamilton 1969).

The effect of stand density on stem growth is generally considered to be through the effect of density on crown size. Since conifer crowns grow in size from the terminal buds, diameter growth was expected to be related to prethinning crown size for some time after thinning. However, the first year after thinning, the correlation between diameter growth and crown size that existed prior to thinning disappeared (table 1), and with the exception of the trees in the 8 x 8-foot spacing, initial spacing did not significantly influence diameter growth (figure 2).

Strub and Bredenkamp (1985) found that plots of loblolly pine (*Pinus taeda*) thinned late produced more total basal area than plots thinned early. Growth efficiency is generally inversely related to crown size (Jack and Long 1992), which together with the improved resource availability to the trees after thinning could be responsible for the rapid independence of diameter growth with initial spacing or prethinning crown dimensions. However, the absence of an initial spacing effect or relation to prethinning crown dimensions was not due to accelerated diameter growth in the more narrowly spaced plots; it was due to reduced diameter growth in the 10 x 10-foot spacing the first year after thinning followed by the trees in the 8 x 8-foot spacing the second year. If the combination of growth efficiency and greater resource availability results in more rapid diameter growth of the narrower initial spacings over that of the wider initial spacings, four years were required by these slash pine trees to manifest the effect. While not statistically significant, diameter growth four and five years after thinning generally decreased with increasing initial spacing (figure 2) and increasing prethinning crown size (table 1).

CONCLUSIONS

In general, the study shows that for these slash pine plantations (1) initial spacing significantly affected diameter growth prior to thinning but had little or no effect on diameter growth after thinning; and (2) the strong correlations between crown dimensions and diameter growth that existed prior to thinning disappeared when stands were thinned to a common stand density. These results suggest that prethinning stand conditions may eventually affect diameter growth, but for the first five years after thinning, the data are inconclusive.

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