GROWTH RING CHARACTERISTICS, SPECIFIC GRAVITY, AND FIBER LENGTH OF RAPIDLY GROWN LOBLOLLY PINE

Fred W. Taylor

Assistant Director
Mississippi Forest Products Laboratory, Mississippi State, MS 39762

and

James D. Burton

Soil Scientist
U.S. Forest Service, Southern Forest Experiment Station, Pineville, LA 71360

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ABSTRACT

Intensive thinning, understory control, and green pruning of loblolly pine trees growing on a test area near Crossett, Arkansas, have produced trees with a diameter of 18.9 inches at breast heights in 35 years. Large increment borings extracted from experimental trees and control trees were examined for growth patterns and wood properties alterations related to growth rate differences.

During some growth periods, radial growth of test trees was almost three times as great as radial growth of control trees. In the outer juvenile wood formed after the first thinning, growth rate differences were greatest between experimental trees. During the last 10 years of the study (mature wood zone), growth rate differences between treated and control trees were not as great, and there were no significant differences in latewood percentage or tracheid length. Specific gravity was not significantly influenced by growth rate differences in any growth zone. This result leads to the conclusion that trees can be rapidly grown without affecting specific gravity.

Keywords: Loblolly pine, fast growth, earlywood, latewood, specific gravity, tracheid length.

INTRODUCTION

On good sites (SI_{50} = 95 ft) with understory control, green pruning, and severe thinning, loblolly pine sawtimber 17 to 18 inches diameter at breast-height can be grown in 33 years. The method that concentrates growth on selected crop trees, sacrificing some of the small-diameter fiberwood usually obtained in light thinnings, has been demonstrated in a study in Southern Arkansas (Burton and Shoulders 1974). The study, initiated in the winter of 1953–54, involved selection of 0.25-acre plots with 33-foot isolation zones in a 9-year-old stand planted at 6- × 6-foot spacing on land retired from cotton and corn. The silvicultural treatments and controls, replicated three times, were:

1. Treatment—At age 9, thin to 100 crop trees per acre. Prune trees to half height triennially until average clear bole length is 33 feet. Thin to 76 trees per acre at age 19, to 64 trees at 24, to 48 trees (65 ft^2 per acre basal area) at 27, and 41 trees (65 ft^2 per acre basal area) at age 30. Mow understory every 2 years after age 19.
2. Control—At age 12, select 100 crop trees per acre. Thin stand to basal area of 85 ft^2 per acre triennially, favoring crop trees, but do no pruning. Mow understory every 2 years after age 27.

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Growth parameters of trees on these plots have been reported in numerous publications since the study began (Bassett 1969; Burton and Shoulders 1974; Williston 1973; Zahner and Whitmore 1960). Measurements during the growth of the trees have shown that diameter growth has been enhanced by thinning. A logical question is what effect such rapid growth has had on the wood produced. The strength, drying characteristics, and machinability of wood are especially significant for its use as sawtimber or veneer bolts. These characteristics will be evaluated when the study is terminated. In the interim, this study has been conducted on increment borings to measure earlywood-latewood ratio, specific gravity, and fiber length. The objective was to evaluate the effect of treatments to stimulate diameter growth on the wood properties measured.

The relationship between growth rate and specific gravity has been investigated under numerous circumstances for most of the southern pines. A considerable number of investigations, based on statistical analyses, report a decrease in specific gravity with increasing ring width. However, other studies, apparently equally valid, report no relationships or the opposite relationship between specific gravity and diameter growth. The confounding data and conflicting viewpoints on the effect of growth rate on specific gravity and fiber length are, in the opinion of Koch (1972), due to an inadequate understanding of the patterns of variation within individual trees.

Correlations of tracheid length with rate of diameter growth have resulted in mostly inverse relationships or in no significant correlation (Richardson 1964). Little correlation was found for loblolly pine (Goggans 1962; Kramer 1957), shortleaf pine (Ralston and McGinnes 1964), or Virginia pine (Thor 1964). However, a negative relationship has been reported for slash pine (Strickland and Goddard 1966), and a positive relationship has been reported for 8-year-old loblolly pine (Choong et al. 1970), and mature spruce pine (Manwiller 1972).

PROCEDURE

In May 1980, all trees on the treated plots (referred to as sawtimber because the study was designed to produce sawtimber in a minimum period of time by intensive thinning) and an equal number of trees on control plots were sampled. Control plot trees, selected for sampling, were distributed proportionally among diameter classes on each plot. Large increment cores (11-millimeters diameter) were extracted from breast height along the southern radius of each sample tree.

While cores were in a green condition, individual growth increments were measured. The radial length of both earlywood and latewood was measured microscopically to the nearest 0.01 mm.

Green cores were then divided into segments that coincide with treatment periods for the test plots. Segments were extracted by elution with alcohol-benzene in a Soxhlet apparatus as advocated for solid wood blocks (Taylor 1974). The volume of extracted segments was determined by water displacement. Segments were dried, and their specific gravity was calculated on a green volume basis.

The latewood portion of rings produced in 1955, 1961, 1970, and 1977, was macerated by Franklin's method (1945). Lengths of 50 tracheids were measured by the method described by Taylor (1975). Latewood tracheids were measured, because their thick cell wall makes them stiffer and easier to measure than ear-

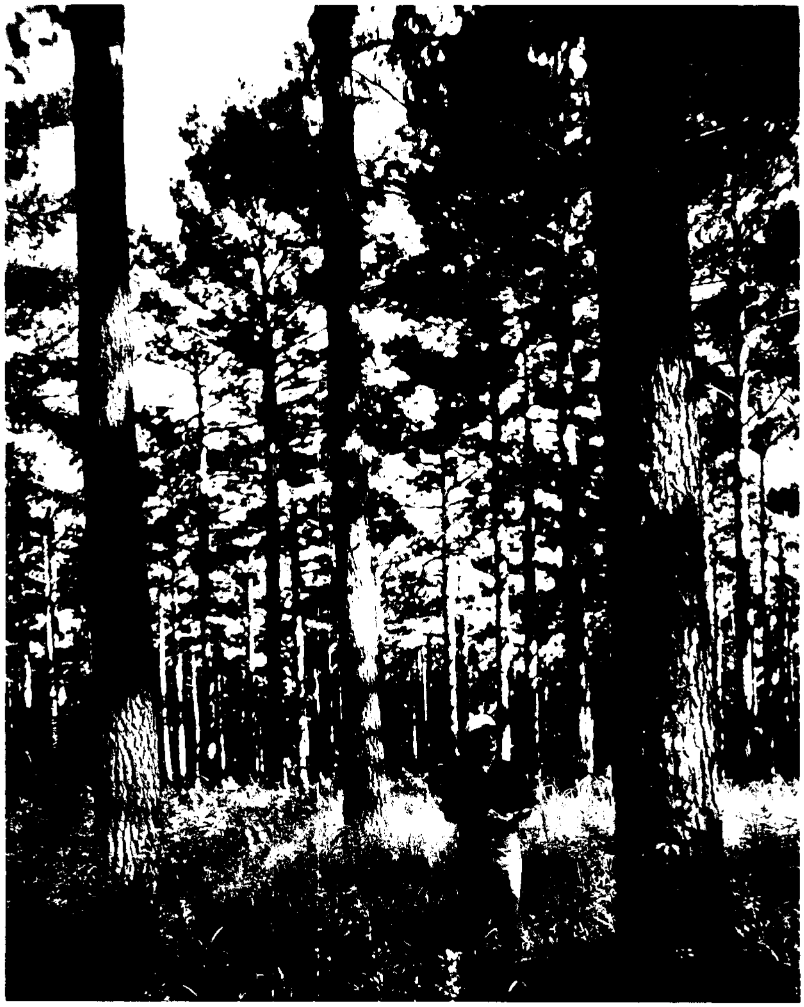

FIG. 1. A sawtimber plot at age 35. Mean dbh was then 47.5 cm.

lywood tracheids. Research with loblolly pine has shown that latewood tracheids are not consistently longer or shorter than earlywood tracheids (Taylor 1979).

RESULTS

The silvicultural treatment resulted in an impressive increase in growth of thinned plots in comparison to control plots. In the 3-year period after the first thinning in 1953, radial growth of the sawtimber plots was almost three times as great as radial growth of control plots (Table 1). However, as trees on the sawtimber plots matured, radial growth decreased until in the 10 years from 1968 to 1979, their radial growth was only slightly more than on the control plots; and the average differences were not statistically significant.

The individual ring width measurements gave no clear indication about the effect of increased growth rate on the earlywood-latewood relationship. The av-

TABLE 1. *Growth (radius length in mm) for distinct growth periods of trees receiving different silvicultural treatments. Values are averages for 30 trees.*

Growth period	Stand age	Control	Sawtimber
1954–56	10–12	10.7	29.6**
1957–59	13–15	16.5	30.0**
1960–62	16–18	13.2	24.3**
1963–65	19–21	10.1	17.0**
1966–68	22–24	10.5	15.1**
1969–71	25–27	13.1	14.2
1972–74	28–30	11.9	13.6
1975–79	31–35	17.7 (10.6)*	20.0 (12.0)*

* Adjusted to correspond to 3-year growth periods.
** Values differ from controls at the 0.01 level of statistical significance.

TABLE 2. *Percent latewood of xylem produced during distinct growth periods of trees receiving different silvicultural treatments. Values are averages for 30 trees.*

Growth period	Stand age	Control	Sawtimber
1954–56	10–12	29	37*
1957–59	13–15	50	47
1960–62	16–18	48	52
1963–65	19–21	55	56
1966–68	22–24	53	54
1969–71	25–27	51	55
1972–74	28–30	56	56
1975–79	31–35	53	54

* Values differ from controls at the 0.05 level of statistical significance.

TABLE 3. *Specific gravity of xylem produced during distinct growth periods of trees receiving different silvicultural treatments. Values are averages for 30 trees.*

Growth period	Stand age	Control	Sawtimber
1954–56	10–12	0.40	0.41
1957–59	13–15	0.49	0.47
1960–62	16–18	0.50	0.49
1963–65	19–21	0.53	0.52
1966–68	22–24	0.52	0.51
1969–71	25–27	0.51	0.51
1972–74	28–30	0.54	0.53
1975–79	31–35	0.53	0.52

TABLE 4. *Length of latewood tracheids (mm) produced during distinct growth periods of trees receiving different silvicultural treatments. Values are averages for 30 trees.*

Growth year	Stand age	Control	Sawtimber
1955	11	3.37	2.81**
1961	17	3.74	3.49**
1970	26	3.93	4.04
1977	33	4.19	4.15

** Values differ from controls at the 0.01 level of statistical significance.

TABLE 5. *Summary of simple correlation coefficients of wood properties. Symbol in parentheses indicates whether "r" is positive or negative. Asterisk denotes statistical significance at the one percent level.*

	% Latewood vs. specific gravity	Segment length vs. specific gravity	Segment length vs. tracheid length
Plot 3 (Control)	(+)*	(−)	
Plot 5 (Control)	(+)*	(−)	
Plot 8 (Control)	(+)*	(+)	
Plot 2 (Sawtimber)	(+)*	(−)*	
Plot 6 (Sawtimber)	(+)*	(−)*	
Plot 11 (Sawtimber)	(+)*	(−)*	
CONTROL			
Growth period 1954–56	(+)	(−)	(+)
Growth period 1957–59	(+)	(+)	
Growth period 1960–62	(+)	(+)	(−)
Growth period 1963–65	(+)	(−)	
Growth period 1966–68	(+)	(−)	
Growth period 1969–71	(+)	(−)	(−)
Growth period 1972–74	(+)*	(−)	
Growth period 1975–79	(+)*	(−)	(−)
SAWTIMBER			
Growth period 1954–56	(+)	(−)	(−)
Growth period 1957–59	(+)	(−)	
Growth period 1960–62	(+)	(−)	(−)
Growth period 1963–65	(+)	(−)	
Growth period 1966–68	(+)	(−)	
Growth period 1969–71	(+)	(−)	(−)
Growth period 1972–74	(+)*	(−)	
Growth period 1975–79	(+)*	(−)	(−)

erage percent latewood produced during discrete growth periods by control trees was similar to sawtimber trees (Table 2). The only statistically significant difference was an increase in the proportion of latewood of the comparatively rapidly growing treated trees after their first thinning (1954–64 growth period). This difference was also detected in a previous study conducted after the first thinning (Smith 1968). Such wood, formed by young trees, is commonly called core or juvenile wood. The conclusion is that diameter growth increases, of the magnitude attainable by thinning, do not affect the earlywood-latewood relationship of growth increments in mature wood.

Specific gravity increased from approximately 0.40 to 0.52 as the trees matured. However, there were no statistically significant differences between control trees and sawtimber trees (Table 3). This result confirms the work of Burton and Shoulders (1974), who reported no differences in the specific gravity of wood produced between 1954 and 1971 of trees removed in the 1971 thinning of the study plots. The results suggest that thinning loblolly pine to maximize diameter growth will not have a depressing effect on the important property of specific gravity.

Latewood tracheids produced during the 1955 growth period (two years after first thinning) were much shorter in the sawtimber plots than in the control plots (Table 4). In the 1961 growth increment (8 years after first thinning), the reduction of latewood tracheid length was not so large, but it was still highly statistically significant. During later measurement periods (increments formed during 1970 and 1977), there were no significant tracheid length differences between sawtimber plots and control plots.

Correlation analysis was used to evaluate the interrelationships of wood properties (Table 5). Correlation of segment length (growth rate) and tracheid length did not explain the short tracheid lengths observed in wood produced after first thinning as compared to control plots. It does reveal the tendency for long segments (fast growth zones) to be associated with short tracheids (negative correlation).

The relationship of increased latewood percentage and high specific gravity is illustrated by the positive correlation for every sample plot and every growth period (Table 5). This relationship is statistically significant for plots and for the outerwood of mature trees in both sawtimber and control plots.

The lack of significant correlation of specific gravity and growth rate for individual growth periods indicates that trees may be grown rapidly by thinning for maximum growth without seriously affecting specific gravity. This agrees with published reports that growth rate does not affect specific gravity in the genus Pinus (Echols 1971; Goggans 1962; Koch 1972; Ralston and McGinnes 1964; and Thor 1964).

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