EFFECT OF SIX SITE-PREPARATION TREATMENTS ON PIEDMONT LOBLOLLY PINE WOOD PROPERTIES AT AGE 15[1]

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Abstract—The impact of weed control and fertilization on increased tree growth is positive and significant but the effects on wood properties are not well known. Increment cores were collected from loblolly pine (*Pinus taeda* L.) trees growing on an existing site-preparation experiment in the lower Piedmont of Georgia at age 15. The levels of site preparation were: 1-clearcut only; 2-chainsaw, 3-shear and chop; 4-shear, chop, and herbicide; 5-shear, rootrake, burn, and disk; 6-shear, rootrake, burn, disk, fertilize, and herbicide. Two, 0.472 in. increment cores were collected at d.b.h. from 35 trees representative of each site-preparation treatment. Wood basal-area growth increased significantly with increased site-preparation treatment. The site-preparation treatments did not affect length of juvenility which averaged 10 years for all treatments. Average increment core specific gravity was not significantly reduced with increased site preparation compared to the control trees. The diameter of the juvenile wood core, however, increased with increased site-preparation treatment.

INTRODUCTION

The pressure to produce wood fiber is leading to intensively managed plantations, which generally accelerate the early growth of the trees and reduce rotation length to maximize return on investments. The wood industry is now using intensive cultural treatments such as intensive site preparation, competition control, and fertilization to increase fiber production of southern pine. The impact of these intensive silvicultural treatments on increased growth is positive and significant, but their effect on wood properties is not well known.

A site-preparation study established in 1982 to evaluate and understand the benefits of various site-preparation treatments on pine survival and growth provided the opportunity to examine the effects of various site-preparation treatments on wood properties. Increment cores, 0.472 in. in diameter, were collected from 15-year loblolly pine (*Pinus taeta* L.) established using six levels of site preparation. The increment cores were analyzed to determine the effect of site preparation treatment on annual earlywood and latewood production, date of transition from juvenile to mature wood, and wood specific gravity.

LITERATURE REVIEW

In the Southeast a typical loblolly pine plantation can produce 50 to 110 ft^3 of wood per acre per year. However, research (Borders and Bailey 1997) has shown that with intensive management practices, such as complete competition control, multiple fertilizations, and genetically improved stock, these growth rates can be increased to 250 to 350 ft^3 per acre per year. These growth rates compare well with the fastest growing loblolly pine anywhere in the world.

A radial cross-section of a pine stem contains three zones of wood: 1-core or crown-formed wood, which is produced by immature cambium in the vigorous crown and has anatomical, chemical, and physical properties that differ from that of mature wood; 2-transition wood, a zone where wood properties are changing rapidly before wood reaches maturity; and 3-mature wood (Clark and Saucier 1989). Juvenile wood is characterized as having lower specific gravity, shorter tracheids, thinner tracheid walls, larger lumens, lower percent latewood, and lower alpha cellulose content than that of mature wood. In the longitudinal direction there is a core of crown-formed wood surrounding the pith from butt to tip of stem surrounded by a band of transition wood from butt to base of live active crown surrounded by a wide outer band of mature wood (Bendtsen and Senft 1986). Both crown-formed and transition wood is commonly referred to as juvenile wood.

The definition of southern pine wood quality depends on the product for which the wood is used. High specific gravity is almost always considered a desirable wood quality trait. High specific gravity is positively correlated with wood strength and stiffness. Wood from young fast-growing pine plantations often has physical and mechanical properties that make it less desirable than older, slower grown wood for structural lumber because of large volumes of low specific gravity, juvenile wood (Bendtsen 1986, Bendtsen and Senft 1986, Bendtsen and others 1988, Biblis 1990, McAlister and Clark 1991, Pearson and Gilmore 1971). Wood and fiber properties that affect paper making include specific gravity, cellulose percent and other chemical constituents, fiber length, and microfibril angle (Erickson and Arima 1974, Megrow 1985, Schmidtling and Amburgey 1977, Zobel and Blair 1976). Paper from juvenile wood will have good tensile, burst, fold and sheet smoothness but lower tear and opacity than paper made from mature wood pulp (Zobel and Blair 1976). Higher specific gravity mature wood pulp will result in higher pulp yield and is generally associated with longer fibers with increased tear for linerboard and kraft sack papers.

The number of years a tree produces juvenile wood at a fixed height level (juvenile period) does not differ between slash and loblolly pine when the species are planted at the same location but does vary with geographic location (Clark and Saucier 1989). The length of the juvenile period of slash and loblolly pine in the Southeast decreases geographically from north to south. In loblolly and slash pine, the period of juvenile wood formation decreases from 10 to 14 years in the Piedmont to 6 to 8 years in the Gulf and Atlantic Coastal Plain. In a study by Cregg and others (1988), it was observed that the transition from earlywood to latewood occurred 1 month earlier in a year of low rainfall and high

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spring evaporate demand than in a year of low evaporate demand and high rainfall. Whether an early transition to latewood leads to an annual ring with a high percent of latewood, and thus high specific gravity, depends on the growing conditions that occur after the transition to latewood production. Based on Moehring and Ralston's (1967) work it appears the moisture supply and pan evaporation in the months of July, August, September, and October control the amount of latewood that is produced. The use of herbicides to reduce competing vegetation in a pine plantation will increase soil moisture and nutrients available for pine growth. Thus, competition controls could significantly influence the proportion of earlywood and latewood tracheids produced. Fertilization at stand establishment with no competition control will stimulate competition growth and thus could reduce soil moisture available for latewood growth.

The objective of this study was to determine the effect of increasing intensity of site preparation from no treatment, shear and chop with and without herbicide to shear, rootrake, burn, and disk with and without herbicide and fertilization on annual growth of earlywood, latewood, and wood specific gravity of loblolly pine in the lower Piedmont of Georgia.

PROCEDURES

The loblolly pine plantation sampled was hand planted with improved loblolly pine seedlings in early 1982 at a spacing of 6- by 10-ft (Edwards 1994). The original stand of loblolly pine and mixed hardwoods on the study tract was harvested in 1981. The 84-acre study tract is located in the lower Piedmont of Georgia, at the Hitchiti Experimental Forest and has an average site index of 80 at base age 50 years. Six site-preparation treatments were evaluated in the study and are listed in order of increasing intensity:

1) Clearcut only, control (CONT) - no site preparation and residual, non- merchantable trees retained.

2) Manual felling (FELL) - all residual trees greater than 1-in. d.b.h. were removed by chainsaw after harvest in August 1981.

3) Shear and chop (SC) - residual trees were sheared with a KG-blade mounted on a D7 tractor in September 1981 and downed residual was chopped with one pass of a single drum chopper in September and November 1981.

4) Shear, chop, and herbicide (SCH) - shear and chop as described in treatment 3 plus application of hexazinone herbicide (Velpar Gridball pellets of 0.5 cm^3) applied in 1.9- x 1.9-ft grid at a rate of 25 lb per acre in March 1992.

5) Shear, rootrake, burn, and disk (SRBD) - residual trees were sheared; rootstocks were raked into windrows and burned; remaining debris was scattered with a dozer blade; and plots were disked with an offset harrow to a depth of 6 to 8 in. in October 1981.

6) Shear, rootrake, burn, disk, herbicide, fertilize (SRBDHF) - site preparation was the same as described in treatment 5 plus the application of ammonium nitrate (34-0-0) fertilizer broadcast by hand at the rate of 300 lb per acre in March 1983 and the application of sulfometuron herbicide (Oust) at a rate of 8 oz per acre in April 1983, with backpack sprayers. Herbaceous weeds were essentially absent during most of the 1983 growing season.

The design of the site-preparation study was a randomized complete block with five blocks and six site-prep treatments randomly assigned to each block. Each treatment plot was 2 acres with a 0.2-acre internal measurement plot. The five blocks were located by topographic position to avoid site quality differences and to ensure reasonable uniformity within blocks. The impact of these site-preparation treatments on soils (Miller and Edwards 1985); size, abundance, and species diversity of competition (Harrington and Edwards 1996); and tree survival and growth (Edwards 1990, 1994) have been reported.

Two 0.472-in. increment cores were extracted at 4 ft above ground from seven trees for each treatment in each of five blocks for a total of 35 sample trees per treatment. Increment cores were taken from trees in the first buffer row next to the measurement plots. Mean d.b.h. of all trees on each measurement plot at age 15 was determined. Trees with d.b.h. within ± 1 in. of the average d.b.h. for the plot were selected for boring to make trees bored representative of the average tree on a plot. Table 1 shows the average d.b.h. and total height of the trees selected for boring by site-preparation treatment.

Increment core number 1 from each tree was dried at 50 °C, glued to a core holder, sanded and the radial growth of earlywood and latewood of each annual ring determined using image analysis. Increment core number 2 was used to determine whole core wood specific gravity based on green volume and oven dry weight.

An analysis of variance was conducted to test for significance by treatment differences in d.b.h., specific gravity, and percent latewood. Tukey's test was used to determine whether differences among means were significant at the 0.05 level. Data analysis was performed using Statistical Analysis Systems (SAS 1985).

RESULTS

The average cumulative wood basal-area growth plotted over year of formation for the trees sampled increased with increasing site-preparation treatment except for the SC compared to the SCH treatment (fig. 1). Thirty-five percent of the pine seedlings in the SCH treatment were killed in the first year because of rapid spread and up-take of the hexazinone herbicide as a result of heavy rain immediately following application. Mortality was replaced in the second year. Thus, about 33 percent of the pines in the SCH treatment are 1 year younger than those in the SC treatment. After the 1996 growing season the SC treatment had 127 percent, the SCH had 88 percent, the SRBD had 158 percent and the SRBDHF had 203 percent more basal area of wood per tree than the controls.

Average annual basal-area growth of earlywood plotted over year of formation increased with increasing site-preparation treatment except for the SC and SCH treatments (fig. 2). Average annual growth of earlywood increased from 1983 to 1989, peaked in 1989, and then decreased for all site-prep treatments.

Average annual latewood basal-area growth plotted over year of formation also increased with increasing site-prep treatment except of the SC and SCH treatments (fig. 3).

Table 1—Average size characteristics for sample trees by site-preparation treatment

Treatment	Sample trees	D.b.h.		Total height	
		Avg.	Range	Avg.	Range
	No.	*Inch*		*Feet*	
CONT	35	3.9	3.1–4.8	35	22–42
FELL	35	4.5	3.3–5.8	41	28–57
SC	35	5.6	5.0–6.1	42	30–48
SCH	35	5.3	3.4–7.0	38	28–55
SRBD	35	6.1	5.6–6.6	41	32–49
SRBDHF	35	6.3	5.7–7.2	43	35–52

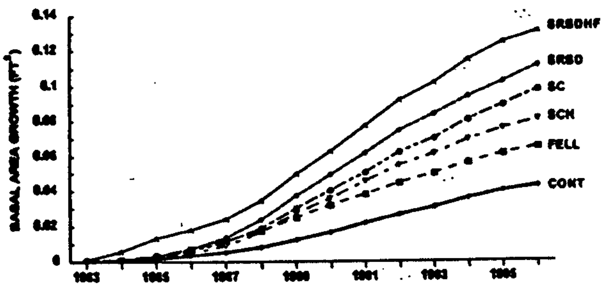

Figure 1—Average cumulative wood basal-area growth over year of formation for 15-year Piedmont loblolly pine by site-preparation treatment.

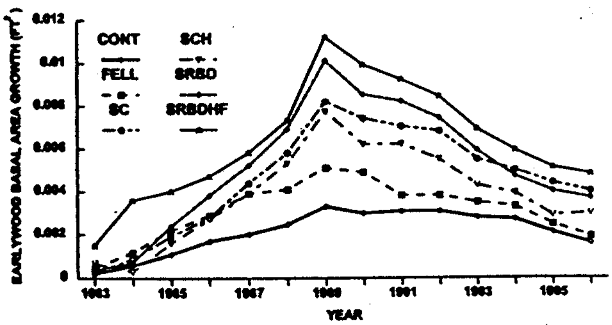

Figure 2—Effect of site-preparation treatment on average annual earlywood basal-area growth for Piedmont loblolly pine at age 15.

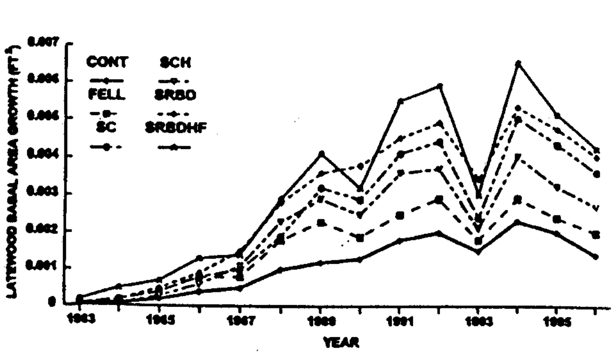

Figure 3—Effect of site-preparation treatment on average annual latewood basal-area growth for Piedmont loblolly pine at age 15.

The decrease in annual basal-area growth in 1990 and 1993 are the result of a mild summer drought in 1990 and a severe summer drought in 1993. The SRBDHF treatment showed the largest decrease in annual latewood growth in response to the summer drought. The decrease in annual latewood basal-area growth from 1994 to 1996 for all treatments is probably in response to overstocking.

Figure 4 shows the average proportion of annual ring in latewood plotted over rings from the pith for each site-preparation treatment. The plots show that for all treatments the trees were producing crown formed wood in rings 1-4, transition wood in rings 5-10, and mature wood by 11 rings from the pith. Thus, the length of juvenility was not significantly effected by site-preparation treatment and was 10 years for all treatments. The trees in SRBDHF treatment contained a slightly lower proportion of their annual ring in latewood for rings 5-9.

Although the length of juvenility was 10 years for all site-preparation treatments, the average diameter of the juvenile wood core increased significantly with increasing site-preparation treatment. The diameter of the juvenile wood averaged 2.2 in. in the CONT, 2.9 in. in the FELL, 3.4 in. in the SC, 3.2 in. in the SCH, 3.7 in. in the SRBD, and 4.1 in. in the SRBDHF trees. This increase in juvenile wood is caused by the increase in earlywood type growth that occurred with the increase in site-preparation treatment.

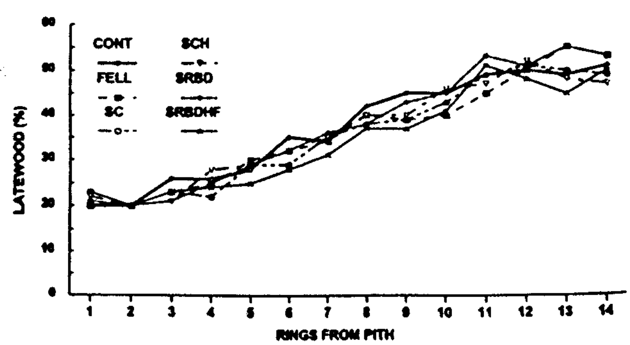

Figure 4—Average proportion of annual ring in latewood over rings from pith for 15-year Piedmont loblolly pine by site preparation-treatment.

The site-preparation treatments examined resulted in increased averaged tree d.b.h. with increasing site-preparation treatment (table 2). The average d.b.h. of the trees on the CONT and FELL sites were significantly smaller that those on the SC, SCH, SRBD, and SRBDHF sites. The trees on the SRBDHF sites had the largest average diameter.

Core specific gravity increase from 0.43 to 0.44 for the FELL and CONT trees to 0.46 for the SCH and SRBD trees and then decreased to 0.44 for the SRBDHF trees (table 2). The decrease in specific gravity of the SRBDHF trees is probably related to the decrease in proportion of latewood for these trees in rings 5-9 (fig. 4). Average increment core specific gravity by treatment was significantly different at the P = 0.08 level. However, Tukey's test showed no significant difference at the P = 0.05 level.

Average proportion of latewood in an increment core did not vary significantly with treatment and averaged 35 to 36 percent (table 2).

Table 2—Average d.b.h., increment core specific gravity, and percent latewood for 15 year Piedmont loblolly pine by site-preparation treatment[a]

Treatment	D.b.h.	Specific gravity	Latewood
	Inches		*Percent*
CONT	3.9 a	0.44 a	35 a
FELL	4.5 ab	.43 a	35 a
SC	5.6 bc	.45 a	36 a
SCH	5.3 abc	.46 a	35 a
SRBD	6.1 c	.46 a	36 a
SRBDHF	6.3 c	.44 a	35 a

[a] Value with same letter not different at 0.05 level.

CONCLUSIONS

Site-preparation treatments consisting of shear and chop without and with herbicide; shear, rootrake, burn and disk without and with herbicide and fertilization 1 year after planting significantly increased wood basal-area growth compared to no site-preparation treatment of loblolly pine in the lower Georgia Piedmont. The average loblolly pine on the shear, rootrake, burn, disk, herbicide, and fertilize plots had 203 percent more wood basal area at age 15 than the tree on the no site-preparation plots. The six site-preparation treatments sampled did not affect length of juvenility, which averaged 10 years for all treatments. Average increment core specific gravity of the fast growing loblolly pine on the shear, rootrake, burn, disk, herbicide, and fertilize plots was not significantly reduced compared t12o that of the controls. However, the diameter of the juvenile wood increased with increased site-preparation treatment.

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