United States
Department of
Agriculture

Forest Service

Southeastern Forest
Experiment Station

Research Paper
SE-288

Ten-Year Effect of Six Site-Preparation Treatments on Piedmont Loblolly Pine Survival and Growth

M. Boyd Edwards

The Author:

M. Boyd Edwards is a Research Ecologist with the Ecology and Genetics of Southern Pine Ecosystems Unit, Southeastern Forest Experiment Station, U.S. Department of Agriculture, Forest Service, Macon, GA.

June 1994

Southeastern Forest Experiment Station
P.O. Box 2680
Asheville, North Carolina 28802

Ten-Year Effect of Six Site-Preparation Treatments on Piedmont Loblolly Pine Survival and Growth

M. Boyd Edwards

ABSTRACT

Limited information is available on growth responses to different levels of intensity for site preparation in the Piedmont. In the present study, six intensities of site preparation were compared for their effect on survival, height and diameter growth, total volume produced, and basal area per acre for the first 10 years after treatment. Rates of survival and growth were lower for pines in the control plots than for any others. In general, tree performance improved as the intensity of site preparation increased.

Keywords: *Pinus taeda*, yield.

Introduction

The need to evaluate and understand the benefits of site preparation is critical to forest managers who daily must make decisions that provide results in terms of pine survival and growth for their customers. There are few long-term studies on loblolly pine (*Pinus taeda* L.) in the Piedmont that can be utilized for this purpose.

The present study compares pine survival, height and diameter growth, total volume produced, and basal area after 10 growing seasons for a variety of site-preparation treatments. This information will benefit foresters and land managers, as well as private landowners in the Piedmont as they select site-preparation treatments that help maximize survival and benefit growth of their planted pines.

Methods

The study is on an 84-acre tract in the lower Piedmont of Georgia, at the Hitchiti Experimental Forest. The original stand of loblolly pine (*Pinus taeda* L.) mixed with dogwood (*Cornus florida* L.) and sweetgum (*Liquidambar styraciflua* L.) was harvested in 1981 and planted with improved loblolly pine seedlings in early 1982 on a spacing of 6- by 10-feet. Site index for the whole study area averaged 80 feet at base age 50 years. Treatment plots were arranged in blocks to reduce the variation of site within blocks.

The following six site-preparation treatments were randomly assigned to the treatment plots and are listed in order of increasing intensity.

1. *Clearcut only (control)*—No site preparation.

2. *Chainsaw*—All residual trees greater than 1-inch d.b.h. were removed by chainsawing in August 1981.

3. *Shear and chop*—Shearing was performed with a KG-blade mounted on a D7 tractor in September 1981. Between September and November 1981, a single pass was made with a single-drum chopper.

4. *Shear, chop, and herbicide*—In addition to shearing and chopping as in treatment 3, 0.5 cm^3 Velpar Gridball pellets (hexazinone) with 10-percent a.i. were applied in a 1.9- by-1.9-foot grid at a rate of 25 pounds per acre in March 1982.

5. *Shear, rootrake, burn, and disk*—Vegetation was sheared and rootraked into windrows in September 1981. Most of the material in the windrows was consumed by burning in October 1981, and the remaining debris and ash were scattered over the plot with a dozer blade. Plots were disked with an offset harrow to a depth of 6 to 8 inches in October 1981.

6. *Shear, rootrake, burn, disk, fertilize, and herbicide*—Site preparation was the same as described in treatment 5, except that ammonium nitrate (34-0-0) was broadcast by hand at the rate of 300 pounds per acre in March 1983 and Oust weed killer, containing 75-percent sulfometuron methyl, was applied at a rate of 8 ounces per acre in April 1983, with backpack sprayers. Herbaceous weeds were essentially absent during most of the 1983 growing season.

Study Design and Measurements

The study design was a randomized complete block. Each treatment plot covered 2 acres, and each of the six treatments was replicated five times. The five blocks were located by topographic position to avoid obvious site-quality differences and to ensure reasonable uniformity within blocks. Two or three soil series occur on the area, and there is much variation in surface texture and organic matter content (Miller and Edwards 1985). Each treatment plot had a 0.2-acre internal measurement plot. Every tree in each measurement plot was measured for d.b.h. with a diameter tape and measured for total height with a telescoping height pole. Every tree was examined for tip moth and fusiform rust infection. Since little or no damage was found when these conditions were measured at the 5-year interval, no further measurements were taken at the 10-year interval (Edwards 1990).

Trees were measured annually for the first 5 years and again after the 8th and 10th growing seasons. Analysis of variance procedures were used to test for significance by treatment differences in height, diameter, percentage survival, and volume growth. Duncan's multiple range test was used to determine whether differences among means were significant at the 0.05 level. All data analyses were performed with the Statistical Analysis System (SAS 1985).

Results and Discussion

Survival

At the conclusion of the first growing season, the only significant difference in survival among site-preparation treatments was for treatment 4 (table 1). Survival in treatment 4 was significantly

Table 1—Loblolly pine survival at 1, 3, 5, 8, and 10 years after reestablishment with six site-preparation treatments

Treatment[a]	Survival after—				
	1 year	3 years	5 years	8 years	10 years
			Percent		
1	92a	89c	84c	77c	72c
2	94a	91bc	88bc	80bc	76bc
3	93a	92bc	90abc	87abc	84abc
4[b]	64b	95ab	94ab	92ab	91ab
5	98a	98a	97a	96a	94a
6	98a	97ab	97a	93ab	91ab

Within growing seasons, means followed by the same letter are not significantly different ($P = 0.05$).

[a]1 = Clearcut only
2 = Chainsaw
3 = Shear and chop
4 = Shear, chop, and apply herbicide
5 = Shear, rootrake, burn, and disk
6 = Shear, rootrake, burn, disk, fertilize, and apply herbicide

[b]Thirty-five percent of planted pines in treatment 4 were killed in the first year by hexazinone in combination with too much rain immediately after application. Mortality was replaced in the second year.

reduced because about 3 inches of rain fell in a short period and rapidly distributed a large quantity of hexazinone on the soil surface. The hexazinone killed about 35 percent of the planted pines. The herbicide also provided approximately 80-percent control of the herbaceous and woody plants after the first growing season. Replacement pines were planted on treatment 4 plots the following winter so that this treatment could remain part of the study.

After three growing seasons, a survival trend became evident: survival was higher on treated plots than on control (untreated) plots. At this time, survival was highest (98 percent) after treatment 5.

Survival through five growing seasons was a respectable 84 percent on control plots. The three most intensive treatments significantly improved survival, and the best results (97 percent) were from treatments 5 and 6. At this time, it was evident that survival increased somewhat as intensity of site preparation increased.

In the eighth growing season, survival was highest (96 percent) after treatment 5. Treatment 6, which provided the highest intensity of site preparation, ranked next with 93-percent survival. Rankings of the remaining three site-preparation treatments and the control were as they had been at the end of the fifth growing season.

After 10 growing seasons, survival averaged 72 percent on control plots. That average was lower than any of the treated averages. As intensity of site-preparation treatment increased, survival percentage gradually improved. Between years 8 and 10, survival of trees in treatments 5 and 6 declined by only 2 percentage points. Both of these treatments show excellent levels of survival, and their difference is only of statistical significance and not of any practical significance. In fact, even on control plots, the overall survival of 72 percent equates to 523 trees per acre after 10 years. Many land managers would be satisfied with this stocking level, and most foresters would characterize survival as excellent after all of the treatments.

The fate of seedlings in treatment 4 is instructive. Some 35 percent of them were replants for spots where hexazinone had killed seedlings. Survival of originals and replants was better than on control plots and those receiving lesser intensities of treatment. At least in this instance, replanting was successful.

Tree Heights

By the end of the third growing season, mean tree height and height growth were beginning to conform to a trend of increasing as intensity of site preparations increased. At this time, mean height for all treatments except treatment 4 exceeded that of the control (table 2). Treatment 6, the most intensive site-preparation treatment, had the tallest trees and the most height growth. At the end of the fifth growing season, heights and height growth of all treatments exceeded those of the control plots. In general, the trend toward better tree-height growth with increasing intensity of treatment continued, and treatment 6 yielded the largest mean tree height and the greatest mean height growth. Shearing and chopping (treatment 3) and shearing, windrowing, burning and disking (treatment 5) produced the second-tallest trees.

In general, trees in all treatments approximately doubled their heights between ages 5 and 8. On treatment 3 (shear and chop) tree heights increased from 10.2 to 21.4 feet. The treatment average was the third largest after eight growing seasons. Results of this treatment are of special interest because this treatment may be the most common site-preparation procedure utilized on Piedmont sites today. Trees in treatment 6 had the greatest average height at 24.2 feet, but this average was not significantly better than the 22.1 feet from treatment 5.

After 10 growing seasons, the trend of increasing height and height growth (except treatment 4) with increasing intensity of site preparation was clear. The control trees had the least height growth since the end of the eighth growing season, when mean height was 20.8 feet. Treatment 4 (shear, chop and herbicide) yielded the next-shortest trees at 23.9 feet but the third-largest increase in growth since year 8 at 6.0 feet. Remember that one-third of treatment 4

Table 2—Effects of six site-preparation treatments on mean height and periodic height growth at 1, 3, 5, 8, and 10 years after establishment

Treatment[a]	Height	Height	Growth	Height	Growth	Height	Growth	Height	Growth
	1 year	3 years		5 years		8 years		10 years	
					Feet				
1	1.1a	3.5c	2.4cd	7.8c	2.0c	15.8c	8.0c	20.8c	5.0c
2	1.2a	4.4bc	3.2bc	9.0bc	2.4bc	18.7bc	9.7b	24.2bc	5.5bc
3	1.1a	4.8b	3.7b	10.2b	2.5ab	21.4ab	11.2ab	28.1ab	6.7a
4	1.0a	3.4c	2.4cd	8.1c	2.4b	17.9c	9.8b	23.9c	6.0ab
5	1.0a	4.8b	3.8b	10.3b	2.7ab	22.1a	11.8a	29.3a	7.2a
6	1.1a	6.3a	5.2a	12.4a	2.9a	24.2a	11.8a	31.2a	7.0a

Within growing seasons, means followed by the same letter are not significantly different ($P = 0.05$).

[a]1 = Clearcut only
2 = Chainsaw
3 = Shear and chop
4 = Shear, chop, and apply herbicide
5 = Shear, rootrake, burn, and disk
6 = Shear, rootrake, burn, disk, fertilize, and apply herbicide.

trees were a year younger. Results from treatment 3 (shear and chop) are only slightly less than from treatments 5 and 6, which yielded the best mean tree height after 10 growing seasons. Height growth since year 8 was similar for treatments 3, 5, and 6.

After 10 growing seasons, trees in treatment 2 (chainsaw) were still growing faster in height than control trees. This site-preparation treatment may interest landowners who do not wish to invest in more costly treatments or landowners who want to minimize the impacts of site preparation.

Diameters

By the end of the fifth growing season, trees were tall enough to measure diameters at breast height (table 3). At all three measurement times, mean diameters from all site-preparation treatments exceed those from control plots. Also, at all three measurement times, the trees in the most intensive treatment (treatment 6) had the largest diameters. Again, with exception of treatment 4, diameters tended to increase with increasing intensity of site preparation.

Table 3—Effects of six site-preparation treatments on individual tree d.b.h. at 5, 8, and 10 years after establishment

Treatment[a]	Diameter breast height at—		
	5 years	8 years	10 years
		Inches	
1	0.8d	1.9d	2.4c
2	1.1cd	2.2cd	2.8c
3	1.5b	3.1ab	3.9ab
4	1.2bc	2.8bc	3.7b
5	1.5b	3.5ab	4.4ab
6	1.9a	3.7a	4.6a

Within growing seasons, means followed by the same letter are not significantly different ($P = 0.05$).

[a] 1 = Clearcut only
2 = Chainsaw
3 = Shear and chop
4 = Shear, chop, and apply herbicide
5 = Shear, rootrake, burn, and disk
6 = Shear, rootrake, burn, disk, fertilize, and apply herbicide

Cubic Volume

Total cubic volume at ages 5, 8, and 10 were calculated with a simultaneous total and merchantable stand volume equation developed by Bailey and others (1985):

$$V = 0.004185\ D^{1.8653}\ H^{0.9359}\ ,$$

Where V = total volume (ft^3),
D = diameter breast height, and
H = total height.

Treatment 6 had 20 percent more volume than treatment 5 after 8 growing seasons and 11 percent more volume after 10 growing seasons (table 4). This treatment yielded 4.8 times more volume per acre than the control after 8 growing seasons and 4.3 times more after 10 growing seasons (fig. 1). The benefits of fertilizing and herbicide application in treatment 6 over treatment 5 continued to accumulate through age 10. At that time, volume growth for all treatments exceeded that of the control. Treatment 2 (chainsaw) was the only one that did not provide significantly more volume growth than the control (table 4).

Table 4—Mean total volume per acre after 5, 8, and 10 growing seasons and periodic volume growth between 5 to 8 and 8 to 10 growing seasons, by treatment

	Volume at end of—			Growth between—	
Treatment[a]	5 years	8 years	10 years	5-8 years	8-10 years
			Cubic feet		
1	15.9d	149.8c	296.0c	133.9c	146.2b
2	31.7cd	227.8c	412.6c	196.1c	184.8b
3	63.8bc	464.4b	879.8b	400.6b	415.4a
4	52.5bcd	430.6b	863.5b	378.1b	432.9a
5	75.6b	594.4ab	1158.7ab	518.8ab	564.3a
6	121.9a	716.1a	1286.7a	594.2a	570.6a

Within growing seasons, means followed by the same letter are not significantly different ($P = 0.05$).

[a] 1 = Clearcut only
2 = Chainsaw
3 = Shear and chop
4 = Shear, chop, and apply herbicide
5 = Shear, rootrake, burn, and disk
6 = Shear, rootrake, burn, disk, fertilize, and apply herbicide

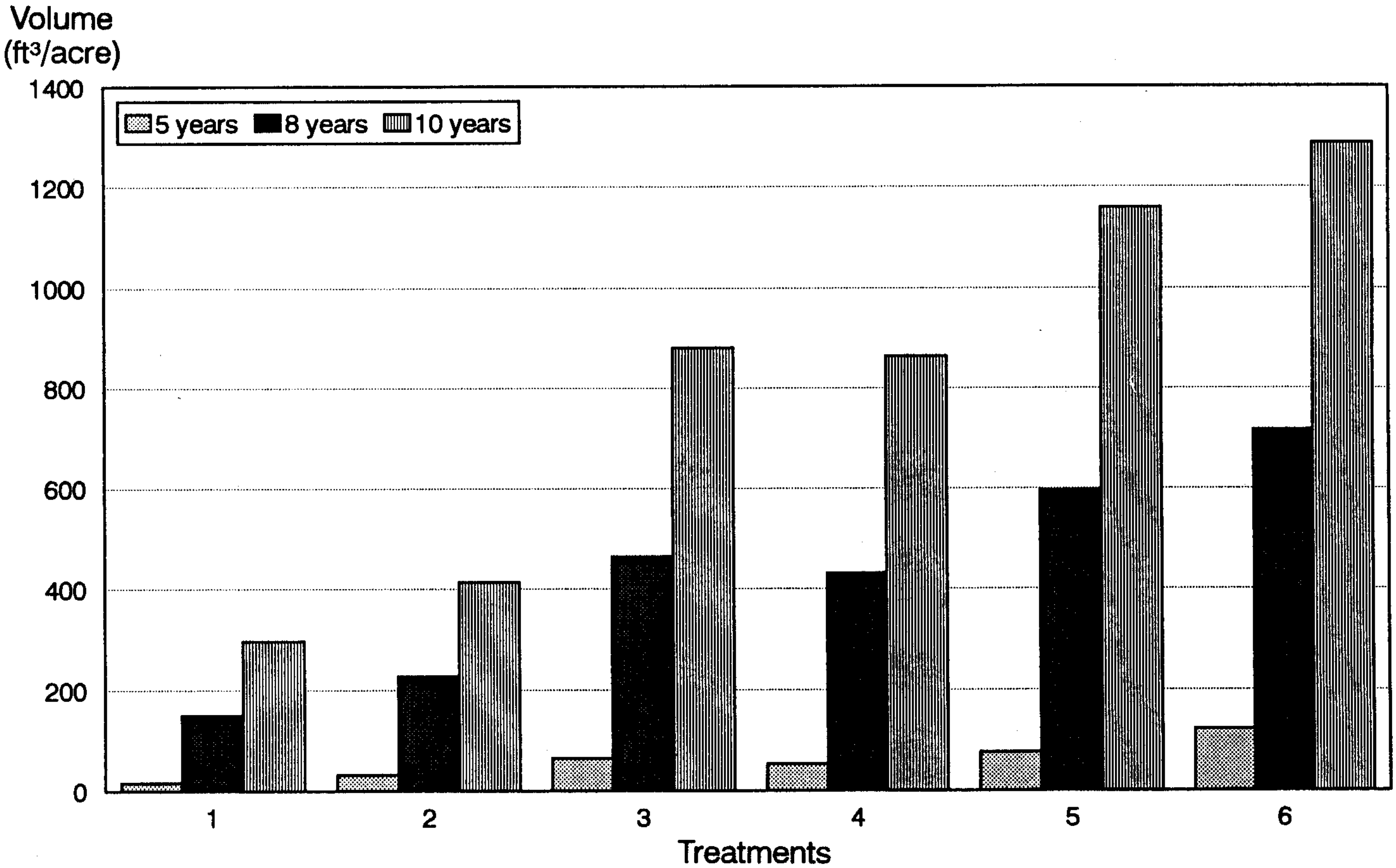

Figure 1—Mean total volume per acre by treatment at 5, 8, and 10 years after establishment, by six site-preparation treatments: (1) clearcut only (control); (2) chainsaw; (3) shear and chop; (4) shear, chop, and herbicide; (5) shear, rootrake, burn, and disk; and (6) shear, rootrake, burn, disk, fertilize, and herbicide.

Basal Area

Table 5 shows average basal area per acre for the different treatments by ages, and figure 2 shows the results in the form of a histogram. Chopping after shearing (treatment 3) doubled the basal area over that of the control (treatment 1) and chainsaw (treatment 2) after 8 years. Treatment 4 shows similar results. Treatment 5 had 3.4 times as much basal area, and the additional fertilization and herbaceous weed control (treatment 6) had 3.8 times more basal area. After 10 growing seasons, significance among treatments levels out into two groups: (1) treatments 3, 4, 5, and 6, and (2) treatments 1 and 2. Group 1 treatments are all significantly better than the less intensive treatments. Likewise, basal area growth from end of year 8 to end of the 10th growing season is in two distinct groupings of significance.

Table 5—Mean basal area per acre, by treatment, at end of years 8 and 10, and mean basal area growth from year 8 to end of year 10

Treatment[a]	Basal area at end of—		
	8 years	10 years	Growth
		Square feet	
1	14.1c	22.0b	7.9b
2	19.0c	27.8b	8.8b
3	37.5b	56.9a	19.4a
4	36.5b	59.3a	22.8a
5	48.1ab	74.8a	26.7a
6	54.0a	79.2a	25.2a

Within growing seasons, means followed by the same letter are not significantly different ($P = 0.05$).

[a]1 = Clearcut only
2 = Chainsaw
3 = Shear and chop
4 = Shear, chop, and apply herbicide
5 = Shear, rootrake, burn, and disk
6 = Shear, rootrake, burn, disk, fertilize, and apply herbicide

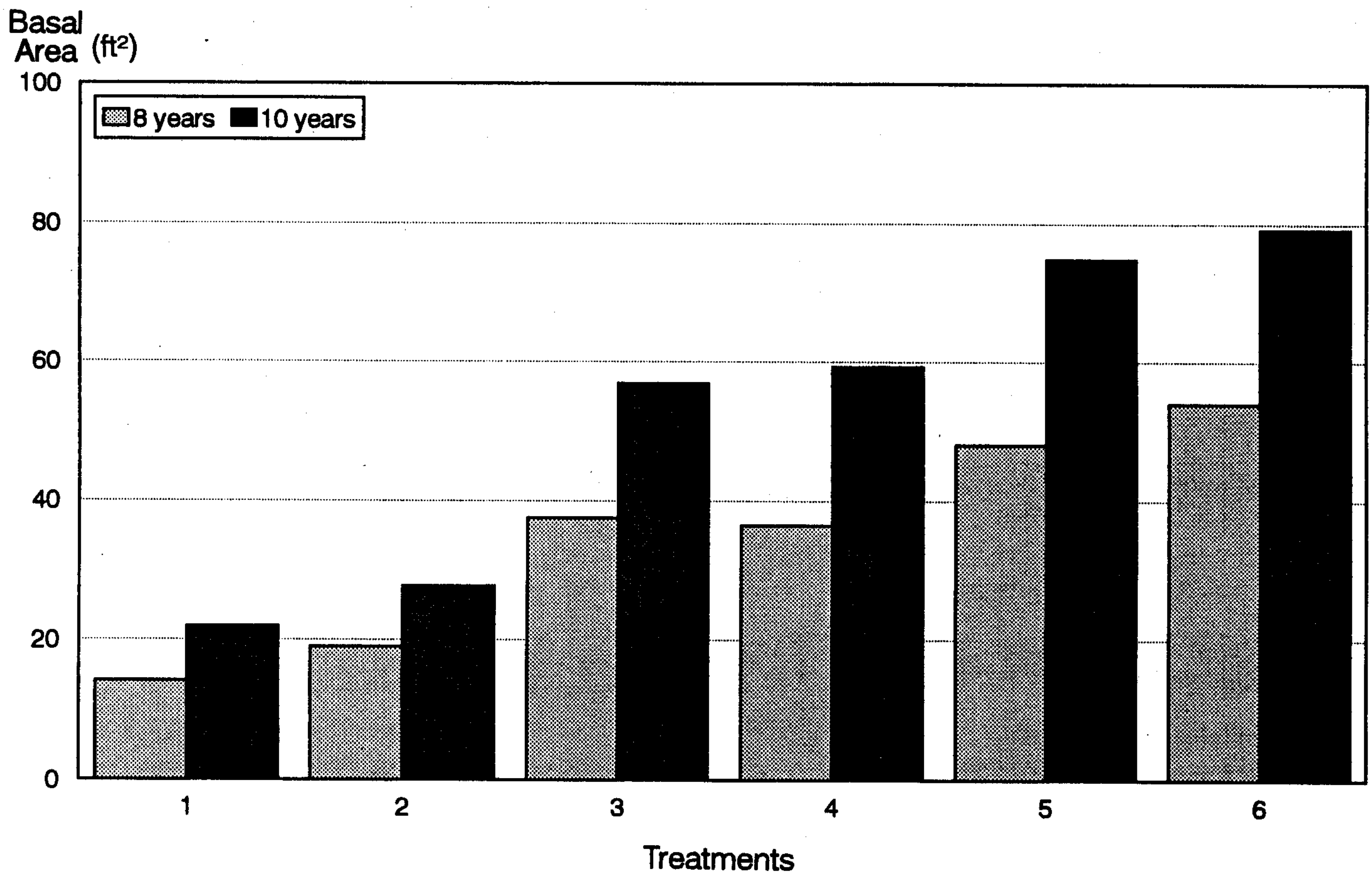

Figure 2—Mean basal area per acre by treatment at end of years 8 and 10, by six site-preparation treatments: (1) clearcut only (control); (2) chainsaw; (3) shear and chop; (4) shear, chop, and herbicide; (5) shear, rootrake, burn, and disk; and (6) shear, rootrake, burn, disk, fertilize, and herbicide.

Conclusions

The plots receiving the highest intensive site-preparation treatments had the most survival after 10 growing seasons. Shearing, rootraking, burning, and disking (treatment 5) was better than the others with 94 percent survival after 10 years. All treatments improved survival. Height growth and volume production were best for the most intensive treatments (5 and 6). Trees in treatment 6 had 2.2 inches more diameter at 10 years than the control trees.

It was previously reported (Edwards and Shiver 1991) that at the end of eight growing seasons total volume per acre for the most intensive treatment was 3.8 times more than for the control and all site-preparation treatments resulted in more growth than the control. After 10 growing seasons, treatment 5 with shear, rootrake, burn, and disk yielded 1,158.7 cubic feet per acre. The most intensive treatment (treatment 6), with additional fertilization and herbaceous weed control, yielded an additional 128 cubic feet per acre. The chainsaw treatment (treatment 2) was not significantly better than the control but appeared to yield an additional 116.6 cubic feet per acre.

Arguably, we will not know the full effects of the imposed treatments until the plantings reach rotation age. We plan to continue the study, and results at later ages will be reported. Results through age 10, however, appear to provide a fairly good basis for choosing among treatments. The cheapest and lowest intensity treatments permitted establishment of loblolly pine plantations after harvest of a pine stand. By age 10, it is clear, that yields can be increased a great deal by preparing sites more intensively. Whether intensive site preparation is the best choice will depend on the objectives and the financial status of the individual landowner.

Literature Cited

Bailey, Robert L.; Grider, Galen; Rheney, John W.; Pienaar, Leon. 1985. Stand structure and yields for site-preparation of loblolly pine plantations in the Piedmont and upper Coastal Plain of Alabama, Georgia, and South Carolina. Res. Bull. 328. Athens, GA: University of Georgia, College of Agriculture Experiment Station. 118 pp.

Edwards, M. Boyd 1990. Five-year responses of Piedmont loblolly pine to six site-preparation treatments. Southern Journal of Applied Forestry 14(1): 3-6.

Edwards, M. Boyd; Shiver, Barry D. 1991. Evaluation of six site-preparation treatments on growth and survival of loblolly pine in the Georgia Piedmont. In: Coleman, Sandra S.; Neary, Daniel G., comps., eds. Proceedings of the 6th biennial southern silvicultural research conference; 1990 October 30-November 1; Memphis, TN. Gen. Tech. Rep. SE-70. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station: 147-154.

Miller, James H.; Edwards, M. Boyd. 1985. Impacts of various intensities of site preparation on Piedmont soils after 2 years. In: Shoulders, Eugene, ed. Proceedings of the 3rd biennial southern silvicultural research conference; 1984 November 7-8; Atlanta, GA. Gen. Tech. Rep. SO-54. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station: 65-73.

SAS Institute Inc. 1985. SAS user's guide: Statistics. 5th ed. Cary, NC: SAS Institute Inc. 956 pp.

Edwards, M. Boyd. 1994. Ten-year effect of six-site preparation treatments on Piedmont loblolly pine survival and growth. Res. Pap. SE-288. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station. 10 pp.

Limited information is available on growth responses to different levels of intensity for site preparation in the Piedmont. In the present study, six intensities of site preparation were compared for their effect on survival, height and diameter growth, total volume produced, and basal area per acre for the first 10 years after treatment. Rates of survival and growth were lower for pines in the control plots than for any others. In general, tree performance improved as the intensity of site preparation increased.

Keywords: Growth response, loblolly pine growth, pine survival, *Pinus taeda*, treatment intensity, yield.

Edwards, M. Boyd. 1994. Ten-year effect of six-site preparation treatments on Piedmont loblolly pine survival and growth. Res. Pap. SE-288. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station. 10 pp.

Limited information is available on growth responses to different levels of intensity for site preparation in the Piedmont. In the present study, six intensities of site preparation were compared for their effect on survival, height and diameter growth, total volume produced, and basal area per acre for the first 10 years after treatment. Rates of survival and growth were lower for pines in the control plots than for any others. In general, tree performance improved as the intensity of site preparation increased.

Keywords: Growth response, loblolly pine growth, pine survival, *Pinus taeda*, treatment intensity, yield.