Eleventh-Year Results of Fertilization, Herbaceous, and Woody Plant Control in a Loblolly Pine Plantation[1]

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[1] Mention of trade names is solely to identify materials used and does not imply endorsement by the U.S. Department of Agriculture. Discussion of herbicides in this paper does not constitute recommendation of their use or imply that uses discussed here are registered. Herbicides that are handled, applied, or disposed of improperly are a potential hazard to the applicator, off-site plants, and environment. Herbicides should be used only when needed and should be handled safely. Follow the directions, and heed all precautions on the container label. Manville Forest Products Corporation provided the study area, equipment, and personnel toward completion of this research which the authors gratefully acknowledge.

*ABSTRACT. Through 11 years, fertilization at planting significantly increased the stemwood volume (outside bark) per loblolly pine (*Pinus taeda *L.) on an intensively prepared moderately well-drained fine sandy loam site in northern Louisiana. Four years of herbaceous plant control significantly increased pine survival, and because herbaceous plant control increased survival, it resulted in a significant increase in total stand volume. Woody plant control no longer produced significant results by age 11.*

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Control of both herbaceous and woody plants alters the competitive balance of early successional vegetation to favor pine survival and early diameter and height growth (Bacon and Zedaker 1987, Clason 1984, 1987, Creighton et al. 1987, Haywood 1986, 1988, Smith and Schmidtling 1970, Tiarks and Haywood 1981, Zutter et al. 1987). Grasses are the most productive herbaceous plants on newly established loblolly pine (*Pinus taeda* L.) sites in the loblolly pine–shortleaf pine (*P. echinata* Mill.)–hardwood forest type of the southern United States (Wolters and Wilhite 1974), and therefore, they are often a chief hinderance to conifer establishment (McDonald 1986). However, this is a short-term problem because as stands develop, woody vegetation increasingly shades the herbaceous plant cover (Grelen 1976, McDonald 1986). Hardwoods are longer term competitors with pine trees. Hardwood trees, if uncontrolled, often become a component of the pine overstory and may form a dense second canopy and understory that reduces pine volume and yield (Cain 1988, Glover and Dickens 1985, Langdon and Trousdell 1974).

Loblolly pine trees in the Upper West Gulf Coastal Plain Region are often deficient in foliar nitrogen and phosphorus (Allen 1988), and researchers have shown an increase in loblolly pine height and diameter after fertilization (Bolstad and Allen 1987, Gent et al. 1986, McKee and Wilhite 1986, Schmidtling 1984). However, fertilization does not always improve loblolly pine diameter and height growth on all sites in the Region (Haywood and Burton 1989, Hunt and Cleveland 1978).

All three of these treatments—fertilization, herbaceous plant control, and woody plant control—are used by forest managers to either alter the competitive balance to favor pine tree establishment and growth or to correct a nutrient deficiency. This study was established to determine the degree that survival and growth of loblolly pine trees is limited by herbaceous or woody plant competition in a new plantation and to evaluate if fertilization interacts with competition control after intensive site preparation.

METHODS

Field Study

The study was established in Winn Parish, LA, in the Upper West Gulf Coastal Plain. The soil is a moderately well-drained Malbis very fine sandy loam (fine-loamy, siliceous, thermic Plinthic Paleudults) with a 7% westward slope. Loblolly pine stands on this soil are often inherently deficient in nitrogen and phosphorus as determined by foliar analysis (Allen 1988, Wells and Allen 1985). Before clearcutting, the site supported a mature loblolly pine-shortleaf pine stand with a dense, mixed-hardwood understory (about 2,000 stems/ac) and a few hardwood trees in the overstory. Typical species were southern red oak (*Quercus falcata* Michx. var. *falcata*), post oak (*Q. stellata* Wangenh.), hickory (*Carya* spp.), and blackgum (*Nyssa sylvatica* Marsh.).

The area was site prepared during September 1977 with a tractor-mounted V-Blade and root-raked to about a 4-in. depth. Most of the large hardwood roots were torn out.

Treatments

Three treatments were examined: fertilizer, woody plant control, and herbaceous plant control. All combinations of these three treatments (a 2^3 factorial) were installed in a randomized complete block design with four blocks. Blocking was based on slope and general site condition.

After the 32 plots were installed, 64 uniformly graded, bareroot 1-0 loblolly pine seedlings were hand-planted at a spacing of 8 × 8 ft (681 trees/ac) during the winter of 1977–78 on each plot. In September 1978, the dead seedlings were replaced with loblolly pine seedlings grown in containers to maintain uniform density.

For the fertilization treatment, 100 lb of nitrogen, 44 lb of phosphorus, and 83 lb of potassium/ac were broadcast by hand as a granular fertilizer (13-13-13) in April 1978. After 5 growing seasons, only the phosphorus portion of the fertilizer proved to be beneficial (Tiarks and Haywood 1986), and Allen (1988) reported loblolly pines trees were deficient in foliar phosphorus when growing on Malbis soils.

For the woody plant control treatment, all competing woody vegetation was treated with herbicides. In 1978 a directed spray of low volatile ester 2,4,5-T [(2,4,5-trichlorophenoxy)acetic acid] was used. In 1979 the few remaining woody plants were severed near the ground and the stumps treated with a picloram (4-amino-3,5,6-trichloro-2- pyridinecarboxylic acid) and 2,4-D [(2,4-dichlorophenoxy)acetic acid] mixture. Visual observation after treatment indicated the herbicides did not injure the pines.

For the herbaceous plant control treatment, plots were carefully hoed to remove herbage three times yearly between April and September for the first 4 growing seasons. Hoeing was done within a 3.8-ft radius of each planted pine with minimal injury to the woody plants. For erosion control, an undisturbed population of herbaceous plants was intentionally left on one-third of the plot area between adjacent pine trees. Both competition control treatments were successful (Tiarks and Haywood 1986).

Measurements and Calculations

Competing vegetation was cut off near the ground on randomly selected 8 × 8 ft subplots for determining the ovendry weights by plot (Tiarks and Haywood 1986). Total height and diameter at breast height were measured on 16 loblolly pine trees in the plot center for 11 years. Total stemwood volume (outside bark) was calculated with Baldwin and Feduccia's (1987) formula. Plot means were analyzed by analysis of variance to test for treatment effects, two-way, and three-way interactions ($P \leq 0.05$). The probability of a greater F-value is reported for each main effect comparison to assist forest managers whose needs are met by a different criterion of significance than we used. Analysis of the data sets, with or without the inclusion of the inplanted pine seedlings, did not change the interpretation of results.

RESULTS AND DISCUSSION

Loblolly Pine Survival

The combined use of fertilizer and woody plant control significantly decreased pine survival by the end of the third growing season (Table 1). The trend toward reduced survival on plots receiving both fertilizer and woody plant control was also evident after the first growing season, whether only the population of original seedlings or the population of original plus inplanted seedlings were considered.

The decrease in survival on plots receiving both fertilizer and

Table 1. Loblolly pine density was influenced by a significant fertilizer × woody plant control interaction; herbaceous plant yields are also shown for comparative purposes.

Woody plant control	Pine density (trees/ac) Fertilizer No	Pine density (trees/ac) Fertilizer Yes	Herbaceous yields (lb/ac) Fertilizer No	Herbaceous yields (lb/ac) Fertilizer Yes
	1st-year survival before inplanting		1st-year yields	
No	580	600	350	880
Yes	600	560	480	1,140
	1st-year survival after inplanting			
No	640	660		
Yes	670	620		
	3rd-year survival		3rd-year yields	
No	620	650	1,050	1,790
Yes	670	610[1]	1,220	2,040
	11th-year survival		11th-year yields	
No	610	640	nil	nil
Yes	650	580[1]	nil	nil

[1] There were significantly fewer pine trees per acre on plots receiving fertilizer and woody plant control (Prob. > $F \leq 0.05$).

woody plant control was associated with an increase in herbaceous plant yields after the first and third growing seasons (Table 1). Conversely, pine survival was significantly greater with herbaceous plant control through 11 growing seasons (Table 2).

Greater pine survival with herbaceous plant control was an important finding. Others have also reported better pine survival following herbaceous plant control (Creighton et al. 1987). They determined that the potential for herbaceous plant control to reduce mortality should be greatest where low soil moisture holding capacity, low rainfall, and severe competitive pressure make stand establishment difficult.

Loblolly Pine Growth and Yield

Interpretation of all results are identical whether the inplanted trees were included or not in the analyses. There were no other significant interactions among the three treatments—fertilizer, herbaceous plant control, and woody plant control—affecting pine height, diameter, and stemwood volume through 11 years. For the interactions, the probability of a greater F-value ranged from 0.15–0.95. Swindel et al. (1988) also found fertilizer and competition control effects to be additive through 4 growing seasons for planted loblolly pine trees on a somewhat poorly to poorly drained soil.

During the first 5 growing seasons, fertilization, herbaceous, and woody plant control each increased loblolly pine height growth. The height growth response to herbaceous and woody plant control were greatest at the end of the seventh and eighth growing seasons, respectively (Figure 1). The height growth response to fertilization was greatest at the end of the eleventh growing season, but the gains in height growth from fertilization were nominal after the seventh growing season. After 11 growing seasons, none of the three treatments continued to significantly affect total height (Table 2).

Since tree height is insensitive to minor differences in stand den-

Table 2. Loblolly pine mean diameter, height, and volume per tree responses to the three vegetation management treatments after 11 growing seasons.

Treatment Effects	Number of plots	Pine density (trees/ac)		Mean height (ft)		Mean diameter (in.)		Volume per pine (ft^3/tree)		Total volume (ft^3/ac)	
Main effect treatment comparisons from the analyses of variance											
Fertilizer	16	610	0.37[1]	41.7	0.09	6.1	0.03	4.6	0.02	2,750	0.09
No fertilizer	16	630		40.2		5.8		4.0		2,490	
Herbaceous plant control	16	650	0.03	41.7	0.07	5.9	0.98	4.3	0.67	2,790	0.03
No herbaceous plant control	16	590		40.1		5.9		4.2		2,450	
Woody plant control	16	610	0.65	41.5	0.22	6.1	0.06	4.5	0.06	2,720	0.19
No woody plant control	16	630		40.4		5.8		4.0		2,520	
Treatment averages											
No fertilizer											
No plant control	4	600		39.2		5.7		3.8		2,270	
Woody plant control	4	640		39.7		5.7		3.9		2,440	
Herbaceous plant control	4	630		40.4		5.6		3.8		2,380	
Woody + herbaceous control	4	660		41.4		6.0		4.3		2,870	
Fertilizer											
No plant control	4	620		40.6		5.9		4.2		2,580	
Woody plant control	4	520		41.0		6.5		5.0		2,510	
Herbaceous plant control	4	660		41.4		6.0		4.3		2,850	
Woody + herbaceous control	4	640		43.9		6.1		4.8		3,060	

[1] For each paired comparison, the probability of a greater F-value is given. Prob. > $F \leq 0.05$ is significant for this research.

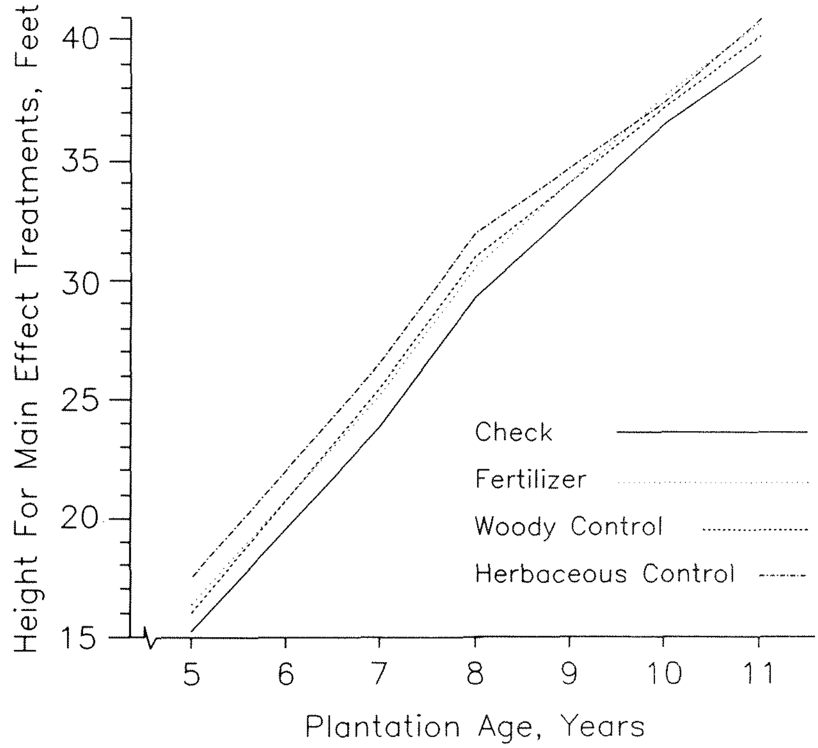

Figure 1. Effect of treatments on loblolly pine tree height through 11 growing seasons. Total heights quit diverging in the seventh and eighth growing seasons on the herbaceous and woody plant control treatments, respectively. Gains in height from fertilization were nominal after the seventh growing season.

sity, the loss of a weed control response, beginning in the seventh growing season, demonstrated that our early phenomenal growth responses (Tiarks and Haywood 1986) were not reliable predictors of future growth potential. Others have had similar results. For example, early gains in height growth from cultivation in a southern Mississippi study (Smith and Schmidtling 1970) were no longer significant by age 22 (Schmidtling 1984).

Through age 7, herbaceous and woody plant control significantly increased pine diameter and volume per tree. The early influence of weeding on pine diameter and volume per tree was similar to the results reported by Swindel et al. (1988) for 4-year-old loblolly pines and by Creighton et al. (1987) for 7-year-old loblolly pines. However, herbaceous and woody plant control were no longer effective by age 11 in our study (Table 2).

Too high a stand basal area may be a contributing factor because total basal area averaged 120 ft^2/ac on the herbaceous and woody plant control treatments by age 11. Either wider planting spacings or a precommercial thinning might have maintained diameter growth differences longer. However, wider planting spacings would have delayed crown closure, requiring added weeding treatments to maintain control of the competing vegetation. Therefore, either wider planting spacings or precommercial thinning would add further to management expenses if maximum early growth differences were to be maintained.

Fertilization caused a significant increase in both mean diameter and volume per tree through 11 growing seasons (Table 2). Stand basal area was not a factor in slowing early gains in stem radial growth from fertilization, although the fertilized plots averaged 119 ft^2/ac by age 11. Haywood and Burton (1990) also reported that phosphorus increased stemwood volume per tree on five other Paleudult soils in northern Louisiana through 12 growing seasons. The phosphorus portion of the fertilizer may continue to influence individual tree growth well into the rotation (Allen 1987), whereas weeding will not.

Greater seedling survival on the herbaceous weed control plots resulted in a significant increase in total stand volume through 11 growing seasons (Table 1). Glover et al. (1989) also reported that herbaceous weed control increased total stand volume through 12 growing seasons on two sites in Arkansas.

Fertilizer and woody plant control, as main effect treatments, did not increase total stand volume because in combination these two treatments adversely affected pine survival (Tables 1 and 2). Haywood and Burton (1990) also reported that phosphorus did not increase total stand yields on five other Paleudult soils in northern Louisiana through 12 growing seasons because of the confounding effects of soil type and mechanical site preparation (for controlling woody competitors) on stand survival and yield.

In conclusion, forest managers wanting to rapidly produce large individual pole-size loblolly pine trees should consider phosphorus fertilization on similar Paleudult soils. If maximizing total stand volume is the primary objective, herbaceous plant control should be considered on adverse sites where herbaceous interference is expected to result in significant mortality among newly planted pine seedlings. □

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