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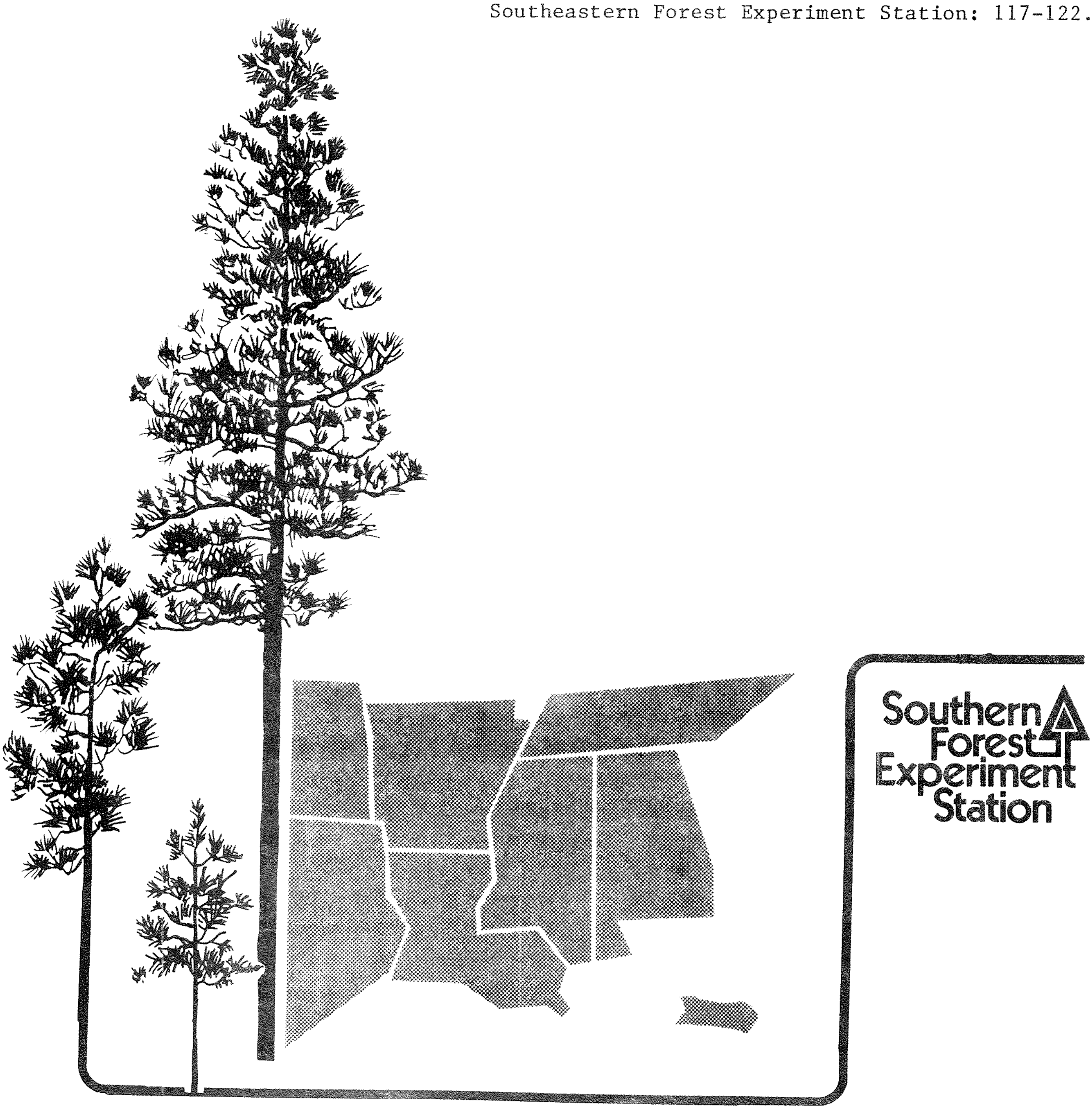

A COMPARISON OF LOBLOLLY PINE GROWTH AND YIELD ON PURE PINE AND MIXED PINE-HARDWOOD SITES

James D. Haywood and John R. Toliver[1]

Abstract. – The case histories of four loblolly pine (Pinus taeda L.) sites were examined to determine if differences in growth and yield could be associated with stand type. The stand types were pure loblolly pine and mixed loblolly pine-hardwood. All sites were located on silt loam soils, and mechanical site preparation was carried out on all sites before regeneration. The pure loblolly pine sites had greater rates of individual tree growth and yielded more inside-bark volume per acre than pine trees on the mixed loblolly pine-hardwood site. Pure loblolly pine yielded approximately 830 to 1,520 ft^3/ac 9 years after site preparation. In contrast, loblolly pine trees on the mixed pine-hardwood site yielded only 152 ft^3/ac after 9 years.

INTRODUCTION

A vegetation management study was established within a mixed loblolly pine (Pinus taeda L.)-hardwood stand in 1984. Almost all the pines in this stand appeared to have a very slow growth rate, even the larger sapling loblolly pine trees. It was concluded that interference from the hardwood trees and shrubs was the most likely reason for the slow diameter and height growth of these pine trees (Bacon and Zedaker 1987, Clason 1984, Glover and Dickens 1985, Haywood 1986), and the severity of hardwood competition partly resulted from a series of management errors that often occur when regenerating lands to loblolly pine (Haywood 1988). Because several data sets were available from pure loblolly pine stands, a decision was made to examine differences in growth and yield associated with stand type.

The purpose of our comparison was to determine if growth and yield differences existed among four independently established field studies. Differences would suggest that forest managers may have to accept a curtailment in pine growth and yield at the beginning of the rotation when managing mixed loblolly pine--hardwood in the West Gulf Coastal Plain, thus eliminating early commercial thinnings.

DATA SELECTION AND PRESENTATION

Inherent differences among sites, climate differences among growing seasons, and differences in genetic quality of the regeneration make it difficult to compare the case histories of independently established research studies. Our analysis was limited to plots established on silt loam soils in order to eliminate as many of these confounding factors as possible. Four data sets were used to represent a full range of stand types: two sites of pure loblolly pine planted on open-range maintained by fire and livestock grazing (Haywood 1983, 1980), one site of pure loblolly pine that had become sucessfully established despite interference from successional woody vegetation (Haywood and Burton 1989, Haywood and others 1981), and one site representing a mixed loblolly pine-hardwood stand (Haywood 1988). Mechanical site preparation had been carried out on all sites before regeneration. For all sites, stand age was referenced to the first growing season after site preparation because the exact age of individual trees in the mixed loblolly pine-hardwood stand was not known, and rotation length is an important economic consideration. Three of the four sites were located in Rapides Parish, Louisiana, and the fourth site was located in Drew County, Arkansas. All loblolly pines growing on a single site were similar in size and yield, so plot data were averaged for each of the four sites. Sampling age and tree size differed among sites, which precluded formal statistical analysis (Walstad and Kuch 1987). For each site, Schmitt and Bower's (1970) formula was used to calculate the inside bark volume for each pine tree at least 4.5 ft tall.

METHODS AND PROCEDURES

Sites I and II

Sites I and II (pure loblolly pine) were located on a cutover longleaf pine (P. palustris Mill.) site in Rapides Parish, Louisiana, that had been maintained as an open range. The growth of bluestem (Andropogon spp.) had been favored by periodic burning and grazing. The woody plant component consisted of small scattered southern bayberry (Myrica cerifera L.), post oak (Quercus stellata Wangenh.), and blackjack oak (Q. marilandica Muenchh.). At Site I, the soils were Beauregard

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(Plinthaquic Paleudult, fine-silty, siliceous, thermic) and Caddo (Typic Glossaqualfs, fine-silty, siliceous, thermic) silt loams. At Site II, the soils were Acadia (Aeric Ochraqualf, fine, montmorillonitic, thermic), Beauregard, and Kolin (Glossaquic, Paleudalf, fine-silty, siliceous, thermic) silt loams. The silt loam soils at both Sites I and II were moderately to highly productive for loblolly pine, with site indices of 85 to 90 feet at 50 years (Kerr and others 1980).

Prior to plot establishment, Site I was prescribe burned, and the woody vegetation was cut and removed at both sites. Site preparation treatments of harrow or harrow-bed were applied 6 months before planting at Site I and 4 to 6 months before planting at Site II. Bare-root 1-0 loblolly pine seedlings were planted by hand at a 6- by 8-ft spacing in February 1962 at Site I and in February 1964 at Site II. Because hardwood trees and shrubs were not a significant component of the vegetation during these studies, hardwood interference with the planted pine trees was considered minimal at both sites.

Diameter at breast height (d.b.h.) and total height of loblolly pine trees were measured 5, 10, and 13 years after site preparation at Site I and 5, 10, and 15 years after site preparation at Site II. Both the harrow-only and harrow-bedding treatments had similar loblolly pine tree growth and yield for each of the two sites. Therefore, the loblolly pine tree data from both treatments were combined before constructing the case histories for Sites I and II.

Site III

Site III (pure loblolly pine) was an upland hardwood sawtimber site in Drew County, Arkansas. Before logging, the dominant and codominant hardwoods were sweetgum (Liquidambar styraciflua L.), white oak (Q. alba L.), willow oak (Q. phellos L.), water oak (Q. nigra L.), and hickory (Carya spp.). The timber was clearcut in 1970 and 1971. After logging, the site averaged at least 500 hardwood stems 1 inch or larger in d.b.h. per acre, with a basal area of more than 20 ft^2/ac before site preparation. The soils were Calloway (Glossaquic Fragiudalf, fine-silty, mixed thermic) and Henry (Typic Fragiaqualf, coarse-silty, mixed thermic) silt loams (Larance and others 1976). These soils were moderately productive for loblolly pine trees with a site index of 80 ft at 50 years.

Mechanical site preparation (chop-burn and shear-burn) was carried out on the research plots the summer before planting in 1970. Bare-root 1-0 loblolly pine seedlings were planted by hand at a 6- by 8-ft spacing that winter. Hardwood trees and shrubs numbered 3,860 stems/ac 3 years after site preparation, and brush interference with the pine trees was considered severe on all plots for 7 years. However, 12 years after site preparation, the pine trees had overtopped most hardwood competitors, and the brush was no longer an important portion of the basal area. Thus, hardwood interference was considered unimportant 12 years after site preparation.

The d.b.h. and height of loblolly pine trees were measured 7 and 12 years after site preparation. During these measurements, the pine trees were each classed as either potential crop trees or suppressed trees. Potential crop trees were pines that should reach merchantable size, were free-to-grow or intermediate, and had at least a 10-percent chance of capturing a place in the crown canopy. Suppressed trees were pines that were overtopped by other woody plants, with less than a 10-percent chance of capturing a place in the crown canopy. Loblolly pine trees from both the chop-burn and shear-burn treatments had similar yields 12 years after site preparation, so the pine data from both treatments were combined to construct a case history for Site III.

Site IV

Site IV (mixed loblolly pine-hardwood) was in Rapides Parish, Louisiana. The soil type was a Beauregard silt loam with a site index of 90 ft at 50 years for loblolly pine. The previous forest stand had been clearcut, which was followed by a chop and burn site preparation in the summer of 1978. In February 1979, the tract was direct seeded from a helicopter at a rate of 1 lb/ac of loblolly pine seeds. Conditions for direct seeding were good, but sufficient regeneration was not obtained. In February 1980, bare-root 1-0 loblolly pine seedlings were planted by hand into a tall grass cover at a 6- by 10-ft spacing. In December 1980, survival of the planted pines was 29 percent, but the site was considered 91 percent stocked (550 pine trees/ac) when natural, direct-seeded, and planted seedlings were combined. Six years after site preparation, the planting rows were undistinguishable, and the number of loblolly pines averaged 1,210 trees/ac, which was well above 100 percent stocking.

Six years after site preparation, hardwood trees at least 4.5 ft tall numbered 2,025 stems/ac at Site IV. Sweetgum, the most common hardwood, was in a mixture that consisted mainly of blackgum (Nyssa sylvatica Marsh.), red maple (Acer rubrum L.), southern red oak (Q. falcata Michx. var falcata), water oak, live oak (Q. virginiana Mill.), and post oak. Shrubs numbered 7,300 stems/ac. Blackberry (Rubus spp.) was common (1,600 canes/ac), as were several vines.

The d.b.h. and height of pine and hardwood trees were measured each year from the 6th through the 9th year after site preparation. Each pine tree was classed as either a potential crop tree or a suppressed tree as at Site III. Data from the pine and hardwood trees were used to construct a case history for Site IV.

RESULTS

Site I

Volume growth of individual loblolly pine trees was very good on this cutover open range, although the total number of loblolly pines decreased by only 36 trees/ac from the 5th to 13th year after site preparation (table 1). Therefore, Site I was the most productive of the four sites based on the combination of good stocking and rapid growth of individual trees (figure 1). Mean annual increment (m.a.i.) was 345 ft^3/ac from the 5th to 10th year and increased to 372 ft^3/ac between the 10th and 13th year after site preparation. Total pine yield was 2,980 ft^3/ac after 13 years.

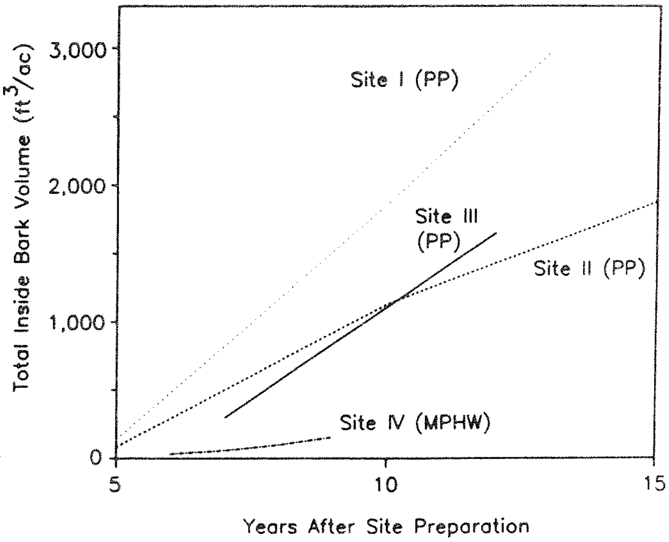

Figure 1.--The total inside bark volume per acre for loblolly pine trees at each site. Sites I, II, and III were pure loblolly pine (PP), and Site IV was mixed loblolly pine-hardwood (MPHW).

Table 1. Density and mean growth and yield of loblolly pine at least 4.5 ft tall on four sites in the West Gulf Coastal Plain.

Years after site preparation	Density	d.b.h.	Height	Average volume per pine
	trees/ac	inches	ft	ft^3
Site I[1]				
5	802	2.1	13.1	0.17
10	795	5.3	37.3	2.34
13	766	6.1	48.3	3.89
Site II				
5	756	1.6	10.7	0.11
10	703	4.8	30.0	1.61
15	662	5.7	37.9	2.83
Site III				
7	772	2.8	17.1	0.38
12	722	5.3	33.3	2.28
Site IV				
6	718	0.6	7.3	0.05
7	849	0.9	8.5	0.07
8	911	1.3	10.4	0.10
9	1,042	1.5	12.5	0.15

[1] Sites I, II, and III were pure loblolly pine, and Site IV was mixed loblolly pine-hardwood.

Site II

Individual loblolly pine tree growth was not as rapid at Site II, although the mortality rate was somewhat greater than at Site I (table 1). The m.a.i. was 210 ft^3/ac from the 5th to 10th year, but this decreased to 148 ft^3/ac between the 10th and 15th year after site preparation. Total pine yield was 1,873 ft^3/ac after 15 years (figure 1).

Site III

The stocking of loblolly pine trees was good despite interference from hardwood trees and shrubs during the first 7 years after site preparation (table 1). Once the pine trees were established, the growth rate increased, and the m.a.i. for all pine trees was 270 ft^3/ac from the 7th to 12th year. It is evident from figure 1 that the m.a.i. was less than the 270 ft^3/ac before the 7th year. Total pine yield was 1,641 ft^3/ac after 12 years (figure 1). Of the three pure loblolly pine sites, this was the least productive 7 years after site preparation, but by 12 years, Site III was producing more volume per acre than Site II.

Six percent of the loblolly pine trees were suppressed 7 years after site preparation; this comprised only 3 percent (8 ft^3/ac) of the total yield. After 12 years, 11 percent of the pines were suppressed because the canopy had closed, but suppressed trees still comprised 3 percent (49 ft^3/ac) of the total yield. The potential crop trees yielded 290 and 1,592 ft^3/ac 7 and 12 years after site preparation, respectively (figure 2).

Site IV

The number of loblolly pines on this site increased by 324 trees/ac from the 6th to 9th year after site preparation, and the mean size of the pine trees was much smaller than at the other three sites (table 1). The increasing number of pine trees had a negative influence on mean d.b.h., height, and volume per tree, so the mean growth of these trees was very slow for the 3-year period. Nevertheless, the m.a.i. for all pine trees was 39 ft^3/ac between the 6th and 9th year after site preparation, and total pine yield was only 152 ft^3/ac after 9 years. Clearly, the mixed loblolly pine-hardwood site was the least productive of the four sites for pines (figure 1).

The actual number of potential loblolly pine crop trees remained constant over the 3-year period, with an average stocking of 632 trees/ac. The number of suppressed pine trees increased from 101 to 425 from the 6th to 9th year after site preparation, showing that although many new pine seedlings and saplings were developing, the majority, if not all, remained as suppressed trees. After 6 years, 14 percent of the pine trees were suppressed, comprising 12 percent (4 ft^3/ac) of the total volume/ac, but after 9 years, 41 percent of the pine trees were suppressed, comprising 18 percent (27 ft^3/ac) of the total volume/ac. The potential crop trees yielded 31 and 124 ft^3/ac 6 and 9 years after site preparation, respectively (figure 2).

Both intraspecific and interspecific competition contributed to the low productivity of loblolly pine trees at Site IV. The loblolly pine regeneration often

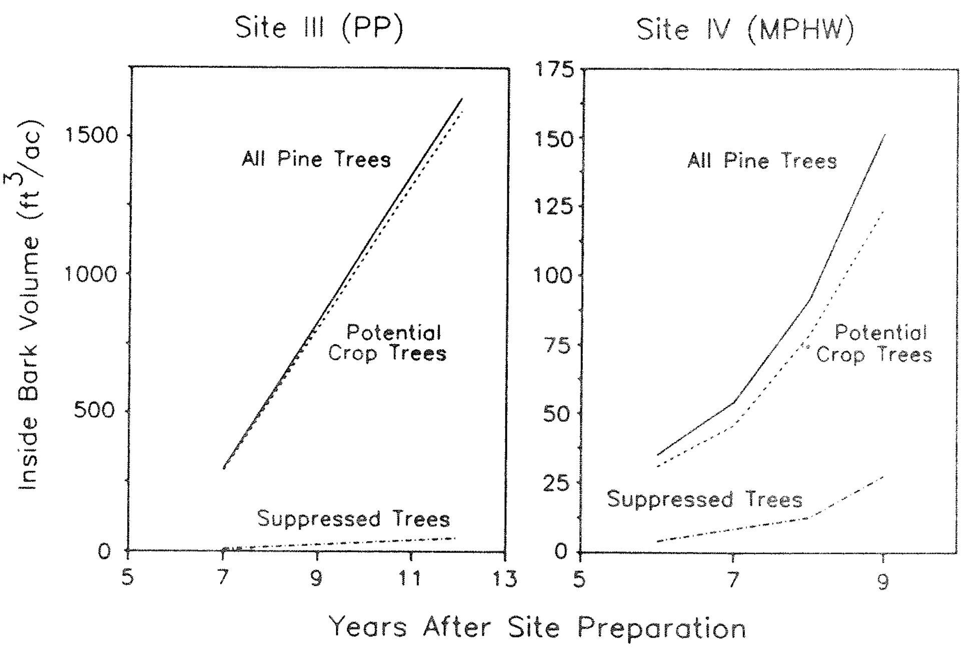

Figure 2.--The inside bark volume per acre for loblolly pine trees at Sites III and IV by three classifications: all pine trees, potential crop trees, and suppressed trees. Site III was pure loblolly pine (PP), and Site IV was mixed loblolly pine-hardwood (MPHW).

Table 2. Density and mean growth of hardwood trees at least 4.5 ft tall on Site IV, a mixed loblolly pine-hardwood stand.

Years after site preparation	Density	d.b.h.	Height
	stems/ac	inches	ft
6	2,025	0.5	7.5
7	1,998	0.6	7.8
8	2,829	0.7	9.0
9	3,206	0.7	9.9

formed clusters of pine trees. Consequently, the larger crop trees crowded or overtopped adjacent pines, and this slowed the diameter and height growth of the smaller trees. Conversely, because the intermediate or suppressed trees were growing so close to the larger pine trees, the diameter and height growth of the larger trees was also adversely affected. Interference from hardwood trees was also a factor. The number of hardwood trees at least 4.5 feet tall increased by 1,181 stems/ac from the 6th to 9th year after site preparation, due largely to ingrowth, and the average d.b.h. and height of these hardwood trees increased 0.2 inches and 2.4 ft, respectively, between the 6th and 9th years (table 2). There were also 1,559 hardwood trees/ac less than 4.5 ft tall and 7,102 shrubs/ac after 9 years.

DISCUSSION

The successful development of planted loblolly pine trees on Sites I and II was probably due to quick establishment of the regeneration where herbaceous plants were the most common competitors. Timely pine regeneration was also established at Site III, and quick establishment permitted planted seedlings to stay abreast of competing hardwoods and to eventually overtop the brush. Once the brush was overtopped at Site III, pine m.a.i. increased. Therefore, timely planting and successful establishment of seedlings after mechanical site preparation resulted in pure stands of loblolly pine trees without additional efforts to reduce competition from other species after planting.

On the other hand, Site IV became a loblolly pine-hardwood mixture primarily because the attempts at artificial regeneration by direct seeding and planting failed. This allowed the hardwood trees to gain a competitive advantage or equal status with the pine seedlings. The site was well-stocked with pine seedlings 2 years after site preparation because of natural loblolly pine regeneration. However, the pine trees at Site IV were clearly inferior in growth and yield to pine trees at the other three sites after a similar period of time.

After the direct seeding failed, planting of seedlings without additional site preparation resulted in further failure and was a poor investment. Although the site eventually became stocked by natural regeneration, the delay from failure of the artificial regeneration resulted in a mixed loblolly pine-hardwood stand.

These results suggest that artificial regeneration must be established quickly after site preparation, otherwise it is likely that the stand will become a mixed loblolly pine-hardwood stand. Such mixed stands result in curtailment of pine growth, and yield at the beginning of the rotation and early commercial thinnings may not be possible.

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