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Effects Of Site Preparation And Release On The Survival And Growth Of Planted Bare-root And Container-grown Longleaf Pine

by
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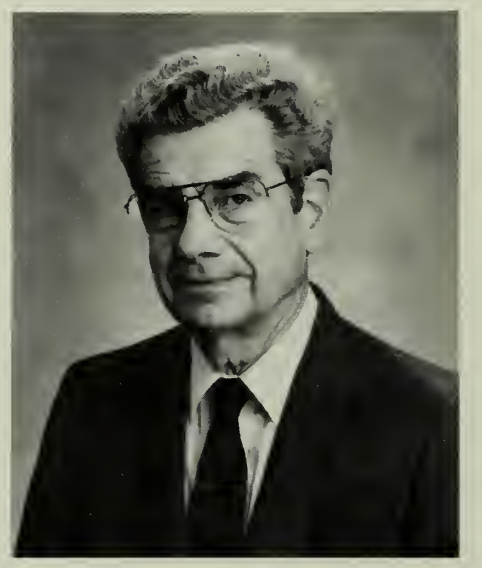

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ABSTRACT

Survival and growth of these plantings were observed for 3 years on a variety of coastal plain sites in Georgia. Treatments included high and low levels of pre-planting site preparation, with and without post-planting release with a herbicide. After 3 years, survival was much better for container (79%) than for bare-root (52%) stock. Survival was better with the high level of site preparation (73%) than with the low (58%). Of the seedling mortality over 3 years, 88% occurred during the first year. After 3 years, more container (78%) than bare-root (56%) stock were in active height growth. Release significantly increased seedlings in height growth (77%) over that of unreleased seedlings (58%). Level of site preparation did not affect seedling height growth after 3 years in the field. The low level of site preparation plus release was more effective in promoting seedling height growth than the high level of site preparation alone. Container seedlings are apparently more resistant to environmental factors that adversely affect survival and growth (drought, poor planting, competition) than are bare-root seedlings.

Effects Of Site Preparation And Release

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INTRODUCTION

Longleaf pine has long had a reputation as a difficult species to regenerate, either naturally or artificially. Repeated regeneration failures have reinforced this reputation, even though it may be largely undeserved *(Mann 1969, Farrar and White 1983).*

Poor survival of planted longleaf pine is a critical problem in Georgia, where planting failures are all too common. As a result, other species have been favored over longleaf, even on longleaf sites, despite the many desirable attributes of the species.

Poor survival of planted longleaf can be attributed largely to one or more of three factors, namely quality of nursery stock; care in handling, storage, and planting; and field conditions at time of planting and through the critical first year. Successful planting of longleaf requires careful attention to details, beginning at the nursery and continuing through planting, as stressed by Mann (1969), White (1981), and Farrar and White (1983).

This study is concerned with only the effect of field conditions, particularly the degree of pre- and post-planting competition control, on the early survival and growth of bare-root stock and container-grown seedlings of longleaf pine planted in 1983 on a range of coastal plain sites in Georgia. The other factors were held relatively constant across all study sites.

PROCEDURES

Study Locations

Five sites in Georgia were selected for this study, as follows:

1. Butler (Taylor County) -- sandhills site with a sandy surface soil > 36 inches in depth; turkey-bluejack oak type.
2. Soperton (Treutlen County) -- sandy, moderately well-drained middle coastal plain site; sandy surface soil underlain by sandy clay loam at 22 to 24 inches.
3. Waycross (Ware County) -- sandy, poorly drained flatwoods site, lower coastal plain; sandy surface soil underlain at 20 to 22 inches by sandy clay loam; palmetto-gallberry type; half of the area a recently cultivated field.
4. Valdosta (Lowndes County) -- deep sandy site, sand surface soil > 36 inches in depth, with high water table; lower coastal plain; hardwood bay type.
5. Albany (Dougherty County) -- sandy middle coastal plain site; sandy surface soil underlain at 8 to 10 inches by sandy loam to sandy clay loam subsoil, grading to compact sandy clay at 20 to 24 inches; pine-wiregrass type.

Treatments

At each location, except Albany, about 3 acres were set aside for the study, with one-half of the area (1.5 acres) for each of two intensities of site preparation. These were designated:

1. Low. Complete removal of all trees, hardwood and pine, plus one mechanical pass (chop or harrow) for residual brush control.
2. High. Same as above, plus additional mechanical pass (chop or harrow) for improved competition control.

Site-preparation treatments were installed in the fall/winter of 1982-83. Each of the two treatments was split for application of the following two post-planting treatments:

1. Release. Using Velpar® L[1]/ applied as a broadcast foliar spray in water (30 gal/acre) at the rate of 1lb. a.i. per acre (0.75 lb. a.i./acre) on the Butler sandhills site). Plots were sprayed July 6-8, 1983 with a sprayer mounted on a crawler tractor.
2. No release. Pre-planting site-preparation treatments only.

The Albany site was not clearcut and had a residual longleaf pine overstory averaging about 20 ft^2 in basal area per acre. A burn was the only site-preparation treatment. As a result, this location was omitted from the experimental design but was carried for observation of the effects of the post-planting release treatment.

Planting

Both longleaf pine 1-0 bare-root nursery stock and container-grown seedlings were planted on all study plots. Planting was begun at the Waycross location on March 1 and was completed at all locations except Valdosta by March 4. The Valdosta location was planted on March 10, 1983.

Nursery planting stock. About 10,000 seedlings from the E. A. Hauss Nursery near Atmore, Alabama, were used in this study. This nursery has produced quality longleaf planting stock for many years. Seedlings were lifted February 24 and transported to the study area on February 26, 1983. All nursery stock was machine-planted with a Whitfield planter drawn by a crawler tractor.

Container seedlings. About 1,900 container-grown longleaf pine seedlings were obtained from USDA Forest Service's Southern Station Research Work Unit 4101, Pineville, Louisana. Seedlings were about 25 weeks old when planted. Seedling plugs were removed from plastic tubes and hand-planted using a dibble.

Spacing. Seedlings were planted at a spacing of about 6X12 feet, usually with three rows of bare-root stock alternating with one row of container stock. In each of the four plots per location (two plots at Albany), about 500 bare-root and 100 container seedlings were planted.

Monumentation

Within each treatment plot, a total of 100 bare-root and 50 container seedlings were marked for observation of survival and growth. Five 20-seedling row segments of bare-root stock were marked in each plot. The first seedling in each sample row segment was marked with a pin and tag identifying the row segment. Five 10-seedling row segments of container seedlings were similarly marked in each plot. All sample seedlings were marked with a flag pin.

Measurements

Survival of marked seedlings was checked at intervals of about 6 weeks during the 1983 growing season and again in February 1984 after 1 year in the field. All marked seedlings were reexamined in June 1984 to check survival and number in active height growth. The next examination was conducted in November 1984, after two growing seasons in the field. The survival of all marked seedlings was checked, and the number in active height growth (>=0.5 ft. to base of terminal bud) was recorded. Total height, to base of terminal bud, was recorded to the nearest 0.1 ft. for all seedlings in active height growth. The percentage of vegetative cover on a 6-ft-wide belt centered on each sample row was estimated to the nearest 10 percent at the end of both the first and second year. Only current year's green vegetation was included in the estimate.

The last examination was conducted in February 1986, after 3 years in the field. Heights of surviving sample seedlings in active height growth were recorded as before. The Valdosta site had been burned by a wildfire shortly before the examination, but no serious damage was observed. The high site preparation area at Waycross had been grazed by cattle during the 1985 growing season, but no damage was detected.

Analyses

Analysis of variance was used to determine the significance of treatment effects on dependent variables. The design was a randomized complete block (location), with each of two site-preparation treatments split for release, plus an additional split for seedling type (bare root and container). Form of the analysis variance is shown in table 1. All tests of significance were at the 0.05 level of probability. All percentage data were analyzed as recorded, and again when transformed arcs in $\sqrt{\text{percent}/100}$. Analyses reported here are from untransformed data, because transformation did not change the results. The Albany location was excluded from all analyses.

RESULTS

Seedling Survival

Overall seedling survival (percentage of those initially planted) in February 1986 for the four locations with all treatment combinations, averaged 65% (Table 2), only a slight drop from the 66% recorded in November 1984 and 70% recorded in February 1984. Seedling mortality occurred primarily during the first growing season after planting, as expected.

Site preparation, release, and seedling type all significantly affected overall seedling survival at the end of the third year (Table 1). The major survival difference was between bare-root (52% survival) and container stock (79% survival) (Table 2). The

[1]/Discussion of herbicides in this paper does not constitute recommendation of their use or imply that uses discussed here are registered. If herbicides are handled, applied or disposed of improperly, there is potential for hazards to the applicators, offsite 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.

Table 1. -- Analysis of variance for longleaf pine seedling survival, height, and height growth 3 years after planting.

Source	df	"F" values and significance		
		Survival (%)	Height (ft)	Height growth (%)
Location (block)	3	3.95 ns[1]/	3.38 ns	0.57 ns
Site Prep.	1	14.54 * [2]/	7.21 ns	1.79 ns
ERROR I	3			
Release	1	8.26 *	15.27 *	24.53 *
Release X Site Prep.	1	0.01 ns	0.01 ns	2.31 ns
ERROR II	6			
Seedling Type	1	23.52 *	12.35 *	31.38 *
Seedling X Site Prep.	1	2.74 ns	0.88 ns	0.38 ns
Seedling X Release	1	.00 ns	1.77 ns	0.12 ns
Seedling X Site Prep. X Release	1	.70 ns	0.07 ns	0.93 ns
ERROR III	12			
Total	31			

[1]/ns = not significant at 0.05 level of probability.
[2]/* = significant at 0.05 level of probability.

higher intensity of site preparation resulted in 73% survival, compared to 58% for the lower intensity. Overall survival of seedlings sprayed for release (57%) was lower than that of unreleased seedlings (74%). None of the interactions were significant (Table 1).

When container and bare-root stock were analyzed separately, spraying for release significantly reduced the survival of bare-root but not container stock. This can probably be attributed to the fact that survival of released container stock was 81% and released bare-root stock only 72% of survival of similar unreleased seedlings.

Overall survival after 3 years, by treatment for each location, is given in table 3 for both bare-root and container stock. The survival of container seedlings was less than that of bare-root seedlings on only the low site-preparation site at Waycross. Apparently, this result is associated with a heavy cover of organic debris, although it is not clear why nursery seedlings were unaffected. This was also the only instance where the survival of unreleased container stock fell below 75%.

A major factor affecting first-year survival of planted pines was drought during the growing season. Spring and summer droughts were widespread in Georgia during 1983, although some study locations were affected much more than others. Growing-season rainfall (6 months, March through August) ranged from lows of 20.3 inches at Soperton and 24.7 inches at Butler up to 33.6 inches at Waycross, 35.8 inches at Albany, and 41.3 inches at Valdosta. Despite differences among locations in site characteristics and weather conditions, first-year seedling survival did not seem to be appreciably affected by location.

First-year survival of longleaf seedlings averaged 58% for bare-root and 83% for container stock at all five locations combined. A similar study, using bare-root longleaf seedlings from the same nursery, was established at the same five locations in February 1980. Droughts, with substantially below normal rainfall, also occurred in Georgia during the 1980 growing season. First-year seedling survivals were reported for all but the Valdosta site, on which plots were destroyed.[2]/ Survival was 30% at Albany, 46% at Butler, 55% at Soperton, and 75% at Waycross, for an average of 52%. For the same four locations, first-year survival of bare-root seedlings planted in 1983 was 46% at Butler, 52% at Albany, 64% at Waycross, and 69% at Soperton. Average survival of 58% was somewhat better than that of the 1980 plantings, even though the latter were not exposed to a herbicide spray.

Planting conditions also affect longleaf pine seedling survival. In general, the machine planting was very good. About 4% of bare-root seedlings at all five locations were planted too shallow (more than 1.5 inches of root exposed), as were 7% of the container seedlings, based on an evaluation in April 1983 after the soil had settled. Of the bare-root seedlings planted too shallow, 75% died. Of the container seedlings planted too shallow, 20% died. This was about the same as the rest of the container seedlings, with 18% mortality. Apparently, container seedlings were better able to survive root exposure than the nursery seedlings.

Table 2. -- Survival of longleaf pine seedlings 3 years after planting in relation to seedling type, site preparation, and release.

Seedling type	High Site Prep.		Low Site Prep.		Average
	Release	No Release	Release	No Release	
	(percent)				
Bare root	43.8	66.0	43.2	55.0	52.0
Container	84.5	97.0	56.5	77.0	78.8
Average	64.2	81.5	49.8	66.0	65.4

[2]/Croker, Thomas C., Jr. Unpublished report to Georgia Forestry Commission, dated March 1981.

Table 3. -- Survival of longleaf pine seedlings 3 years after planting, by treatment, for each study location.

Location	High Site Prep.		Low Site Prep.		Average
	Release	No Release	Release	No Release	
	(percent)				
	Bare-root stock				
Butler	27	58	31	60	44.0
Valdosta	47	76	43	39	51.2
Waycross	36	59	51	64	52.5
Soperton	65	71	48	57	60.2
Albany	--	--	38	37	37.5
	Container stock				
Butler	66	94	40	90	72.5
Valdosta	82	98	82	84	86.5
Waycross	96	98	16	58	67.0
Soperton	94	98	88	76	89.0
Albany	--	--	84	90	87.0

An estimated 5% of bare-root seedlings were planted too deep (more than 1.5 inches from soil surface to top of bud) after the soil had settled. There was no apparent excess mortality in this group through the first year, although development was retarded.

Some seedling mortality occurred at the Valdosta location because of flooding and ponding of water for relatively long periods; all flooded seedlings died. Affected were 5% of the bare-root (0.5% of container) seedlings at the Valdosta location, or about 1% of all marked bare-root seedlings in the study.

Poor planting of bare-root seedlings (too shallow or too deep), including flooding, affected an estimated 10% of these seedlings, with associated mortality of about 4%. This accounts for only about 10% of all bare-root seedling mortality recorded through the first year.

Some mortality may also have been associated with seedling size and vigor because all seedlings were planted with no systematic attempt to cull or grade by size, although unusually small or obviously unhealthy seedlings were discarded. The intention was to simulate a normal commercial planting operation.

Seedling survival during the second year, based on those alive at the beginning of the year, was significantly better for container stock (97.8%) than for bare-root nursery stock (90.8%). Survival was also significantly better with the high (95%) than the low (93.6%) intensity of site preparation. Release no longer affected survival, which averaged 94.3% for released and 94.2% for unreleased seedlings. Second-year survival among all five locations ranged from 87.0% at Albany to 97.7% at Butler.

Seedling survival during the third year, based on those alive at the beginning of the year, averaged 97.8% and no longer differed significantly among treatments or seedling type. Third-year survival among all five locations ranged from 94.1% at Albany to 98.7% at Valdosta.

Growth

Most longleaf pine seedlings had initiated height growth by the end of three growing seasons in the field (Table 4). For the four locations with all treatment combinations, the percentage of seedlings in active height growth (>=0.5-ft. height to base of bud) was significantly affected by only seedling type and release. A total of 78% of container seedlings were in active height growth, compared to 56% for bare-root stock. Release boosted the percentage of seedlings in height growth from 58 to 77. At time of planting, the root-collar diameters of bare-root seedings were larger than those of container stock. At the end of the first year, the situation reversed, and root-collar diameters of container stock, averaging 0.55 inch, were slightly larger than those of bare-root stock at 0.49 inch.

Although site preparation significantly affected the percentage of seedlings in active height growth at the end of the second year, this was no longer the case a year later.

A summary of the percentage of 3-year-old seedlings in height growth, by treatment and seedling type, is given in Table 5 for each location. Container seedlings were the best performers at all locations. With the high site-preparation/release treatment, 94% to 98% of marked container seedlings were in height growth on the Valdosta, Waycross, and Soperton sites (Figure 1). The benefits of releasing container seedlings was greatest on the harsher sites (Butler and Albany). Even on the dry sandhills site (Butler), 86% (high site preparation) and 85% (low site preparation) of released container seedlings were in active height growth, compared to 48% for all unreleased container seedlings and 46% for unreleased bare-root seedlings (Figure 2). Height growth at the Albany site (not included in the analysis) was very low, probably due to the heavy wiregrass sod, plus presence of a pine overstory and lack of

Table 4. -- Longleaf pine seedlings in height growth 3 years after planting in relation to seedling type, site preparation, and release.

Seedling type	High Site Prep.		Low Site Prep.		Average
	Release	No Release	Release	No Release	
	(percent)				
Bare root	64.0	56.0	66.1	39.0	56.3
Container	93.1	74.9	83.0	60.6	77.9
Average	78.6	65.4	74.6	49.8	67.1

Figure 1. Three-year-old longleaf pine with high site preparation/no release treatment at Valdosta site. Ninety-five percent of container seedlings (row shown) are in active height growth.

Table 5. -- Longleaf pine seedlings in height growth 3 years after planting, by treatment, for each study location.

Location	High Site Prep.		Low Site Prep.		Average
	Release	No Release	Release	No Release	
	(percent)				
			Bare-root stock		
Butler	48.3	51.7	71.0	40.0	52.8
Valdosta	74.5	54.0	74.4	46.1	62.2
Waycross	47.2	54.2	62.8	48.4	53.2
Soperton	86.2	64.2	56.2	21.4	57.0
Albany	--	--	21.0	2.7	11.8
			Container stock		
Butler	85.8	44.7	85.0	51.1	66.7
Valdosta	95.1	71.4	87.8	81.0	83.8
Waycross	93.8	98.0	75.0	55.2	80.5
Soperton	97.9	85.7	84.1	55.3	80.7
Albany	--	--	69.0	13.3	41.2

Figure 2. Three-year-old longleaf pine with low site preparation/no release treatment at Butler site. Most seedlings are beginning or about to begin active height growth.

Table 6. -- Average longleaf pine seedling height 3 years after planting in relation to seedling type, site preparation, and release.[1]/

Seedling type	High Site Prep.		Low Site Prep.		Average
	Release	No Release	Release	No Release	
	(feet)				
Bare root	1.5	0.9	1.1	0.5	1.0
Container	2.5	1.3	1.7	0.7	1.6
Average	2.0	1.1	1.4	0.6	1.3

[1]/Seedlings not in height growth considered to have zero height.

Table 7. -- Average longleaf pine seedling height 3 years after planting, by treatment, for each study location.[1]/

Location	High Site Prep.		Low Site Prep.		Average
	Release	No Release	Release	No Release	
	(percent)				
			Bare-root stock		
Butler	0.8	0.8	0.8	0.5	0.7
Valdosta	2.2	0.8	1.4	0.6	1.2
Waycross	0.8	0.8	1.3	0.6	0.9
Soperton	2.2	1.1	1.0	0.2	1.1
Albany	--	--	0.4	0.0	0.2
			Container stock		
Butler	1.0	0.6	1.3	0.5	0.8
Valdosta	3.2	1.0	2.5	1.2	2.0
Waycross	3.0	2.6	1.8	0.7	2.0
Soperton	2.7	1.1	1.3	0.6	1.4
Albany	--	--	0.9	0.2	0.5

[1]/Seedlings not in height growth considered to have zero height.

Table 8. -- Percentage of ground cover at end of first and second growing seasons in relation to site preparation and release.

Year	High Site Prep.		Low Site Prep.		Average
	Release	No Release	Release	No Release	
First	19	39	19	37	29
Second	56	68	57	70	63

site preparation other than fire. Container stock were better able to cope with this adverse environment, especially when sprayed for release.

Average seedling heights at 3 years were significantly affected by only seedling type and release. Average seedling height ranged from 2.5 ft. for released container stock with high site preparation to 0.5 ft. for unreleased bare-root stock with low site preparation (Table 6). Average seedling heights, by treatment for each location, are given in Table 7.

When container and nursery stock were analyzed independently, release was the only variable significantly affecting seedling height in each case. A year earlier, both release and site preparation significantly affected heights of container seedlings. Heights of bare-root seedlings, at that time, were not affected by any study variable, probably because too few had initiated height growth.

Vegetation Density

Estimates of the density of competition, in terms of percentage of cover, were made in the fall of 1983 and again in the fall of 1984 (Table 8). Release was the only treatment significantly affecting ground cover in either year. Intensity of site preparation had no effect on cover, which was primarily herbaceous vegetation. Most woody vegetation had been destroyed. The effect of the Velpar spray was greatest in the first year, with an average difference of 19% cover between sprayed and unsprayed plots (Figure 3). This difference declined to 12% at the end of the second year and was no longer apparent at the end of the third year.

Figure 3. Valdosta site, high site preparation treatment at end of first year. Sprayed with a herbicide (foreground) and unsprayed (background).

CONCLUSIONS

In this study, both the survival and growth of containerized longleaf pine seedlings were superior to those of bare-root nursery stock during the first 3 years after planting. The container stock and nursery stock did not come from the same seed lot, so differences in seed origin could have played a role in their comparative performances. Also, bare-root stock was machine-planted and the container stock hand-planted. In terms of percentage of seedlings poorly planted, the hand-planting had no real advantage over machine-planting. Because the effects, if any, of the above two factors on observed field performance of seedlings in this test cannot be evaluated, neither can differences in seedling performance associated solely with bare-root versus container origin. Goodwin, however, reported that longleaf pine container stock survived and grew better than 1-0 bare-root nursery stock on both a sandhills *(Goodwin 1980)* and a lower coastal plain site *(Goodwin 1976)*.

The survival advantage of planted container seedlings increased from 21% at end of the first year to 25% at the end of the second year and finally to 27% at the end of the third year. From the end of the first to the end of the third year, survival of container seedlings dropped from 80% to 79% and bare-root seedlings from 59% to 52%. The survival of bare-root stock was significantly reduced by the herbicide spray, but the survival of container stock was not. When survivals for both container and bare-root stock were combined for analysis, the more intensive site preparation improved overall seedling survival.

Results suggest that container seedlings may be more resistant than bare-root seedlings to the environment stresses, such as drought, competition, poor planting, and herbicide exposure, that were encountered in this study.

By the end of the third year, 78% of container seedlings were in active height growth, compared to only 56% of the surviving bare-root seedlings. Given a higher survival, combined with improved growth, the potential advantage of container stock is multiplied. With 600 seedlings per acre initially planted, container stock after 3 years had an overall average of 368 height-growth seedlings per acre, compared to 176 height-growth seedlings per acre for bare-root seedlings. Survival differences of this magnitude could easily make the use of container stock more cost-effective than the use of bare-root stock, compensating for differences in seedling costs *(Guldin 1982)*.

Although seedling release with a herbicide spray in July of the first year reduced seedling survival, it accelerated height growth by the survivors. Seventy-seven percent of released seedlings were in height growth at the end of the third year, compared to 58% of unreleased seedlings. Seedling heights at the end of the third year were similarly affected, with released seedlings averaging 1.7 ft., compared to 0.8 ft. for unreleased seedlings.

The low level of site preparation plus release resulted in better seedling growth than the high level of site preparation alone, suggesting that a post-planting release treatment could be substituted for a second pass with mechanical equipment with better results. Level of site preparation did not affect degree of herbaceous weed competition, or as a result, seedling growth; only the herbicide treatment did so.

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John W. Mixon, Director

Cost $2,431
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