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ESTABLISHING LONGLEAF PINE SEEDLINGS ON AGRICULTURAL FIELDS AND PASTURES

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Abstract—Acres planted to longleaf pine (*Pinus palustris*) increased annually through the 1990s until 2000 with peak plantings exceeding 110 million seedlings annually. Many of these longleaf seedlings were planted on agricultural crop fields and pastures. Agricultural areas have unique characteristics that can make them more challenging to successfully plant than comparable cutover sites. Seedlings planted on agricultural sites may suffer increased mortality from insect predation, disease, competition, and inhospitable soil conditions. Inadequate knowledge of longleaf pine's unique requirements on agricultural sites has led to many avoidable planting failures. Adequate site preparation, herbaceous release, and planting methods are critical for the successful establishment of longleaf on old fields and pastures. Combinations of site preparation and herbaceous release that have proven to be superior in the artificial regeneration of longleaf pine on agricultural sites will be discussed in this paper. Results from 4 herbicide screening trials and a site preparation study are included.

INTRODUCTION

The Longleaf Alliance was formed in 1995. Tens-of-thousands of agricultural acres were enrolled in the Conservation Reserve Program (CRP) at approximately the same time. The Longleaf Alliance played a crucial role in educating and informing CRP participants about the many benefits and challenges unique to longleaf pine (*Pinus palustris* Mill). Unfortunately, the best available information was often inadequate, and success rates varied considerably. With the benefits of hindsight and much experience, we believe that most planting failures were avoidable. Furthermore, many planting failures were attributed to factors that may not have played a role in seedling mortality on a given site.

Even without the CRP, millions of longleaf pine seedlings are planted annually on agricultural sites across the Southeastern United States, often with mixed success. Longleaf pine is selected as the primary tree species on many of these agricultural sites because of an increased interest from foresters, agency personnel, and landowners. Additionally, several State and Federal cost-share programs have monetary and regulatory incentives for longleaf that are not available for other southern pines species.

A new CRP enrollment has been authorized for 2003. In all likelihood, tens-of-thousands of additional acres will be enrolled in the CRP in the near future. If we have not learned our lessons from plantings in the late 90s, we are doomed to repeat many mistakes that were made during the initial CRP longleaf plantings—at considerable expense to landowners, State agencies, and the Federal Government.

The Longleaf Alliance has a unique advantage in that it is a regional organization with members from every State in longleaf pine's natural range. The alliance works directly with State forestry commissions, the U.S. Department of Agriculture, Forest Service, the Natural Resource Conservation Service, the Farm Service Agency, forestry consultants, herbicide applicators, tree planters, and landowners from across the Southeastern United States. Alliance personnel have witnessed almost every possible combination of site preparation, seedling stock, and herbaceous release on a variety of soil types from North Carolina to Texas. This wide-ranging experience has allowed us to work with others to identify many of the leading factors in longleaf seedling mortality.

SITE SELECTION

Before planting an agricultural field or pasture, it is important to determine if the site is appropriate for longleaf pine. Some sites are inappropriate and repeated planting failures are preordained. We do not recommend planting longleaf pine on sites that have high pH/basic soils (> 7.0 pH), excessive soil nutrients, or excessively wet soils.

High pH (Basic) Soils

The majority of soils across the Southeastern United States are acidic in nature and acceptable for longleaf pine seedling establishment. However, many agricultural sites have had their soil pH artificially raised by repeated applications of lime. The alliance has received reports of tomato fields in north-central Florida with pH readings approaching 8.0. Planting failures are the norm for any southern pine species on these sites. It could take many years for the soil to reach an acceptable pH for longleaf seedling establishment. Other soils are naturally basic (> 7.0 pH)—in particular, many prairie type soils in central Alabama and Mississippi. Experience has shown that it is very difficult to successfully establish longleaf pine on soils that have a pH greater than 7.0.

Excessive Soil Nutrients

Some areas have become so nutrientloaded that seedlings pick up toxic concentrations of normally beneficial nutrients. The alliance has visited, or received reports, concerning sites where large amounts of chicken litter were deposited or cattle catch pens were located. On these nutrient-loaded sites, longleaf seedling mortality approached 100 percent during the first growing season.

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Excessively Wet Sites

Ponded soil types are typically problematical. Seedling mortality increased dramatically when seedlings were under water for more than a few days. Mortality can be reduced by planting seedlings with most of the plug protruding above the soil surface. However, excessively wet soils (Pelhams & Gradies) are generally ill suited for longleaf pine.

BAREROOT OR CONTAINER

After determining the site is appropriate, selection of seedling stock is the next important step. Longleaf seedlings are grown and planted as both bareroot and container-grown seedlings. Seedling survival varies considerably based upon seedling quality and, to some degree, on seedling type. A 1995 survey (Boyette 1995) found that foresters, tree planters, and landowners using container-grown stock averaged 85-percent survival but only 65-percent survival using bareroot stock. Although some tree planters are consistently successful planting bareroot seedlings, the trend has been towards the use of container-grown seedlings (table 1). The successful establishment of container-grown seedlings is the focus of this paper.

Inadequate containers were an early problem for a relatively new industry producing container-grown longleaf seedlings. The absence of ribs in some containers led to root spiraling, which is extremely detrimental to seedling survival, growth, and form. Also, longleaf seedlings were occasionally grown in containers that were too small to produce a quality seedling.

Another early problem was the absence of seedling standards. Seedlings were often shipped with small root collar diameters (RCD), poor root systems, diseased foliage, and with weeds in the plug. In response to the lack of seedling standards, The Longleaf Alliance cooperated with the USDA Forest Service to produce a set of interim standards for growing seedlings in containters (Barnett and others 2002). This publication has recommendations for ribbed containers, minimum root collar diameters (1/4 inch), plug attributes, foliage attributes, minimum container volumes and depths, and other characteristics to look for in a quality longleaf seedling.

There are several different types or classes of seedlings in a typical lot of longleaf seedlings. The Longleaf Alliance installed two studies to identify easy diagnostics that would allow sorting out of seedlings that would not survive and grow well (Barnett and others 2002). Study sites were installed in or near Monroeville and Samson, AL. Seedling types utilized in these studies included: hybrids (or seedlings that looked like hybrids), doubles (two seedlings per plug), culls/floppies, and good-quality seedlings without weeds in the plug. Survival was assessed approximately 6 months to 1 year postplanting (table 2). Culls or "floppies" were seedlings in which the plug "drooped" or would not hold itself parallel to the ground when held by the terminal bud.

Table 1—Production of bareroot and container-grown longleaf pine seedlings over a 6 year period

	Bareroot	Container	Percent[a]
	- - millions of seedlings - -		
1996	30.2	31.1	51
1997	27.6	36.3	57
1998	25.0	42.6	63
1999	26.2	56.4	68
2000	32.6	82.3	72
2001	23.8	73.2	75

[a] Container-grown seedlings as a percent of total longleaf pine seedling production.

Table 2—Survival of longleaf pine seedlings by seedling type

Site	Good	Double	Floppy	Hybrid
	- - - - - - - - - - percent - - - - - - - - - -			
Monroeville				
Age 1 year	75	N/A	21	64
Samson				
Age 6 months	91	96	80	81

As expected, good-quality seedlings demonstrated some of the best survival rates. Likewise, doubles did very well at the Samson study site but were not included at the Monroeville study site. Hybrid seedlings had lower survival rates than good quality seedlings. Floppies had the lowest survival rates, doing much worse on the Monroeville site but only slightly worse than good-quality seedlings on the Samson site. These findings are in line with those of Barnett and others (2002): "Seedlings that fail to meet the criteria for the preferred category may survive and grow well under favorable site conditions." The Samson site was planted December 14, allowing seedlings to establish a better root system than the Monroeville seedlings, which were planted February 21. It is likely that planting dates were an important factor in the lower overall survival of seedlings on the Monroeville site and the abysmal performance of the floppy seedlings in Monroeville.

From these two studies and previous work done by the USDA Forest Service, we recommend that landowners or foresters:

1. Sort through seedlings boxes before delivering to the tree planter.
2. Establish counts of good quality seedlings per box.
3. Return boxes to the nursery if an excessive number of culls are found.
4. Request additional seedlings if your seedling count is short.

SITE PREPARATION

Over the past several years, the alliance has witnessed and directly participated in many attempts to establish longleaf pine in pastures or agricultural sites with significant components of perennial pasture grasses including bahia (*Paspalum notatum* Fluegge), fescue (*Festuca arundinacea* Schreb.), and bermuda grass [*Cynodon dactylon* (L.) Pers]. Most pasture plantings ended in failure. It was soon established that grasses had to be removed or controlled through site preparation prior to planting. Planting seedlings directly into pastures with the intention of controlling grasses through a postplanting herbaceous release was a recipe for failure.

The Longleaf Alliance addressed this problem in a 1998 study entitled "Comparison of Site Preparation Methods and Herbaceous Releases for Longleaf Pine Establishment in an Old Pecan Orchard". The study site was located in Covington County, AL. Soils were sandy loams with a history of frequent liming and fertilization. The site had a full compliment of old-field broadleaves and grasses including bermuda, bahia, and crab grasses (*Digitaria spp.*) and many other competitive old-field weed species. Three site preparations were tested in this study: scalping and subsoiling, broadcast chemical (glyphosate & imazapyr) plus subsoiling, and check or subsoiling only plots. This study utilized a randomized complete block design with four replications. The main plot treatment was the site preparation, and subplot treatments were herbaceous releases. Site preparation was completed in the fall of 1998, and container-grown longleaf were hand-planted in January 1999. After planting, seedlings were released in April and May of 1999. Eleven herbaceous release treatments were applied (table 3). Survival was assessed in the first and second growing seasons (table 4). Differences were significant and increased with time postplanting. Consistent with work previously conducted in Florida (Barnard and others 1995), survival and growth were significantly better on scalped plots than on check (subsoil only) plots. Survival and growth of longleaf were also significantly better on scalped vs. chemically site-prepared plots.

HERBACEOUS RELEASE

The Longleaf Alliance has conducted four herbicide screening trials (as of December, 2002) with further demonstrations and trials planned in 2003. Results from the 11 herbaceous release treatments tested in the old pecan orchard were consistent with previous and subsequent screening trials. From these screening trials, our most consistently effective release is the "split" treatment. The split treatment is composed of an early preemergent application of Oust® at 2 ounces in March or April, followed by a postemergent

Table 3—Herbaceous release treatments (subplot treatments) used in site preparation comparison test

Product	Active ingredient	Timing of application
Ounces per acre		
Check	N/A	N/A
Velpar DF10.67/ Oust 2	hexazinone/sulfometuron	4/7/99
Oust 2	sulfometuron	4/7/99
Arsenal 4/ Oust 2	imazapyr/sulfometuron	4/7/99
Arsenal 4 /Oust 2	imazapyr/sulfometuron	5/12/99
Atrazine 64	atrazine	4/7/99
Atrazine 64/ Oust 2	atrazine/sulfometuron	4/7/99
Oust 2 & Arsenal 4	sulfometuron & imazapyr	4/7/99 & 5/12/99 (2 apps.)
Fusillade 24	fluazifop-P-butyl	4/7/99 & 5/12/99 (2 apps.)
Velpar DF 21.34	hexazinone	5/12/99
Velpar DF 10.67	hexazinone	4/7/99

Table 4—Seedling survival in the first and second growing seasons and costs per second-year seedling and per acre

	Check SP—subsoil only	Chemical SP + subsoil	Scalp SP + subsoil
Percent surviving (age 1)	64	72	88
Percent surviving (age 2)	46	61	82
Percent starting height growth (age 2)	30	54	72
Total $ per acre (site prep, planting, seedlings, and release)	175.00	245.00	195.00
$ per surviving seedling (age 2)	0.77	0.86	0.48
$ per seedling initiating height growth (age 2)	3.48	2.21	0.78

Arsenal® application of 4 to 6 ounces. Wait for grasses to emerge before applying the second Arsenal® application. On low fertility, sandy sites, the first Oust® application is often sufficient by itself. On more fertile sites, problematic grasses or weeds will generally start to appear approximately 6 weeks following the initial pre-emergent Oust® application. Typically the second postemergent treatment will go out between mid-May and late July.

Alternatively, for those who can only afford a single application, an Arsenal® (4 to 6 ounces)/Oust® (2 ounces) tank mix has consistently tested as one of the best herbaceous releases. We recommend the Arsenal®/Oust® tank mix be applied after May 1, as injury and seedling mortality have been associated with earlier preemergent applications.

Many people believe their herbaceous release application has led to increased seedling mortality. In many cases, they are probably correct. Reviewing the first four herbicide screening trials conducted by The Longleaf Alliance, we believe trends are emerging with late plantings or high pH soils or both and mortality related to soil-active herbicides such as Oust® or Oustar®. In general, seedling mortality will be greater with late plantings, agricultural sites, and high pH soils, regardless of the herbicide applied.

Root growth prior to herbaceous release appears to be the key in avoiding increased seedling mortality or injury following an herbaceous release. Seedlings appear to be more tolerant of soil-active herbicides if a good root system is established prior to the herbicide application. If an insufficient number of fine roots have exited the plug, expect increased mortality associated with early applications of soil-active herbicides. To avoid this, plant good-quality seedlings early in the planting season and excavate several seedlings prior to any herbicide application. If several roots have exited the plug, soil-active herbicides can be applied with less risk. If the root system is still confined to the plug, it is probably better to avoid soil-active herbicides that could potentially increase seedling mortality. Dig before you spray!

PLANTING DEPTH

Planting depth may be the most critical factor affecting seedling survival and growth. We believe that a large percentage of early unexplained planting failures were a direct result of planting seedlings too deep. Results from the first four planting depth studies installed by The Longleaf Alliance have been extremely consistent (table 5). When soil covers the terminal bud, seedling mortality increases dramatically, whereas seedling growth is set back with surviving seedlings.

Prior to this research, the "wick" theory was widely promoted across the Southeast. The premise of the wick theory is that seedlings planted with the plug exposed will "wick out" or desiccate and die. The wick theory promotes deep planting and the avoidance of exposing the plug at all costs. Studies conducted by The Longleaf Alliance show that in every study conducted thus far, seedlings planted with the plug exposed have outperformed seedlings planted with the terminal bud beneath the soil surface. Studies installed in 2002 and 2003 in Alabama, South Carolina, and Georgia are exploring this further.

TIME OF PLANTING

Historically, planting season has been restricted to the winter months with the majority of seedlings planted in December, January, or February. With the advent of container-grown seedlings, a longer planting season was advocated with some people delaying plantings until March. Although little research has been conducted on time-of-planting with container-grown seedlings, the majority of anecdotal evidence suggests that earlier plantings are more likely to succeed than later plantings. Given adequate soil moisture, The Longleaf Alliance recommends planting as early as October. In moist soils, longleaf seedlings frequently initiate root growth very quickly. Early planted container longleaf seedlings appear more tolerant of winter droughts than bareroot seedling stock. Seedlings planted early in the planting season have more developed root systems in spring and thus appear more tolerant of spring droughts and herbaceous competition. Seedlings planted in late February or March appear much less hardy and are more susceptible to injury or mortality from herbaceous release treatments, herbaceous competition, and spring or summer droughts. From plantings on or around the Solon Dixon Center, one good rain (> 1 inch) soon after planting is sufficient to ensure a successful establishment of container-grown longleaf seedlings on most sites.

Many people are unaware that summer planting is a viable option. The Longleaf Alliance has planted longleaf on several sites in May, June, and July of 2001 and 2002. Overall survival rates have averaged approximately 80 percent at 1 year postplanting. With this limited experience, we only recommend summer planting in areas where seasonal

Table 5—Mortality by planting depth from deep to shallow (height to terminal bud) 1 or 2 years post-planting

	Planting depth						
Study site	-3 CM	-1 CM	Level	+1 CM	+2 CM	+3 CM	+6 CM
	percent mortality						
Silvopasture	57	41	24		21		
Godwin	79	71	39		36		
Orchard		56	19	17	20		
Monroe			38			33	21

rainfall is high during the summer months. June and July are typically wet months along much of the Lower Coastal Plain. From our experience, summer planting is a good option for filling in mortality on winter plantings, as long as adequate soil moisture is present and competition has been controlled through an herbaceous release treatment.

SUMMARY

We conclude the following: Use good seedlings; scalp agricultural fields; plant as early as possible; plant shallow with the terminal bud well above the soil surface; release seedlings from herbaceous competition for increased growth; examine roots before applying soil-active herbicides; and interplant mortality (May-July) if soil moisture is adequate.

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Description: Ninety-two papers and thirty-six poster summaries address a range of issues affecting southern forests. Papers are grouped in 15 sessions that include wildlife ecology; fire ecology; natural pine management; forest health; growth and yield; upland hardwoods - natural regeneration; hardwood intermediate treatments; longleaf pine; pine plantation silviculture; site amelioration and productivity; pine nutrition; pine planting, stocking, spacing; ecophysiology; bottomland hardwoods - natural regeneration; and bottomland hardwoods—artificial regeneration.