

The ABC's of Longleaf Artificial Regeneration

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Many foresters and tree planters avoid longleaf because of its reputation for being difficult to plant and slow to establish height growth. In this paper, we will address these concerns and provide practical recommendations that should allow many landowners to realize good survival and improved growth on most sites.

The Longleaf Alliance is a non-profit organization formed to disseminate practical information on the establishment, restoration, and management of longleaf pine ecosystems. With limited resources, we focus our research on the most pressing problems facing landowners who wish to establish and/or manage longleaf pine forests. Artificial regeneration of longleaf became an early focus of The Longleaf Alliance. We quickly identified some of the more persistent artificial regeneration misconceptions as:

1. Longleaf pine is impossible to plant successfully.
2. Bareroot longleaf is impossible to plant successfully.
3. Seedlings stay in the grass-stage for several years.
4. Container-grown seedlings are too expensive.
5. Container-grown seedlings are always better than bareroot seedlings.
6. It is OK to plant longleaf in the spring as long as you use container-grown seedlings.
7. Planting seedlings deep is better than planting shallow.
8. Clean-old fields or pastures are easier to reforest than trashy cutover sites.

Contrary to popular belief, it is much easier to establish longleaf pine on cutover sites than in fertile old fields recently removed from row cropping or pasture use. Ag sites have particularly aggressive weed species that are usually not prominent on cutover sites. The additional effects of residual herbicides, fungal pathogens, insect pests, drought, and a wide range of soil acidity/alkalinity, make old agricultural sites some of the most challenging areas imaginable for longleaf restoration efforts.

Whether the site is a cutover or an agricultural site, observations, research, surveys, and practical experience have demonstrated that a few key factors, if properly addressed, will almost always result in successful longleaf pine plantings.

1. Apply the proper site preparation before planting; through mechanical, chemical, or fire-related means.
2. Plant early. Having all your seedlings in the ground before Christmas greatly increases your chances of a successful planting. Good quality container-grown seedlings planted at the Solon Dixon Center in December 2000 had 4" of new root growth by mid-March, 2001. These seedlings survive spring or summer droughts.
3. Plant good quality seedlings. Container-grown seedlings improve your chances of success. However, a good quality bareroot seedling is more desirable than a poor quality container-grown seedling. Ask around. Nurseries should be able to provide references from tree planters, satisfied landowners, and foresters.
4. Plant seedlings at the correct depth. Research conducted by the Longleaf Alliance

indicates deep planting – when soil covers the terminal bud - is severely detrimental to seedling survival and growth.

5. Control competition through the first growing season. Late germinating weeds and grasses can be a problem in old fields. Agricultural sites may require two herbicide treatments to reduce competition to longleaf seedlings during the first growing season.

Planting Longleaf Pine on Cutover Sites

In general, even inexperienced foresters or landowners should be successful planting longleaf pine on cutover sites. Planting longleaf pine does not require extraordinary site preparation or herbaceous release. From our experience planting longleaf pine on several cutover sites at the Solon Dixon Center, and numerous examples we have visited across the Southeast, we have developed a simple formula for consistently establishing longleaf pine on cutover sites.

Start with the correct site preparation. We have found that a chemical site preparation is a good first step. A chemical site preparation has three main advantages over a mechanical site preparation.

First, a chemical site preparation tends to yield better and longer-lasting control of woody and shrubby competition on most sites. While we want to maintain as much of the herbaceous community as possible, it is to our advantage to control offsite oaks, gums, hollies, and other unwanted hardwood species. Mechanical site preparation may give you a site that looks clean, but subsequent sprouting and competition will typically be more severe when compared to a good chemical site preparation.

Second, chemical site preparations tend to retain more of the native perennial herbaceous species that are valuable for wildlife food, aesthetics, and diversity. For instance, most native legumes are tolerant of two of the three most commonly used chemicals: *hexazinone* (Velpar DF®, Velpar L®, Pronone®, & ULW®) and *imazapyr* (Arsenal®). Following a chemical site preparation, legume rootstocks often remain intact and viable, and will frequently bloom profusely one to two years after the herbicide application. On the other hand, an intensive mechanical site preparation will generally eliminate many of these root systems, and most of the species that invade the site will be weedy annuals.

Thirdly, a chemical site preparation causes less soil movement. Less soil movement means more consistent planting depth and seedling placement. Since incorrect planting depth or seedling placement frequently causes planting failures, the decreased soil movement associated with a chemical site preparation is a major advantage. The Longleaf Alliance has now established eight separate studies looking at the effects of planting depth on container-grown longleaf pine seedlings. From these outplantings, we found survival and growth rates suffer when seedlings are planted with the terminal bud beneath the soil surface. On the other hand, seedlings planted with the plug exposed tend to perform as well or better than seedlings planted with the terminal bud at the soil surface.

A consistent formula for artificially establishing longleaf pine on cutover sites without a longleaf overstory is: clearcut, apply a chemical site preparation, burn, and hand-plant good quality container-grown seedlings early in the planting season.

Even in drought years, we have witnessed excellent survival rates among seedlings that went 6-8 weeks with no significant precipitation the spring following planting. Good quality container-grown seedlings appear to handle the stress of extended dry periods better than do bareroot seedlings. For example, in 1998 three sites were clearcut site-prepared using chemical

only, mechanical only, or chemical and mechanical site preparation methods. The sites were then divided in half and planted with bareroot and container longleaf pine seedlings. The following spring was very dry and 1-year bareroot survival averaged 55% across the three sites. Container seedling survival averaged 95%.

Where container seedlings allow the landowner to be successful in one planting verses two plantings with bareroot seedlings, the large difference in seedling price is easily justified. On these three sites it was significantly cheaper to plant once with container seedlings as compared to buying seedlings twice, planting twice, and losing one year's growth in the areas originally planted to bareroot seedlings.

When selecting container-longleaf seedlings, an emphasis must be placed on *quality*. Unfortunately, we have witnessed numerous examples of exceptionally poor quality container-grown longleaf pine seedlings being shipped to landowners and tree planters over the last 3-4 years. Oftentimes, people assume that because the seedlings are container-grown, they are always superior to bareroot seedlings. This could not be further from the truth. A good quality bareroot seedling is almost always superior to a poor quality container-grown seedling. Paying 2 or 3 times as much for a container longleaf pine seedling does not ensure you will receive a seedling that is worth twice or three times as much as a bareroot seedling. Luckily, most container nurseries produce good quality seedlings. The Forest Service and the Longleaf Alliance have worked with longleaf nurseries to develop criteria for identifying good quality container-grown seedlings (Barnett et al. 2002). Please call the Longleaf Alliance for a free copy of these seedlings guidelines.

Whether you select bareroot or container stock, the earlier seedlings are planted, the better they appear to handle spring droughts. Late planted seedlings (February or March), have less developed root systems and are more likely to perish from moisture stress incurred by spring droughts or herbaceous competition. We recommend planting as early as October, provided the site has adequate soil moisture.

When selecting your planting contractor for cutover sites, hand-planting crews are strongly recommended. On sites that were chemically site prepared or bedded, hand planting will typically yield more consistent planting depth and the resultant increased seedling survival and growth. Gulf States Paper is a good example of one company that follows this regimen. Gulf States generally tries to have all their container longleaf in the ground by Christmas.

An exception to the hand-planting rule may be areas subjected to intensive mechanical site preparation. Mechanical tree planting is a viable option on these clean sites, especially when planting bareroot seedlings. Cedar Creek Land & Timber is one example of a timber company that mostly machine plants bareroot seedlings on mechanically prepared, cutover sites. Cedar Creek and other companies that consistently achieve good survival rates with bareroot longleaf know that bareroot seedlings should be planted within hours of lifting them from the nursery. At the longest, try to have your bareroot planted within 2 days of lifting. Don't stack bundles of seedlings, and the shorter the distance between your planting site and the nursery, the better.

After planting your seedlings, you should consider applying a herbaceous release the spring following planting. The most commonly used herbicides for herbaceous release on cutover sites are hexazinone (Velpar DF® or L), sulfometuron (Oust XP®), and imazapyr (Arsenal®). Hexazinone and sulfometuron are also premixed and sold as Oustar®.

The Longleaf Alliance has examined the effects of herbaceous release using Oust and Velpar on bareroot seedlings on a cutover site. Seedlings that were not released in the first

growing season averaged 5.4' in height 4 years post-planting. Seedlings that were released with Velpar and Oust in the first growing season averaged 9' in height at age 4. With near total weed control in the first two growing seasons, seedlings averaged 12.1' in height at 4 years post-planting. Contrary to what many foresters may say or think, we have found that the majority of longleaf pine seedlings will initiate height growth within 2 years if weeds are controlled in the first growing season and seedlings are not planted too deep.

These are some general recommendations for successfully establishing longleaf pine on cutover sites. Follow these guidelines, and you should be successful planting longleaf pine the vast majority of the time.

Planting Longleaf Pine on Agricultural Sites

The Longleaf Alliance was formed in 1995. At approximately the same time, tens-of-thousands of agricultural acres were enrolled in the Conservation Reserve Program (CRP). The Longleaf Alliance played a crucial role in educating and informing CRP participants as to 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.

A new CRP enrollment was 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 90's, 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 USDA Forest Service, the Natural Resource Conservation Service, the Farm Service Agency, forestry consultants, herbicide applicators, tree planters, and landowners from across the Southeastern, US. 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 foreordained for those attempting to plant 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, US 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 years for these soils 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 are basic in nature. Experience has shown that it is very difficult to successfully establish longleaf pine on soils that are greater than 7.0 pH.

Excessive soil nutrients

Some areas have become so nutrient-loaded 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 was deposited, or, cattle catch pens were located. On these nutrient-loaded sites longleaf seedling mortality approached 100% during the first growing season.

Excessively wet sites

Ponded soil types are typically problematical. Seedling mortality increases dramatically when seedlings are 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 averaged 85% survival using container-grown stock and 65% survival using bareroot stock. While some tree planters are consistently successful planting bareroot seedlings, the trend has been away from bareroot and towards container-grown seedlings. (Table 1) Consequently, this paper will focus on the successful establishment of container-grown seedlings.

Table 1. Annual Longleaf Seedling Production (Millions)

	Bareroot	Container	% of Total Production (Container)
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%

Inadequate containers were an early problem for a relatively new industry producing longleaf seedlings in containers. 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 *The Interim Standards for Producing Longleaf Pine Seedlings in Containers* (Barnett & others 2002). This publication has recommendations for: ribbed containers, minimum root collar diameters (1/4"), 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 an individual to sort out seedlings that would not survive and grow well when compared to seedlings that met preferred criteria in the Interim Guidelines (Barnett & others 2002).

Study sites were installed in or near Monroeville and Samson, AL. Seedlings 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-one year post-planting (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 2. Survival by seedling type

	Good	Double	Floppy/Cull	Hybrid (lob x long)
Monroeville Site (age = 1 yr.)	75%	N/A	21%	64%
Samson Site (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. Finally, floppies/culls 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 the *Interim Standards*: "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 14th, allowing seedlings to establish a better root system than the Monroeville seedlings which were planted February 21st. 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/cull 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 If an excessive number of culls are found, send them back to the nursery.

#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). For several years, most pasture plantings ended in failure. It was soon established that grasses had to be removed or controlled through the site preparation prior to planting. Planting seedlings directly into pastures with the intention of controlling grasses through a post-planting herbaceous release was a recipe for disaster.

The question was, "What is the best site preparation for agricultural sites that have pastures grasses in place?" The Longleaf Alliance attempted to answer this question through a 1998 study: *Comparison of Site Preparation Methods and Herbaceous Releases for Longleaf Pine Establishment in an Old Pecan Orchard*. The study site was an old pecan orchard 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.*), among many other competitive old field weed species. Three site preparations were tested in this study: scalping and sub-soiling, broadcast chemical (glyphosate & imazapyr) plus sub-soiling, and check or sub-soiling 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):

Table 3. Herbaceous Release Treatment (Subplot Treatments)

Product oz/acre	Active Ingredient	Timing of Application
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 app.s)
Fusillade 24	fluazifop-P-butyl	4/7/99 & 5/12/99 (2 app.s)
Velpar DF 21.34	hexazinone	5/12/99
Velpar DF 10.67	hexazinone	4/7/99

Survival was assessed in the first and second growing seasons (Table 4). Differences were significant and increased with time post-planting. Consistent with work previously conducted in

Florida (Barnard 1995), survival and growth was significantly better on scalped plots as compared to check (subsoil only) plots. Survival and growth of longleaf was also significantly better on scalped vs. chemically site prepared plots. Overall, scalping provides a much better return in seedling survival and growth as compared to chemical or site preparation (Table 4).

Table 4. Survival, Growth, and Costs by Site Preparation.

	Check SP - Subsoil Only	Chemical SP + Subsoil	Scalp SP + Subsoil)
% Surviving (Age 1)	64%	72%	88%
% Surviving (Age 2)	46%	61%	82%
Starting Height Growth (Age 2)	30%	54%	72%
Total \$\$/Acre (Site Prep, Planting, Seedlings, & 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

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 eleven 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 pre-emergent application of Oust® at 2 oz in March or April, followed by a post-emergent Arsenal® application of 4-6 oz. Wait for grasses to emerge before applying the 2nd 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 six weeks following the initial pre-emergent Oust® application. Typically the 2nd post-emergent treatment will go out between mid-May and late-July.

Alternatively, for those who can only afford a single application, an Arsenal® (4-6 oz)/Oust®(2 oz) tank mix has consistently tested as one of the best herbaceous releases. We recommend the Arsenal®/Oust® tank mix be applied after May 1st, as injury and seedling mortality have been associated with earlier pre-emergent 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 and/or high pH soils 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 to avoiding increased seedling mortality or injury following an herbaceous release. If good root systems are established prior to the herbicide application, seedlings appear to be more tolerant of soil active herbicides. If few or

no fine roots have exited the plug, expect increased mortality associated with early applications of soil active herbicides. To avoid this conundrum, 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

Of all the factors that come into play, planting depth may be the single most critical factor affecting seedling survival and growth. Again, with hindsight, 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 while 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 prove the wick effect is a fallacy. In every study conducted thus far, seedlings planted with the plug exposed have outperformed seedlings planted with the terminal bud beneath the soil surface. Subsequent studies installed in 2002 and 2003 in Alabama, South Carolina, and Georgia, are being tracked at this time.

Table 5. Mortality by Planting Depth from Deep to Shallow (height to terminal bud) 1 or 2 Years Post-Planting

Study Site	-3 CM	-1 CM	Level	+1 CM	+2 CM	+3 CM	+6 CM
Silvopasture Site	57%	41%	24%		21%		
Godwin Site	79%	71%	39%		36%		
Orchard Site		56%	19%	17%	20%		
Monroe Site			38%			33%	21%

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. While little research has been conducted on time-of-planting with container grown seedlings, the majority of anecdotal evidence suggests that earlier plantings are much likelier to succeed as compared to 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 come 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") soon after planting is sufficient to insure 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 & 2002. Overall survival rates have averaged approximately 80% at one year post-planting. With this limited experience, we only recommend summer planting in areas where seasonal 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

- #1 Use good seedlings.
- #2 Scalp agricultural fields.
- #3 Plant as early as possible.
- #4 Plant shallow with the terminal bud well above the soil surface.
- #5 Release seedlings from herbaceous competition for increased growth.
- #6 Examine roots before applying soil active herbicides.
- #7 Interplant mortality (May-July) if soil moisture is adequate.

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