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New Pine Planting Strategies

For the Western Gulf States

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The structure of forest industry has experienced major changes over the last few years, not only across the South, but globally as well. Mills are closing, companies are merging, and large forest products corporations are divesting their lands. The demand for small-diameter trees in the South has diminished largely due to the amount of wood fiber and wood products now available from other countries around the world. As a result, countries that have traditionally depended upon the southern US for fiber (e.g., Japan) are now being supplied by other global markets.

Competition is global and fierce, and in order to stay competitive, healthy, and profitable, foresters and forest landowners must use efficient stand establishment strategies. This paper outlines several such new strategies beyond the normal course of plantation establishment (e.g., proper site preparation, seedling care, and competition control). Much of what is covered in this paper will challenge traditional stand establishment philosophies as we explore stock type, initial stand density, planting season, fertilization, and insect control.

Traditional Pine Strategies

In the early years of a pine plantation's life, maximizing seedling survival is a primary management concern. Historically, stand establishment would fail only on those rare occasions when summer months were excessively hot and dry for extended periods. However, summer months are becoming increasingly hot and dry in the Western Gulf region. The Keetch/Byram Drought Index (KBDI) is a measure originally intended to determine forest fire potential. The index measures drought by combining average temperature and rainfall into a calibrated scale between 0 and 800 units, with 800 being the most extreme drought condition. KBDI can also be used to track long-term weather patterns.

Figure 1 illustrates the KBDI for Texas during the past 100 years. The red line indicates the long-term average drought index for the state. Drought indices above that line indicate years that are hotter and drier than average. The purple line is the long-term average index of these hotter, drier years. Conversely, the yellow line is the long-term average index of the cooler, wetter years. The curved black line indicates the trends for the last 100 years.

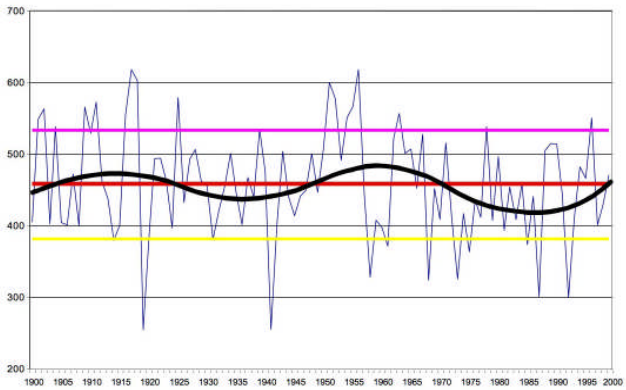

Figure 1. Long-term, yearly Keetch/Byram drought index for Texas (adapted from Taylor and Murphrey, 2002).

Obviously there are annual fluctuations between hotter-drier and cooler-wetter years, but the general trend suggests that Western Gulf states are approximately six years into a cyclical, 25-year hot/dry period. This cycle is expected to continue placing exceptional stress and demand on seedling survival and stand establishment. This adds an additional burden on foresters and forest landowners when considering pine planting strategies.

There are several silvicultural alternatives to the traditional planting scenario, however, that can optimize economic yields of southern pine plantations in the Western Gulf region. These silvicultural strategies entail planting seedlings with high survival and growth potential at the optimum time of the year at an optimum density. In addition, these management decisions also strive to provide the seedlings with the nutrients and freedom from pests needed to fulfill their growth potential.

New Strategy: Containerized Stock

Bare-root loblolly pine seedlings (figure 2) are most commonly used for reforestation in the Western Gulf States because they are easily and affordably produced in large quantities in nurseries. Bare-root seedlings are relatively fragile, however, and are susceptible to wounding. These injuries can occur from seemingly insignificant events at all points along the reforestation timeline, from the time they are lifted at the nursery to final planting.

Figure 2. Quality produced bare-root loblolly pine seedling just after lifted from nursery bed.

Sunny, windy days, which are not uncommon throughout the planting season, can quickly desiccate and kill bare-root seedlings and coordinating planting operations with suitable weather can be difficult. Consequently, private landowners are often forced to plant on inappropriate days, especially in March, causing greater loss of seedlings and accordingly a poorly stocked stand.

The conventional tactic for overcoming survival problems has been to plant more seedlings, sometimes more than twice needed, for full stand occupancy in hope that enough "leftovers" will remain for suitable stand density. However, this strategy is silviculturally and economically flawed. Seedlings rarely die in an evenly distributed pattern. As a result, the stand may contain sufficient stems per acre to represent a fully-stocked stand, but growing space is not optimized and production will suffer. Furthermore, cost of extra seedlings reduces economic yields because the cost is carried for the entire rotation.

Containerized seedlings offer several benefits over conventional bare-root seedlings. Containerized ("plug") seedlings (Figure 3), like the name implies, are seedlings grown in small-capacity containers that resemble thin flowerpots. Unlike bare-root seedlings, where the seedlings are grown in beds with no barrier confining the root system, a container-grown seedling's root system remains confined to a particular shape from the time of seed germination (or propagation) to the time of planting.

Figure 3. Quality loblolly pine "plug" illustrating the intact, protective soil media.

With containerized seedlings everything stays intact – the root system, the soil medium, and sometimes the container itself – until the seedling is in the ground. The potting medium in which the seedling grows insulates the root system from damage. Because of this, containerized seedlings tend to suffer fewer injuries throughout the planting process than bare-root seedlings. Consequently, the use of containerized seedlings has been shown to decrease mortality over a wide range of sites.

For example, an eleven-year containerized versus bare-root loblolly pine growth study at Louisiana State University's Hill Farm Research Station found that containerized seedling survival exceeded that of the bare-root seedlings by 16 percent on a particularly harsh site (well-drained, gravelly, loamy fine sand). Well-drained, sandy soils are among the most problematic soils on which to establish and profitably manage loblolly pine plantations in the Western Gulf region.

Containerized survival has also been shown to be significantly improved on wet sites. A study in southwest Louisiana, on deep, poorly drained silt loam alfisols on level ground showed that survival of containerized seedlings was 21 percent higher than that of bare-root seedlings.

Some foresters, however, may be concerned about the possibility of poor root development from containerized seedlings after planting. This phenomenon is usually only a problem with stock that has been left too long in the container and has become root-bound, when they are planted with the wrong type of implement, or in heavy clay soils. Further-more, new types of containers are continually being developed. Some feature a copper coating in the cavity to chemically root prune the seedlings. As a result, roots are poised with their growing tips facing laterally and are ready to grow outwards once planted.

Others may be reluctant to use containerized stock because of the extra cost per seedling (4 –6 cents for bare-root versus 12 – 16 cents per containerized seedlings). However, containerized seedlings have a higher survival potential than bare-root seedlings since their intact root systems give them a superior ability to take up moisture and nutrients immediately after planting. Due to their higher survival potential, it is not necessary to plant relatively high numbers of seedlings and hope for "leftovers" to ensure good stand establishment. As such, establishment costs using containerized seedlings are comparable to establishment costs using bare-root seedlings.

New Strategy: Planting Season

We can improve further upon the volume gains of containerized seedlings by planting earlier than the traditional season dictates. Planting in fall can improve tree survival and growth because seedlings have more time to grow good root systems and acclimate to the site before summer months arrive. Research suggests that containerized loblolly pine seedlings planted in mid to late October grow more in both diameter and height than seedlings planted during the traditional planting season. The differences are especially significant when compared to seedlings planted in March and on well-drained, droughty sites.

Preliminary data from a study at Texas A&M University's Agricultural Research & Extension Center in N.E. Texas shows that fall planted containerized loblolly pine seedlings had greater total tree height than did the seedlings planted the following spring (March). On average, fall planted seedlings were about 16 cm taller than spring planted bare-root seedlings at the end of their second growing season.

To illustrate, Figure 4 compares the height of a fall planted containerized seedling versus a spring planted bare-root seedling. The pole shown in both photographs is approximately 5 feet tall. Both trees are from the same family and nursery, each photograph was taken just moments apart, and each tree is at the start of the third growing season. The tree on the left was typical of the mid-October (fall) planted containerized seedlings. The tree on the right is representative of the mid-March (spring) planted bare-root seedling.

Figure 4. Comparison of containerized loblolly pine planted in mid-October (left) versus bare-root loblolly pine planted the following spring (right).

In addition to growth, survival was improved with fall planting. Fall-planted, containerized seedlings had 94 versus 83 percent survival for spring planted bare-root seedlings.

A study in southwest Louisiana comparing slash pine bare-root seedlings and containerized rooted cuttings found the same trend (Figure 5). At the end of the second growing season the seedlings planted in September were about 25 cm taller than the bare-root seedlings planted in March and even taller than containerized seedlings planted in January. This study also showed a 27% increase in survival for fall-planted containerized stock versus spring-planted bare-root stock. Containerized seedling survival remained fairly constant across the various planting months while survival of bare-root seedlings ranged from 54 to 95 percent.

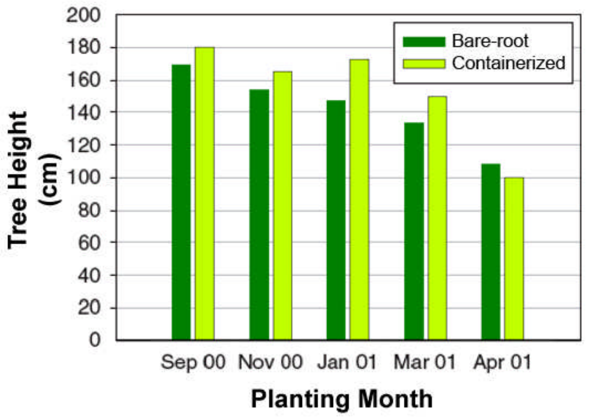

Figure 5. Comparison of mean height growth for containerized loblolly pine stock versus bare-root stock over five planting dates (adapted from Akgul et. al., 2004).

Fall-planted loblolly pine containerized stock has higher survival and growth than bare-root seedlings planted during the traditional planting season. Differences are even more pronounced when compared to bare-root seedlings planted in March, which is the month when many non-industrial forest owners must plant due to planting vendor availability. Growth differences are largely due to fall-planted seedlings having additional time to acclimate to the site, recover from transplant injury, and develop healthy root systems before the hot, dry summer months arrive.

New Strategy: Initial Stand Density

With the planting strategies above, seedling survival and growth during the early years of the rotation can be improved. By incorporating these new strategies, foresters and forest landowners can plan for success instead of failure. With higher seedling survival potential, the number of seedling planted per acre can be reduced by more than half. This strategy better promotes fully stocked stands with seedlings that are evenly distributed throughout the site and may possibly eliminate other management activities during the early part of a stand's life, such as cost associated with pre-commercial thinning.

The conventional view of pine plantation management is that high stand densities are needed to improve wood quality, minimize juvenile wood, and maximize fiber production per acre. However, landowners seldom realize premiums for slow-growing trees. Currently, when a premium is paid, it is typically for the quantity of physically attractive trees (straight, free of knots, etc.) and not for the number of growth rings per inch or proportion of juvenile wood. Also, because of the growth pattern of loblolly pine, height growth is largely independent of stand density. In other words, high stand densities are not required to influence loblolly pine to grow tall and straight. Thus, tree height in a lower density stand, within reason, will equal the height of trees in a higher density stand. Diameter, however, is highly related to stand density. As a result, moderate to high stand densities severely restrict diameter growth, thus, lower planting densities are required to maximize individual tree volume and quickly attain higher value products.

For example, Figure 6 shows the volume of wood products harvested from a 21 year-old loblolly pine plantation planted at five different densities in northwest Louisiana. The best overall yields came from stands planted at 200 to 600 seedlings per acre. Because of the optimum mix of chip-n-saw to sawtimber, the best returns per acre were from 200 to 300 trees per acre. Notice while total volumes are relatively consistent, sawtimber production increases as stand density decreases while chip-n-saw and pulpwood volumes generally decrease.

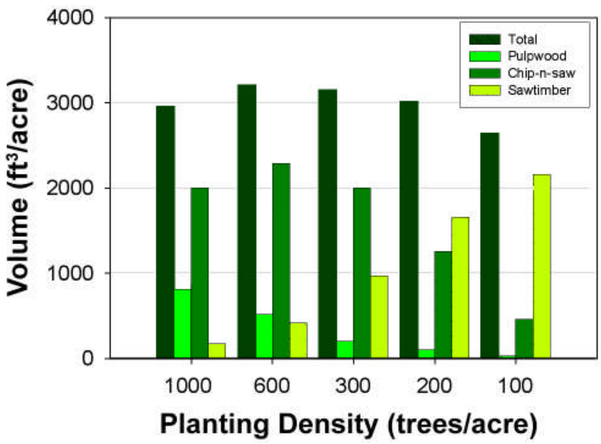

Figure 6. Volume of pulpwood, chip-n-saw, and sawtimber obtained at five different planting densities (adapted from Blazier and Clason, in press).

New Strategy: Fertilization

Most forest soils in the Western Gulf region are unable to supply the nutrient levels required to maximize growth of loblolly pine trees. With the planting strategies discussed above, nutrients naturally available in the soil are more efficiently allocated to seedlings by planting seedlings with good root systems and by planting fewer seedlings to reduce pine-to-pine nutrient competition. To further improve a soil's ability to grow pine plantations, it is necessary to fertilize. Numerous studies, as in Figure

7, have shown that replacing nutrients removed from previous harvests or other land uses can increase survival and growth. When combined with a comprehensive management regime that incorporates the strategies listed above, fertilization can significantly increase chip-n-saw and sawtimber yields. Potential returns on fertilization investments have been shown to be as high as 29 percent.

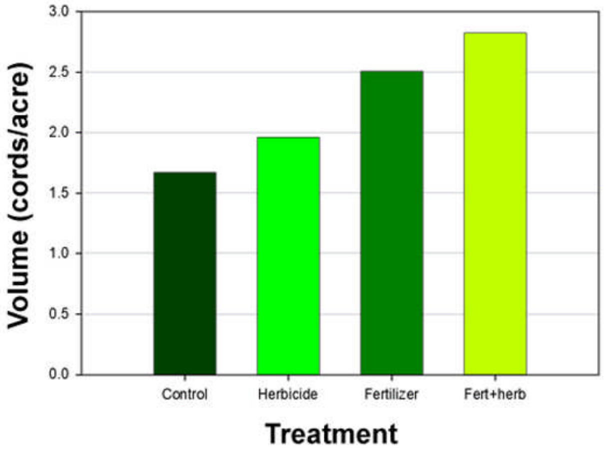

Figure 7. Loblolly pine growth response within one year of fertilization and/or herbicide release at age four in N.W. Louisiana.

Western Gulf forest soils respond well to fertilizer because most forests are grown on inherently nutrient-poor soils. Often pine plantations are established on "spent" agricultural land where the nutrients have been depleted through years of crude agricultural practices. Later these "old fields" reverted to forests, but the nutrients were never replaced. Fertilization, however, is not for everybody or every site. Information on landowner management goals and pre-fertilization stand conditions are vital. Either may negate the need to fertilize. If a landowner's primary management objective is to produce sawtimber, then a closer analysis of nutrient levels is warranted. Proper foliage or soil testing ($5 to $10 per sample at most laboratories) can identify the type and amount of elements necessary to produce optimum growth. In other words, let the site dictate what nutrients are needed.

The nutrient element most likely to be deficient for successful stand establishment is phosphorus (P), especially as the percentage of clay increases. Soils in the Western Gulf States should have from 3 to 5 parts per million of phosphorus prior to stand establishment. Triple super phosphate (TSP) can be used to remedy P deficiencies by applying it at 250 lbs per acre. The current cost for P fertilization usually ranges between $40 and $50 per acre. Relatively low cost, growth responses that last as long as 15 years, and dramatic volume gains (up to 50 cubic feet per acre per year) makes P fertilization an attractive management option.

Nitrogen (N) is usually not a limiting factor in most plantations until approximately age 5, which is the point at which pine growth rates begin to exceed soil N supplies for many soil types. Pulling a few samples of needles throughout the plantation and having them analyzed for N (at a cost of $5 to $10 per sample) can substantiate whether or not the trees are N deficient. N deficiencies can be corrected by applying 220 lbs of urea and 90 lbs of TSP per acre.

New Strategy: Regeneration Pests

The last strategy to consider deals with protecting the newly planted stand from the various regeneration pests common to the Western Gulf states. These pests when left unchecked can cause severe damage to seedlings. At best, damage will deform trees and retard growth, reducing the economic return on investment. Commonly, regeneration pests decimate the stand, negating the benefits achieved by the new strategies previously discussed. Regeneration pests include the Texas leafcutting ant, regeneration weevils (Pales and pitch-eating), Nantucket pine tip moth, and red-headed sawfly (to a lesser extent). Consider then as a new tactic treating seedlings with the insecticide permethrin (Pounce®).

Unfortunately, the active ingredient, permethrin, is classified as a "Restricted Use" chemical due to toxicity to fish and aquatic organisms. However, nurseries throughout the Western Gulf states offer Pounce treated seedlings. Treatment adds only a minimal cost and will offer at least some level of protection for all regeneration insect pests. In areas where pests are a greater threat, an additional insecticide application may be required. For example, studies have shown that chemical applications can be effective in protecting loblolly pine tree from the growth losses associated with Nantucket pine tip moth. However, carefully timed application must be used that coincide with the insect's life cycle in order to reduce the number of necessary applications and to increase insecticide efficacy.

Cost Comparison

Consider the cost of establishing a stand using traditional methods in comparison with the cost using the new strategies. For this example, assume a site that was recently harvested with the clearcut method and that the summer weather patterns and summer moisture regime follows the current KBDI trend for warmer and drier summers. The example will use the 2005 price structures from the two major loblolly pine seedling suppliers in Texas for non-industrial private forest landowners and various vendors.

Site Preparation

Poor quality trees, small trees, and brush left during the harvest operation must be removed. Therefore, a shearing operation is required, but a windrow operation will not be performed on this site. Instead, the course woody debris will be pushed between the planting rows as the seedlings are planted, in what are referred to as mini-windrows. Note that this option may not be operationally feasible with traditional planting densities where the distances between rows are extremely close. In such a case, an additional site preparation operation may have to be performed to remove debris (windrow, burn, mulch, chop, etc.) at additional cost to the landowner.

Shearing Site Prep Operation = $90.00 per acre

Competition Control

Controlling unwanted vegetation is perhaps the most important site preparation activity to be performed in order to ensure the success. Although it can be important throughout the life of the stand, it is particularly important during the seedling establishment period. Chemical site preparation is preferred over release because it offers greater flexible with the chemical and tank mix needed to achieve greater control of hard to kill species.

Site Prep Aerial Spray = $120.00 per acre

Seedling Cost

In either case, advanced generation seedlings are selected because they tend to provide production gains over other, less expensive choices.

Bare-root = $47.50 per thousand seedlings

Bringing containerized seedlings to market requires more labor and larger facilities and is thus reflected in their price.

Containerized = $135.00 per thousand seedlings

Recall we are assuming a cutover site, so we would expect a substantial component of pine debris. The time interval between harvest and planting is also less than 6 months – an interval in which seedling susceptibility to weevil damage can be high. To protect the seedlings from various regeneration pest, Pounce® treated seedlings are used.

Pounce® treatment = $4.50 per thousand

Every shipment of seedlings will have some number of seedlings not suitable for planting (culls) because of height, diameter, roots, condition, etc. Studies have shown that the percent of cull seedlings ranges from 5 percent for bare-root seedling stock to 2 percent for containerized seedlings. As previously described, the current or “traditional” trend is to plant more seedlings than may be necessary to fully occupy the site. Average total cost per usable bare-root seedling (including insecticide and culls) is $0.0547 per seedling (Table 1).

Table 1. Cost per acre for bare-root seedlings at various planting densities (includes Pounce® treatment and culls).

Spacing (feet)	Seedlings per Acre	Seedling Cost per Acre ($)
6 x 8	908	49.67
7 x 8	778	42.56
8 x 8	681	37.25
6 x 10	726	39.71

Recall that one of the new strategies is to employ containerized seedlings on a wider spacing. Average total cost per usable containerized seedling (including insecticide and culls) is $0.143 per seedling (Table 2).

Table 2. Containerized seedling cost per acre at various planting densities (includes Pounce® treatment and culls).

Spacing (feet)	Seedlings per Acre	Seedling Cost per Acre ($)
10 x 10	435	62.20
8 x 12	454	64.92
9 x 12	403	57.63
10 x 12	363	51.91

Planting Cost

The cost for planting depends upon several factors, the most important of which are:

- paying for and insisting upon a quality job,
- number of seedlings per acre,
- hand or machine planting, and
- difficulty of the terrain.

On the lower end of the price scale, the site would have easy access, fewer seedlings per acre, a poorer planting job. The row spacing makes a difference in cost because the closer the spacing between the rows, the more traverses the operators must make to plant the site. A wildland planter will travel nearly 10 additional miles to plant the typical 25-acre tract on an 8-foot row spacing versus a 12-foot spacing. The spacing within a row, within reason, does not affect cost. Our example will incorporate a wildland planter pulled by a dozer equipped with a V-blade. As a result, debris can be removed and seedlings planted during a single pass.

Wildland planting with V-blade = $65 – $100 per acre

Planting Density

Traditional logic has been to plant approximately twice as many bare-root seedlings as eventually desired to ensure adequate stocking following mortality. Therefore we will assume that our site is planted using a 7 x 8 spacing, yielding approximately 778 bare-root seedlings per acre.

Because we expect containerized seedling to take advantage of the survival benefits of fall planting, we will assume adequate stocking will occur with a spacing of 9 x 12 feet, yielding 403 containerized seedlings per acre.

Replant/Interplant

Assume that the seedlings experience a dry, hot summer as the KBDI suggests. With the traditional method, the stand may end up with the desired stocking, but the seedlings may not be evenly distributed. Such a case will require an additional planting to fully and evenly occupy. The entire site will not need to be replanted, however. We can assume that only half of every acre needs additional seedlings and that only one additional planting is required to fully occupy the site. This is a very conservative assumption as it has not been uncommon to replant three or more times given a series of hot, dry summers.

Replant/Interplant cost equals = $25/acre for seedlings + $40/acre to hand plant = $65

Production Costs

Within our proposed scenario, planting with containerized seedlings, although more expensive per seedling, results in an approximate $200 savings over bare-root seedlings (Table 3). Although this is a simplified analysis, the basic point has been made: The use of containerized seedlings in conjunction with the other new strategies can be an effective tool in establishing a new stand.

These new strategies center around the use of containerized seedlings planted during the fall as the trigger for success. The Texas Forest Service estimates that, on average, pine plantations can earn approximately $120.00 per acre per year. Thus, each year a stand is delayed costs the landowner $120.00 per acre in lost return on investment. The earlier a stand can be established, the earlier it can be harvested, shortening the amount of time capitol is tied up in the investment.

Table 3. Stand establishment total cost comparison between traditional methods and selected new strategies.

	Traditional ($)	New Planting Strategies ($)
Mechanical Site Prep	90	90
Chemical Site Prep	120	120
Seedlings	45 (7 x 8)	57 (9 x 12)
Planting	90	65
Subtotal	345	332
Replant	65	0
Production Loss	120	0
Total	530	332

The Bottom Line

We have shown how implementing new strategies in reforestation can offer landowners and foresters powerful tools to successfully establish a successful pine stand. The bottom line with these new strategies is that you may:

- Increase diameter and height growth,
- Reduce the excessive production of unmarketable, small-diameter trees,
- Reduce intraspecific competition,
- Minimize or eliminate the need to perform future non-commercial thinnings, and
- Reduce planting cost and waste.

No matter which strategy you choose, ALWAYS follow Best Seedling Care & Planting Practices.

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