



# Planting Southern Pines

## *A Guide to Species Selection and Planting Techniques*

Mississippi landowners have made a strong commitment to tree planting in recent years. The Conservation Reserve Program, which offers financial incentives to encourage tree planting on marginal cropland, has spurred additional interest.

As more landowners become involved with tree planting, they learn that proper species selection and careful handling and care of seedlings are vitally important in the success of their reforestation investments. Use this publication as a guide for selecting the proper species and handling seedlings throughout all phases of tree planting.

### **Selecting a Proper Species**

Species selection is the critical first step in tree planting. Maximum growth and yield in the plantation are possible only if you select the right species for the particular planting site and geographic location (**Table 1**). Planting the wrong species on a site results in poor survival, poor growth, and low product yield. Geographic location limits species choice (**Figure 1**). For example, slash pines planted in northern Mississippi suffer from branch and stem breakage when glazed ice forms on needles.

Species selection also influences the products produced. Longleaf pine may be preferred if high-quality



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**Table 1. Species–Site Selection Guide**

Species	Suitable Planting Range	Soils
Loblolly Pine	Piedmont and Coastal Plain	<p>Preferred: Best growth in Coastal Plain on soils with poor surface drainage, a deep surface layer with a firm subsoil (clay layer) within 20 inches of the soil surface. In the Piedmont, uneroded soils with a deep surface and friable subsoil are best.</p> <p>Poor: Deep, well-drained sandy soils of the Coastal Plain and eroded Piedmont soils with clay subsoil exposed or near the surface. In the Coastal Plain, productivity decreases as surface drainage increases.</p>
Slash Pine	Coastal Plain	<p>Preferred: Spodosols with depth to a clay layer greater than 20 inches from the surface. These are common soils of the “flatwoods.” They are characterized by light-gray to white sands over dark sandy loam subsoils. Hardpans or fragipans that restrict root growth and downward water movement are common.</p> <p>Poor: Deep, excessively well-drained sands and very poorly drained soils.</p>
Longleaf Pine	Coastal Plain	<p>Preferred: Generally found on well-drained to moderately well-drained, light-colored sandy soils that are acid and low in organic matter. With proper weed control, longleaf is well adapted to more productive loamy soils.</p> <p>Poor: Growth on poorly drained and excessively well-drained soils is slow.</p>
Shortleaf Pine	Northern Piedmont and Mountains	<p>Preferred: Fine sandy loams or silt loams with indistinct profile development, friable subsoil, and good internal drainage.</p> <p>Poor: Heavy clay soils or eroded soils with clay subsoil at or near the soil surface.</p>

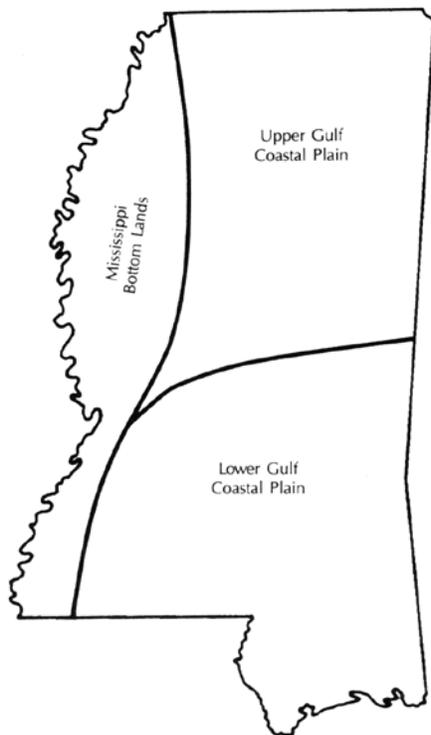


Figure 1. Physiographic regions of Mississippi.

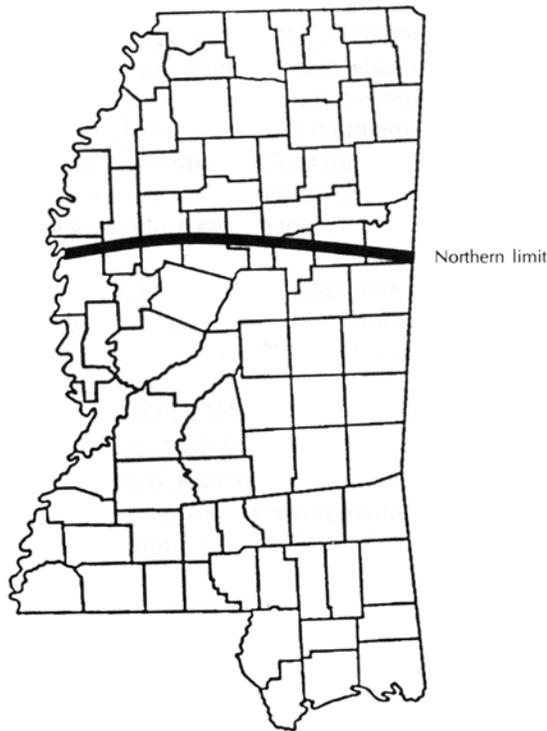


Figure 2. Northern limit for planting Livingston Parish loblolly pine.

sawlogs and poles are the product objective. If maximum fiber yield is required, loblolly or slash pine could be favored.

The commercial ranges of the various Southern pines are shown in **Figures 3 through 6**. Loblolly pine is usually planted, with limited acreages of shortleaf pine, slash pine, and longleaf pine planted on appropriate sites.

#### **Loblolly Pine** (*Pinus taeda* L.)

This pine is found throughout Mississippi and is the most important and widely planted pine in the South. Loblolly pine produces more than half the total pine volume in the region. Since it is found in a variety of areas and sites, there has been a great deal of research into development of breeding and seed stock.

Pine tip moth can be a problem in young stands, damaging terminal shoot growth. However, control is practical only in unusual cases. Older trees are not seriously damaged by this pest. Pine bark beetles cause excessive damage to weak, overcrowded, slow-growing stands of loblolly pine. Good management practices that promote vigorous stand growth greatly reduce pine bark beetle hazards.

The Livingston Parish loblolly source is commonly available and has good growth and resistance to fusiform rust. It is well suited for planting on high hazard fusiform rust sites in the Coastal Plain and on other loblolly pine sites. This variety can be planted throughout most of the Coastal Plain. However, ice glaze damage restricts plantings to the southern two-thirds of the state (**Figure 2**), particularly in heavily thinned, open stands. Light, frequent thinnings minimize ice glaze damage.

#### **Slash Pine** (*Pinus elliottii* Englem.)

Originally restricted to a limited natural range of only 7 million acres, planting has greatly extended the present range of slash pine to more than 12 million acres. However, many of these plantings were off-site and beyond the northern limits of their natural range (**Figure**

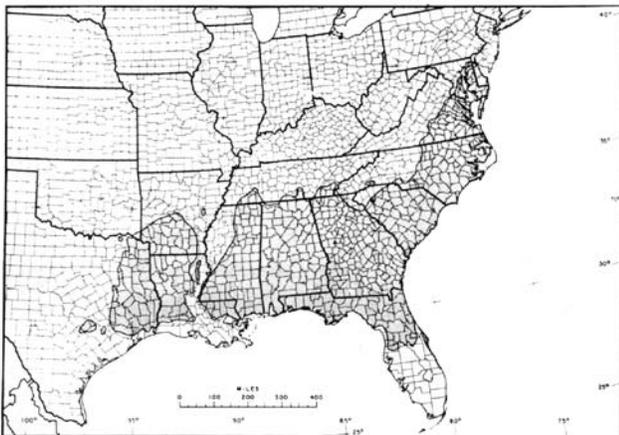


Figure 3. Natural range of loblolly pine.

4). These off-site plantings suffered from ice damage and severe fusiform rust infections.

Slash pine is sometimes planted in the Lower Coastal Plain for pulp, sawlog, and pole productions. Stands tend to stagnate if not thinned early to maintain adequate crown development. If thinnings are delayed until trees are 25–30 years old, little response will be gained from the thinning.

Bark beetles attack slash pine, particularly during extended dry spells, after stem damage from lightning strikes, and after logging operations. Other insect pests, such as pine tip moth, cause only minor damage in most cases.

Slash pine is very susceptible to fusiform rust. Trees that develop galls in the main stem are prone to breakage and early mortality. The fungus *Fomes annosus* can invade recently thinned slash pine and loblolly pine stands. The fungus attacks the tree's root system, ultimately killing the tree. Thinnings made during the summer lessen the chance of disease. Use chemical controls during thinning operations in high-risk areas.

#### **Longleaf Pine** (*Pinus palustris* Mill.)

Longleaf pine once dominated the Coastal Plain forest of Mississippi and naturally occurs over much of the southern and south-central portions of Mississippi. It extends north to Claiborne County on the western border and to Kemper County on the eastern border (**Figure 5**).

With the advent of statewide fire control and because of its inability to tolerate weed competitions, the longleaf pine has largely been replaced in its native range by slash and loblolly pine and native hardwoods. (Periodic fires once kept competing vegetation to a point where the more fire-resistant longleaf was easily established and flourished.) During the grass stage of longleaf seedlings, which may last 3–8 years, no height growth occurs. This delay of height growth allows competing vegetation to occupy the site at the expense of the longleaf seedlings. Once out of the grass stage, longleaf grows rapidly, producing trees with

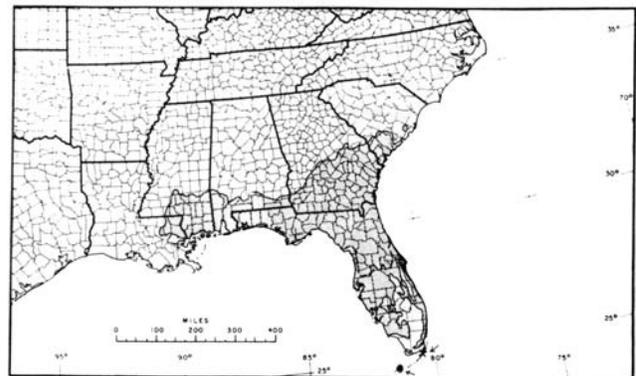


Figure 4. Natural range of slash pine.

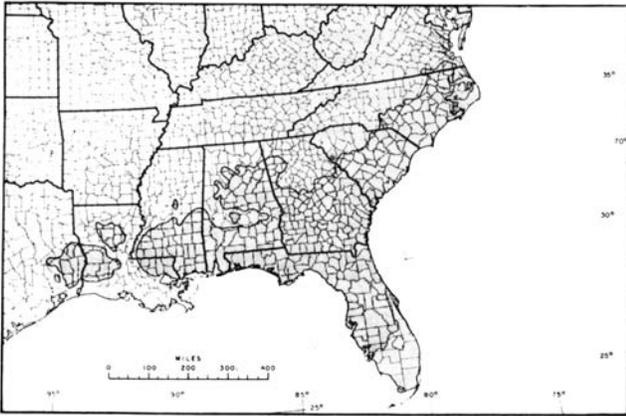


Figure 5. Natural range of longleaf pine.

straight, clear trunks that are highly valued for lumber, poles, and piling.

Research shows that the grass stage is shortened and successful regeneration is possible by using high-quality seedlings developed in breeding programs, proper planting techniques, and adequate site preparation with herbaceous weed control during the first growing season. Longleaf is a good choice for dry and intermediate sites where fusiform rust is a hazard to successful establishment and growth of loblolly and slash pine.

Longleaf pine is less susceptible than other southern pines to bark beetles and other insect pests. Fusiform rust is not a serious problem in longleaf stands. However, in some areas, seedlings are susceptible to brown spot needle blight fungus. When brown spot infestations are severe and prolonged, seedling death occurs. Use chemical treatments and prescribed burning to control brown spot.

**Shortleaf Pine (*Pinus echinata* Mill.)**

Few landowners plant shortleaf pine; most prefer loblolly pine because of its superior growth. However, on well-drained and drought-prone sites in the northern range of loblolly pine and where damage from glaze is severe, shortleaf pine is an alternative if drought- and cold-resistant sources of loblolly pine are unavailable (Figure 6). Shortleaf pine resists fusiform rust, but seedlings are damaged by pine tip moths. Southern pine beetles and other bark beetles cause great damage to shortleaf pine. Slow-growing stands are most readily attacked. Maintain adequate stocking and growth rate by timely thinning to reduce serious damage from pine bark beetles.

Littleleaf disease is the most serious problem with shortleaf pine management. Trees in stands established on fine-textured soils that periodically are excessively wet and then dry begin showing stunted, yellowing needles when their age exceeds 30 years.

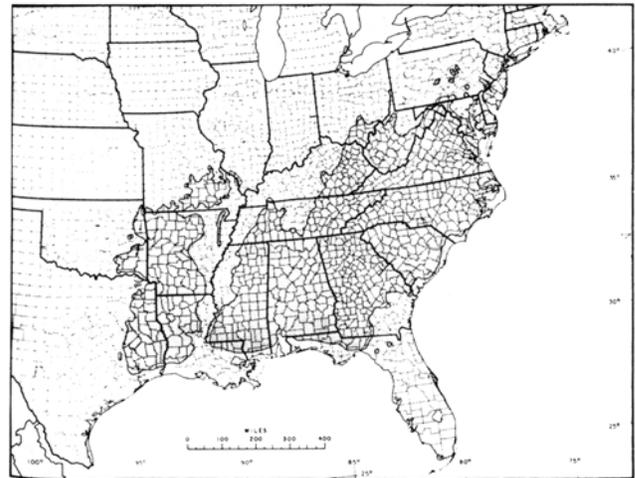


Figure 6. Natural range of shortleaf pine.

Damage is caused by a fungus pathogen that feeds on tree roots, reducing water and nutrient uptake. Diameter growth is greatly reduced, and mortality is very high. Control is impractical. The recommended treatment is to salvage the trees before they die or before they are attacked by bark beetles, and then to replant loblolly pine.

**Comparing Species**

Table 2 provides a quick comparison of traits of the major Southern pines. Consider characteristics of your planting site and geographic location when evaluating these species traits.

Species selection in Mississippi is normally an easy task since loblolly pine is preferred on most sites. However, landowners in the Lower Coastal Plain are faced with several alternatives and must compare several species to determine which is best for their site. The

**Table 2. Pine Species Trait Comparison**

Trait	Pine Species Ranking (High-1, Low-4)			
	Loblolly	Slash	Long-leaf	Short-leaf
Fusiform rust resistance/tolerance	2	3	1	1
Susceptibility to Southern pine beetle	2	3	4	1
Susceptibility to littleleaf disease	2	2	4	1
Drought resistance	3	4	2	3
Cold tolerance	2	4	3	1
Resistance to ice damage	2	4	3	1
Tolerance to poor drainage	2	1	3	3
Fertility requirement	1	2	3	3
Resistance to stand stagnation	3	4	3	2

**Table 3. Coastal Plain Soil–Site Relationships<sup>1</sup>**

Drainage Class	Soil Horizon Description	Species Preference
Very poorly to somewhat poorly drained	No spodic <sup>2</sup> horizon; clay layer within 20 inches of soil surface	Loblolly <sup>3</sup> , slash
Very poorly to somewhat poorly drained	No spodic horizon; clay layer greater than 20 inches from soil surface	Slash, loblolly <sup>3</sup>
Very poorly to somewhat poorly drained	Spodic horizon; clay layer present	Loblolly <sup>3</sup> , slash, longleaf <sup>4</sup>
Poorly to moderately well drained	Spodic horizon; no clay layer present	Slash, loblolly, longleaf <sup>4</sup>
Moderately well to well-drained	No spodic horizon; clay layer within 20 inches of soil surface	Loblolly, slash, longleaf
Moderately well to well-drained	No spodic horizon; clay layer greater than 20 inches deep	Slash, loblolly, longleaf
Somewhat excessively to excessively drained	No spodic horizon; clay layer may or may not be present	Longleaf
Very poorly to poorly drained	Organic surface (peat, muck) greater than 20 inches thick	Loblolly <sup>3</sup> , slash

<sup>1</sup> Adapted from Fisher (1981).

<sup>2</sup> Spodic horizon refers to a spodosol common in “flatwoods” areas. These soils are characterized by a surface of a light gray to white sand over a darker sandy loam subsoil. A fragipan may be present that restricts root growth and limits downward movement of water.

<sup>3</sup> Phosphorus may be required for establishment of loblolly pine on very poorly drained soils.

<sup>4</sup> Use longleaf only on the better drained soils in these groups.

most common problem is deciding between slash pine and loblolly pine. Slash has historically been favored in the Coastal Plain, not only for pulp and timber production, but also as a source of resin and turpentine, along with longleaf pine. However, loblolly pine plantings have greatly increased in the region, and many landowners and foresters are unsure as to the merits of loblolly over slash pine.

The following comparisons should help make the slash–loblolly pine selection in the Coastal Plain clearer. As with any tree, it is critical to match the species to the site. Soil properties and drainage are often used to decide between planting slash or loblolly pine on a particular site. General soil–site conditions and species preference are summarized in **Table 3**.

Other generalizations have been made to compare loblolly and slash pine in the Coastal Plain:

- Slash pine is usually preferred on wet, poorly drained flatwoods sites; loblolly is favored on moist to better-drained soils.
- Loblolly is favored on good sites where hardwood competition is a problem because slash pine is less tolerant of hardwood competition.
- Slash pine grows better than loblolly pine on poorly drained sites where phosphorus is limited (determined by a soil test) if the site is not fertilized.
- Although both slash and loblolly become infected with fusiform rust, slash pine grows better than loblolly pine if the site is not fertilized.
- On well-drained sites with moderate incidence of fusiform rust, improved seedlings of loblolly and slash pine perform about the same.
- Longleaf pine and slash pine are suited for resin and turpentine production. A slash pine variety is available for “high gum” production that produces

up to 50 percent higher gum yields than nursery-run slash pine.

- Loblolly pine is more susceptible to attack from Southern pine beetles than slash pine.

### ***Seed Source and Planting Zones***

When seedling supplies are short, landowners often buy seedlings from other states. Seedlings produced out-of-state may or may not be appropriate for some areas within Mississippi. The following guidelines will help you in selecting a source for seeds and seedlings. (Refer to *A Guide to Southern Pine Seed Sources* in the reference section.)

### ***Loblolly Pine***

Loess Hills planting sites—Seedlings produced from local seed sources or from seed sources east or west within the region are suitable. Avoid moving seed sources too far north.

Coastal Plain planting sites—Fusiform rust is often severe in the Lower Coastal Plain areas. Seedlings from improved strains of loblolly pine exhibiting good growth and resistance to fusiform rust are preferred. Livingston Parish loblolly pine seedlings are a proven rust-resistant source suitable for planting throughout the Lower Coastal Plain.

### ***Slash Pine***

On sites where fusiform rust is common, plant seedlings from sources of demonstrated rust resistance. If such seedlings are unavailable, Livingston Parish loblolly, other rust-resistant loblolly sources, or longleaf pine may be used. Avoid planting seedlings produced from South Florida seed sources.

**Table 4. Seedlings per Acre by Spacing**

Spacing (feet)	Number of Seedlings	Spacing (feet)	Number of Seedlings
6 x 8	907	9 x 9	537
6 x 9	806	9 x 10	484
6 x 10	726	9 x 11	436
6 x 11	660	9 x 12	403
6 x 12	605	10 x 10	435
7 x 7	888	10 x 11	396
7 x 8	777	10 x 12	363
7 x 9	691	12 x 11	330
7 x 10	622	12 x 12	302
7 x 11	565	12 x 15	242
7 x 12	518	15 x 7	414
8 x 8	680	15 x 8	363
8 x 9	605	15 x 9	322
8 x 10	544	15 x 10	290
8 x 11	495	15 x 15	193
8 x 12	453		

### *Longleaf Pine*

Favor local sources. Avoid seedlings from southern Florida and west of the Mississippi River. Seedlings produced from seed from central gulf states should do well.

### *Shortleaf Pine*

Few private landowners plant shortleaf pine because loblolly pine is preferred. Most planting is on national forest lands. Where shortleaf pine is planted, use seedlings produced from local sources within that geographic region.

## Ordering Seedlings

Once you select your species, order your seedlings from the nursery. Plan ahead to allow for adequate site preparation and to ensure availability of seedlings. Most state and private nurseries begin taking seedling orders in midsummer. Place orders early so that you have enough seedlings to meet your planting needs.

Several decisions must be made before ordering seedlings, such as how many seedlings you need and when they should be delivered. Information in the preceding sections will help you select the right species for your planting sites.

To determine the number of seedlings to order, consider several points:

1. How many acres are you going to plant? Determine acreage by actual field measurement, or estimate from maps, aerial photos, or other records.
2. What spacing will you use? Most pine plantations are established with 600–700 seedlings per acre.

More or fewer seedlings may be planted based on the landowner's objectives. A minimum of 600 seedlings per acre may be required for participation in many federal assistance programs. In some cases, the forest industry has planted seedlings at densities of up to 1,000 seedlings per acre to maximize fiber production in short rotations for use in their pulp mills. However, most landowners will get better returns by planting 600–700 trees per acre and managing for multiple products, such as pulpwood, chip-n-saw, sawtimber, and poles. Seedlings are planted at different spacings to achieve the desired density. A general trend is toward wider spacing between rows for better stand access for fire control, thinning, and harvesting equipment. Compare various spacings by using **Table 4**.

Determine the number of seedlings required for any spacing by using this formula:

Multiply desired spacing in feet and divide that product into the number of square feet per acre. For example, how many seedlings would be required to plant 1 acre at a spacing of 6 by 12 feet?

$$\begin{aligned}
 &6 \text{ feet by } 12 \text{ feet} = 72 \text{ square feet} \\
 &43,560 \text{ square feet per acre} / \\
 &72 \text{ square feet per seedling} \\
 &= 605 \text{ seedlings per acre}
 \end{aligned}$$

3. Make an allowance for cull seedlings. Cull seedlings are seedlings that are too small or too large to plant and those that died or were damaged before planting. Identifying cull seedlings is covered in detail in a later section. When ordering, allow for a 10 percent cull factor. Deduct these from the total number of seedlings ordered. In effect, you will be ordering 10 percent more seedlings than you calculated you needed for planting. This also helps to account for any shortage in the number of seedlings actually packaged.

If you order seedlings to plant 35 acres at 7 by 10 spacing and allow for a 10 percent cull factor, you need to order 24,000 seedlings.

$$\begin{aligned}
 &7 \text{ by } 10 \text{ spacing} = 622 \text{ seedlings per acre (see Table 4)} \\
 &35 \text{ acres by } 622 \text{ seedlings per acre} \\
 &= 21,770 \text{ seedlings} \\
 &10\% \text{ cull factor: } 21,770 \times .10 = 2,177 \text{ seedlings} \\
 &23,947 \text{ rounded to the next highest } 1,000 \\
 &= 24,000 \text{ seedlings to be ordered}
 \end{aligned}$$

### ***Delivery Dates***

Planting season begins in December and should be completed in March. The optimum period is from late December to mid-February. Weather conditions often force extension of the planting season, causing problems with proper seedling storage.

Early planting before cold weather can kill seedlings if they have not hardened off while still in the nursery beds. Hardening-off is a physiological process where seedlings become acclimated to colder temperatures by reaching a stage of dormancy where active growth is temporarily suspended. Some nurseries use chilling hours (temperatures between 33 °F and 40 °F) as an indication of dormancy. Chilling hours are monitored in the nursery, and seedlings are lifted after 200 or more chilling hours have accumulated. This allows seedlings to be planted immediately or stored for no more than 2 or 3 days. When 400 chilling hours have accumulated, seedlings reach peak dormancy and can be cold-stored for up to 8 weeks. When you order seedlings, ask how the nursery determines that seedlings are properly hardened-off and are ready to lift.

If large acreages are to be planted or delays are expected, arrange with the nursery to split shipments of seedlings to allow you to store and handle a minimum number of seedlings at a time.

### **Seedling Storage and Care**

Pine seedlings are commonly packaged in open-end bales, kraft-polyethylene line (K-P) bags, and wax-coated boxes. These packages protect seedling quality during transport and storage.

Proper storage conditions must be provided before planting to maintain seedling quality. It is always best to plant seedlings as soon as possible. Do not store nondormant seedlings lifted early or late in the planting season; plant them immediately. Plant longleaf pine seedlings within 1 week after lifting from the nursery. These seedlings are extremely perishable and should be planted immediately if possible.

When your seedlings are delivered from the nursery, you should be sure that they are protected from direct sun, high temperatures, and freezing temperatures. If you pick up your seedlings from the nursery or distribution point, provide cool, shaded conditions during transportation. Arrange to pick up seedlings in late afternoon and schedule long-distance hauling at night to prevent heat buildup from the sun. If an open truck or trailer is used, a tarp can shade the seedlings, but be sure to allow for ventilation under the tarp and around the seedlings to prevent heat buildup.

To prevent water loss from open-end bales, avoid exposing the bales to wind during transport. Avoid stacking bales or bags of seedlings over two high without providing space between packages for air circulation and support to prevent crushing.



Figure 7. Water baled seedlings during storage to prevent drying.



Figure 8. Seedlings suffer damage from crushing and heat buildup when improperly stacked.



Figure 9. These seedlings are properly stacked, allowing air circulation to prevent heat buildup and crushing.

Cold-storage facilities offer the best conditions to store pine seedlings. Dormant seedlings packaged in bales, bags, and boxes can be kept for 8–12 weeks in cold storage at temperatures of 33–36 °F and high relative humidity. If seedlings are packaged in bags, relative humidity is less important.

Baled seedlings may require periodic watering to prevent drying during long storage periods (Figure 7). Always allow excess water to drain from the bales to prevent damage from decay. Discolored roots and a sour smell indicate damage from lack of water drainage. Seedlings in K-P bags and boxes and seedlings with clay-coated roots do not require watering if the packages have been unopened and undamaged. (Roots coated with kaolin clay are white.)

To prevent seedlings from drying out, store them at a relative humidity of 85–95 percent. If the relative humidity inside the storage chamber falls below 80 percent, spray water on the walls and floor to increase humidity. Do not stack bales, bags, or boxes over two high, and always allow for adequate air circulation around all containers. This also prevents damage from crushing (Figures 8 and 9).

Most landowners do not have access to cold-storage facilities; therefore, when seedlings cannot be planted immediately, landowners must rely on shed storage where seedlings can be protected from wind and temperature extremes. Baled seedlings can be stored for up to 8 weeks when watered every 2–3 days, draining excess water from the bales.

Seedlings in bags and unopened boxes trap heat generated from respiration. This heat buildup within the package damages the seedlings. If storage temperatures exceed 40–50 °F for several days, the vigor of seedlings in bags is reduced. Because of the potential damage from overheating, do not store seedlings packaged in bags or boxes for more than 4 weeks without cold storage.

Warm air temperatures may limit safe shed storage time. Allowing storage temperatures to reach 80 °F causes mold to develop on the seedling roots, initiating decay. Mold may be detected by the presence of fungal hyphae (spiderweb-like strands around the seedling roots) and a musty smell when the packages are opened.

If seedlings freeze, let them completely thaw before attempting to separate and plant. Immersing the frozen seedlings in cool water for short periods helps to speed thawing. (Do not soak for more than an hour.) Freeze-damaged root systems will appear limp and discolored, and root tips will easily slough off in handling. Discard seedlings that have suffered freeze damage. Longleaf pine seedlings are likely to be killed if frozen.

You can store seedlings by removing them from their packages and heeling them into shaded, shallow trenches. Cover roots with moist soil and water



Figure 10. Unless seedlings are graded at the nursery, they will not be of uniform size and quality.



Figure 11. Seedling roots must be kept moist by dipping in water or a gelatin-like root dip.

frequently. Lift seedlings before active root growth begins. Look for expanding white root tips as a sign of active root growth. Seedlings are easily damaged when removed from the trenches as roots are stripped off.

**Table 5. Grading Standards for Southern Pine Seedlings<sup>1</sup>**

Species	Height inches	Root collar inches	Condition of stem	Needles/fascicle	Winter bud
Loblolly and Slash Pine	6–12	1/8+	stiff, woody	2s and 3s	usually present
Longleaf	8 clipped 12 unclipped	1/2+	—	large, 2s, 3s free of brownspot	thickly scaled
Shortleaf <sup>2</sup>	6–10	1/8+	stiff, woody	2s and 3s	usually present

<sup>1</sup> Adapted from Wakely (1954) and May (1986).

<sup>2</sup> Grade sand pine to shortleaf pine standards.

### Preparing Seedlings for Planting

Seedlings of various sizes and quality may be in your order (**Figure 10**). Some nurseries grade seedlings to a uniform size before packaging. Others attempt to produce a uniform seedling in the nursery bed to eliminate the added expense of hand grading after lifting. Grading before planting removes seedlings that are too large or too small to be planted. It also removes seedlings with broken or crushed roots and stems, missing bark, stripped roots or needles, stem swellings indicating fusiform rust, or other damage.

Seedlings can also be selected for planting on particular sites. For example, short, stout seedlings with dense, fibrous root systems would perform better than taller seedlings with long root systems on sites with shallow, droughty soils. Taller seedlings with well-developed root systems are preferred over shorter seedlings on sites where herbaceous competition is uncontrolled and will quickly overtop the seedlings.

Grade the seedlings in a cool, high-humidity area protected from sun and wind before they are taken to the field and given to the planters. As seedlings are removed from their packages, dip them in water, clay, or a synthetic gel root dip to reduce drying of the roots (**Figure 11**). (Check with forestry and farm chemical dealers for gel dips.) Seedlings with roots coated with kaolin clay can stand brief periods of exposure with minimal damage to roots.

After grading, promptly repackage seedlings in their original containers with sufficient moisture, or place them in buckets or tubs with water to keep them from drying out while being transported to the field. Do not allow seedlings to sit in water for more than 1 hour. Allowing planters to grade during planting slows work and can result in cull seedlings being planted.

One or two people can handle grading and any necessary root pruning. Graders should know the grading standards presented in **Table 5** and be aware that stem length is less important than stem root-collar diameter and root system development. Seedlings with thick, sturdy stems 6–12 inches long and well-developed root systems with five or more lateral roots have the best initial survival and growth.

An optimum root system is 6–8 inches long with at least five to seven or more strong first order lateral roots that are at least 3 inches long (**Figure 12**).

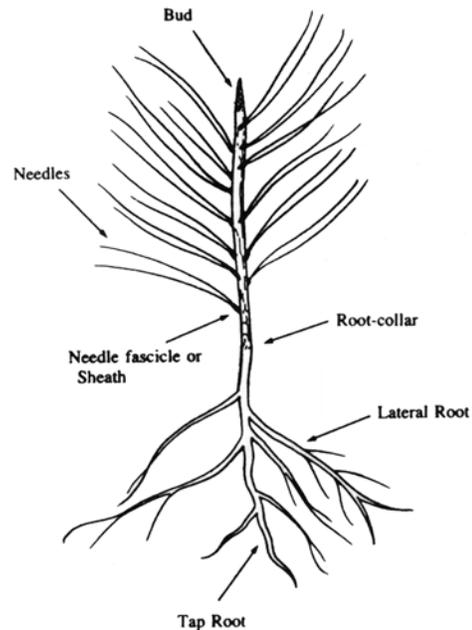


Figure 12. Seedling morphology.

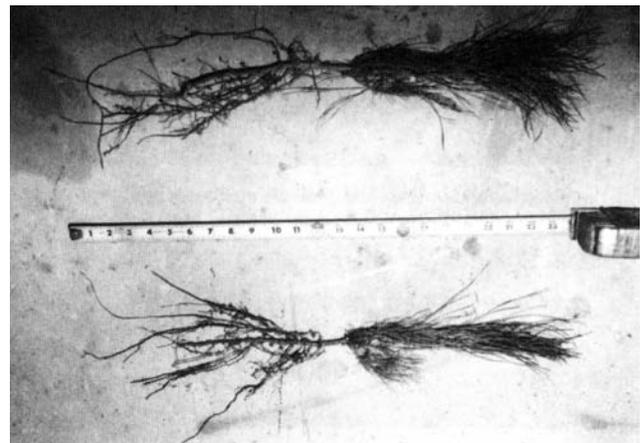


Figure 13. Seedlings with long, fibrous root systems require careful root pruning to allow proper planting.

Use seedlings with root systems 5–6 inches long with good lateral root development on sites with restricted rooting zones or high water tables. Otherwise, cull all seedlings with root systems less than 5–6 inches long and those with less than three strong lateral roots. If root systems are more than 8 inches long, the seedlings are difficult to plant correctly without special care and supervision (**Figure 13**).



Figure 14. Root prune only when necessary by making a single clean cut, removing as little of the root system as necessary.

Do not allow planting crew members to prune roots during the planting operation. This results in the roots being stripped off and leads to poor survival. Prune roots with scissors, shears, a hatchet, or a machete. Make a single clean cut, removing as little of the roots as necessary (**Figure 14**). When root pruning is necessary, keep the pruned root system in balance with the top. Prune roots to no less than 8 inches in length for seedlings with tops of 8–12 inches.

### ***Seedling Care in the Field***

When transporting seedlings to the planting site, take only as many as can be planted in a day. If time and logistics permit, arrange to have seedlings delivered twice a day to the planting site. Load and transport packages carefully to avoid damage to seedlings (**Figure 15**).

Seedling quality deteriorates quickly with careless field storage and handling. Always provide a shaded storage area. A tarp can be erected as a canopy above the seedlings to keep off direct sun. Be sure there is ample ventilation to prevent heat buildup in the packages. Temperatures exceeding 50 °F inside the packages quickly reduce the quality of the seedlings.

Do not lay a tarp directly over the seedlings during the day as temperatures inside seedling packages can quickly exceed 50 °F on sunny days, even when air temperatures are moderate. Cover seedlings left overnight in the field with a tarp to protect against freezing damage. Repair any tears or holes to the packages with duct tape. Repackage the seedlings as necessary. If seedlings are to be graded at the field site, be sure to do so in a cool, shaded spot protected from wind and sun.

When giving seedlings to the planters, open and empty only one package at a time. Make sure planters carry seedlings in bags or buckets. Never allow seedlings to be hand-carried with roots exposed while planting. Have water and clay or synthetic gel dips



Figure 15. Baled seedlings are easily damaged by oil and fuel spills, by exposure to high temperatures, and by wind when transported to the field site.

available to keep seedling roots moist. Do not leave seedling roots in water for more than 1 hour; instead, return them to their original packages.

### **Planting**

The key to successful planting is the ability of the root system of the newly planted seedling to begin quickly taking up water and nutrients. Plant seedlings in moist mineral soil where moisture is immediately available. Newly planted seedlings may be unable to take up moisture in dry soils or until drainage is achieved in flooded soils. If drainage does not occur until late March or April, use container-grown seedlings to extend the planting season.

Depending on the site, both hand and machine planting are efficient and reliable options. Large, open tracts are more easily planted by machine; smaller or irregularly shaped tracts, sites with minimal site preparation, and rocky sites are more easily planted by hand.

Show planters the correct depth to plant seedlings. The depth will vary with soil–site conditions, but plant seedlings no deeper than the length of the dibble bar or planting foot on the machine. Shallow planting results in early seedling mortality, particularly during early spring and summer droughts. On many “old field” sites where the soil contains a dense traffic pan or

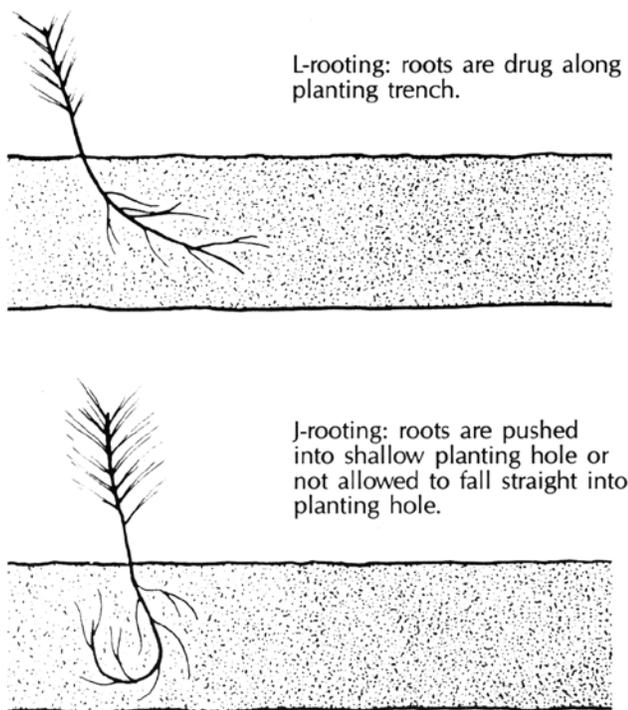


Figure 16. L-rooting is a common problem when seedlings are machine planted. J-rooting is common in hand-planting operations.

hardpan near the surface, subsoiling breaks up the pan to permit deeper planting. Slash, loblolly, and shortleaf pine can be planted up to 2–3 inches above the root collar, provided the planting hole is deep enough to avoid root deformation. Improper planting, resulting in J-rooting or L-rooting, slows early seedling growth (Figure 16). In wet soils with a high water table, plant only to 1 inch above the root collar.

Longleaf pine requires special care in planting and great attention to planting depth. Plant longleaf seedlings so the bud is not buried or the root collar exposed (Figure 17). The large tap root and lateral root system of high-quality longleaf seedlings require larger and deeper planting holes than other pines (Figure 18). Hand planters should use the large KBC dibble rather than the narrow OST dibble. Machine planting is preferred when possible.

Regardless of planting method, plant seedlings at the correct spacing and depth so that the roots are not deformed and the soil is firmly packed around the roots. This eliminates air pockets. Have a written contract that details all planting specifications, including transport and handling of seedlings, planting dates, packing, and conditions when planting is to be suspended (site too wet or dry, freezing weather, or summer-like conditions). The contract should provide for inspections during planting to ensure that quality standards are met before payment is made. This is especially important when planting with assistance of cost-share programs.



Figure 17. This longleaf seedling was planted too shallow, leaving the root collar below the needles exposed, a common cause of seedling mortality.

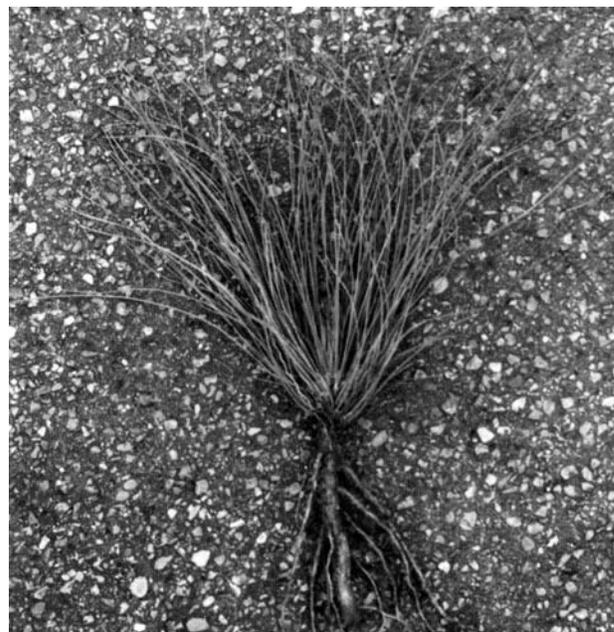


Figure 18. High-quality longleaf pine seedlings have a thick carrot-like taproot with many lateral roots. Special care is required to properly plant large seedlings.

### **Hand Planting**

A good hand-planting crew can average 1,000 seedlings per man-day; inexperienced crews average far less. This ranges from 600 on very poor sites to 1,200 on open fields. Most planters use a dibble bar that has a blade at least 4 inches wide and 10 inches long. Seedlings can be carried in a bucket, but a planting bag is a more efficient way for the planter to carry seedlings in the field. The planting bag is strapped around the planter's waist and will hold several hundred seedlings. Seedlings are dipped in synthetic gel or packed into the bags with wet moss. The bag protects seedlings from sun and wind.

The planter removes one seedling at a time after the dibble has been used to open the planting slit. **Do not** allow planters to carry seedlings in hand while planting, as seedlings rapidly dry out. Two minutes of exposure to wind and sun can kill the seedlings. Always provide planting bags or buckets and insist that seedlings be kept moist at all times.

Have a supervisor at the site to ensure that planting proceeds smoothly and properly. The supervisor should watch the planters for poor practices, such as stripping off roots to make planting large seedlings easier, discarding seedlings to “catch up” with the faster planters, shallow planting, loose packing, and carrying seedlings in hand during planting.

To ensure correct spacing, frequently check distances of planted seedlings within and between rows. Proper packing is necessary to eliminate air pockets around the roots. Check by grasping several needles at the tip of the seedling between thumb and forefinger and gently trying to pull the seedling from the soil. The needles should break if the seedling is firmly packed. A shovel can be used to dig around seedlings to check for J-rooting.

Show your planting crew the correct dibble planting technique (Figure 19):

1. Insert the dibble straight down into the soil to the full depth of the blade, and pull back on the handle to open the planting slit. (DO NOT rock the dibble back and forth, as this causes soil in the planting slit to be compacted, hindering root growth.)
2. Remove the dibble and push the seedling roots deep into the planting slit. Pull the seedling back up to the correct planting depth (1–3 inches above the roots to fall straight inside the planting slit). DO NOT twist or spin the seedling into the planting slit or leave the roots J-rooted.
3. Place the dibble several inches in front of the seedling and push the blade halfway in the soil. Twist and push the handle forward to close the top of the slit to hold the seedling in place.
4. Push down to the full depth of the blade and pull back on the handle, closing the bottom of the planting slit, and then push forward to close the top, eliminating air pockets around the roots.
5. Remove the dibble, and close and firm up the opening with your heel.

### Machine Planting

When machines are correctly matched to the site and operators are trained and supervised, 7,000–9,000 or more seedlings can be planted per day. The condition of the planting site is important in selecting the proper size of machine. Plant old fields and cropland with light-duty planters pulled by wheeled tractors of 20–100 hp (Figure 20). Rough sites require the use of heavy-duty planters pulled by large farm tractors or crawler tractors of 50–350 hp (Figure 21).

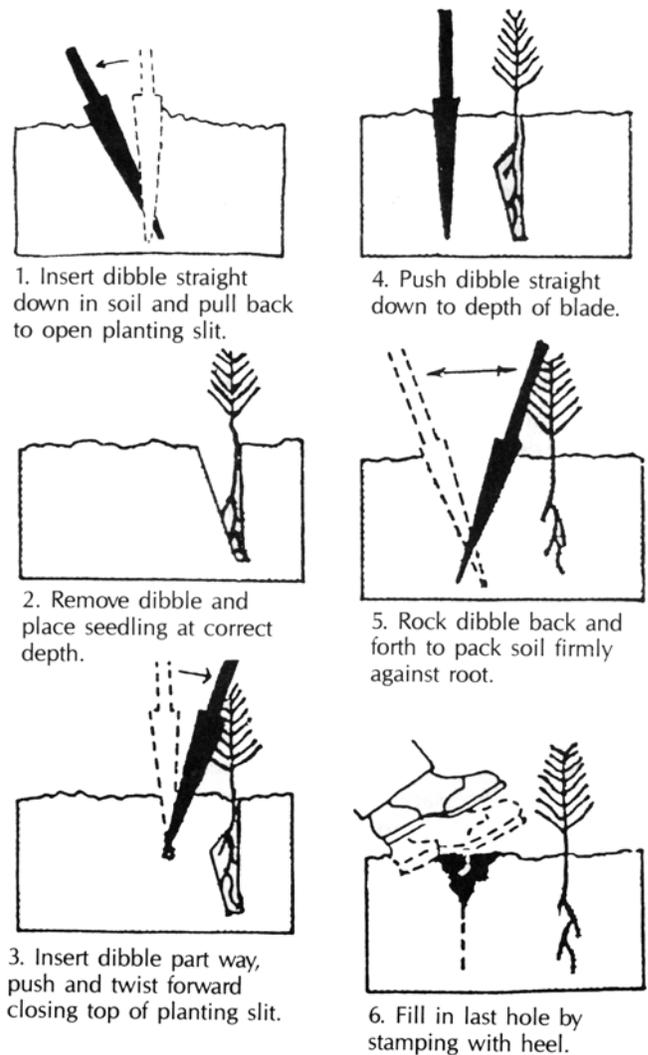


Figure 19. Dibble planting technique.

Seedlings are planted with machines using two systems: a manual system, where the seedling is placed into the trench by hand, or an automated system, where seedlings are placed in “fingers” that then place the seedlings into the planting trench.

Frequently check planting performance to ensure proper planting, particularly when soil type, texture, moisture, or amount of harvest debris changes on the site. Maintain proper adjustment by carefully checking planting performance under actual site conditions. Adjust packing wheels to close completely the planting trench from top to bottom. Be sure seedlings are planted straight and at the proper depth. Follow the planter and use a shovel to open the planting trench to judge root placement.

L-rooting is a common problem with machine planting. Adjust the planter to open the trench to maximum depth and make sure the seedlings are placed at the proper depth and released quickly so the roots are not dragged along the trench.



Figure 20. Light-duty manual tree planters are suited for open fields and pastures.



Figure 21. Heavy-duty mechanical planters are commonly used on large tracts and rough conditions.

### ***Planting Conditions***

Carefully check the site and environmental conditions at planting time. Planting on bright, sunny, windy days in dry soil can result in dead seedlings. Dry soil is difficult to pack around the seedling. When soils are too wet, especially clay soils, machine planting can result in soil compaction around the seedlings, as well as other site damage.

The best planting conditions are when temperatures are between 35 °F and 60 °F with relative humidity greater than 40 percent and wind speeds less than 10 mph. When air temperatures are in the 70s and low 80s with low humidity (less than 40 percent) and wind speeds of 10 mph or greater, plant cautiously, as seedlings can quickly dry out after planting.

If the situation allows, delay planting until conditions improve, or plant in the afternoon hours when seedlings will face less environmental stress. If planting must continue under these conditions, have planters carry fewer seedlings in the field and take more care to prevent them from drying out. Do not plant in freezing weather or summer-like conditions when temperatures are below 32 °F or above 85 °F.

### ***Container-Grown Seedlings***

Seedlings produced in containers are becoming increasingly available in the South. Their use was originally developed in the Scandinavian countries and Canada where operational planting of container-grown stock has long been common.

Container-grown stock offers the advantage of extending the planting season over bareroot stock. Early-season planting in the South can begin in October, allowing seedlings to become established before freezing weather occurs. Planting can extend into late spring and even summer on sites that may be too wet to plant during the fall or winter with bareroot seedlings. The protected root systems of container-grown seedlings reduce the damage associated with lifting, storing, and planting bareroot seedlings.

Seedlings are best stored in their containers where they are protected from root damage and drying out. Protect them from freezing, as the root plugs can easily freeze. The limited soil volume of the container makes the seedlings susceptible to drying out in sunny and windy conditions. Store in partial shade, and water frequently to maintain adequate moisture throughout storage and planting.

Container-grown seedlings may be machine or hand planted, but in both methods it is critical that the planting hole be deep enough so that the top of the root plug can be completely covered with soil. If the top of the root plug is not covered with soil, it will rapidly dry out, and the seedling will die. (This also reduces first heaving of fall-planted seedlings.) Take special care when planting container-grown longleaf pine seedlings. If planted too deep, the bud is covered; if planted too shallow, the root plug is exposed, which rapidly dries out the rooting media.

### ***Evaluating Planted Stands***

Survival and stocking are two important factors in evaluating the success of your planting effort. Survival is the number of planted seedlings alive at a given time. It is best estimated by establishing permanently marked plots soon after outplanting. Seedlings are then counted at the end of the first field season and compared to the initial number of seedlings in the plots. Ten to twenty well-distributed plots are usually sufficient for survival estimates.

Stocking represents the number and distribution of living seedlings over the plantation. This information is used to determine whether replanting a portion or the entire stand is necessary. A systematic sampling system is the best way to sample stocking. The number of live trees is counted in fixed-area plots, usually circular plots. These plots are uniformly spaced across the plantation (**Figure 22**). Plots of 1/50 acre to 1/100 acre in size are convenient.

You need 40–60 plots to get accurate estimates of first-year stocking, regardless of plantation size. Orient sample plots on lines that cross the planting rows throughout the entire plantation.

### Replanting

If the survey reveals that at least 300 seedlings per acre are evenly distributed over the plantation at the end of the first growing season, replanting or interplanting the skips will not be necessary. If there are large areas with poor stocking, these areas can be replanted. Some additional site preparation may be required.

Avoid interplanting the skips within rows. Newly planted seedlings do not compete favorably with established 1-year-old seedlings. Interplants seldom add to the volume production at harvest, and the added investment for the seedlings and planting costs will not be recovered.

If you attempt interplanting, plant no closer than 20 feet to an established seedling. Interplanting may be required in stands established under federal incentive programs to meet minimum stocking requirements. If so, spot herbicide treatments for weed control around the interplants may aid their survival and growth.

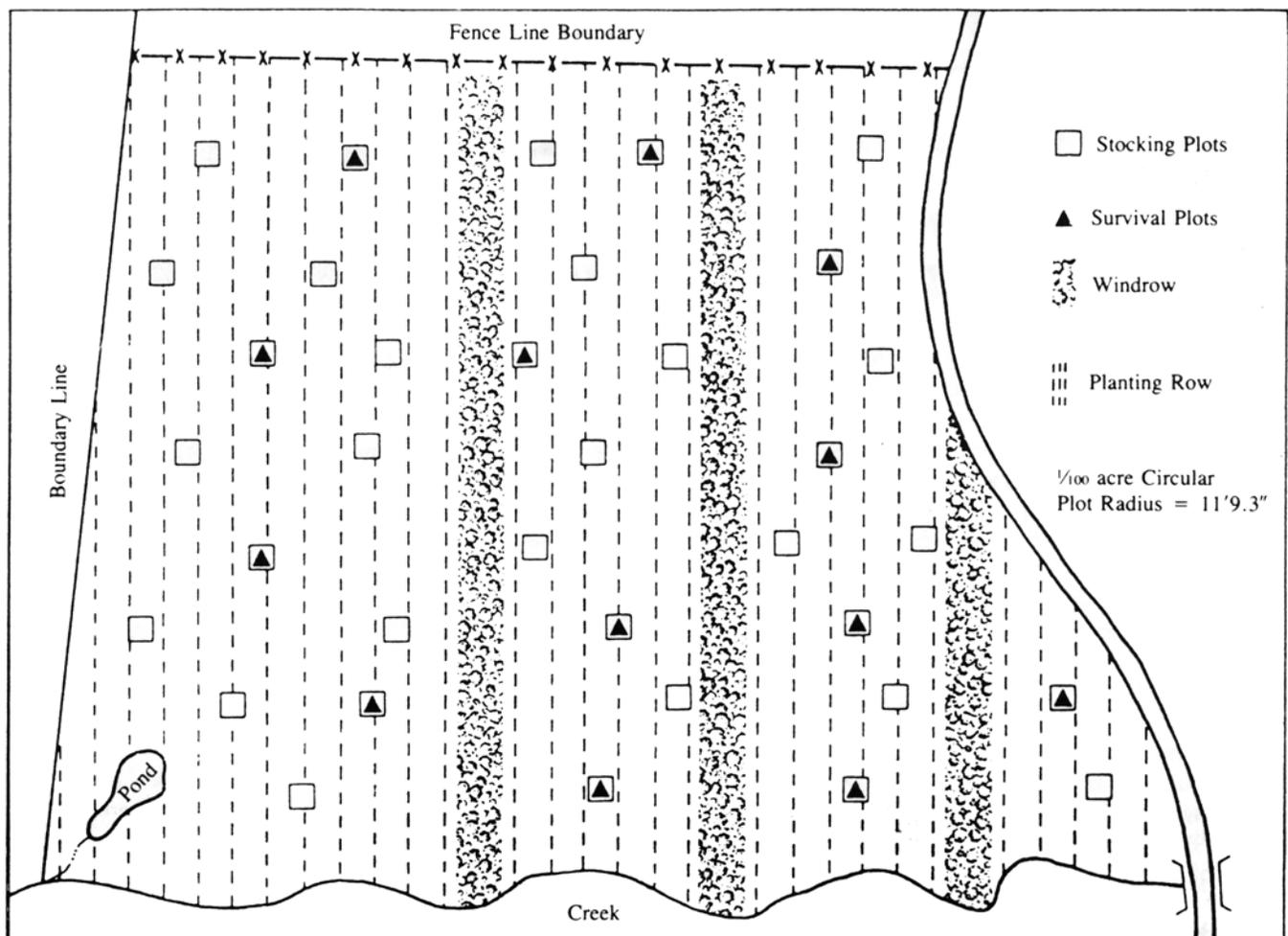


Figure 22. Plantation stocking and survival sampling.

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