Chapter 16
Lifting, Storing, and Transporting Southern Pine Seedlings

William C. Carlson

Abstract

Tree seedlings are living plants with specific desirable morphology and physiology, and monetary value. Stock performance in the field depends on seedlings being lifted, sorted, packaged, stored, and transported in environments that maintain physiological quality. Indoors or out, temperature and moisture conditions, and care in handling by workers and with machines, are of utmost importance. Maintaining seedling quality from nursery to field requires planning, proper facilities, trained crews, and close coordination between nursery manager and regeneration forester.

16.1 Introduction

Nursery cultural practices are extremely important to the development of a high-quality seedling. Once a high-quality seedling has been cultured, then the next step in a successful regeneration program is to maintain or improve that seedling's quality through lifting, packing, storing, and transporting stock to the planting site. These processes are extremely important to seedling quality because the survival and growth potential of the planting stock can be altered dramatically during any of them. This chapter focuses on the biology and operational procedures for transfering southern pine seedlings from the nursery bed to the planting site.

16.2 Principles of Maintaining Stock Quality from Nursery to Planting Site

16.2.1 Dormancy Status

At the end of the nursery culture period, seedlings should have a well-formed terminal bud containing the preformed shoot that will elongate after outplanting [15]. This bud must be in the proper stage of dormancy, determined for a genetic family by the relationship among chilling-hour accumulation and bud dormancy status, to permit a high root-growth (RGP; see chapter 8, this volume) potential.

Dormancy stages were first described for horticultural tree species [12, 28], but have also been studied in conifers [9, 20, 21, 24, 27]. Helmers and Hesketh [17], Garber [13] and Carlson [6, 7] discussed aspects of loblolly pine *(Pinus taeda* L.) dormancy. In general, seedlings that must be stored for more than a few days should be dormant. If nondormant stock must be used, then it should be planted within 5 to 7 days or less after lifting, and should not be planted into stressful environments.

16.2.2 Root-System Size

In principle, the nursery should lift as much of the root system as can be planted properly by the planting crew. Water uptake after planting and root growth potential are improved by increasing initial root-system size [8]. However, seedlings with excessively long roots either may become deformed in the planting hole or, in many cases, cause planters to root prune seedlings in the field. Such poor planting practices can reduce growth at establishment [16] and for many years to come [23]. It is therefore necessary that nursery culturing and lifting be done in a manner that induces development and maintenance of a compact, fibrous root system that can be easily planted. Lifting should be preceded by lateral pruning and undercutting to finalize plantable root-system size.

16.2.3 Packing and Culling

Packing and culling operations should remove undesirable seedlings in an environment that will prevent seedling desiccation and heating. Packaging should be designed to prevent seedlings from drying out, allow dissipation of ethylene gas, and unitize stock (usually 1,000 seedlings/package). Unitization allows the landowner to tally seedlings upon receipt and planting crews to deter-

M.L. Duryea & P.M. Dougherty (eds), Forest Regeneration Manual, pp. 291–301.

mine payment (by number of packages). This latter factor also improves quality — trees counted in the field by planting crews tend to dry out. Each package should identify the grower, date of lifting, recommended maximum storage time, genetic identity, and any specific treatments (such as pesticide-laden clay slurry root dip).

16.2.4 Special Considerations for Container Seedlings

Container seedlings have biological requirements similar to those of bareroot seedlings [22]. Shoots should be dormant and cold hardy, and roots should fill the container well enough to allow extraction without loss of the potting medium. Greenhouses should be well vented to allow seedlings to meet their chilling requirement without freezing.

The seedling can be shipped in the container in which it was cultured, in a special shipping container, or as a plug (i.e., root mass without the container). This choice is heavily contingent on weight of the culture container, uniformity of the seedling crop, and method to be used to plant the seedlings. Choice of container and degree of crop uniformity depend on crop culture procedures (see chapters 6 through 8, this volume). Once these decisions are made, then seedlings that fail to meet height and diameter standards or that are diseased are culled.

16.2.5 Storage

Seedlings should be stored under refrigerated conditions that also protect against freezing. Temperatures just above freezing (1 to 3°C) are suitable for southern pines; this temperature range reduces respiratory loss of carbohydrates while also inhibiting growth of storage molds. If refrigerated storage is not available, then seedlings should be stored for shorter periods, kept in a cool shaded location, and packaged to allow respiratory heat to dissipate. Such packaging usually requires watering seedlings in storage, so a water supply and adequate drainage for excess water must be provided.

16.2.6 Transportation

Transportation should be viewed as cold storage on wheels. The transport system should permit good temperature control, palletized handling, and easy identification of stock. Unrefrigerated packages should be transported in covered vehicles to protect seedlings from direct sunlight.

16.2.7 On-Site Handling and Storage

The volume of seedlings transported to and stored at the planting site should be limited to the number of seedlings that can be planted in 1 day. Planting crews should not handle seedlings except while loading them into planting bags or during actual planting. Seedlings stored on planting machines should be kept moist and protected from direct sunlight.

16.3 Prelifting Considerations

To maximize seedling quality at the planting site, several factors must be considered before lifting. First, it is imperative that the forester responsible for obtaining seedlings for planting stay in contact with the nursery providing them so that schedules for lifting and storage can be properly coordinated. Second, lateral roots that have grown downward from the point of undercutting should be undercut again. This removes a relatively small amount of root tissue, usually only two to four roots about an inch (about 2.5 cm) long, but substantially improves planting quality checks because these roots are easily swept upward at planting. This undercutting also loosens the soil to facilitate lifting. Third, seedling dormancy status should be reviewed and an acceptable storage time determined. Fourth, seedlings should not be lifted when the soil is frozen because this causes excessive root damage.

16.4 Lifting Operations

Lifting quality is a function of coordinated fine-tuning of stock species, soil conditions, and weather.

16.4.1 Machine Lifting

Lifting is commonly done by machine. The machine shown in Figure 16.1a is designed to lift eight double seedling rows (an entire nursery bed) in one pass. Because machine design is an important consideration, nursery workers should test machines thoroughly before purchase.

Species to be lifted should be considered. Lifters such as the one shown in Figure 16.1a harvest seedlings by passing a reciprocating blade under them and then lifting them slightly as seedling stems are fed into soft rubber belts that carry them to the conveyor. This works well for loblolly, shortleaf *(Pinus echinata* Mill.), and slash *(Pinus elliottii* Engelm.) pine but not for longleaf *(Pinus palustris* Mill.) pine, which requires a full-support conveyor because the stem is not elongated enough to allow a belt-type conveyor. "Potato chain"-type conveyors have been incorporated into some machines to handle longleaf.

Other considerations include ability of the machine to lift seedlings with fine roots intact, and the associated speed and soil moisture conditions under which this can be done. Often overlooked is the fact that machine-lifting quality varies greatly with machine speed and soil moisture conditions. Machine lifting quality, measured in terms of lack of root damage, frequently can be substantially improved by slowing the forward motion of the machine when soil moisture levels are high.

16.4.2 Hand Lifting

Hand lifting, often used when soils are too wet for machine operation, must be done very carefully to avoid root stripping, more likely in wet or heavy soils. Hand

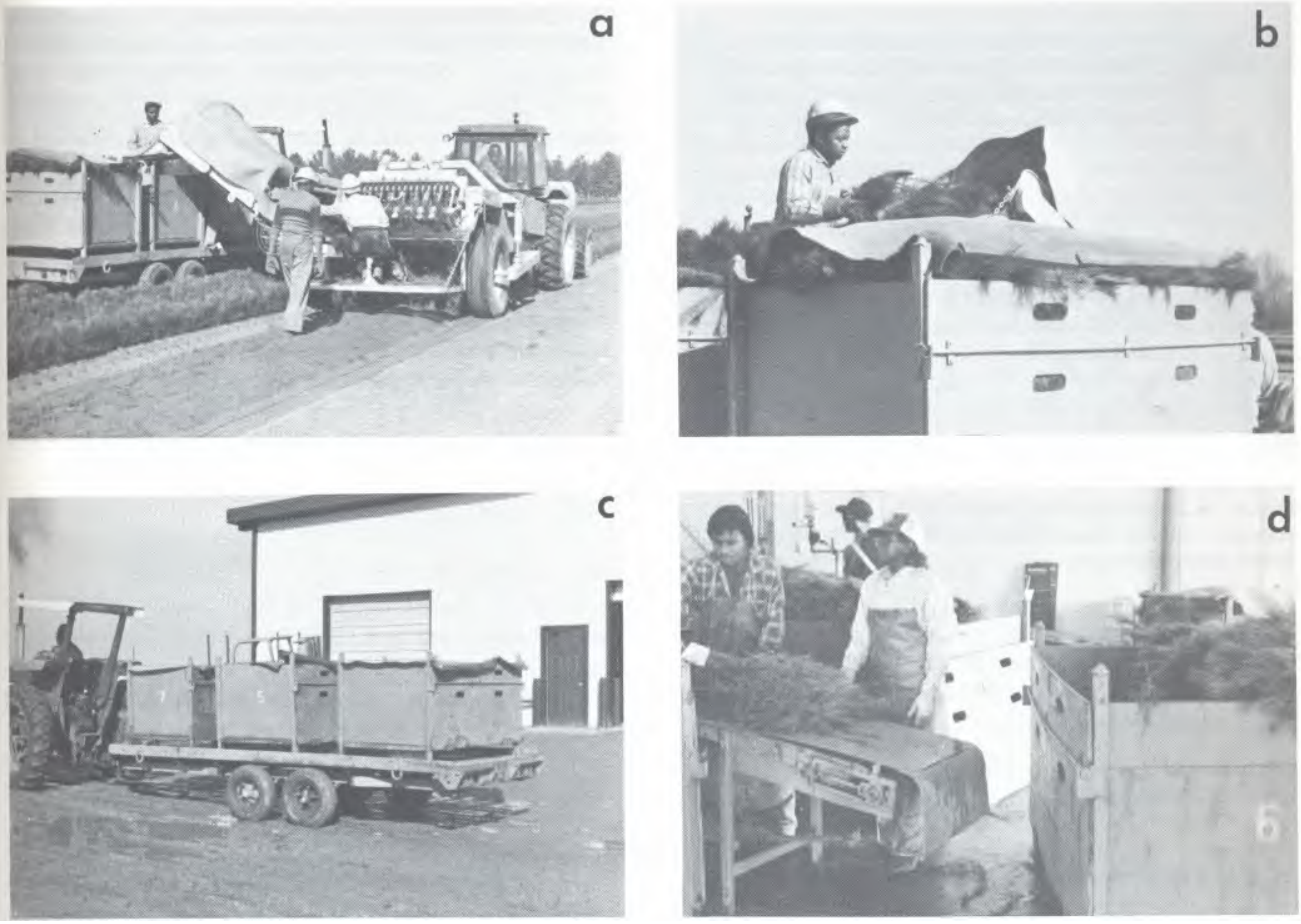

Figure 16.1. (a) An eight-row lifter at work on a bed of loblolly pine seedlings at Magnolia Forest Regeneration Center, Weyerhaeuser Co., Magnolia, Arkansas. Note the tank on the front of the tractor used to supply spray nozzles on the lifter so that seedlings are moistened as they are lifted. (b) Seedlings are conveyed from the lifter into large boxes for transport to the packing room. Note canvas lid on box to shade the seedlings during filling and transport. (c) Boxes are hauled to the packing shed, off-loaded by fork lift, and placed either in short-term storage in the cooler or directly in position to feed a packing conveyor line (d).

lifting varies much more in quality than machine lifting, usually because of poorly trained labor. Seedlings should be lifted a handful at a time to minimize root stripping at the soil-root interface.

16.4.3 Combined Approaches

Some lifting operations combine a machine that lifts the seedlings to the soil surface but requires manual labor to gather them for transportation to the packing shed. In addition to the quality considerations already described for the machine in Figure 16.1a, stock must be kept from drying out while exposed on the soil surface.

16.4.4 Weather

Lifting is best done when the soil is moist but friable so that soil readily parts from roots. Care must be taken to protect the lifted seedlings from excessive exposure and desiccation. Lifting trailers should be shaded, and under dry weather conditions seedlings should be moistened with a spray of water on the lifter. As previously noted, seedlings should never be lifted when the soil is frozen because of excessive root damage.

16.5 Transportation to the Packing Shed

Transportation to the packing shed is quite variable across the industry. Traditionally, seedlings have been packed into bushel-basket-sized tubs when hand lifted, and placed with root systems centered in canvas slings when machined lifted. In the last few years, Weyerhaeuser Co. has introduced large boxes (Fig. 16.1b) that can be filled directly by the machine lifter with manual guidance. This system reduces seedling exposure and considerably increases efficiency due to unitization during transport (Fig. 16.1c).

Once inside the packing shed, the unit of handling (tub, sling, or box) is either fed directly onto a conveyor for culling, grading, or direct packaging or placed into cold storage until needed in the packing shed (Fig. 16.1d). It is

Figure 16.2. Seedlings are inspected and culls removed on a conveyor line at Quail Ridge Nursery, Weyerhaeuser Co., Aiken, South Carolina.

important that seedlings be moist when they arrive at the packing shed. Seedling moisture level should be inspected there and stock remoistened if necessary before further processing or cold storage.

16.6 Packing Operations

16.6.1 Packing-Shed Environment

Environmental considerations in packing-shed design should be separated into those favoring the maintenance of seedling quality and those intended to make workers more comfortable. Seedlings should be cool and moist. Workers should be warm and dry. To accomplish this, the packing shed should be kept cool, seedlings should be moistened by nozzles at the entrance to the conveyor belts, and workers should be outfitted with rubberized aprons, gloves, and boots. Warm clothing is generally a better option than radiant or forced-air area heaters. If heaters are used, they should be pointed at workers' feet or legs and not at seedlings.

16.6.2 What Seedlings Should Be Shipped?

Seedlings to be packaged and shipped are usually chosen by one of four methods: (1) "bed run" packing of previously inventoried stock that exceeds a set quality standard, (2) sorting of stock into certain size classes (i.e., grading), (3) culling (i.e., removing seedlings below a set standard), or (4) packaging of all seedlings produced without regard to standards. Methods 1 and 4 can be done in the field or packing shed. Methods 2 and 3 require close inspection of the lifted seedling crop and are therefore best done in the packing shed (Fig. 16.2).

Method 2 (grading) most commonly involves total or at least partial adherence to Wakeley's [33] morphological classification system (Table 16.1). However, the improvement of nursery crop uniformity due to the culture of specific half-sibling families utilizing techniques that consider genetic identity has made grading less common than method 3 (culling). In culling, the goal is to prevent damaged or poorly developed seedlings from being shipped. Culling standards are commonly set at a minimum diameter at groundline of 3 mm, a maximum height of 25 cm, a minimum of six first-order lateral roots, a single well-developed terminal bud (not included for growers that top prune seedlings), and no sign of disease or open tissue wounds. Method 1 is generally chosen where at least 90% of the seedling lot has been determined to meet the culling standards. This is not to be confused with method 4, in which all seedlings are packaged regardless of quality. Method 4 generally leads to field grading by the planting crew and/or planting of many high-risk seedlings, either of which can lead to reduced survival.

16.6.3 Root Treatments

16.6.3.1 Root pruning

Seedlings should be lateral root pruned and undercut before being lifted (see chapters 6 and 7, this volume). If they have been, additional root pruning is seldom necessary. If additional root pruning is deemed necessary, then it should be done in the packing shed, not on the planting site. This allows a higher degree of quality control in an environment that protects seedlings from exposure. When root pruning, workers should keep in mind that the amount of root tissue that is planted determines the potential of the tree to take up water until roots initiate and/or elongate [8]. It is, therefore, advisable to maintain the largest root system that can be planted properly.

16.6.3.2 Root coatings

Root systems are often coated with clay slurry to retard desiccation in storage and at the planting site. The protection offered by clay slurry is most apparent under moderate drying conditions [11, 29, 31]. Other coating materials such as absorbent gels are used in some nurseries, although tests to date do not clearly distinguish them as being superior to clay slurry.

16.6.3.2. Pesticides in coatings

Clay slurry can also be used as a chemical carrier, most commonly of Furadan®, which provides protection against Pales weevil on recently logged sites when insect activity is high. Benlate® is currently being tested as a fungicidal treatment to allow longer storage of longleaf and shortleaf pine and may be of general use in reducing degradation from storage pathogens [3].

16.6.4. Packaging Methods

Three packaging methods are in common use in the southern pine region: (1) kraft-polyethylene (KP) bags, (2) U.S.D.A. Forest Service bundles, and (3) wax-impregnated corrugated cardboard boxes (Fig. 16.3).

KP bags are constructed of multiple layers of kraft paper coated with polyethylene to retard moisture loss and add wet strength to the bag. These bags, best for refrigerated

Table 16.1. Grading method for southern pines proposed by Wakeley [33].

Species and grade[1, 2]	Usual heights (cm)[3]	Thickness of stem at ground (mm)	Nature of stem	Bark on stem	Needles	Winter buds
Longleaf:						
1	30 to 41	6 to 13 or larger			Abundant. almost all in 3s or 2s	Usually present; usually with scales
2	20 to 38; 15 to 20 if stem and buds are good	At least 5			Moderately abundant; at least part in 3s or 2s	Buds with scales usually lacking; some without scales usually present
3	< 20	< 5			Scanty; short; often none in 3s and 2s	Not present
Slash:						
1	15 to 36	5 or larger	Stiff; woody	Usually on entire stem	Almost entirely in 3s and 2s	Usually present
2	13 to 20; sometimes 30	At least 3	Moderately stiff	On lower part at least; often all over	Part at least in 3s and 2s	Occasionally present
3	Usually < 15	< 3	Weak; often juicy	Often lacking	Practically all single; usually bluish	Almost never present
Loblolly:						
1	13 to 30	5 or larger	Stiff; woody	Usually on entire stem	Almost entirely in 3s	Usually present
2	10 to 18; sometimes 25	At least 3	Moderately stiff	On lower part at least; often all over	Part at least in 3s	Occasionally present
3	Usually < 13	< 3	Weak; often juicy	Often lacking	Practically all single; usually bluish	Almost never present
Shortleaf:						
1	10 to 25	About 3	Stiff; woody Usually a crook at groundlevel; often branching	Usually on entire stem	Almost entirely in 3s and 2s	Usually present
2	8 to 16; sometimes 20	About 5	Moderately stiff; often with crook and branches	On lower part at least; often all over	Part at least in 3s and 2s	Occasionally present
3	Usually < 10	Distinctly < 3	Weak; often juicy; often straight	Often lacking	Practically all single; bluish	Practically never present

[1] Grades 1 and 2 usually considered plantable, and grade 3 culled.
[2] Any seedlings with roots < 13 cm long should be considered as grade 3 (culls), regardless of the quality of the tops.
[3] Needle lengths of longleaf pine seedlings; stem lengths of other three species.

cold storage, most commonly are used to package seedlings in units of 1,000. Units of 28 bags (28,000 seedlings) are then palletized and cold stored; later, pallets are moved as units onto refrigerated trucks. Though resistant to moisture loss, KP bags allow the growth regulator ethylene, which can reduce quality if allowed to build up in storage, to dissipate.

If seedlings are to be stored without refrigeration for more than a few days, then Forest Service bundles are preferred because they more readily dissipate heat and can be more easily rewatered. The need for rewatering twice weekly is one of the drawbacks of this system, whether in refrigerated or uncontrolled storage. Each bundle can be rewatered with a watering wand; or, if equipment is available, bundles can be dipped by forklift or front-end loader, a pallet load at a time, into a tank of clean water or a pond. If a tank is used, water should be changed often to prevent fungal spores from migrating from one batch of seedlings to the next. Regardless of method, rewatered bundles must be adequately drained at an angle so that water does not accumulate in the center of the bundle and cause molding. In general, unrefrigerated bundles should be stored no more than a week. It is important that such storage be shaded and protected from freezing.

Wax-impregnated cardboard boxes have found some use in the South. They have the advantage that they can sometimes be stacked without pallet shelving but the disadvantage that they must be reused to be economical. Reuse requires additional handling and replacement of damaged units. Whether ethylene can dissipate from these boxes remains to be determined.

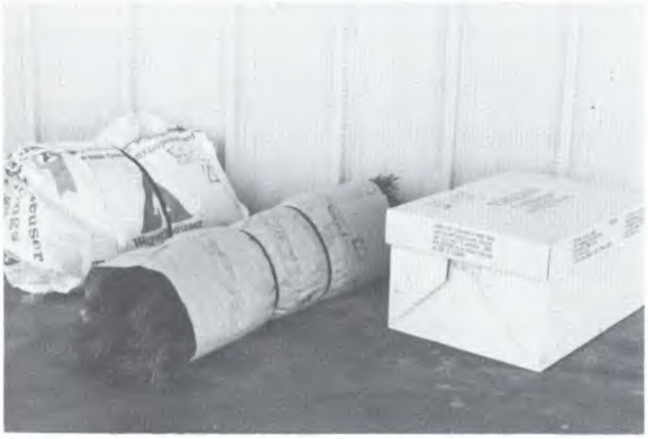

Figure 16.3. Left to right: a kraft-polyethylene (KP) bag, a Forest Service bundle, and a wax-impregnated cardboard box. All are used for packaging southern pine seedlings.

16.7 Storage Environments

16.7.7 Temperature

On most nursery sites refrigerated cold storage is available. Such units should be operated at 1 to 3°C. It is very important that storage temperatures always remain above freezing. Freezing of stored stock has been demonstrated to cause high mortality, probably because root tissues which are usually protected by the soil are much less cold hardy than the shoot or needles (Fig. 16.4).

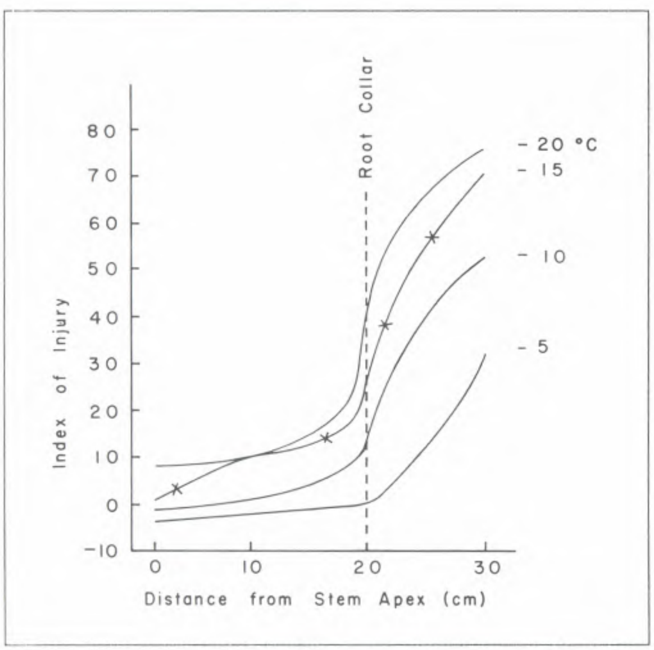

Figure 16.4. Roots of southern pine seedlings are much less cold hardy than shoots and should never be allowed to freeze. This graph shows how various temperatures affect the relative tissue-damage levels in the shoot (0 to 20 cm from stein apex) and the root (> 20 cm). Cold hardiness levels also change by season, genotype, and species.

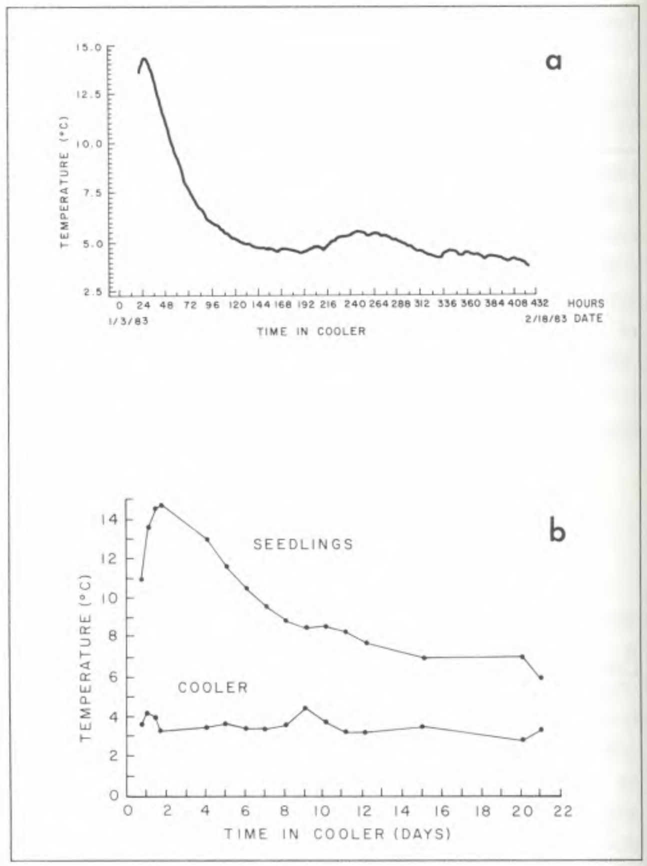

Figure 16.5. (a) Reduction of temperature in the center of a KP bag, holding 1,000 loblolly pine seedlings when the temperature of the air in the cooler is 1 °C ± 0.5 °C. (b) Temperature at the center of 1,000 seedlings in a KP bag held in a cooler at an ambient temperature of 3 to 4 °C. Note that after 15 days, temperature is relatively constant at around 7 °C. In (a) where ambient temperature was 1 °C, the temperature of the seedlings is 4 to 5 °C by day 6.

Storage temperatures have a large effect on the time required to bring the center of seedling bags to a constant temperature. The temperature reached is usually slightly higher than the ambient temperature of the cooler because of the heat of respiration. Minimum temperature is, however, a function of the ambient cooler temperature. Figure 16.5 illustrates the effect of ambient cooler temperature on the temperature in the center of KP bags of seedlings. Although KP bags readily release ethylene, the level that the seedlings produce is a direct function of temperature (Figure 16.6). Barnett [1, 2] and with coworkers [4] demonstrated that ethylene can cause decreased root regeneration, although dose-response relationships with survival were complex. It is clear that this area deserves more research attention before operational recommendations can be made.

Temperature in the cooler should be continuously monitored and recorded so that adjustments can be made when necessary. These records should be referenced to the seedling population in the cooler by date so that the effects of any malfunction can be documented. As with any instrumentation, it is important to calibrate the monitoring

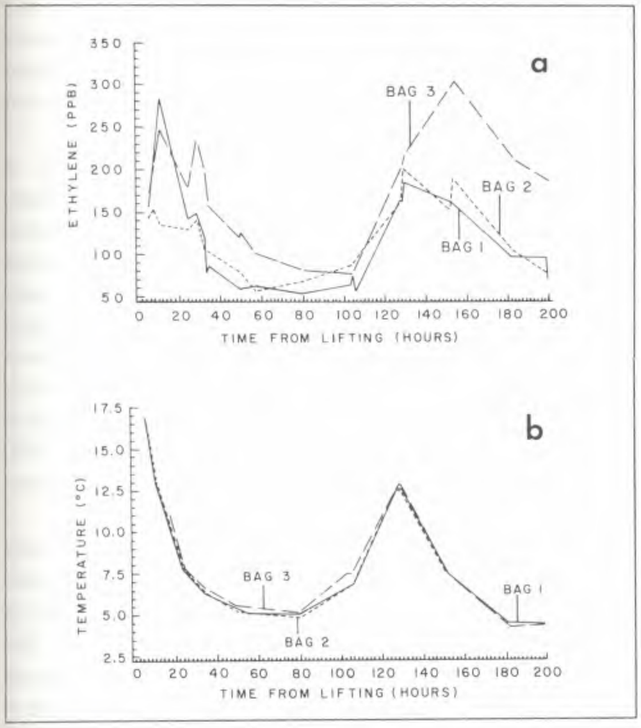

Figure 16.6. (a) Ethylene level inside KP bags of loblolly pine seedlings. (b) Temperature pattern of chamber in which seedlings were held. Note close relationship between temperature and ethylene level. This indicates that bags are transparent to ethylene and that production is a function of temperature.

instrument often, and to locate it in a representative spot [34].

16.7.2 Air Circulation

Storage buildings should provide for high-volume circulation of the cooled air, which should also be humidified. Weyerhaeuser's new facility at Aiken, South Carolina, makes use of a plenum system to uniformly circulate high volumes of cooled (1 to 3°C), humidified (95% relative humidity) air (Fig. 16.7). Cooler doors should be designed to block loss of cooled air during forklift sorties; this is often done with plastic ribbon curtains (Fig. 16.8a) or air curtains, or by rapidly closing electric doors (Fig. 16.8b).

16.7.3 Cleanliness

Coolers should be kept free of decaying plant material or other potential substrates for fungi and should include only very short-term storage of unpacked trees. Floors and walls should periodically be cleaned with soap and water.

16.8 Post-Nursery Storage

16.8.1 Transportation and Intermediate Storage

Seedlings should be transported from nursery cold storage to forestry-management district storage in

Figure 16.7. (a) Seedling storage cooler at Quail Ridge Nursery, Weyerhaeuser Co., Aiken, South Caronlina. Note the rectangular structure at the middle of the ceiling. This is a plenum to distribute air in a circular pattern from the center of the room to the edge. The cords hanging from the ceiling at regular intervals are part of a network of thermocouples that monitor temperature. (b) Pallets of seedling bags are spaced to insure good air circulation.

refrigerated vehicles that maintain the same temperature and humidity as the nursery cooler. Likewise, district storage should also provide the same temperature and humidity as the nursery cooler. It is particularly important that seedlings going in and out of the facility be accurately inventoried so that each batch is planted before the expiration date.

16.8.2 Unrefrigerated Storage

If cold storage is not available on the management district, then the forester should make special preparation to put the seedlings in the best environment available. A cool, shaded site with a water supply and good surface drainage away from the storage area is desirable. A level gravel pad can be used to insure that the seedlings are not in direct contact with soil. Racks that allow easy access for moving shipments, drainage following irrigation, and taking inventory should be provided. As mentioned previously, the Forest Service bundle is the most desirable package for unrefrigerated storage (see 16.6.4 for details of using bundles).

Figure 16.8. (a) Plastic ribbon curtains prevent loss of cold air when manual doors are used. (b) An alternative is electrically actuated doors that minimize air loss by facilitating operation by forklift drivers.

16.8.3 Storage Duration

Wakeley [33] noted :I relationship between lifting date and survival of southern pines (Fig. 16.9). Variation in planting success over the season depends strongly on the physiological condition of stock [19]. Switzer [32] showed that survival is stongly related to the amount of new root growth after planting; this is due to the tremendous increase in the conductivity of the root system when unsuberized root tips are present [8] and to the increased volume and depth of soil penetrated by the new roots.

Storage duration strongly affects seedling quality in southern pines [11, 14, 18]. Carlson [6] showed that Root-Growth-Potential (RGP) of early-lifted (late November) loblolly pine seedlings decreased during storage, whereas that of seedlings lifted later (mid-January) either maintained or improved RGP. As an indicator of physiological quality, RGP does not estimate actual numbers of roots produced in the field because seedlings are subjected to many variables after planting. For example, root growth in the field is delayed until the soil temperature reaches 10°C (50°F) [5, 8]. Ritchie [25] suggests that RGP estimates overall resistance to stress.

Root-growth potential has been related to dormancy status in many species [26]. In loblolly pine, RGP increases with dormancy release up to at least 1,200 chilling hours (at 0 to 8°C) [6]. This same study has shown, however, that dormancy release occurs normally in cold storage whereas early storage damages RGP. The mechanism of damage to RGP in early storage is not known.

Early-lifted stock should be stored only a few days. Storage of longleaf pine should be restricted to a few days throughout the season, although recent research indicates that fungicidal root dips could eventually allow longer storage of this species (see 16.6.3.3). Storability of other southern pine species, whether container or bareroot stock, can be predicted from chilling-hour accumulation. Number of chilling hours (at 0 to 8°C) are recorded from October 15 [13]. Prediction tables should be developed according to genetic source by the grower involved. Stock should not be stored more than a few days if lifting continues after budbreak.

16.8.4 Transportation to the Planting Site

Seedlings should be moved to the planting site in the quantity that will be planted in one day. Transport should be in a covered vehicle, preferably insulated. If a covered vehicle is not available, then the seedling load should be covered with a reflective tarp.

The truck should be outfitted with shelves that permit easy loading and easy inventorying at off-loading points. Seedlings should be loaded by species and genetic identity so that they may be properly allocated to each planting site.

16.9 On the Planting Site

16.9.1 Care at the Planting-Site Staging Area

Seedling packages should be off-loaded at the planting site into a cool, shaded storage area, free of standing water. A portable knock-down storage setup can be constructed of PVC pipe, a space blanket, and (if necessary) some structure to hold the seedling packages up out of the mud

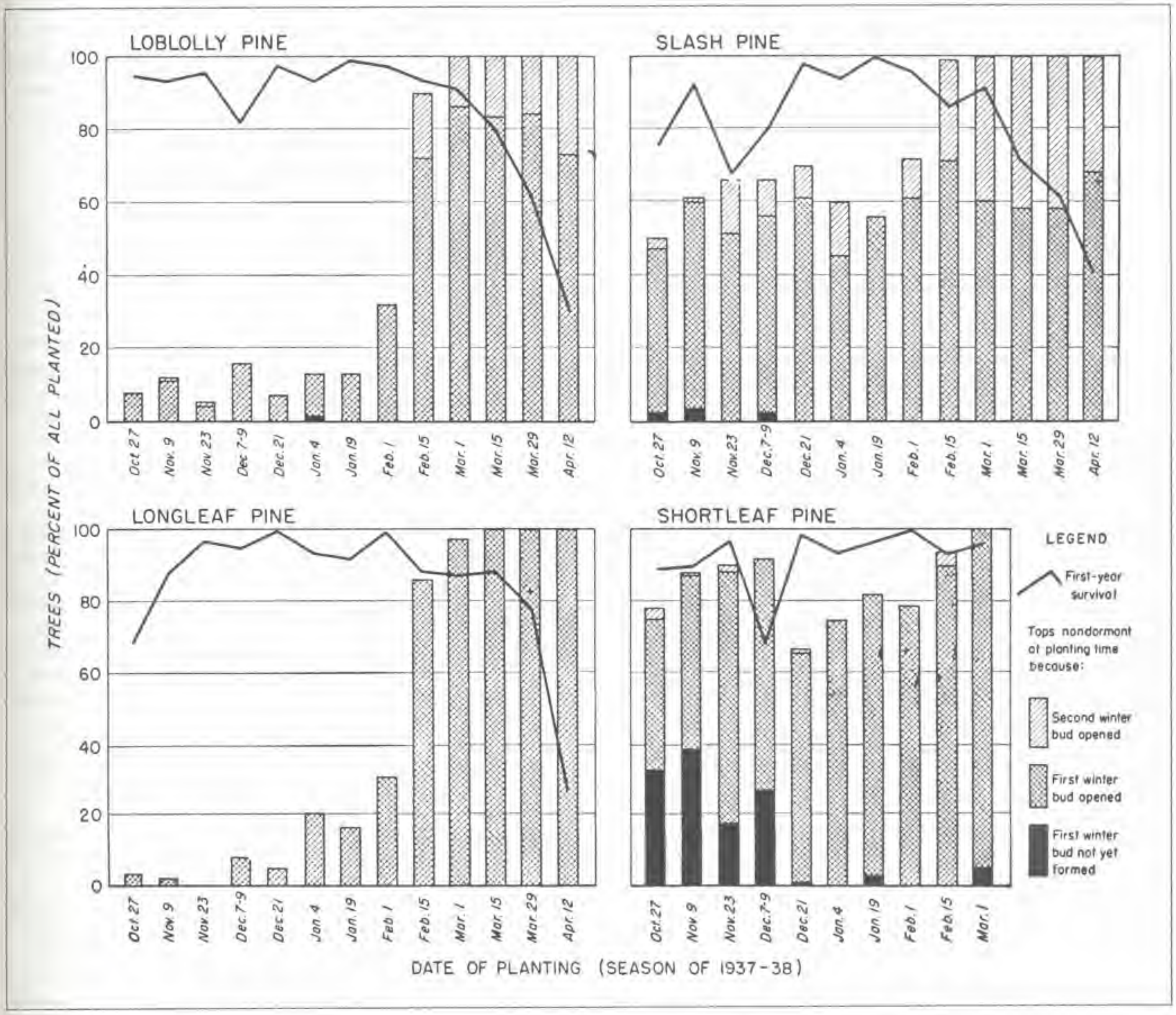

Figure 16.9. Effect of date of planting on survival of unstored southern pine planting stock. Taken from Wakeley [33].

(Fig. 16.10). A space blanket used shiny side out, white side in, is especially efficient at providing the equivalent of "deep" shade where none is available naturally [10].

Seedling handling should be minimized on the planting site. Counting, culling, and/or root pruning should be prohibited; if necessary to improve the quality of the planting stock, these activities should be done at the nursery. This is also true of check counting. In this case, the nursery should be asked for statistics on distribution of package counts, and any check counting should be done with a nursery representative, the buyer, and a planting-crew representative present in the nursery packing shed.

16.9.2 Care During Planting

Seedlings should be planted from an interim container either on the person or planting machine. These containers should provide the same moisture conditions as the storage package (i.e., moist but no standing water). Seedlings should be loosely loaded into interim containers so that roots are not stripped as seedlings are removed for planting. Because planting machines carry more seedlings and more weight, their storage area should be insulated and shaded.

16.10 General Considerations

Seedlings are living plants with specific desirable morphology and physiology, and with specific monetary value. Planting programs should be set up with incentives that respect these attributes.

16.10.1 Logistics

The regeneration forester should work closely with the nursery manager to assure that seedling quality can be maintained throughout the planting operation. This means a good deal of planning. Logging and site preparation must

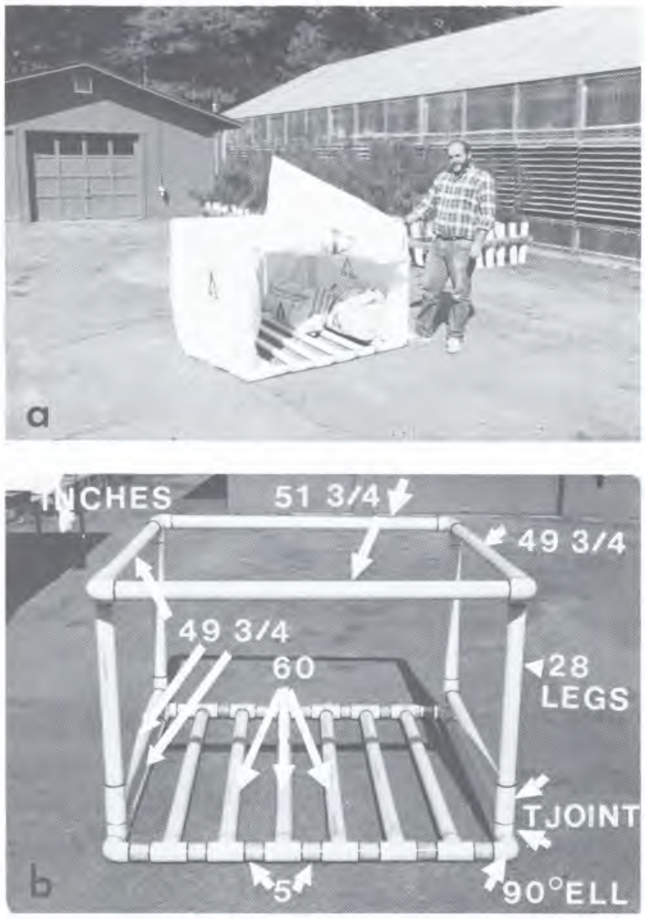

Figure 16.10. An on-site storage shed constructed from PVC pipe and a plastic cover.

be coordinated with the regeneration plan so that all possible sites to be planted in a particular year can be considered. The scheduling of seedling deliveries should take into account planting-crew production rates, and what various weather conditions can do to them. The nursery should be warned as early as possible if soil moisture or temperature conditions become limiting for quality planting; this will often allow the nursery to reschedule lifting operations so that seedlings need not remain in storage overly long.

16.10.2 Recordkeeping

The regeneration forester should keep records of the stock in each plantation including: (1) for logging and site preparation, methods and dates (2) for planting stock, seed source, genetic family, nursery of origin, location in that nursery (on file at most nurseries), date of lifting, nursery inventory records of population distributions of height and diameter, packing-shed treatments (e.g., Furadan clay slurry root dip), time in each storage facility, and type of transportation at each stage; and (3) for the planting operation, planting contractor and on-site crew, planting method, date of planting, soil moisture and temperature, and weather conditions. These records should be regularly entered into a computer system to be available for troubleshooting. On-site field inspections should be summarized in a standard format and printed on field sheets to facilitate notetaking. When exceptional performance - good or poor - is observed, the forester then can inspect the records for obviously correlating factors.

16.10.3 Feedback

If problems arise in the field, then the nursery manager supplying the seedlings should be contacted and an on-site visit arranged. It is important to use the experience of each plantation to improve the probability that the next one installed will be successful (good survival and growth). Thorough, accurate records and active communication between regeneration foresters and nursery managers can facilitate this process.

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