CHAPTER 8—LIFTING AND FIELD PACKING

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INTRODUCTION

The lifting season is a period of peak activity in a nursery. Seedling distribution operations may include pretreatment of seedlings or seedbeds, undercutting and lifting, grading, counting, packaging, storage and shipment of plants. These activities should be geared to field planting programs so that newly-lifted seedlings are available as needed. Careful advance planning, purchase of supplies and timely maintenance of equipment are essential to maintain a seedling lifting and distribution schedule that may process 1 to 2 million seedlings daily.

The methods of lifting, handling and storage of seedlings should be planned before a nursery is constructed, as different techniques require different, and sometimes special, equipment and facilities. Other considerations are seedling inspection and seedling certification before lifting, time of lifting, and pretreatments before lifting.

Two distinctly different procedures used in southern nurseries are: (1) lifting and packaging in the field, and (2) lifting and packing in a packing shed. The second procedure may include grading, counting and treatment for pest control (see chapters 9, 10, 13 and 14). The same basic lifting machines can be used for either field or packing shed operations. Specific equipment modifications are required for packaging in the field, primarily room and apparatus for packing seedlings, usually in bags, and a method of adding moisture-holding media (Sims 1983). Scales or other equipment for determining how many seedlings are packed may also be used.

INSPECTION AND CERTIFICATION BEFORE LIFTING

Several States require that nurseries be inspected and the stock certified by the State's plant quarantine board or equivalent agency before seedlings can be lifted or shipped. Common carriers cannot accept seedlings for interstate shipment without inspection certificates. Quarantine regulations may prevent movement of seedlings with black or charcoal root-rot or other diseases. Seedlings from areas infested with whitefringed beetles, Japanese beetles, fire ants or other pests may also be quarantined. State plant quarantine boards should be contacted early in the growing season to arrange for field inspection.

SEASON OF LIFTING

Consider the stage of seedling development when you select the lifting dates. Based on morphological features, seedlings may be large enough to plant in September or October. The stems may have stopped elongating but the buds may not have formed. Dormancy does not occur until the specific chilling requirement is satisfied (chapter 7). Mycorrhizal rootlets may be present on seedlings by midsummer, but root development continues through late summer and fall. Formation of new roots or the extension of lateral roots is generally at a peak during the so-called dormant season, from December to February.

The dry weight of tops and roots increases by 20 to 80 percent during December and early January (chapter 7). This increase in stored food reserves during late fall and early winter may have an important effect on the initial survival of seedlings (Wakeley 1954). Starch content in the roots may be particularly important as it directly affects the ability of seedlings to grow new roots after planting. Bernard et al (1981) found a strong, positive relationship between the amount of root starch and first-year survival of slash pine seedlings from four Florida nurseries.

Ideally, lifting should not begin until the seedlings become fully dormant. Early-lifted loblolly pine seedlings do not store well. They should be planted within a day or two after lifting to get adequate survival (Dierauf 1976). The seedlings may also fail to attain expected growth or survival rates if lifted after the shoots have begun to lengthen in the spring.

Unfortunately, the time of lifting usually depends more on field planting conditions and schedules than on the condition of the seedlings. The planting season in the South begins after Thanksgiving and extends through February or March—depending on the number of seedlings to be planted, the number of planting sites and weather conditions. Neither late fall or winter planting should begin until soil moisture is suitable.

Lifting should also be adjusted to the prevailing weather conditions at the nursery. The North Carolina Division of Forest Resources has developed seedling handling standards for lifting, delivery and storage, and field planting (Jeffries 1983), see appendix 8-2.

In Florida and adjoining States, in areas where normal summer rainfall is 1.5 to 2 inches per week, slash pine summer planting is feasible (Schultz and Wilhite, 1967). Fall-sown slash or loblolly pine seedlings are occasionally planted in August or September on poorly-drained sites that are too wet to plant in the winter. Containerized seedlings are also used under these conditions. Late spring and early summer plantings are made occasionally when seedlings cannot be planted earlier and when soil conditions are favorable.

SEEDLING TREATMENTS BEFORE LIFTING

With mechanized lifting, damage to root systems is reduced if the tap roots and lateral roots are pruned before the seedlings are lifted. From observations of lifting operations in many nurseries, it appears that best results are obtained if both lateral-root pruning and undercutting

precede the lifting operations by several weeks. In some nurseries lateral-root pruning is done only a few days before lifting and is considered a part of the harvesting operation rather than a cultural practice (see chapter 7 for root pruning).

LIFTING OF SEEDLINGS

Critical aspects of harvesting bare root stock are the date and method of lifting. The seedlings' physiological condition when lifted and the method used, either hand or mechanical, have dramatic impacts on field performance. Regardless of timing or method of lifting, attention must be directed to: (1) retaining the maximum amount of fibrous roots and mycorrhizae, (2) avoiding damage to the roots and tops, and (3) preventing both roots and tops from drying out or becoming overheated.

When seedlings are lifted they invariably suffer some root loss and damage. While root damage directly affects seedling quality, the severity and amount of damage depends on three factors: soil texture, soil moisture and method of lifting. The soil texture is important because seedlings are more difficult to lift from fine-textured soils than from coarse-textured soils. The organic matter content is also important because it influences friability of the soil. Soil moisture is important because seedlings lift best from moist, but not wet soils.

AN HISTORICAL REVIEW OF LIFTING SEEDLINGS

Minimizing damage to roots while lifting seedlings as economically as possible has been a prime consideration in the development of lifting equipment and techniques. History has a tendency to repeat itself and a brief review of lifting operations may be valuable.

Hand Lifting

Before 1934, seedlings were lifted with hand tools and manual labor. Roots were pruned to 7 or 8 inches with shovels as the first step in lifting. Seedlings were then loosened or removed from the seedbeds with shovels, spades or 4-tine lifting forks. Injury to roots was kept at a minimum by lifting only when the moisture content of soil allowed the soil to crumple easily. Roots were separated from each other and from the soil by gentle shaking and pulling. One person could lift 15,000 to 35,000 longleaf and 40,000 to 80,000 slash or loblolly seedlings in a day, depending on the soil texture and seedling density. (figure 8-1).

In 1935, an undercutting blade was mounted on the axle of a two-wheel cart, and placed at one end of a seedbed. A tractor with a winch and cable was located at the other end of the seedbed. The cable was attached to the cart,

Figure 8-1. — Hand lifting of seedlings.

which was winched to the tractor as the undercutting blade was held in the ground by means of a hand lever. The process was repeated by moving the tractor to the other end of the next bed.

In 1936, a tractor-mounted lifting blade was developed. It consisted of a 12-inch cutting blade mounted on a frame directly behind a crawler tractor with a 6-foot tread. The blade was raised and lowered by means of a straight arm ratchet and wheel lift. The lifter loosened the soil so that seedlings could be easily removed (May 1937).

Figure 8-2. — Undercutting blade.

By the mid-1950's seedling lifters were mounted on tool bars and operated by hydraulic cylinders or the power take-off (Langdon 1954, Sowash 1954, Day 1957, Einspahr 1957, Heintz 1957, Cooler 1961) (figure 8-2). A

rotating agitator shaft was built into the power-take-off lifter. This device loosened the soil more than the straight blade. Round or flat tines attached to the blades also helped loosen the seedlings from the soil (see figure 7-8). Hand labor was still needed to remove seedlings from the soil.

Lifters of these types are still used, and are also used for undercutting in some nurseries. Cooler (1961) suggested that the agitator seedling lifter could be modified to not only remove seedlings from the bed but to feed them into a detachable hopper.

Hand lifting is used exclusively in a few nurseries and some of the time in all nurseries. Seedbeds are undercut once or twice with the undercutting blade. Seedlings are then pulled out of the soil by hand and simultaneously pulled apart and shaken to remove the loose soil. Snatching of seedlings from the soil and beating the roots against a solid object can tear off many fine laterals and mycorrhizal roots, leaving only a taproot and large laterals. Sometimes seedlings are root-pruned in the field after lifting, using a hatchet and a chopping block. More often the roots are pruned in the packing shed.

Machine Lifting

In 1958, the first mechanical seedling harvester was developed by Dr. Charles Rice and S.P. Darby in the Agricultural Engineering Department, University of Georgia. This harvester was an 8-row belt type lifter and the prototype of the later lifters known as the Virginia, Florida, Missoula, Weyerhaeuser, Love, Mathis and Whitfield lifters. Belt-type lifters that will handle either 1, 2, 4, 7 or 8 rows are currently in use in the South (figure 8-3).

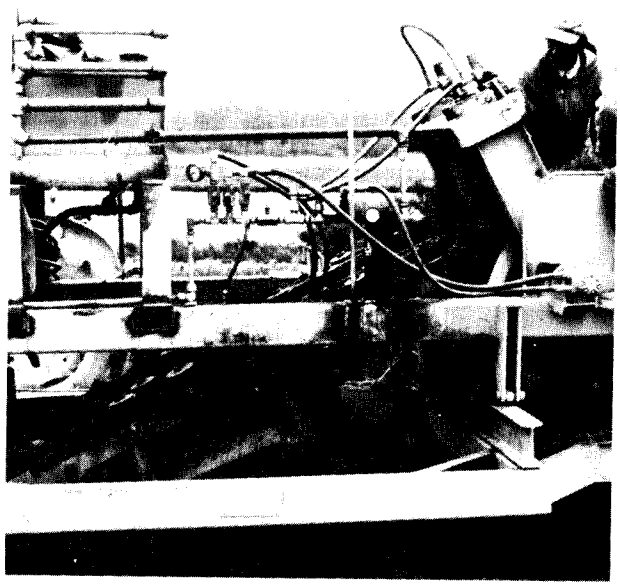

Figure 8-3. — Belt lifter.

The 7- or 8-row machines have either an oscillating or fixed undercutting blade that is full-bed width and can be adjusted to various depths. The 8-row belt harvester uses 16 counter-running pickup belts set on 6-inch centers. The belts are shaped for holding seedlings without excessive pressure, which could cause damage. Activated tines or a knocker below the belts remove soil from the seedling roots. The 1-, 2- and 4-row lifters are not equipped with an undercutting blade, and conventional undercutting must be done before lifting.

The model TH Grayco harvester is essentially a modified potato digger that undercuts the entire seedbed, then lifts soil and seedlings onto a digger chain. The seedlings are transferred onto an inclined agitator chain where vibration shakes the soil from the roots and delivers seedlings without soil to the rear of the lifter (figure 8-4).

When used properly, either type of lifter will do a good job of harvesting seedlings with minimum damage. The basic requirements of a seedling harvester therefore, are:

1. It must work in soils ranging in texture from sands to sandy loams.
2. It must be able to operate in soils from field capacity to a soil moisture tension of 5 atmospheres.
3. The lifter should be able to undercut the seedling roots at varying depths from 6 to 10 inches.
4. It must gently extract seedlings from the seedbed.
5. Most of the soil should be removed from the root system by the lifter.
6. The seedlings must be elevated and transferred to a position where they can be packaged or bundled together for additional processing.

Both types of lifters work exceedingly well in sands and loamy sands when the soil is moist. The 8-row lifter with the undercutting blade and the Grayco harvester will work in sandy loams and other coarse-textured soils if the soil moisture is favorable. The Grayco machine appears to be more adaptable because it sometimes works better with soil moisture contents near field capacity. Neither machine will do a good job of lifting in heavy loams, silt loams or sandy clay loams. The 1- or 2-row belt lifters may be effective in sands and loamy sands. They do not do well in wet, loamy or fine-textured soils. Soil compaction may be a problem with these machines because several trips are required to lift a single bed (Arnold 1970; Black 1976; Britton 1973; Clifford 1956; Hanks 1968; Heltzel 1970; McDonald 1976 a,b; Rice, et al, 1968).

Machine-harvested seedlings can be processed on the machine or transported to the packaging shed for grading, counting, treating and packaging. The lifting process is identical for either procedure. Seedlings are transported from the seedbed to the rear of the machine which is about 5 feet above the ground. This process moves the seedlings about 12 to 15 feet, in only 30 to 90 seconds from the ground to a container. Although there is little opportunity for roots to dry, seedlings may benefit from a water spray when evaporation rates are high. McDonald

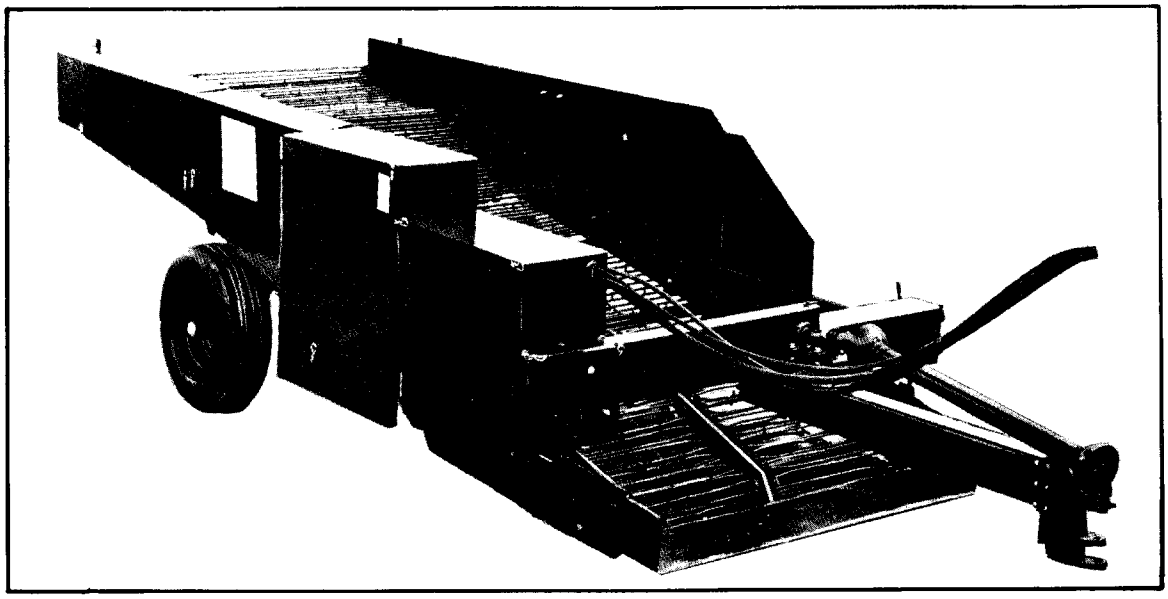

Figure 8-4. — Grayco lifter (Grayco Harvesters).

(1976 b) modified the Grayco lifter for more effective seedling handling in work at the Coeur d'Alene nursery in Idaho (figure 8-5).

TRANSPORTING SEEDLINGS TO THE PACKING SHED

Each mechanical lifter has a bulk handling platform or trailer that receives seedlings as they pass from the belts or chains. A crew of 3 to 10 workers orients the seedlings and places them in containers which, in turn, are carried on a trailer to the packing shed. Containers include plastic rectangular boxes, tubs, and canvas slings.

Between lifting and packaging, seedlings are very susceptible to both mechanical injury and damage from exposure. Seedlings must be handled carefully. Both tops and roots must be protected from heating and drying until they are packaged. Overloading the tubs or canvas slings can overheat the seedlings enroute to the packaging shed and may also crush the roots and stem. If tubs are used, they should be covered with wet burlap to limit drying during transit. Canvas slings provide good protection for seedlings in transit (figure 8-6).

If they cannot be brought into the packing shed immediately, seedlings must not be left exposed but should be kept in cold storage or under shade with ventilation. If the soil is dry, seedlings in containers should be watered immediately after arrival in the packing shed area. Seedlings lifted from moist soil may remain in containers for about 12 hours without watering. They should be covered and placed in cold storage whenever possible.

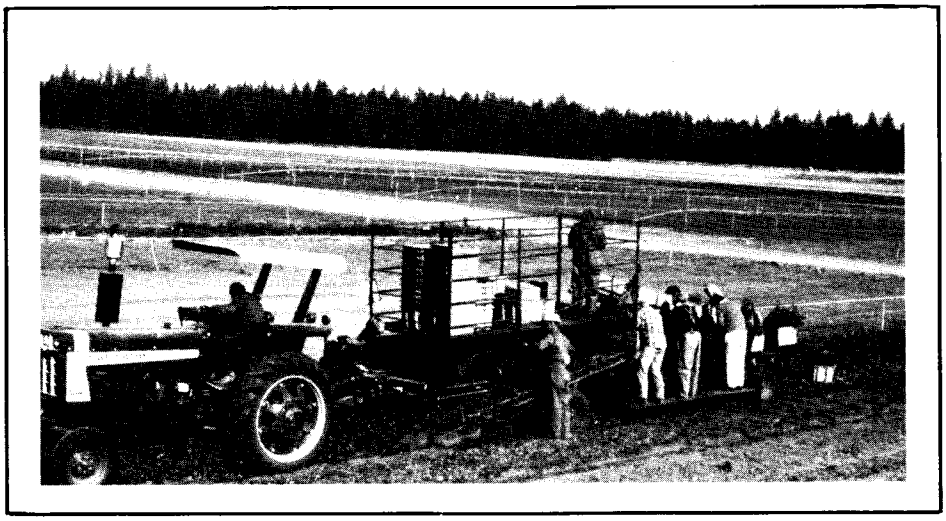

Figure 8-5. — Modifications for the Grayco lifter.

Figure 8-6. — Canvas slings provide good protection for seedlings in transit. (Exposed seedlings are for demonstration only.)

FIELD PACKING

Seedlings are packed in the field when they are about the same size, less than 10 percent are culls, and seedbed inventories are accurate to about 5 percent. Weather conditions must permit seedling handlers to work outside at the nursery and the tree planters must not need an exact number of seedlings in each package.

Belt lifters and the Grayco lifter can be modified to permit packaging of seedlings almost immediately after they leave the belts or chain conveyors (Simms 1983, Vande Linde 1983). Some lifters have an extension of the basic frame and others have a trailer attached directly behind the harvester frame. These sections of the harvester have room for seedling handlers, a means for putting moisture-holding material in the package, and power-operated equipment to sew bags or strap bales (figure 8-7). Power for this equipment comes from the tractor or a separate battery. Some harvesting units have a water tank on the tractor and are equipped with a low-pressure pump to sprinkle seedling roots before packaging.

Two methods of packaging are usually used on the harvesting machines. Bags are used more frequently than bales. About 1 to 1½ pints of wet moss, shavings or other absorbent material is placed in the bag among the seedlings. An alternative is to spray the roots with a gelatinized starch mixture from a tractor-mounted tank (Simms 1983). The bags are filled almost full with seedlings. A small

Figure 8-7. — Field packing on the lifter.

quantity of moss or other absorbent is sometimes put in the middle of the bag and at the top. The top is sewed or strapped so the bag will be practically airtight.

The standard Forest Service bale system of packaging is also used on mechanical harvesters. One company immerses all baled seedlings in a deep tank of water for about 1 minute as the seedlings are moved from the field to storage. Water forces the air out of the bales and soaks into the bales before they are placed in cold storage. The water in the tank should be changed daily to avoid pathogenic conditions.

Packaged seedlings are transported by truck or trailer to the storage area for immediate shipment to the field, temporary storage or cold storage if they need to be stored for a longer period of time. Packaging and storing procedures are discussed more thoroughly in chapter 10.

Field packing offers an alternative that may improve efficiency during the nursery lifting season. Some of the advantages and disadvantages of field packing are listed below.

Advantages

1. Minimizes seedling root exposure to heat, drying and damage.
2. Can be accomplished with a smaller work crew, which often results in a lower cost per thousand seedlings.

Disadvantages

1. Requires more accurate seedbed inventory.
2. Requires greater uniformity of seedlings and fewer culls.
3. Less control of morphological quality (through culling).
4. More dependent on weather (working conditions).

EFFECTS OF LIFTING OPERATIONS ON SEEDLING QUALITY

The first culprit assumed to be responsible for low survival of field planted seedlings is the nursery. Seedlings with optimum morphological and physiological characteristics in the nursery can be easily injured during lifting, handling and storage. Damage done in these operations is often difficult to detect and is usually overlooked. Comparisons between machine-lifted and very carefully hand-lifted seedlings in Florida indicated higher survival of the hand-lifted seedlings from three of the four nurseries studied (Barnard et al 1981). An early study showed 60-percent survival for hand-lifted seedlings compared to 41 percent for seedlings handled with a one-row belt lifter (Langdon 1954). The roots of shovel-lifted seedlings were cut off sharply and most of the secondary rootlets on the lifted portion were intact. The machine-lifted seedlings were pushed forward in the bed and slightly pulled through the soil. This process stripped many of the secondary rootlets and mycorrhizae from the seedlings.

Comparisons of hand-lifted versus one-row belt-lifted seedlings in 1978 and 1979 showed that machine-lifted seedlings had 30 to 60 percent fewer lateral roots longer than 1 inch than did hand-lifted seedlings from the same seedbeds. Soil samples from the seedbeds were sifted for loose roots, and the roots were weighed. Soil from machine-lifted samples contained 50 percent more roots than did soil from hand-lifted plots[1].

Personal observations of seedlings lifted with an 8-row harvester with an undercutter blade attached and the Grayco lifter showed no significant difference in the number of lateral roots compared with hand-lifted seedlings. Some reasons for poor lifting by the one- and two-row belt lifters are:

1. Tractor travel is too fast
2. Soil is too wet to readily release seedlings as they are pulled from the ground
3. Soil is too heavy for use of the one- or two-row lifter
4. Elapsed time between undercutting and actual lifting allows the soil to resettle around seedling roots
5. Improper use of "root knocker"

With any lifter, slow tractor speeds result in less damage than do fast speeds. Texture of the soil and soil mosture content can influence the relationship between tractor speed and seedling injury. Wet soils are sticky and will not crumble from the roots, nor will the roots glide easily over the lifter blade. Wet soil and seedlings will roll together on the front chains of the Grayco lifter and form a ball. The agitator chains will not break up the mass of soil and seedlings if the tractor is in continuous forward motion. Alternating moving and stopping may give the best results with both wet and heavy-textured soils.

A small amount of wet soil on individual roots can increase the weight of a package of seedlings by almost 100 percent. Conversely if seedlings are packed by weight, soil clinging to roots will reduce the number of seedlings that can be included in a package. It is easier to remove wet soil from roots when seedlings are packaged in sheds rather than on machines.

The one- and two-row belt lifters pull seedlings from the soil as a separate operation from the actual undercutting. If the soil is not loose and friable, the seedlings cannot be pulled from the soil without stripping off many fine lateral and mycorrhizal roots. Also, if seedlings have not been laterally root-pruned, their roots may intertwine with roots of seedlings in the two adjacent rows. Therefore, belt lifters will strip the roots from the seedlings being lifted as well as from seedlings in adjacent rows.

Seedlings have also been damaged by belt pressure crushing the cambium hard enough to slip the bark from the xylem. Plants with this type of injury will never survive.

Belt lifters usually do not pick up small seedlings as the belts travel about 1 to 2 inches above the ground. At this level the belts pull the needles from small seedlings, but the seedlings remain in the seedbeds. Also belt lifters are designed to pick up seedlings that are in narrow drills. If the seeds are scattered during sowing, many seedlings will grow outside the range of the belts. One person must then follow the harvester to hand pull any plantable seedlings left by the machine.

SUMMARY

Lifting of seedlings without injury should be a prime goal of the nursery staff. Seedbeds are undercut with a flat undercutter blade before hand-lifting or lifting with 1-, 2-, or 8-row belt lifters. Some whole-bed lifters include an undercutter blade as part of the harvesting machine. Two types of lifters used in southern nurseries are the belt-lifters and the modified potato digger. These harvesters can lift from 400,000 to 1 million seedlings per day. Extensions or trailer attachments on either machine will allow field packaging using K/P bags or standard Forest Service bales. Extreme care is needed in lifting and handling seedlings to prevent injuries that affect survival and growth of out-planted stock.

[1]Personal communication from Ted Sweetland, Continental Forest Industries.

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APPENDIX 8-1.

Checklist for Operation of a Mechanical Lifter

1. Check the lifter for proper adjustments, such as forward chain movement when seedlings are being lifted out of the beds. Check wear on the lifter chain where the chain contacts the rollers. Do this before the lifting season.
2. Check the lifting shear blade for proper root pruning depth: 7 to 8 inches for slash, loblolly and longleaf pine; 5 to 6 inches for shortleaf pine seedlings. Made periodic checks on seedling root lengths as the lifter moves down the bed.
3. Check soil conditions before lifting the seedlings. The small, fibrous roots and mycorrhizae will be broken off if the soil is either too wet or too dry.
4. During dry atmosphospheric conditions (sun shining, low humidity). Seedlings should be kept damp by spraying with water and/or by covering them with a damp cloth when lifted. When the soil is very dry and hard, it may be necessary to irrigate ahead of the lifter to avoid damage or to get the blade into the ground. Soil clodding signals this condition.
5. During extremely wet soil conditions additional shaking of the seedlings by hand is necessary to remove excess soil.
6. Never lift seedlings when the air temperature is below freezing or when the soil is frozen.
7. Maintain an adequate supply of repair parts because they may not be locally available during the lifting season.

Source: Notes by Charles Martin and Chuck Gramling, USDA Forest Service, Ashe Nursery, Brooklyn, MS.

APPENDIX 8-2.

OPERATIONAL GUIDELINES FOR HANDLING SEEDLINGS

Kenneth F. Jeffries[1/]

Abstract.-- Realizing that seedling mortality is not caused by any one phase of the reforestation process, the North Carolina Division of Forest Resources has developed seedling handling standards for lifting, delivery and storage, and field planting.

Like most of you, we have experienced varying degrees of seedling survival problems over the last few years. The high cost of site preparation and the increased use of improved seedlings make poor survival much harder to take and also harder to explain to the boss and/or landowner.

We feel that poor practices in the nursery will reduce survival to some degree. If improper practices continue through storage, transport and planting, the cumulative effect will mostly likely end in a planting failure.

We have developed standards for seedling processing in three general categories: (1) Nursery Lifting and Processing Standards, (2) District/County Delivery and Storage Standards, and (3) Field Handling and Planting Standards.

These three stages of the reforestation process are divided into three classes of days: (1) Normal Conditions, (2) Critical Conditions, and (3) Severe Conditions.

As you might expect, any one of these requirements could be below par, but excellent conditions in the other requirements could compensate and allow a Normal Condition to exist. Just as in setting fire readiness plans, some experience and judgement is required. I will go through the highlights of these standards.

NURSERY LIFTING AND PROCESSING STANDARDS

NORMAL CONDITIONS

Temperature:	35°F to 75°F
Relative Humidity:	50% +
Wind:	Less than 10 miles/hour
Soil Moisture:	75% to field capacity (100%)

1/ Senior Staff Forester, Nursery and Tree Improvement, North Carolina Division of Forest Resources, Department of Natural Resources and Community Development, Raleigh, North Carolina.

Lifting

1. Use of all types of seedling lifters permissible.
2. Roots of seedlings on lifter conveyor will be exposed maximum of three minutes.
3. Full, tightly packed boxes will be removed from the field and placed in the packing shed within 20 minutes. Partially filled boxes where roots are exposed will be covered with moist burlap, etc. to prevent drying out.

Packing

1. Boxes of seedlings on conveyors in packing room will be protected from heat and direct sunlight.
2. Seedling roots will be exposed a maximum of two minutes from time removed from box to weighing for packing.
3. Standard amount of moisture retention material will be added to bag.
4. Packed bags will be protected from heat and direct sunlight until placed in storage.
5. Unrefrigerated bags may be loaded on non-refrigerated transports without pre-chilling when properly loaded (see transporting).
6. Full boxes of seedlings may be left on the packing room coveyors overnight if properly watered and temperature maintained from 35°F to 55°F.

Loading and Delivery

A. Non-refrigerated transports
   1. Must be covered to protect from direct sunlight.
   2. Bags not stacked over three deep per layer.
   3. Spacers used to provide air circulation between layers.
   4. At least 12" of air space between top of bags and cover.
   5. Vehicle must not be parked in direct sunlight. In case of emergency, stops should not exceed more than 45 minutes in direct sunlight. Advise supervisor if exposure exceeds this amount.
   6. Torn bags will be repaired immediately.
B. Refrigerated transports
   1. Pre-chilled seedlings (36 hours) may be transported for up to five hours without spacers for air circulation.
   2. Seedlings that have not been pre-chilled must be loaded as if the van were not refrigerated, i.e., with no more than three layers deep with spacers being used.

CRITICAL CONDITIONS

Temperature:	76°F to 85°F
Relative Humidity:	30% to 50%
Wind:	10 miles/hour +
Soil Moisture:	50% to 75%

Lifting

1. Use of Grayco harvesters given top priority (if other lifters must be used -- entire beds will not be undercut ahead of lifters).
2. Roots of seedlings on lifter conveyor will be exposed maximum of three minutes.
3. Full, tightly packed boxes will be removed from the field and placed in the packing building within 10 to 15 minutes. Partially filled boxes

of seedlings will be covered immediately with moist burlap, etc. to prevent drying out.
   a. Lift fields close to facility, when possible.
   b. Use additional tractor(s) for delivery from field to packing building.
4. When soil moisture reaches less than 50%, fields will be irrigated prior to lifting.

Packing

1. Boxes of seedlings on conveyors in packing room will be protected from heat and direct sunlight, and boxes not processed within 30 minutes after arriving in packing building will be watered.
2. Seedling roots will be exposed a maximum of two minutes from time of removal from box to weighing for packing.
3. Roots of seedlings will be watered (or sprayed with other material) just prior to being packed.
4. Packed bags will be protected from heat and direct sunlight until placed in storage.
5. Without exception, seedlings will be chilled for 36 hours before loading.
6. All boxes of seedlings in the packing room will be processed daily and none left unfinished.

Loading and Delivery

A. Only pre-chilled seedlings will be loaded for transport.
B. Non-refrigerated transport
   1. Use only if absolutely necessary.
   2. Must be covered to protect from direct sunlight.
   3. Bags not stacked over two deep in layers.
   4. Spacers must be used to provide air circulation between layers.
   5. At least 12" of air space between top of bags and cover.
   6. Emergency stops only, advise supervisor if stops made.
   7. Early evening transportation should be utilized when possible.
   8. Torn bags will be repaired immediately.
C. Refrigerated transport
   Pre-chilled seedlings (36 hours) may be transported for up to five hours without spacers for air circulation if unloaded promptly upon arrival at destination.

SEVERE CONDITIONS

(Freezing Conditions)

Temperature: 32°F or less and/or frozen ground conditions
Relative Humidity:
Wind:

Lifting

All lifting operations will cease.

Packing

1. If seedlings have been stored properly in packing building, packing may be done.

2. Seedlings stored in boxes for packing will be protected by maintaining a temperature between 32°F and 55°F in the packing building and will be watered as needed to prevent drying out.
3. Seedling roots will be exposed a maximum of two minutes from the time removed from box to weighing for packing.
4. Packed bags will be protected from heat, direct sunlight, and/or freezing until placed in storage.
5. Unrefrigerated bags may be loaded without pre-chilling only on insulated or refrigerated vans using proper loading techniques. Do not ship on transports without adequate protection.

Loading and Delivery

A. Non-refrigerated transports

Transportation of seedlings on vehicles without proper protection from freezing is not allowed.

B. Refrigerated transport
   1. Pre-chilled seedlings (36 hours) may be transported for up to five hours without spacers for air circulation.
   2. Seedlings that have not been pre-chilled must be loaded as if the van were not refrigerated, i.e., with no more than three layers deep with spacers being used.

(Hot, Dry Conditions)

Temperature:	85°F +
Relative Humidity:	30% or less
Wind:	15 miles/hour +
Soil Moisture:	Less than 50%

Lifting

Usually will cease; however, Senior Staff Forester, Nursery and Tree Improvement, will be notified of conditions, and he will make final decision. If lifting is done:
1. Fields will be irrigated. Do not lift in sandy soil.
2. Only Grayco harvesters will be used.
   (Roots of seedlings on lifter conveyor will be sprayed).
3. Roots of seedlings on lifter conveyor will be exposed maximum of three minutes.
4. Full, tightly packed boxes will be removed from the field and placed in the packing building within ten minutes. Partially filled boxes of seedlings will be covered immediately with burlap, etc. to prevent drying out.
   a. Lift fields close to facility.
   b. Use additional tractors for delivery from fields to packing building.

Packing

1. Boxes of seedlings on conveyors in packing room will be protected from heat and direct sunlight, and boxes not processed within 30 minutes after arriving in packing building will be watered.
2. Seedling roots will be exposed a maximum of two minutes from time of removal from box to weighing for packing.

3. Roots of seedlings will be watered (or sprayed with other material) just prior to being packed.
4. Packed bags will be protected from heat and direct sunlight until placed in storage.
5. Bags will not be loaded on transports without pre-chilling (36 hours).
6. All boxes of seedlings in the packing room will be processed and not left overnight.

Loading and Delivery

A. Only pre-chilled seedlings will be loaded for transport.
B. Non-refrigerated transport
   Seedlings will not be transported on units without refrigeration.
C. Refrigerated transport
   Pre-chilled seedlings (36 hours) may be transported for up to five hours without spacers for air circulation if unloaded promptly upon arrival at destination.

DISTRICT/CONTRACTOR DELIVERY AND STORAGE STANDARDS

NORMAL DAY

Temperature: 35°F to 75°F
Relative Humidity: 50% +

Delivery

1. Vehicles used for transporting seedlings will have a cover to shade and protect seedlings.
2. Bags/bundles will not be stacked over three deep per layer unless spacers are used to provide air circulation between layers.
3. At least 12" of air space between top of bags/bundles and cover will be left to avoid heat build-up.
4. Vehicles will not be parked in direct sunlight. In case of emergency stops or breakdowns when stops exceed 45 minutes, seedlings should not be planted until their condition has been determined.

a. Things that indicate seedling deterioration:

   (1) Sour smell -- fermentation
   (2) Yellow needles
   (3) Trees hot to the touch
   (4) Mold developing

   If any of these conditions exist, contact the District Staff Planting Coordinator prior to planting.

b. Things that indicate dead seedlings:

   (1) Bark, especially on roots, slips off easily
   (2) Cambium layer has turned brown

   (Do not plant if these conditions exist.)

5. Inspect and repair torn bags immediately.

Storage

1. Store seedlings in building, shed, etc. that will protect from freezing, heating, and direct sunlight.

   a. Ideal temperature 35° to 38°F. (These temperatures usually can be maintained only with refrigerated units.)

      (1) Bags stored under ideal conditions can be kept at least three months (usually longer.)
      (2) Bales with seedlings dipped in clay slurry will keep from eight to ten weeks.
      (3) Bales with seedlings packed in moss will keep from eight to ten weeks, but will require watering of bales at least two times per week.

   b. Termperatures inside storage area from 38° to 50°F.

      (1) Bags stored under these conditions can be kept up to three or four weeks.
      (2) Bales with seedlings dipped in clay slurry will keep two to three weeks.
      (3) Bales with seedlings packed in moss will keep two to three weeks, but will require watering at least two times per week.

   c. Temperatures inside storage area above 50° not exceeding 75°F -- seedlings should be removed within three to five days.

2. Bags/bundles should be stacked on pallets or slats and should not be stacked over two deep without spacers to allow air circulation between layers.

CRITICAL DAY

Temperature: 76°F to 85°F
Relative Humidity: 30% to 50%

Delivery

1. Field delivery in non-refrigerated vehicles should be held to a minimum. Seedling delivery from a non-refrigerated storage point to destination should not exceed one hour's time.
2. Vehicles used for transporting seedlings will have a cover to shade and protect seedlings.
3. Bags/bundles will not be stacked over two deep per layer unless spacers are used to provide air circulation between layers.
4. At least 12" of air space between top of bags/bundles and cover will be left to avoid heat build-up.
5. Vehicle will not be parked in direct sunlight. In case of emergency stops or breakdowns, seedlings should not be planted until their condition has been determined.

a. Things that indicate seedling deterioration:

(1) Sour smell -- fermentation
(2) Yellow needles
(3) Trees hot to the touch
(4) Mold developing

If any of these conditions exist, contact the District Staff Planting Coordinator prior to planting.

b. Things that indicate dead seedlings:

(1) Bark, especially on roots, slips off easily.
(2) Cambium layer has turned down.

Do not plant if these conditions exist.

6. Inspect and repair torn bags immediately.

Storage

1. Store seedlings in building, shed, etc. that will protect from freezing and heating. If temperatures inside storage area is above 75°F, do not store seedlings more than 24 hours.
2. Bags/bundles should be stacked on pallets or slats and should not be stacked over two deep without spacers to allow air circulation.

SEVERE DAY

Temperature: 85°F + or 32°F or less
Relative Humidity: 30% or less

Delivery

1. Field delivery in non-refrigerated units should not be made when the temperature is 85°F or higher.
2. Field delivery in non-insulated units when the temperature is 32°F or less will be made only if the vehicle is covered adequately to prevent freezing.
   a. Caution -- seedlings can heat excessively on a cold day if vehicle is parked in the sun and seedlings are dead packed, preventing air circulation.
   b. Unload seedlings immediately upon arriving at destination.
3. Inspect and repair torn bags immediately.

Storage

1. Seedlings should not be stored in bags/bundles for more than a few hours at temperatures above 85°F.
   -- Lethal temperatures occur in bags/bundles at 118°F, but seedlings can be weakened or damaged if the temperature in the bag/bundle remains at 85°F for very long.

2. Do not store seedlings in an area where the temperature is 32°F or less.
   a. Do not allow seedlings to freeze.

b. If trees have not been frozen more than 36 hours:
   (1) Thaw seedlings slowly
   (2) Determine condition
c. If frozen more than 36 hours, then seedlings most likely have been severely damaged and should not be planted.

FIELD HANDLING AND PLANTING STANDARDS

NORMAL CONDITIONS

Temperature:	35^{o}-75^{o}F
Relative Humidity:	50% +
Wind:	Less than 10 miles/hour
Soil Moisture:	0-30 build-up

On-Site Storage of Seedlings

1. Bags/bundles should not have prolonged exposure to direct sunlight. Store the seedlings in a shaded location at all times.
2. If no shade is available at planting site, improvise a portable shelter such as a lean-to made of opaque plastic, canvas, or plywood.
3. Bags/bundles should not be stacked in layers more than two deep without spacers. Spacers allow air to circulate freely around the seedlings and keep them cool. (Heat builds up even at low storage temperatures when the seedlings are stored in direct sunlight or without air circulation--especially in sealed bags).
4. Keep close check on seedlings stored at the planting site and water uncoated roots of seedlings in bags or bundles if roots begin to dry. Be careful not to puddle water in bags as excess water can drown root tips or promote mold on the seedlings.
5. Do not water coated roots of seedlings since the water will remove the coating. Since the coating of roots will not give absolute protection against moisture loss, restrict the exposure of the roots the same as if they were uncoated.
6. Inspect and repair torn bags immediately.
7. Keep opened bags closed tightly by folding flap over bag and laying flat-side down or by placing a band or cord firmly around bag. Keep in shade.
8. Keep opened bundles covered at all times with wet burlap. Keep in shade.
9. If opened bags of seedlings, coated or uncoated, must be kept for over two days before planting, seedling roots must be dipped in water and bag tightly closed, or heel seedlings in.
10. If opened bundles of seedlings are not used shortly after opening, they should be heeled in.
11. Store trays of containerized seedlings in shade and keep root plugs wet until seedlings are planted. During storage, open book-type containers and check moisture of root plugs.

Culling Non-Plantable Seedlings

1. Open only one bag/bundle at a time. Be careful not to leave open more than a few minutes.
2. Remove only a small number (handful) of seedlings at a time. Do not allow the roots to be exposed to the sun or wind any longer than five minutes.
3. Cull 1-0 loblolly or 2-0 white pine seedlings that have:
   a. Broken, skinned or weak stem

b. Fermented smell
c. Mold on needles
d. Slippery bark
e. Root collar smaller than 1/8 inch
f. Root collar larger than 3/8 inch (large seedlings must be balanced; have a balanced root-to-top ratio)
g. Root systems less than four to five inches long
h. Root systems longer than 12 inches if more than 50% of the laterals must be pruned in order to plant

4. Cull 1-0 longleaf seedlings if root collars are smaller than 1/4 inch or tap roots shorter than seven inches.
5. Cull containerized pine seedlings that are very small and poorly developed. Also, cull seedlings if root plug has become dry and hard.
6. Cull hardwood seedlings having root collars smaller than 1/4 inch. Also, cull broken or skinned seedlings and seedlings with stems that have not hardened off.
7. Roots must be kept visibly moist at all times. If not visibly moist, dip roots in water. If being placed back in bag, shake excess water from roots prior to placing in bag to prevent puddling. (Do not dip coated seedlings). Close bags properly.
8. For best results, assign one trained person to be responsible for culling seedlings. Closely supervise and check on culling procedures. Be sure person(s) properly trained.

Root Pruning Seedlings

1. Assign only properly trained persons to be responsible for root pruning. For best results, assign only one well-trained person to root prune. Closely supervise and check on root pruning.
2. Remove only a small number (handful) of seedlings at a time. Do not allow the roots to be exposed to the sun or wind any longer than five minutes. Root prune seedlings at same time as being culled, if feasible.
3. Roots must be kept visibly moist at all times. If not visibly moist, dip roots in water. If being placed back in bag, shake excess water from roots prior to placing in bag to prevent puddling. (Do not dip coated seedlings). Close bags properly.
4. Do not root prune unless necessary to plant seedlings at proper depth and to avoid J-rooting. Planting tongs must be used to plant long roots that are not pruned.
5. If pruning is necessary, do not remove more than 50% of lateral roots. (Will reduce survival and growth).
6. Prune roots to uniform lengths. This can be done by aligning root collars in bunches before pruning roots.
7. Use a sharp knife, machete, axe, or hatchet for root pruning. Never break or twist roots off by hand.
8. Do not prune roots of small loblolly and white pine seedlings (5-8 inch tops) shorter than five inches in length.
9. Do not prune roots of larger loblolly and white pine seedlings (8-12 inch tops) shorter than seven inches in length.
10. Prune longleaf tap or lateral roots only if absolutely necessary. Limit pruning to excessively long roots. Clip longleaf needles back to 4 to 5 inches, if feasible.

Tree Planting Operations

1. Train all new personnel prior to allowing them to plant. Give refresher

training to experienced planters at start of seasons (and later if poor techniques are observed). Do not assume labor is trained or skilled.

2. While hand planting, carry seedlings in a canvas bag, bucket, etc. to protect the roots. Bags should contain wet hydro-mulch, wet sawdust, etc. Be sure roots are visibly moist before placing in container. If not, dip roots of uncoated seedlings in water. (Do not carry seedlings in hand with roots exposed).
3. If machine planting, be sure roots are visibly moist before placing in seedling box on planter. If not, dip roots of uncoated seedlings in water. Cover roots in seedling box with wet burlap to protect from exposure.
4. When handling, carefully separate seedlings to reduce damage or breaking lateral roots. (Damage to laterals will reduce survival).
5. When hand planting, make a fairly straight hole 8 to 10 inches deep. Do not use dibbles or other tools that will not make a hole or slit at least eight inches in depth.
6. Remove only one seedling at a time from container.
7. Insert root system to bottom of hole and lift seedling to proper planting depth. Be sure not to bend, ball, or leave roots outside hole.
8. Adjust planting depth according to drainage or soil type:
   a. On well-drained sites (sandy loams and sandy soils) plant root collars two to three inches below ground line, except for longleaf. Plant the longleaf collars at ground level when hand planting. Machine plant by lightly covering bud to allow for soil washing away.
   b. On poorly-drained sites (silt and clay soils) plant root collars one inch below ground line.
   c. Plant containerized seedlings deep enough to allow tops of plugs to be covered with soil (prevents drying by wicking effect).
   d. Warning -- seedlings should not be planted in excessively wet, sticky soils or in standing water. Allow the site to dry before planting.
9. Close hole properly. (If soil not tightly compressed around roots, moisture cannot be taken up by the seedling). Make sure hole firmly closed at bottom.
10. Periodically check machine planting to insure proper seedling depth and proper packing by the machine.
11. Space seedlings at approximate spacing prescribed for tract. Avoid planting seedlings in areas of loose soil that cannot be compressed around roots or closer than 2 to 3 feet of hardwood stumps and sprouts.
12. Plant seedlings just as near the edge of windrows as possible.
13. Closely supervise and maintain quality control of all planting.

CRITICAL CONDITIONS

Temperature:	$76^{o}F$ - $85^{o}F$
Relative Humidity:	30% - 50%
Wind:	10 miles/hour +
Soil Moisture:	30 - 80 build-up

On-Site Storage of Seedlings

1. Bags/bundles should have minimum exposure to direct sunlight.
2. Otherwise, very closely follow same standards for Normal Conditions.

Culling Non-Plantable Seedlings

1. Make a special effort to keep roots of seedlings exposed to sun and wind for no longer than three minutes.

2. Otherwise, very closely follow same standards for Normal Conditions.

Root Pruning Seedlings

1. Make a special effort to keep roots of seedlings exposed to sun and wind for no longer than three minutes.
2. Roots must be kept visibly moist at all times. Prior to placing back in bag or planting containers, dip uncoated roots in one of the following:
   a. Super water gel (one ounce of Terra Sorb gel/gallon water).
   b. Clay slurry (five pounds Kaolin Clay/gallon water).
   c. Plain water (shake excess from roots before placing in bag).
3. Otherwise, very closely follow same standards for Normal Conditions.

Tree Planting Operation

1. If seedling roots have not been coated with gel or clay as described above, they must be carried in water. Also, tops of seedlings should be wet (reduces transpiration).
2. Otherwise, very closely follow same instructions for Normal Conditions.

SEVERE CONDITIONS

Temperature:	32°F or less; ground frozen* or 85°F +
Relative Humidity:	30% or less
Wind:	15 miles/hour +
Soil Moisture:	80+ build-up

*NOTE: If weather forecast indicates cold temperatures that will freeze ground for several days immediately after planting; do not plant.

On-Site Storage of Seedlings

1. Seedlings will not be stored at planting site under these conditions. Bags/bundles should be stored in buildings, sheds, etc. that will protect from freezing and/or heating.

2. Refer to Storage Standards as given under DISTRICT/CONTRACTOR DELIVERY AND STORAGE STANDARDS, Severe Conditions.

Culling Non-Plantable Seedlings

1. Culling will not take place at planting site.
2. Culling is permissable in a building, shed, or other protected area.
3. When culling in such an area, follow very closely the same standards for Normal Conditions.

Root Pruning Seedlings

1. Pruning will not take place at planting site.
2. Pruning is permissible in a building, shed, or other protected area.
3. When pruning in such an area, follow very closely the same standards for Normal Conditions.

Tree Planting Operation

All planting should STOP, unless localized site exceptions exist.

Localized Site Exceptions

If a localized site exception to the severe soil or weather conditions does exist, planting may continue. Follow the standards for Critical Conditions.

SUMMARY

We realize this system will not solve all problems with survival, but we believe it is a start in the right direction.

Pressures from tree planters and from within our own organization will probably prevent strict adherence to the guidelines, but if we can reduce plantation failures by 50%, we will have made the effort worthwhile.

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