Seedling Lifting, Packing, and Storage at the ArborGen Georgia Nursery

11d

R.E. Cross, Jr.
Robert E. Cross, Jr., retired as Nursery Manager, ArborGen Georgia Nursery, ArborGen Inc., Shellman, GA

Outline

Facing Page: *Field crew lifting hardwoods. (Photo by Robert Cross, Jr.)*

Nursery Description

The ArborGen Georgia Nursery is located in Randolph County, GA. This location is in the southwest corner of Georgia, 30 miles west of Albany, and 30 miles east of Eufaula, AL, or 2 1/2 hours south of Atlanta, and 2 hours north of Tallahassee, FL. The nursery is located at 402 feet (ft) (122 meters [m]) elevation, with deep sandy soils of Lakeland and Troup soil types. The nursery has produced up to approximately 65 million seedlings annually, including 2.5 million hardwoods, which can include more than 50 different species of hardwood seedlings, the majority being in the genus *Quercus*.

The Timing of Lifting and Outplanting

Dormancy

The best time to harvest and outplant hardwood seedlings in the Southeastern United States is when they are most dormant. Typically, this may occur between late December and early March. Fully dormant seedlings are easier to lift and are more resistant to stresses caused by the lifting process. Seedling storability and resistance to adverse outplanting conditions increase as seedlings become more dormant. As a result, dormancy has a direct impact on seedling quality.

The onset of dormancy is almost entirely weather-dependent. Seedlings will exhibit more dormancy as the temperatures drop in the fall. A fairly good indicator of dormancy is the timing of leaf fall (see table 1 in chapter 11c), although some species tend to hang on to their leaves even after several frosts, such as sweetgum (*Liquidambar styraciflua* L.) and the oaks (*Quercus* spp.) (fig.11d.1). Dormancy can also be estimated with the amount of chilling hours received at the nursery. A chilling hour is one hour between 32 and 45 ˚F (0 and 7 ˚C). Chilling hours at the ArborGen Georgia nursery are monitored with a Davis Instrument weather station using Vantage Pro software from the first week of October through the first week of January. The minimum for lifting hardwoods is 200 chilling hours. These hours are kept in a spreadsheet for a yearly reference. It is assumed seedlings will become more dormant as chilling hours accumulate, with full dormancy reached at 400 chilling hours.

Figure 11d.1—*Shumard oak in November, 2008. These trees are ready to be lifted. (Photo by R. Cross.)*

"Hot Planting"

Customers sometimes request that seedlings be lifted and outplanted when nondormant. This "hot planting" (less than 100 chilling hours) can begin as early as November 15 in USDA Plant Hardiness Zones 7 and 8, as long as extra attention is given to root handling and moisture retention. Extra root gel (approximately 5 percent) needs to be added to each package during this period of harvesting. (Extra gel should not cause storage problems because the seedlings will not be in storage for an extended period.) The seedlings will need to be replanted in moist soil within 72 hours of harvesting at the nursery. These same "hot planting" precautions regarding seedling handling and outplanting conditions also apply to seedlings lifted after the first week of March, as seedlings may be breaking dormancy by then.

Outplanting Conditions

Another condition that is just as important as dormancy is soil moisture at the outplanting site. A seedling placed in dry soil will have difficulty with survival regardless of dormancy. A nondormant seedling transplanted into dry soil has little to no chance of survival, as root desiccation starts immediately without adequate soil moisture.

The nursery manager has to make a decision as whether to harvest the seedlings requested or delay harvesting until adequate soil moisture is obtained at the planting site. However, if the decision to harvest has already been made by the customer, then other factors need to be addressed. These factors include noting the dry soil conditions, indicating that seedlings be transplanted at 3 to 4 inches (in) (7.5 to 10 centimeters [cm]) deeper than the original ground line in the nursery bed, and suggesting that seedling root systems not be exposed to open air or wind until time of planting. These concerns and factors are not species specific, as dry roots in dry soil results in seedling mortality.

Seedling Preparation for Harvesting

In preparation for harvesting hardwood seedlings, several key objectives must be accomplished to enhance

seedling morphology and to ensure outplanting survival and growth. The more species a nursery grows, the more complicated the enhancement process.

Top Pruning

Top pruning is done to produce the desired balance between shoot length and root length. The target is a seeding whose shoot length is, at maximum, three times the root length. If the shoot length is over three times the root length, then unacceptable stress on the seedling root system occurs upon outplanting, as roots will not be able to provide transpiring leaf surfaces with enough moisture to ensure survival. Top pruning helps keep transpirational surfaces in balance with moisture-absorbing surfaces. The timing of top pruning is discretionary, depending on nursery location and temperature patterns. Timing is species dependent, can be started at any time after reaching 18 in (46 cm) of shoot height, and should be completed 2 to 3 weeks before harvesting begins. The objective is to modify the root:shoot ratio and slow growth if needed. The goal is to have seedlings no more than 24 in (61 cm) tall. Oaks and sycamore (*Plantanus occidentalis* L.) respond well to top pruning and may need to be top pruned more than once. Some genera do not respond as well to top pruning, particularly the ashes (*Fraxinus* spp.) and the maples (*Acer* spp.), as their opposite branching pattern results in multiple sprouts when pruned.

Over the years, top pruning hardwood seedlings has been accomplished using several different methods, including handheld cutters, hedge-type trimmers, rotary mowers, and sickle-type hay mowers. A typical sickle-type mower that is easy to maintain and operate is the Enorossi (fig 11d.2). This is a double-action mower that makes a clean and even cut (fig. 11d.3). A double-action mower cuts in both directions on the cutting bar as the blades reciprocate, thus making a cleaner cut. As with any morphological modification of seedlings, extreme care should be taken to ensure a healthy, vibrant seedling is produced (fig. 11d.4).

***Figure 11d.3**—Nuttall oak seedling after top-pruning in September, 2005. (Photo by R. Cross.)*

***Figure 11d.2**—Nuttall oak being top pruned in September, 2005. (Photo by R. Cross.)*

***Figure 11d.4**—A field of* Quercus *spp after being top-pruned in August, 2008. (Photo by R. Cross.)*

Figure 11d.5—*Sawtooth oak being undercut in November, 2007. (Photo by R. Cross.)*

Figure 11d.6—*Root system of sawtooth oak after undercut in November, 2007. (Photo by R. Cross.)*

Undercutting

The objectives of undercutting are to produce the desired balance between shoot length and root length, enhance the development of fibrous feeder roots, and make transplanting more successful. As indicated earlier, the root length should be one-third that of the shoot length. The goal for a good hardwood root system is to undercut the tap root at 8 in (20 cm). This depth also meets Federal Government guidelines for the Conservation Reserve Program, the Wildlife Reserve Program, and mitigation plantings.

In order to undercut hardwood seedlings that are 2 ft (61 cm) in height, an undercutter with a raised frame is needed to keep from damaging seedlings as they pass through the undercutter body (fig. 11d.5). The Whitfield undercutter has a raised frame with enough clearance for hardwood top passage. This model also has a reciprocating blade that moves side to side. This motion helps make a cleaner cut and assists with movement through the soil.

Typically, undercutting is performed at least 1 month before expected harvest. This timeframe is critical to ensure the cut-off tap root has sufficient time to recover from the effect of undercutting (fig. 11d.6). A high soil moisture content will assist with the firmness of the soil and hold the seedlings and seedling bed in place, resulting in little or no disruption to both. A good soil moisture content for undercutting is 85 percent to 90 percent. As with any morphological adjustment, seedlings should be monitored and irrigation applied if seedlings have been unacceptably stressed.

Lateral Pruning

There are three principal objectives for lateral root pruning. The first objective is to shorten the lateral roots to assist with transplanting and help ensure that all roots are inserted into the planting hole. The second is to promote the development of fibrous feeder roots next to the main tap root. This improves the ratio of root weight to shoot weight and hopefully improves outplanting survival by increasing water absorption into the roots. The third objective is to facilitate lifting. The lateral root trench will sub-divide the bed down the drills so that seedlings can be hand-lifted easily from just the drill in which they were planted (fig. 11d.7). The lateral pruner is inserted between the five drills of hardwoods and the outside bed edges (fig. 11d.8).

Seedling Harvest

Equipment Preparation

Equipment selection depends on the quantity of hardwood seedlings produced, available labor source and supply, soil

Figure 11d.7—*Whitfield® lateral pruner. (Photo by R. Cross.)*

Figure 11d.8—*Whitfield® lateral pruner over sawtooth oak. (Photo by R. Cross.)*

types, customer demands, and, to some degree, expected weather conditions. The following equipment is the minimum needed: two tractors, two haul-in wagons to transport seedlings from the field, a lifter (such as a Fobro), a vehicle (preferably a pickup truck), and a radio for communications. Another small but often important item required is a bed map describing the location of each species in the nursery beds.

It is important that equipment used during lifting is in proper working condition prior to operation. Tractors and vehicles should be checked to verify they have completed normal maintenance with oil and filter changes. In the case of cab tractors, the internal filters in the cab for air conditioning and heating systems should be checked and changed if needed. Similarly, tires should be checked for any needed repairs or replacement. It is always a good idea to keep a spare front tractor tire mounted on a rim and ready for replacement. Haul-in trailers used for seeding transport should be checked for wheel bearing greasing or replacement, and a rim-mounted spare tire is very helpful. Trailer frames need to be checked for major cracks or other structure damage, including the front connecting tongue and the handrail and step used for mounting and dismounting the trailer.

The lifter is a major piece of equipment used in the harvest process, and hand harvesting could come to a halt without it. With a sizeable crop of hardwood seedlings, two lifters need to be on site and ready to use, along with a reliable stock of spare parts. Several maintenance items need to be considered with any lifter, including bearings, power take-off (PTO) shafts, PTO joints, gear box, chain with chain repair tool, and spare tire. Lifters are very rugged and can be operated for an entire harvest season with little or no repairs if the proper maintenance is performed, plenty of grease is applied, and little or no water is used during the cleanup process until year end. These lifters tend to be one-person machines, meaning that if the same person operates the lifter every day, there will be fewer maintenance issues during the harvest season.

Harvest Scheduling

As customer requests come in, a daily lifting schedule is prepared of species and the quantities to be harvested. This schedule is given to the hardwood supervisor, who reviews the lifting schedule and prepares the harvest plan. This plan includes labor requirements, bags, bag labels, gel, species location and bed location map, and racks and cooler space required. At this time, the supervisor also determines if the harvest will be picked up, delivered, or shipped, so it can be determined how the lifting schedule will require seedlings to be packaged in the field and at the packing room. The bags for each species are counted, labeled, and placed on a haul-in wagon that is headed to the field.

The footage needed to be lifted for a particular species is determined using the bed location map. This process is facilitated by software that tracks each linear bed foot planted by species. This bed map also has the density listed by species, along with the exact location, total footage, and total seedlings. The supervisor reviews the required quantity of seedlings scheduled for harvest and calculates the footage needed to harvest this amount of seedlings.

Lifting

The first step of the lifting operation is to run the lifter through the species of seedlings scheduled for harvest. The lifter speed is determined by species, soil moisture, and operator experience. Soil moisture plays a major role in the harvesting process, but sometimes the luxury of lifting during ideal soil conditions is not an option. Therefore, proper care and effort should be made to slow down the lifting process so as not to damage the seedlings or cause any undue safety hazards. The lifter has a metal blade that is sharp on the leading edge and, elevated vibrating tines at the rear to loosen the soil and remove as much soil as possible from the seedling root system without causing damage to the seedling roots or tops (fig. 11b.9). The Fobro lifter is a good example of this type of lifter, and it also has enough frame clearance to minimize damage to the seedling shoots and roots.

Figure 11d.9—*Fobro® Lifter. (Photo by R. Cross.)*

There are some safety issues that apply to most lifters:

- The fins on the rear of the lifter become extremely sharp during the lifting season due to soil movement over these fins.
- Extreme caution should be used when removing seedlings or soil from this area.
- A tarp or cover should be placed over these fins when the lifter is not in use.
- Covers for the PTO shaft may have to be made to prevent a hand or arm injury.
- The lifter should be placed on blocks when not in use to prevent erosion of the blade edge.
- Have a radio on hand for communications for the safety of the lifting crew.

Typically, the lifting crew has one person on the lifter tractor, one person on the haul-in wagon, and an even number of crew members on opposite sides of the bed (fig 11d.10). Ideally, the nursery would have a smaller crew of 6 to 8 people harvesting, but on occasion it may be necessary to use as many as 30 crew members to harvest the quantity needed for that particular day's schedule. The members of the lifting crew are separated by 10 to 12 ft (3 to 3.6 m) along the bed to prevent soil or leaf residue from flying onto their fellow workers. This separation also increases production. As the crew progresses down the bed, the crew members maintain this interval, harvesting their section of the bed then moving forward to the head of the lifting line. As the seedlings are harvested, they are culled and counted into bundles of 25 or 50, depending on species or customer request. The seedlings are placed on the ground in these bundled counts (fig. 11d.11). A separate crew of two to four members follows the lifting crew and immediately places the seedlings in paper bags. Bags are kraft paper with a thin, wax-coated liner (fig. 11d.12). Because seedlings have been top pruned, they can be laid horizontally in the bag,

Figure 11d.11—*Field crew lifting sweetgum in January, 2008. (Photo by R. Cross.)*

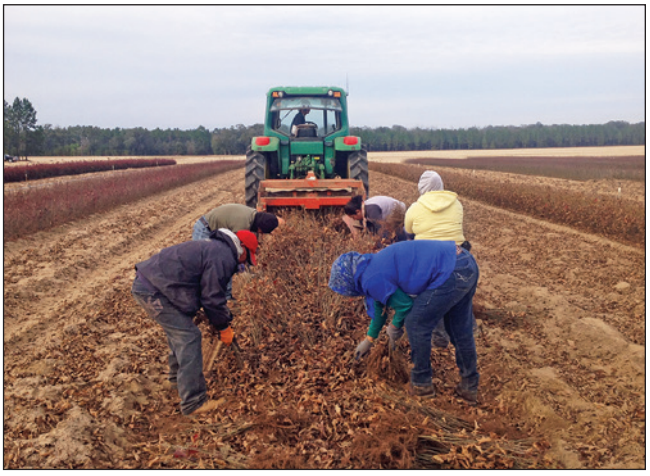

Figure 11d.10—*Field crew lifting hardwoods. (Photo by R. Cross.)*

Figure 11d.12—*Sweetgum bagged and ready for transport to packing room in January, 2008. (Photo by R. Cross.)*

Table 11d.1—Minimum recommended hardwood seedling size specifications used by the ArborGen Georgia Nursery.

Customer type	Height (in)	Root length (in)	Caliper (in)
Government programs, regardless of species	18-24	8	.25
Nongovernment programs, regardless of species	12-18	6-8	.125

in = inches

allowing for complete bag closure. Most of the seedlings are bagged at 200 per bag, so the crew will put in either 4 or 8 bundles per bag, depending on customer request. Occasionally, a smaller quantity of 25 seedlings is shipped, so these are bagged separately in smaller bags at the same time.

The lifting crew supervisor, who is preferably a company employee, will have the responsibility and accountability to ensure that safety, equipment maintenance, and proper harvesting procedures are followed, and that the correct quantity, species, and seedling specifications meet the customer's request. A contract crew with a foreman is sufficient for the other labor sources.

Culling

Seedlings are culled in the field during lifting operations, removing seedlings that are too small, diseased, or damaged. These culled seedlings are pulled at the same time the other seedlings are lifted and then placed on a haul-in wagon and discarded before the wagon returns to the field. The desired seedling specification is a height of 18 to 24 in (46 to 61 cm), a minimum root collar diameter (RCD) of 1/4 in (6 mm) with a tap root length of 8 in (20 cm). These specifications have to be met for any seedling grown for a Federal Government-subsidized program (table 11d.1). If they are not part of such a program, then seedlings may be grown or selected to meet customer specifications. Some minor species such as dogwood (*Cornus florida* L.), catalpa (*Catalpa bignonioides* Walter), and redbud (*Cercis canadensis* L.) that are often grown for the horticultural industry or game management do not have to meet these specifications.

A company employee can supervise the culling procedure and train contract workers to help with this process. Species-specific culling criteria are communicated to the contract crew involved in the actual lifting process. The culling procedure requires the use of a measuring stick, tape measure, and digital calipers, and is closely monitored to ensure that seedlings meet customer specifications.

Figure 11d.13—Spraying gel on roots inside bag prior to shipment. (Photo by R. Cross.)

Storage

Processing Into Storage

The bags of 200 seedlings lifted in the field are transported on haul-in wagons to the packing room. Further review is done to ensure there are no culls in the bag, correct species labeling is on the bag, and gel is sprayed inside the bag to the root system (fig. 11d.13). The bag is then rolled down as snuggly as possible and double-strapped. The bags of 200 are then counted as they are loaded onto a seedling rack for either storage or shipment. Smaller quantity seedlings, such as 25, 50, or 100, are kept separate and prepared for customer pickup or shipment. The seedling racks are labeled and tagged with species identification and quantity. This information is then entered into a computer using software that tracks the species, number of bags, and bag counts that have been moved into the cooler.

Storage Facilities

The storage facility is designed to maximize the available space. The facility has front and rear doors large enough for forklift entry, as well as a pedestrian door. Clear vinyl strips over the cooler doors help keep cold air inside the cooler and warmer air outside during constant entry and exit of the forklift (fig. 11d.14). Cooler height evenly accommodates seedling storage racks. The cooler is 55 ft long, 34 ft wide, and 18.5 ft high (17 by 10 by 5.5 m) and can store 140 racks. An additional concrete rack storage area is available to accommodate empty racks so cooler space is not consumed with empties. Jarke racks are used for storage of hardwood seedlings. These racks are 44 in high (including the leg), 70 in wide and 45 in deep

Figure 11d.14—*Sawtooth tree seedlings in storage on racks. (Photo by R. Cross.)*

(1.1 by 1.8 by 1.1 m). They are easily handled with a forklift and can be stacked four high inside the cooler or two high inside a refrigerated van. A temperature and humidity monitor is mounted on the upper wall inside the cooler. This equipment feeds a constant stream of readings to two wireless consoles located in the main office. The readings are real-time with an alarm for unsuitable conditions in the cooler—lower than 90-percent humidity and/or below 34 and above 36 °F (below 1 and above 2 °C).

Maximum Recommended Storage Times

There is no substitute for planting freshly harvested seedlings. These are seedlings that are lifted and replanted within 3 days. This ideal situation rarely occurs, however, and seedling storage is an inevitable and an important part of the seedling handling process. The amount of time seedlings can be stored depends on several factors, including species, cooler storage temperature and humidity control capability, seedling packaging, root coating, and type of storage.

Some species, such as sweetgum, do not respond well to storage and need to be planted within a week of harvest. Other species, such as sycamore, are very resilient when fully dormant and with the proper temperature and humidity control can be stored for 3 months with minimum loss in outplanting survival. Rewatering is not necessary when seedlings are top-pruned and placed horizontally in a closed bag with a good root coating of gel for moisture retention. On the other hand, open-topped bags with the seedling tops exposed (and to some degree the roots) may require that each bag be rewatered after 3 to 4 weeks of storage, depending on cooler temperature and humidity conditions.

The type of storage is critical in determining length of storage. A well-maintained drive-in cooler with forklift access, loading docks, seedling rack storage, and humidity and temperature control provides the best long-term storage capability. Other refrigerated storage types, refrigerated vans for example, require constant monitoring and make long-term storage difficult, if not impossible. Weather conditions often determine the feasible length of nonrefrigerated storage, such as enclosed or open sheds. Seedlings need to be planted within 3 to 5 days when the temperature inside the storage area is between 50 and 70 °F (10 and 21 °C). If temperatures inside the storage area remain above 75 °F (24 °C), seedlings should not be stored more than 24 hours. Seedlings in bags/bundles/boxes cannot be stored for more than a few hours at temperatures above 85 °F (29 °C). Lethal temperatures occur in bag/bundles/boxes at 118 °F (48 °C), but seedlings can be weakened or damaged if temperatures in bags/bundles/boxes remain at 85 °F (29 °C) for very long. The ArborGen Georgia Nursery recommends hardwood seedling storage times and temperatures be similar to those of pine, as specified by the Mississippi Forestry Commission.

Potential Storage Problems

Issues relating to top desiccation, root system dehydration, or diseases are often storage-related discussion topics. All of these are important and relevant, but there are other factors and issues with storage. When producing hardwoods in large quantities (1 million or more), storage capacity is a major issue, as hardwoods take up 6 times more space than pine. Tracking the location, inventory, and date packed of multiple species in a near-capacity storage area can also be a challenge. These problems are compounded when rotating the inventory to ship the longest-stored material first is a priority. Packaging can be another issue when seedlings are stored for an extended time (greater than 4 weeks). The more time seedlings are stored, the more susceptible packaging becomes to the break-down effects of moisture and handling. Some of the best practices for storage include rotating older stock, not over-applying root coating, and using high-quality packing material.

Hardwood seedlings produced in the Southeastern United States are sensitive to freeze damage after lifting. While seedlings may have hardened-off to above-ground freezing temperatures in the nursery, root exposure to below-freezing temperatures after lifting often results in damage to the seedling's root system, resulting in mortality. Seedlings should not be stored where the temperature is 32 °F (0 °C) or less. If temperatures below freezing are expected in the storage area, then temperatures in

the storage area and temperatures in the seedling package should be monitored every 2 hours after the temperature goes below 32 °F (0 °C). Seedlings should be moved or covered with a thermal tarp to keep the root systems from freezing.

References

Williams, R.D.; Hanks, S.H. 1976. Hardwood nursery guide (formerly Hardwood nurseryman's guide, revised 1994). Agric. Handb. 473. Washington, DC: U.S. Department of Agriculture, Forest Service. 78 p.

Mississippi Forestry Commission. 2016. Seedling tips and care. http://www.mfc.ms.gov/seedling-tips-care. (January 2017).