

Planting and Care of Fine Hardwood Seedlings



Hardwood Tree Improvement and
Regeneration Center

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Planting Hardwood Seedlings in the Central Hardwood Region

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Introduction

Forest tree planting in the United States on public and private land exceeded 2.6 million acres in 1999. Of that total, approximately 1.3 million acres (48 percent) were planted by private individuals (AF & PA 2001). In the Central Hardwood Region (Fig. 1), forest tree planting by private landowners exceeded 100,000 acres in 1999. Trees are planted for various reasons including, timber production, wildlife habitat, riparian buffers, native woodland restoration, windbreaks, watershed protection, erosion control, and conservation (Indiana NRCS 2002).

Successful establishment of hardwood plantings requires planning, a commitment of time and resources, proper planting, maintenance, and protection. Planting hardwood seedlings has advantages over direct seeding. Seedlings will more effectively compete with unwanted vegetation such as grasses, herbaceous plants, and shrubs for moisture, soil nutrients, and sunlight. Growth and development of the tree seedlings is usually accelerated over the seeding method.

Successful establishment and development of hardwood trees is usually higher with seedlings if the site is prepared properly; the appropriate species is selected for the site; quality seedlings are purchased; proper care and handling of seedlings before, during, and after planting are observed; and proper planting techniques are used. Proper planting techniques and tree maintenance practices can greatly enhance the prospects for successful hardwood tree establishment.

Planting Season

Hardwood seedlings must be planted at the proper time of year in order to guarantee a successful planting. **Hardwood tree seedlings are best planted (late winter or early spring) when the seedlings are dormant and the ground has thawed.** In the Central Hardwoods Region, this



Figure 1. The Central Hardwood Region (shaded)

period lies between March and May, but the exact dates will vary with latitude and the weather conditions. During the March to May period, soil moisture and temperature are ideal for seedling growth and survival. A cool (35° to 60°F) overcast day with little or no wind (less than 10 mph) provides an ideal setting for planting hardwood seedlings.

In most areas, orders for tree seedlings are placed with nurseries in the fall and shipped, or picked up, in the spring. Fall planting is not recommended for hardwood seedling species because planting failure can occur as a result of freezing and thawing of the soil (frost heaving), seedling desiccation, disease problems, wildlife damage, and winter injury. Avoid planting seedlings when the site is excessively wet or dry, as water-logging or drought stress may result in poor seedling survival and growth. Planting at the proper time allows the seedling root system to become properly established before it is subjected to seasonal changes (high temperatures, low rainfall, and excessive wind).

Bare-Root Versus Containerized Seedlings

There are two types of seedlings used in tree planting operations, bare-root (Fig. 2) and containerized plants. **Hardwood plantings are mainly established in the Central Hardwood Region using bare-root seedlings.** Bare-root seedlings are grown at local and state forest tree nurseries. These seedlings are generally less expensive and easier to plant than containerized seedlings. Bare-root seedlings are grown in a nursery seedling bed (usually for only one year), lifted from these beds (by cutting the tap root 8 to 10 inches below the soil surface and mechanically loosening the soil around the roots), graded, and packed into bundles at the nursery to keep the roots moist. Bare-root seedlings are stored in controlled environments (33° to 40°F with 85 to 95 percent humidity) until shipped.

Bare-root hardwood seedlings should have at least a shoot height of 18 inches (18 to 24 inches preferred) (Allen et al. 2001). The caliper of the seedling measured at the root collar (the part of the root just below ground level) should be at least ¼ inch thick. Some species, such as white oak (*Quercus alba* L.), can be excellent seedlings at the 10 to 12 inch height, if they have good caliper. Initial root collar diameters are good indicators of field performance of northern red oak (*Quercus rubra* L.) seedlings, two years after planting (Dey and Parker 1997). The roots should be healthy looking, well-developed, have several lateral roots, and have a minimum root length of 8 to 10 inches.

Research on northern red oak has shown that survival, height growth, and diameter growth were significantly greater for seedlings with 10 or more large first-order lateral roots (FOLR) than for seedlings with four or fewer (Thompson and Schultz 1995). Red oak seedlings with at least five FOLR and black walnut (*Juglans nigra* L.) with at least seven FOLR had better survival and early growth than seedlings with fewer roots (Schultz and Thompson 1996). Larger seedlings (greater than 18 to 24 inches) with greater caliper (up to ½ inch) are needed where no site preparation or weed control has been carried out.

Seedlings should have a good shoot to root ratio. Hardwood seedlings with too much shoot growth versus root volume may die back and re-sprout from the root collar. Purchasing larger, better quality seedlings at the start of the planting project reduces mortality. Fewer seedlings will



Photo courtesy of Douglass F. Jacobs

Figure 2. Good quality bare-root ash seedling

need to be replaced after the first year or two. Planting higher quality seedlings allows for more time to be spent on vegetation control and browse protection (Ward et al. 2000). The proper care and handling of quality bare-root seedlings is extremely important to planting success.

Containerized seedlings are grown and sold in a variety of containers from tubes to gallon pots and are transplanted into the ground using different planting techniques than those used for bare-root seedlings. Containerized seedlings can be used when planting on harsh sites, for restoration projects (e.g. land reclamation), or when planting outside (fall) of the dormant season.

Containerized seedlings are not recommended for large-scale plantings of hardwoods because of the expense. If hardwoods are grown in too small of a container, the roots may become restricted in growth, causing the seedling to become root-bound with roots curled around the inside of the pot. Root-bound seedlings will not form a good, vigorous root system when planted. These seedlings may grow for several years in the field and then fail as a result of the inability to obtain adequate water during drought periods (Allen et al. 2001).

In some cases, containerized seedlings are preferred because there is less transplant shock,



the fine roots are left intact (some of these can be lost during lifting of bare-root seedlings), and the roots of the seedlings retain moisture longer because they are still surrounded by the soil in which they were grown.

Air-root pruned liners (RPM) have a vastly improved root system obtained through a multi-step program of air-root pruning (Lovelace 2002). This system produces a plant with a dense fibrous root system (Fig. 3) that improves transplantation, growth, and survivability when there is a need for planting in the fall or in drought prone areas.

Seedling Care and Handling

Before planting. Hardwood bare-root seedlings are perishable and require careful handling to prevent the roots from drying out. Bare-root seedlings are stored in controlled environments (33° to 40°F with 85 to 95 percent humidity) at tree nurseries until shipped or picked up. Seedlings from the nursery are packed in sphagnum moss or other types of moisture retaining material around the roots, bundled in packages, and placed in waterproof bags or boxes.

Transport your seedlings (or arrange for delivery) to the planting site in a refrigerated truck, if available. Seedling buds may break dormancy if the temperatures become too warm. **Seedlings should be transported (or delivered) as close as possible to the date planting will actually begin.** If refrigeration transport is not possible, seedlings must be protected from sun, wind, and excessive drying.

In open truck beds, stack the bundles properly to allow adequate ventilation to prevent overheating, cover the bundles with a reflective, insulated tarpaulin, and leave sufficient air space between the tarpaulin and the seedlings (for air circulation) to reduce heat buildup. Seedlings should be unloaded as soon as they arrive to the planting site and kept in the shade at all times.

Seedlings should be planted as soon as possible (within one week of delivery). If they are not planted immediately, they need to be placed in cold storage (33° to 40°F) and protected. Storage in a barn, shed, or dense shade with protection from the sun (overheating), wind (drying out), and extreme temperatures (freezing) are adequate for a few days to a few weeks (only if temperatures are kept cool, 40°F). Stack bundles loosely with spacers (two bundles high) to permit adequate ventilation. Seedling roots need to be kept moist, but not wet, so a small amount of water may

need to be added to the open end of the bundles. If seedlings are properly stored for a short amount of time (few days), this step should not be necessary.

During planting. Proper care and handling of hardwood bare-root seedlings during the planting process is critical to seedling survival. Planting on cool, overcast days helps minimize seedling exposure to harsh, drying conditions. The seedling roots must be protected from drying out at all times. Only take as many seedlings as can be planted in one day from storage to the planting site. Seedlings should be removed from the nursery bundles and planted immediately, or transferred to a planting bag where the roots can be kept moist. Gently separate seedlings from the bundle, do not root prune, and keep lateral roots intact. **The most important step during planting is protecting the roots.** Cover seedling roots with moist burlap, peat moss, or a similar material to protect them from drying out; do not submerge root systems in buckets of water. Brief exposure of bare-root seedling roots to direct sunlight can cause dehydration and seedling death.



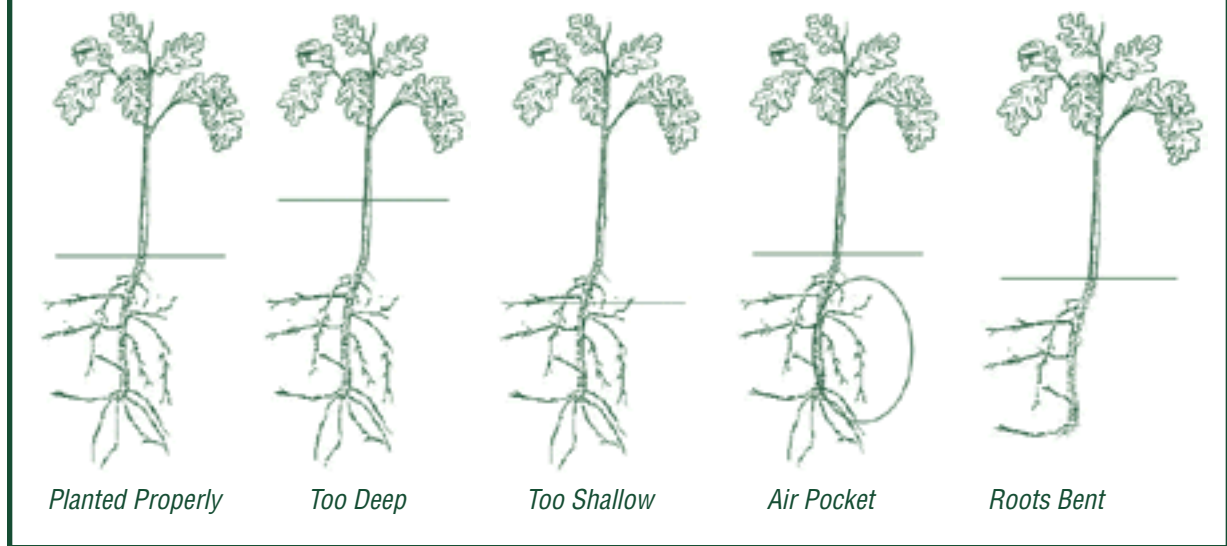
Figure 3. One-year-old air-root pruned liner [RPM™] containerized stock (right) vs. bare-root oak seedling (left)

For large acreage, a planting bag is the norm, but do not allow the seedlings to be left in the bag for a long period of time. When planting, always hold the seedling by the shoot top, never by the roots. Whenever possible, plant when the weather conditions are ideal (cool temperatures, overcast day, adequate moisture). If available, watering after planting will aid seedling survival.

After planting. Once seedlings are in the ground, a maintenance program should be developed. Watering helps newly planted



Proper Planting Equals Successful Seedling Establishment



hardwood tree seedlings, but on large-scale plantings this may not be feasible. **Weed control for the first three to four growing seasons will greatly increase seedling survival and growth.** The minimum weed-free area around a seedling should be a three to four foot diameter square or circle. On small-scale plantings, this can be accomplished with mechanical tilling equipment, mulches, weed barrier fabric, and chemical control (herbicides applied with hand-held or back-pack sprayers). On large planting sites, a tractor mounted cultivator or disc will be required.

After two years, damage may occur to tree roots when using a cultivator or disc. Herbicide application for large plantings is most easily accomplished using a power sprayer mounted on or pulled behind a tractor.

Mowing is not considered adequate weed control. Mowing increases sunlight to the seedlings, but does not eliminate the root systems of vegetation competing for soil moisture and nutrients. Mowing may damage the seedlings; and it also causes soil compaction and favors the establishment of grass, which is a severe competitor with trees. Except for access lanes, mowing should be avoided whenever possible. Removing the shoot and root system of competing vegetation during the first three to four years makes the difference between success and failure of plantings.

Planting

Bare-root hardwood seedlings are either planted by hand or machine planted. Planting by hand is appropriate for small sites, areas where tree-planting equipment is unavailable, or where the site will not accommodate planting equipment. An experienced two-person hand planting crew can typically plant 1000 to 1500 seedlings per day. For large plantation sites, planting equipment should be used. Three people can plant around 4000 to 6000 seedlings per day using a tractor and a mechanical planter. Regardless of the planting method, four basic requirements need to be accomplished.

- 1) The hole or furrow should be large enough to accommodate the entire root system.
- 2) The seedling should be planted with the root collar just below the soil surface.
- 3) The roots need to be straight within the hole, not twisted or bent (J-rooted).



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Figure 4. Tools used for hand planting bare-root hardwood seedlings. (Left to right, dibble bar, planting bar, mattock, sharpshooter shovel, and auger)

4) The soil should be firmly packed around the seedling to avoid air pockets (this can cause the roots to dry out causing seedling death).

Hand planting. Various tools can be used for hand planting bare-root seedlings. These include dibble bars, power augers, hoe dads, shovels, tree bars, and mattocks (Fig. 4).

A well-planted seedling should remain in the ground if gently tugged upward by the terminal tip. The seedling should also stand freely in a vertical position when not held upright. Hand planting has both advantages and disadvantages.

Hand planting is less expensive than machine planting, but more labor intensive. Fewer seedlings can be planted per unit of time compared to machine planting. The planting depth can be adjusted for each individual seedling, but spacing is not precise and can vary widely with the planting crew. Seedlings can be critically wounded during the hand-planting process, resulting in low seedling survival. Care must be taken by the planting crew to insure that seedlings are kept moist, roots are not injured when removing seedlings from the planting bags, and seedlings are properly planted.



Photo courtesy of R.A. Whitfield Manufacturing Company

Figure 5. Tow-type transportable transplanter

Machine planting. Machine planting involves the same basic steps as hand planting, except that mechanization is used to open and close the planting hole (Fig. 5). Most mechanical seedling planters have a coulter disk that slices the soil surface and a single narrow plow that opens a deep slit in the soil.

Continuous-furrow planting machines may have a cage to protect workers from injury and debris, as well as covered trays or storage bins for carrying the seedlings. A regular farm tractor can be used to pull the planter. The operator sits on a seat mounted over the plow (Fig. 6). Wings on the plow hold the slit open while the operator reaches down to insert a tree seedling,



Photo courtesy of Douglass F. Jacobs

Figure 6. Mechanical hardwood seedling planter

allowing the roots to hang freely. The seedling is held upright until the packing wheels pass by the seedling. Packing wheels, at the rear of the plow, compress the soil back into place around the roots, as the planter moves along.

There are other types of semiautomatic planters where the machine actually moves the seedling into position between the packing wheels (Fig. 7).

Site conditions must be favorable in order to use a machine planter. Planting machines may not operate properly at sites where there is heavy debris, stumps, heavy clay soil, steep or gullied slopes, rocks, and logging slash. Machine planting is less labor intensive; it permits precise spacing and planting depths, allows more seedlings to be planted per unit time, and may produce a higher survival rate of seedlings versus hand planting.



Photo courtesy of R.A. Whitfield Manufacturing Company

Figure 7. Semi-automatic hardwood transplanter



Direct Seeding

Direct seeding (Herman et al. 2003) is simply the process of establishing tree plantings by the use of seed instead of seedlings. ***Direct seeding is rarely used in the Central Hardwoods region for establishing hardwood plantings.*** In areas where direct seeding is appropriate (poor access, difficult terrain, or when the site and tree species make seedling planting too difficult or expensive), it can be a viable alternative and relatively inexpensive compared to seedling plantings.

In addition to the usual conditions that must be met for successful hardwood seedling plantings (site preparation; appropriate species; quality of material; care and handling before, during, and after planting; and proper planting techniques), direct seeding will depend upon the price and availability of seed, labor costs, and availability of seeding equipment.

There are several steps that need to be taken in order to have a successful planting via direct seeding. With direct seeding, five basic requirements need to be met.

- 1) Plan ahead to minimize poor germination of seed or seedling failure.
- 2) Obtain adequate amounts of quality, viable seed from an appropriate source and prepare it for sowing (match species to the site).
- 3) Determine the proper sowing rates for desired density and spacing.
- 4) Select an appropriate method for dispersing the seed.
- 5) Have a follow-up plan if sowing yields too many or too few seedlings.

Direct seeding has several advantages, as well as disadvantages, compared to planting seedlings. The planting time (season) for direct seeding is longer than that for seedling planting. This allows for more time and flexibility in planning, preparing the site, and implementing the seeding process.

Direct seeding is less labor intensive, but more seed per acre is required to obtain the desired number of seedlings. Direct seeding allows seedlings to become established in the soil with their root systems spreading and developing naturally. Root systems that are allowed to develop naturally with minimal damage enable the seedlings to be more tolerant of stress and wind damage. Hardwood seedling roots are more susceptible to damage and transplanting shock

because they are handled several times (nursery, planting site, etc.) before becoming established at a site.

However, delayed seed germination, slower rates of development, and loss of seed to predation or drought may lengthen the time to seedling establishment (or cause complete planting failure) as compared to planting bare-root seedling stock. Other disadvantages with direct seeding are the lack of control over seed density, and unfavorable weather conditions during the germination process. Direct seeding can be a successful venture to establish hardwood plantings if proper planning and attention is paid to obtaining quality seed; choosing the appropriate species for the site; controlling competing vegetation and predators; site preparation; and the method, depth, and time of sowing. Mainly large-seeded species, such as walnuts and oaks, are suitable for direct seeding and specialized equipment is required.

Planting season. Seeds of most native hardwood species mature and drop from the trees in the fall. By direct seeding in late fall, the natural stratification process (moist, cold temperatures) breaks seed dormancy and promotes rapid germination of the seed in the spring. Loss of seed to predators may be higher in the fall. If direct seeding is planned for late winter or early spring, proper storage and seed preparation (pre-germination treatments) must be observed, depending upon the species.

Site preparation. The ideal site for direct seeding is an area with as much exposed soil as possible. Reducing debris and controlling competing vegetation allows for more uniform distribution of the seed and favors germination. Mowing, herbicide treatment, plowing, and disking existing vegetation also aids in reducing rodent (mice and voles) predation.

Depth of sowing and spacing. Depth of sowing is dependent upon the species, seeding method, and predator pressure. Most large seeds, such as oak acorns, butternuts, and walnuts, are covered with soil to a depth of one to five inches. Smaller seed, such as white ash, black cherry, and sugar maple, are covered to a depth of $\frac{1}{4}$ to $\frac{1}{2}$ inch of soil. A general rule for depth of sowing is two times the diameter of the seed. Planting too shallow increases losses to predators and drought. Planting too deep can delay germination.

Seeding rates range from 24 to 36 pounds per acre for northern red oak to 75 to 112 pounds per



acre for black walnut (3000 to 4500 seeds per acre for both species) (Indiana NRCS 2002). High-density planting can produce natural competition, which produces good form (no pruning needed) and close crowns faster. Direct seeding spacing depends on the method of sowing the seeds, the number of seeds sown per acre, and the planting site.

Methods of direct seeding. There are three basic ways one can direct seed a site: by hand, by machine, and by air (leaves the seed exposed on the soil surface). Hand sowing is accomplished by making a planting hole, dropping the seed into the hole, and covering the seed by hand or foot with soil. Machine sowing is accomplished using mechanical planters that have been modified from agricultural use (no-till planters). Modifications are made to the planters so that the size of the hopper bottom and drop tubes can accommodate larger seed. Other parts are added to the planter equipment so that the planter can dig deep enough into the soil. Aerial seeding has been used in the southern United States to sow pine seed, but it is not used for direct seeding of hardwoods.

After seeding care. Control of predators, and elimination or control of competing vegetation for at least two to three years, are keys to a successful seed planting operation. Controlling competing vegetation with herbicides, disking, or other means, also reduces the habitat for mice, voles, chipmunks, and squirrels that feed upon the seed.

Natural Regeneration

Natural regeneration relies on established mature hardwood trees on the site, or from a nearby existing forest, to provide seed for regeneration. Natural regeneration is the least expensive method of establishing a hardwood stand, unless extensive site preparation is required. Tree species and genotypes that are native to the area or have become adapted to a site will most likely become the dominant species that regenerate. Natural regeneration depends on good seed crops; means of seed dispersal or spread of vegetative parts; suitable seedbed or soil conditions; and the conditions essential for seed survival, germination, growth, and development.

Some hardwood species only produce a heavy seed crop every two to five years. Therefore, herbaceous perennials may dominate a site for several years before hardwood seedlings regenerate and become established. The means of seed dispersal will also play a large role in natural regeneration.

Seeds dispersed by wind, or moved by animals and birds, can be established; this depends on environmental factors (wind, rain, etc.) and the activities of the dispersing agents. Natural regeneration of hardwood species by vegetative reproduction depends on the level of disturbance activity at the site (fire, logging, thinning, etc.). Landowners, in consultation with a forester, must determine if the site requires some means of preparation in order for successful natural regeneration to occur. If logging or thinning is recommended for a site, several key steps must be followed.

Seed trees must be selected and marked (with paint) before the site is prepared. The number of seed trees to leave depends on the species composition desired. Seed trees should be spaced over the site in order to allow more uniform distribution of the seed. During the logging or thinning operation, the landowner should insure that the seed trees are not damaged. Additional site preparation may be required so that the soil conditions are ideal for seed germination and survival. Burning, mechanical scarification, and spraying with herbicides are some options to prepare a site for natural regeneration. Control of weeds and undesired vegetation for the first few years may also be required.

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