PURDUE UNIVERSITY | Extension

Forestry and Natural Resources
purdue.edu/fnr
FNR-IDNR-36-W

Authors

Ron Rathfon
Purdue Extension forester
Southern Indiana Purdue Agricultural Center

***Douglass Jacobs**, professor*
Fred M. van Eck Endowed Chair of Forestry Biology

Lenny Farlee
Purdue Extension
Sustaining hardwood specialist

10 STEPS TO SUCCESS

Planting Forest Trees and Shrubs in Indiana

Introduction

Successfully planting trees and shrubs involves much more than sticking the right end in the soil. It requires proper planning, preparation, technique and follow-up maintenance. This publication provides an abbreviated 10-step approach to plant and establish healthy, productive forest and conservation plantings in Indiana.

The Department of Forestry and Natural Resources at Purdue University, the U.S. Department of Agriculture Forest Service and the Hardwood Tree Improvement and Regeneration Center have cooperatively produced *Planting and Care of Fine Hardwood Seedlings*, a series of publications on hardwood tree planting in the North Central states. This series provides more detailed information and will be referenced throughout this publication. Other types of plantings, such as landscape, ornamental, Christmas tree and windbreak plantings, are covered in publications listed in the Related Publications section.

10 Steps for Successful Tree and Shrub Planting

1. Get help
2. Make a planting plan
3. Select the right species
4. Design the planting
5. Prepare the planting site
6. Obtain quality seedlings
7. Care for the seedlings
8. Plant the seedlings
9. Post-planting care
10. Take a break – a tax break

Step 1. Get Help

First-time tree planters account for 75 percent of the annual plantings in Indiana (Ross-Davis and others, 2005). Planting your own trees may be feasible if 1) you are planting a small area (no more than 2 or 3 acres), 2) hand planting is required, 3) you have a strong back and lots of energy, and

4) you follow the steps outlined below. If you can't meet all the above criteria, don't worry. Help is available. Even if you intend to plant your own trees or personally supervise your own tree planting crew, we strongly urge you to first seek the help of a forester.

Professional Foresters

Research shows tree plantings done under the guidance of a professional forester have twice the success rate of those done without their expertise (Jacobs and others, 2004). Many private consulting foresters in Indiana provide tree-planting services. State district foresters provide guidance and assist in securing government cost-share funding to help pay for tree planting expenses. Purdue Extension foresters provide information, offer workshops and refer landowners to other sources of assistance.

Incentive Programs

A variety of state and federal government tree planting incentive programs are available to fit varying landowner needs and circumstances. Specific programs change frequently. Contact your state district forester or local Natural Resources Conservation Service (NRCS) office for current conservation financial incentive information.

Private organizations may pay for tree planting on your property if you meet very specific criteria. Some conservation organizations help landowners pay for tree planting along streams and rivers in selected watersheds, or in large river bottoms and wetlands. Some electric utilities are planting trees for carbon sequestration as a means of offsetting their own atmospheric carbon emissions. Talk to your state district forester about private funding opportunities in your area.

Step 2. Make a Plan

Most successful ventures start with a plan. For government cost share assistance, you are required to develop a tree planting plan. This section outlines a process to follow to make your tree planting plan.

When to Start Planning

Most folks get a notion to plant trees in the spring. Spring is not a bad time to start planning — the spring prior to the spring you hope to plant, that is! Start at least one year before you want to do the actual planting. This is especially important if you want cost share assistance and the help of a forester. Your state district forester or a consultant forester can help you make a plan.

Plan Elements

A tree planting plan contains your objectives and should answer such questions as, "Why are you planting trees?" and "What do you hope the tree planting will do for you, others, future generations and the environment?" Elements of a plan include:

- A description of the planting site conditions, including soil types.
- Selected species and planting stock types and nurseries from which seedlings will be purchased.
- Planting design, including spacing.
- Needed site preparation.
- Planting method, equipment and labor.
- Planting maintenance, including weed control and animal damage control.
- A budget should also be included, showing how planting and maintenance will be financed.

Individual elements will be covered in greater detail throughout this publication. FNR-223, *Planning the Tree Planting Operation*, provides more information on making a tree planting plan.

Contact Information

Indiana Division of Forestry
402 W. Washington St., Room 296W
Indianapolis, IN 46204-2639
(317) 232-4105
http://www.in.gov/dnr/forestry/

Directory of Professional Foresters:
Indiana Forestry & Woodland Owners Association
1007 N 725 W
West Lafayette, IN 47906-9431
(765) 583-3501
www.ifwoa.org

Purdue Extension Foresters
(765) 494-3583
http://www.fnr.purdue.edu/

Find an Indiana forester
www.findindianaforester.org

Step 3. Select the Right Species

Indiana has more than 100 native tree species. This diversity reflects the many different types of soils and site conditions found across our landscape. Sites vary tremendously in terms of moisture availability, fertility, degree of shading, depth of topsoil, etc. Each tree species is adapted to survive and thrive under certain site conditions. It is critical that you select species that are adapted to the conditions of the site you plan to plant. Native species are best adapted to the growing conditions here. In most cases, exotic species (meaning

those native to other regions of the world) should not be planted. Many exotic species planted for conservation and landscaping in the past are now illegal to plant under ***Indiana's Terrestrial Plant Rule*** due to their invasiveness and disruption of native plant and animal habitats.

There are many ways to describe and classify site conditions, but for tree planting purposes, they can be simplified to three basic types: dry, moist, and wet. Planting sites may have all three site types and thus require careful selection and proper placement of species (Table 1). Your county soil survey is available through USDA at the Web Soil Survey online (https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx). You can also contact your local county Natural Resources Conservation Service (NRCS) office to obtain information on soil types for your planting site. This tool along with the advice of a forester will help you make the best tree species selections. FNR 211, *Regenerating Hardwood Seedlings in the Central Hardwood Region: Soils*, provides more information on soil and site factors that influence tree planting decisions.

Consequences of Selecting the Wrong Species

The most obvious consequence of selecting poorly adapted species occurs when seedlings die and the plantation is considered a failure. An example is when seedlings adapted to dry or moist upland sites are planted in bottomlands subject to flooding. The trees might grow well for 10 or more years, but a 50-year flooding event may kill all the trees within a matter of weeks.

More commonly, however, moisture- and nutrient-demanding species are planted on dry sites and simply grow slowly. In this case, the plantation does not realize the growth potential that it might have if properly adapted species had been planted. For example, black walnut is very site sensitive, preferring moist sites with deep, rich soils that are well drained and not subject to prolonged flooding. It grows very slowly on dry upland sites (Figure 1).

What to include in a tree planting plan:

- Your objectives
- Location of the planting site
- Description of soil types and moisture conditions
- Maps and/or air photos
- Species to be planted
- Planting stock type
- Nursery(ies) that seedlings will be ordered from
- Planting design specifications
- Planting equipment
- Site preparation — weed control, fertilization, tillage
- Labor — self, family, volunteer, hired or professional forester
- Financing — expected costs of site preparation, planting, and follow-up maintenance and how those costs will be financed
- Maintenance — includes follow-up weed control, animal damage control, thinning and pruning
- Timetable for all the above activities

Three mistakes to avoid:

Failure to match the right tree species to the site, control weeds and prepare for animal damage (primarily deer, voles and rabbits) are the most common causes of tree plantation failure. These must be addressed in the planning stages.

Select native species to plant

Many exotic species (those not native to our area) planted in the past have become invasive and now cause widespread damage to native plant and animal habitats. Asian bush honeysuckle, once widely planted for soil erosion control, wildlife food and cover, and highway beautification now poses a major threat to forest health and regeneration through its rapid growth and spread into forest environments.

Step 4. Design the Planting

Foresters may have standard recommendations for tree plantings based on site type and management objectives. There are, in fact, many options and tremendous flexibility in designing tree plantings. If you

Table 1. *Recommended tree and shrub species for major planting site conditions in Indiana*

Topographic Position	Site Condition[1]	Adapted Species			
		Large Trees (>50 feet)			Small Trees & Shrubs (<50 feet)
		Species Latitude Suitability in Indiana			
		Northern	Entire State	Southern	
Upland	Very dry – excessively drained soils such as sands, ridgetops and steep south-facing slopes with little soil over bedrock or very rocky and/or very infertile.	Oak – northern pin Pine – jack, red	Cedar – eastern red Gum – black Hickory – mockernut, pignut, shagbark Oak – black, bur, chinkapin, shingle, scarlet, white	Oak – blackjack, chestnut, post Pine – shortleaf, Virginia Persimmon	Crabapple Dogwood – flowering Hawthorn New Jersey Tea Plum – American Redbud Serviceberry
	Dry – well-drained soils on ridgetops and south-facing slopes with moderate soil depth and fertility.	Oak – northern pin Pine – jack, red	Cedar – eastern red [2]Chestnut – American Gum – black Hickory – pignut, shagbark Oak – black, bur, chinkapin, northern red, shingle, scarlet, white	Oak – chestnut, post Pine – shortleaf, Virginia Persimmon Sourwood	Blackhaw Crabapple Dogwood – flowering Hawthorn New Jersey Tea Plum – American Redbud Serviceberry
	Moist – well-drained to moderately well-drained soils on nearly flat to gently sloping land, at base of slopes, in coves, or on north-facing slopes with deep, fertile soils.	Birch – yellow Cedar – northern white Pine – jack, red	[2]Ash – white Cherry – black [2]Chestnut – American Gum – black, sweet Hickory – bitternut, mockernut, pignut, shagbark Kentucky Coffee Tree Locust – black, honey Maple – red, sugar Oak – black, bur, cherrybark, chinkapin, northern red, shingle, Shumard, white Pine – white Persimmon Poplar (true) – cottonwood, hybrid poplar Sycamore Tulip poplar Walnut – black, butternut	Hickory – pecan Magnolia – cucumber, umbrella Pine – shortleaf, Virginia Sourwood Yellowwood	Arrowwood Blackhaw Chokeberry Chokecherry Crabapple Dogwood – flowering, silky, gray Hawthorn Hazelnut Ninebark Pawpaw Plum - American Redbud Serviceberry Witch-hazel
Bottomland	Moist – well-drained to somewhat poorly drained soils with loamy texture on elevated topography in stream and river bottoms or in flatwoods. May be seasonally flooded or with seasonally high water table during dormant season.	[2]Ash – black Birch – yellow Cedar – northern white Tamarack	[2]Ash – green Birch – river Hickory – bitternut, shellbark Maple – silver, box elder Oak – bur, cherrybark, pin, Shumard, swamp white Poplar (true) – cottonwood, hybrid poplar Sycamore	Bald Cypress Gum – sweet Hickory – pecan Oak – swamp chestnut	Buttonbush Dogwood – red osier, silky Elderberry Ninebark Winterberry
	Wet – poorly drained to very poorly drained soils in river bottoms and wet flatwoods. Soils usually fine textured with high clay content. Seasonal to prolonged flooding or high water table and/or prone to flooding during growing season.	[2]Ash – black Tamarack	[2]Ash – green Birch – river Hickory – shellbark Maple – silver, box elder Oak – bur, pin, swamp white Poplar (true) – cottonwood Willow	Bald cypress Oak – overcup, swamp chestnut	Buttonbush Dogwood – red osier, silky Highbush Elderberry Ninebark Winterberry

[1] These are general site descriptions. A forester should be consulted to ensure that well-adapted species are selected for the planting site. Most tree species grow well in mildly to moderately acidic soils (pH 4.5 to 7)

Highlight – species tolerates slightly alkaline soils (pH < 8)

Highlight – species tolerates very acidic soils (pH between 4 and 4.5)

[2] The introduction of insect and disease pests to North America currently make it unlikely that these tree species will thrive and survive over the life of the tree planting. However, in the future, including these species in plantings may be essential to their long-term conservation as insect- and disease-resistant planting stock becomes available.

Douglass Jacobs

Figure 1. *All the trees in this black walnut plantation were planted at the same time. Notice how the diameters of the trees decrease substantially when moving from the more fertile site adjacent to a creek to the hillside site.*

receive government cost share assistance, your tree planting will need to comply with their requirements. A forester will assist you in designing a tree planting that fits your objectives, meets government cost share assistance requirements and achieves the highest likelihood of success.

Species Mixes

After deciding which species are best suited for the planting site, select the species to plant based on your objectives and the species' compatibility with one another. Monocultures (single-species plantings) are very common throughout the world, particularly for plantings where the primary objective is timber or biofuel production. However, monoculture plantings are more prone to insect and disease epidemics that focus on a single species. You may have several goals in establishing your plantation (e.g., wildlife, timber, and stream bank protection), which may best be met using a mixture of species. Mixed plantings grow into forests that are more resilient to pests and environmental extremes and provide a more diverse habitat for wildlife.

Species may be mixed together within rows, separated by rows or grouped into independent clusters. When species are mixed closely within a planting, it is important that all species have similar growth rates. For example, if tulip-poplar and white oak are planted adjacent to each other in a dense planting, the white oak will likely be overtopped, crowded and eventually killed by the shade of the faster-growing tulip-poplar. In this case, white oak should be planted in separate areas of the planting, away from the tulip-poplar, or should be planted at wider spacings. Alternatively, only heavy-seeded species like oak and walnut may be planted, while allowing light-seeded species, like tulip-poplar, to seed in naturally.

Nurse or trainer trees may be planted in alternating rows with crop trees. White pine is often planted with hardwoods to train them to grow straight and to shade lower limbs to provide knot-free logs at a younger age. Eventually, hardwoods will overtop and shade out most of the white pine (Figure 2).

Shrubs planted within a tree planting will likely be shaded out over time as the trees close canopy above them. Shrubs can provide more long-term wildlife benefits by planting them along the edge, especially

Figure 2. *Specialized planting designs help achieve very specific purposes. White pine, planted in alternating rows, help train hardwood trees to grow straight and tall while shading lower limbs to encourage natural pruning. This contributes to better quality timber.*

along the south edge of a tree planting, where they can receive adequate sunlight as the trees grow and mature.

Spacing

Your objectives, species choice, planting equipment, mowing equipment and your future commitment to thinning the plantation, not to mention the amount of money you wish to spend on planting, all affect both within-row and between-row spacing. Figure 3 provides equations for calculating tree spacing and number of trees per acre. Table 2 shows recommended tree spacing for a number of common tree planting objectives.

When growing trees for high-quality timber, higher planting densities — 680 to more than 1,000 trees per acre (8 ft. x 8 ft. to 5 ft. x 8 ft.) are desirable. However, higher planting densities mean higher planting costs. Dense young stands also require thinning at 10 to 15 years of age to relieve overcrowding. Unfortunately, many landowners in Indiana fail to maintain their tree plantations after planting. You should carefully consider your future commitment to thinning. Lower planting densities may be considered where a high likelihood

exists that desirable natural regeneration will seed in from surrounding forests to provide the higher densities needed for quality timber growth.

If you plan to mow between the rows of your planting, be sure to allow adequate space for your mowing equipment. Remember that the trees will grow and fill the space between the rows, making it increasingly difficult to mow. However, good weed control during the initial one to three years after planting, followed by rapid crown closure in dense plantings, should make mowing an unnecessary task. If certain noxious weeds like Johnson grass or Canada thistle are in your tree planting, your local weed control board may require you to mow or otherwise control them. FNR-213, *Designing Hardwood Tree Plantings for Wildlife*, provides tree planting design principles and ideas for improving wildlife habitat. See also Purdue Forestry and Natural Resources' *Habitat Management for Wildlife* webpage, https://extension.purdue.edu/pondwildlife/wildlife.html for recent content on improving wildlife habitat on your property.

$$\text{TPA} = \frac{43560\ \text{ft}^2 / \text{A}}{\text{Space}_{wr}\ (\text{ft}) \times \text{Space}_{br}\ (\text{ft})}$$

$$\text{Spacing}\ (\text{ft}^2) = \sqrt{\frac{43560\ \text{ft}^2 / \text{A}}{\text{TPA}}}$$

$$\text{No. of Trees Needed} = \frac{\text{A}_p \times 43560\ \text{ft}^2 / \text{A}}{\text{Space}_{wr} \times \text{Space}_{br}}$$

TPA = Trees Per Acre
wr = Within Row
br = Between Row
A = Acres
A_p = Total Project Acres

Figure 3. *Equations for calculating number of trees per acre, spacing and total number of trees needed to plant a selected area.*

Table 2. *Recommended tree spacing and stocking rates for common tree planting objectives*

Tree Planting Objectives	Spacing (wr x br,)	Stocking (trees/acre)
Mixed hardwood forest establishment, timber, forest wildlife habitat, multiple forest uses	5 ft x 8 ft to 8 ft x 8 ft	1089 to 680
Black walnut for timber (using standard nursery stock)	8 ft x 8 ft to 8 ft x 10 ft	680 to 545
Nut or seed production	15 ft x 15 ft to 25 ft x 25 ft	194 to 70
Oak savannah	20 ft x 20 ft	109
Pine for erosion control	6 ft x 6 ft to 7 ft x 7 ft	1210 to 889
Pine for wildlife cover and windbreaks	8 ft x 10 ft to 20 ft x 20 ft	545 to 109

5. Prepare the Planting Site

Preparing the site for planting enhances tree seedling establishment, survival and early growth. Often this site preparation means the difference between successful tree plantation establishment and complete plantation failure. Site preparation may include the following:

- Weed control
- Tillage
- Fertilization

FNR-220, *Site Preparation for Tree Planting in Agricultural Fields and Hardwood Forests*, provides more information on preparing the site for planting.

When dense is better

Jack Seifert

If timber production is one of your objectives, relatively dense plantation spacing ranging from 680 to over 1,000 trees per acre provides the following advantages:

1. Results in earlier canopy closure shading out competing vegetation.
2. Improves the genetic potential of the stand by increasing the probability that trees with superior growth traits will be included in the planting.
3. Provides a larger number of potential crop trees to choose from when conducting a first thinning.
4. Stimulates more rapid height growth.
5. Promotes a straighter tree bole with less lateral branching, resulting in increased timber value.

Planting at higher densities will likely require thinning at 10 to 15 years of age.

Figure 4. *Good weed control frees young tree seedlings from other vegetation that competes for water, nutrients, and sunlight.*

Weed Control

Controlling competing vegetation is the most important site preparation activity (Figure 4). It is almost always necessary. A weed control program should be tailored for each tree planting. A forester can do this for you. Weed control should be done a minimum of two growing seasons, preferably three. After that, most tree plantings are established well enough that weedy competitors will not seriously impede tree growth.

Weed control in forest plantings usually involves the use of herbicides. Nonchemical alternatives may be considered. Broad spectrum herbicides such as glyphosate (Roundup®, Glypro®, Accord® and many others) control most species of both annual and perennial grasses, and broadleaf plants. These herbicides can be applied in late summer prior to the spring when planting occurs to control sod-forming grasses and broadleaf perennials. Depending on existing and potential weed competition, a pre-emergent herbicide, like sulfometuron (Oust®) or pendimethalin (Pendulum AquaCap®) may be applied at the time of planting or shortly thereafter to control weed seedlings before they emerge from the soil.

Except for very specific pesticides and applications, federal and state law prohibit applying pesticide directly into any water body. Special care should be taken when applying herbicides near ditches, streams, rivers, lakes, ponds, wetlands, springs, seeps and sinkholes. Each herbicide label provides specific instructions for use near any of these water bodies.

Figure 5. *Following spring bud break, herbicide spray should be directed to avoid overspraying seedlings.*

Tractors drawing tree planting machines are often mounted with herbicide application equipment. Some herbicides are designed to spray over the top of dormant tree seedlings. However, following bud break in the spring, the herbicide spray should be directed to avoid overspraying the tree seedlings. (Figure 5). FNR-224, Weed Competition Control in Hardwood Plantations, provides more information on the use of herbicides as well as non-herbicide alternatives for weed control.

Many foresters are licensed pesticide applicators and can plan and carry out the weed control program in your tree plantings.

Non-herbicide alternatives for weed control in tree plantings:

- Tilling
- Mulches
- Weed cloth or mats
- Tree-compatible groundcover vegetation
- Mowing

Mowing by itself may only encourage sod-forming grasses, thus intensifying below-ground competition for water and nutrients.

A strong word of caution

The misapplication of herbicides can kill or damage trees and other non-target vegetation. The mishandling of pesticides may be harmful to the environment, drinking water supplies, yourself and others. If you are inexperienced, seek training through your county Extension office before attempting to apply herbicides.

Tillage

Soil compaction and the presence of a hard pan in the soil limit tree root development. Plowing or subsoiling enhances tree root growth and helps to improve soil aeration and water drainage. Whether you hand plant or machine plant, tillage improves planting conditions by loosening the soil, making it easier to dig and replace soil around tree roots. It also helps control competing vegetation.

The disadvantages of tilling include cost, access to equipment, poor access to planting site with equipment, and increased risk of soil erosion. In most cases tillage is not essential. See *FNR-220* for more information.

Fertilization

Trees have low nutrient requirements compared to agricultural crops. Foresters rarely recommend fertilizing tree plantations in Indiana. Yet tree growth on many sites would likely benefit from fertilization.

If you are planting on a poorly managed, eroded site, you may have nutrient deficiencies. Contact your local county Purdue Cooperative Extension Service for information on soil testing and fertilizer recommendations.

Fertilizers may be broadcast or spread in a 2-foot band in the planting row several weeks to a month prior to planting. Applying conventional, salt-based fertilizer too near the time of planting increases the risk of damage to new seedling roots. Controlled release forms of fertilizer may be applied at the time of planting. These fertilizers release small amounts of plant nutrients over an extended period of time. Thus, they avoid salt damage to young tree roots and provide the optimum amount of nutrients as the trees need them.

Conventional, concentrated fertilizers should NOT be placed directly into the tree planting hole. This will damage tree roots and possibly kill the tree. Avoid placing fertilizer within 50 feet of streams, lakes, springs, and sinkholes.

Fertilization also stimulates weed growth. Thus, fertilization should not be done in young plantings without good weed control. See FNR-215, *Fertilizing, Pruning, and Thinning Hardwood Plantations* and FNR-220 for more information on fertilization in hardwood plantations.

Step 6. Obtain Quality Seedlings

Obtaining good-quality seedlings is crucial to the success of your tree planting. Plantings may be established by sowing seed directly into the field. However, success with this method in Indiana is mixed and unpredictable, making it less preferred by many foresters than using nursery-grown seedlings. Because direct seeding has had limited operational use in Indiana, it is not addressed in this publication.

Where to Purchase Seedlings

Purchase seedlings only from reputable nurseries. Plan to order seedlings the fall prior to a spring planting. Tree and shrub seedlings may be ordered from state nurseries operated by the Indiana Division of Forestry or from private nurseries. (see Appendix for nursery contact information) Orders are filled on a first-come, first-serve basis, so ordering early will help ensure that your selected species will be available. The state nursery begins accepting orders the first business day in October.

Jack Seifert

Figure 6. *Indiana Dept. of Natural Resources, Division of Forestry's Vallonia Nursery.*

Seedlings purchased from Indiana's state nurseries are grown mostly from local seed sources and are adapted to our growing conditions. Be sure that seedlings purchased from private nurseries are well adapted to Indiana conditions by inquiring about the source of their seed.

Types of Nursery Stock

Nearly all the seedlings used to establish forestry plantations in Indiana are bare-root seedlings that are grown in nursery beds in fields (Figure 6). Following the

Figure 7. *Containerized hardwood seedlings are usually larger than bare-root seedlings.*

onset of dormancy in the fall, seedlings are lifted out of their beds, packed in bundles with sphagnum moss to keep their roots moist, and kept in cold storage so they remain dormant until planting time.

Other types of tree planting stock include cuttings and seedlings grown in containers. Large-size container stock, usually grown in 1- to 5-gallon plastic pots, is available for many tree species, including genetically superior walnut produced as grafted seedlings.

Containerized hardwood seedlings are more consistent in size and quality and are usually larger than bare-root seedlings. Container stock is very expensive compared to bare-root stock and is not used in Indiana forestry or conservation plantings except for very specialized purposes (Figure 7). Use of containerized stock is most prevalent in the western United States and other parts of the world where conifers are primarily planted. Research is ongoing to develop recommendations for the use, planting and care of containerized hardwood planting stock in Indiana.

Stem cuttings are sometimes used to establish hybrid poplar or willow on specific sites. Unlike containerized stock, they are not expensive, but they also are used only in special circumstances.

Your planting site conditions, along with your planting equipment, will affect the planting stock type you should choose. For instance, if you plan to plant the seedlings where tall competing vegetation is likely to grow, then tall seedlings are desirable. On droughty sites, seedlings with large roots relative to their shoots are preferred. Machine planters can accommodate most common bare-root stock types and some smaller containerized stock, but not large containerized seedlings. Similarly, if the ground is very rocky then a smaller seedling may be necessary to ensure that the roots are planted correctly in the ground.

Evaluating Seedling Quality

Quality seedlings are healthy and vigorous, with well-balanced stems and roots — meaning, the stem is not too big for the root system to support and maintain it once outplanted. For most forestry and conservation

Univ. Minnesota Coop.Ext.

Jack Seifert

Figure 8. *The root collar (top) is where stem and root meet and is very close to the planting depth in the nursery bed. Stem caliper (bottom), as measured at the root collar, and numbers and size of roots are good indicators of hardwood seedling quality.*

plantings, hardwood bare-root seedling heights should range from 18 to 36 inches tall, and stem calipers should range from 1/4 to 3/4 inch (Figure 8). For most hardwood species 10 or more large lateral roots and numerous smaller fibrous roots are desirable. Pine seedling heights should range from 9 to 18 inches, and stem caliper should range from 1/8 to 3/8 inch.

Acceptable size criteria vary by species. A typical bag of bare-root stock contains seedlings with a range of sizes.

Foresters and other experienced tree planters judge seedling quality by looking at their size and vigor. They may discard the smallest 5% to 15% of seedlings within each bag. If overall seedling size appears to be smaller than desired, plant seedlings at a higher density, since some of these small seedlings will not live.

Seedlings should be dormant when received and planted. Buds should not be swelling or opening, and leaves should not be flushing out. Properly stored seedlings will have moist roots that are free of mold. Seedlings received with dry roots are unacceptable and will likely be dead at planting. Finally, seedlings should be free of evidence of any insect or disease problems. See FNR-210, *Planting Hardwood Seedlings in the Central Hardwood Region* for more information on planting stock.

Step 7. Care for the Seedlings

Most reputable forest tree nurseries take exceptional care to ensure that seedlings are handled properly from the time of lifting from nursery beds until they are delivered to the customer. The customer must also carefully transport, handle and store the seedlings from time of pickup until planting. See FNR 210 for more information on seedling care.

Transporting

When transporting seedlings, protect them from the sun and wind to prevent them from drying. When transporting seedlings in open truck or trailer beds, do so on cool, cloudy or even rainy days when possible. On sunny days, pick up seedlings either in the morning or evening or cover them with a tarp. Be sure containerized trees have recently been watered. It is important to remove any sharp objects or chemicals from truck or trailer beds that might damage seedlings during transport. To ensure good air circulation and prevent overheating or crushing, seedlings should not be stacked too high. If seedlings are being shipped by a commercial carrier, exposure to high temperatures becomes a concern later in the planting season. In this case, an early spring shipping date should be requested. When shipping large loads, the use of a refrigerated truck or trailer may be needed.

Storage at Home

Ideally, seedlings should be planted within 24 hours of leaving the nursery. If this is not feasible, bare-root seedlings may be stored for several days in a cool, damp basement or cellar. For very short-term storage, if temperatures are less than about 70° F, seedlings may be left outside in a shaded area that is also sheltered from the wind. Garages are usually poor seedling storage locations because they tend to get too hot and dry.

When storing seedlings for more than several days, seedling packages should periodically be opened to inspect the roots. If the roots are beginning to dry out, spray them down with a modest amount of water and rewrap the packages tightly. Stack seedling bags no more than one to two deep and two high, or use spacers between bags to facilitate air circulation.

The potting soil or root medium in containerized seedlings should be checked daily and watered only when beginning to dry out. Cuttings should be kept in their plastic bags and refrigerated with their buds pointing upward until their pre-planting preparation described in the following section.

At the Planting Site

Bring only the number of seedlings to the planting site that you expect to plant in one day. Protect seedlings from wind and sun. If natural shade and wind protection is unavailable, a tarp with a reflective surface provides adequate shelter.

Open only those bundles of seedlings that are needed for immediate planting. The remaining seedlings should remain under shade. If you use only a partial bundle, be sure to moisten the roots, rewrap the bundle and return the bundle to the shade until you are ready to plant more seedlings.

When finished planting for the day, return unplanted seedlings to cold storage unless weather conditions are cool, cloudy, and/or rainy and you plan to return the next day to finish planting.

Preparing Seedlings for Planting

Usually, after removing them from bundles, nothing additional needs to be done to prepare bare-root seedlings for planting. In some regions, pruning seedling roots prior to planting is a common procedure. When planting hardwoods with a machine planter onto a former field, pruning of roots is almost always unnecessary because the size of the planting trench is usually adequate to accommodate the entire root system. When hand planting, some seedlings with unusually long roots may need to be pruned to properly fit them into the planting hole. However, root pruning should be done only when absolutely necessary. It is always preferable to use the appropriate planting tool to create the proper size planting hole rather than to prune roots on a majority of seedlings to accommodate a particular size planting hole. If roots appear to be drying, soaking them in a bucket of water for 30 minutes to an

hour immediately prior to planting will rehydrate them. This is especially important if soil conditions are drier than optimal.

The only preparation required for containerized stock is to water them immediately prior to planting. Cuttings should be soaked with the bottom end down in 4 inches of water for two to five days prior to planting.

Step 8. Planting

Tree seedlings are planted either by hand or by machine. The choice of hand or machine planting depends on how many trees or how much acreage you are planting, the terrain and planting conditions, the availability of equipment or resources to buy or rent planting equipment, and the availability of labor and/or financial resources to hire a forester or professional tree planting crew.

Figure 9. *Hand tools commonly used for tree planting. From left: A mattock, a garden spade and a KBC bar.*

Hand Planting

Hand planting is ideal for small acreages (individual areas of less than three acres) or where the terrain is too rough, rocky or steep for machine planters. If affordable labor is available, larger acreages may be hand-planted. Small numbers of trees may easily be planted using an ordinary garden spade. Professional hand planting crews often use dibble bars or KBC bars (Figure 9). KBC bars are designed for planting in harder, denser soils and in rocky soils. Either of these specialized tools may improve hand planting efficiency over that of a garden spade under a wide range of field and forest planting conditions. However, where large-rooted seedlings are planted, a spade may prove most efficient.

Figure 10. *Tree planting machines increase tree planting production manyfold over hand planting. Many forestry consultants use tree planting machines.*

Machine Planting

Machine planters improve tree planting efficiency manyfold over hand planting. A three-person hand-planting crew may be able to plant 2,000 moderate-size seedlings in a day. The same three-person crew on a machine planter could plant between 6,500 and 13,000 seedlings a day. Tree planting machines come in a variety of sizes and configurations (Figure 10), all of them drawn by a tractor or dozer. Large planting stock requires a bigger machine that opens a slit deep enough to accommodate large roots. Conventional machine planters work best in open field conditions. They cannot be used on steep slopes, rocky soil or where thick debris or brush remains, such as after a timber harvest. Some foresters and professional tree planters in Indiana own machine planters.

A variation on machine planting is the use of tractor or skid steer mounted augers (Figure 11). Tracked

Figure 11. *The versatile skid steer, mounted with an auger, can be used to plant trees on rougher terrain, in rockier soils and around logging slash and stumps where machine planters would not work.*

skid steers can be used on steeper, rougher terrain, in rocky soil, and where logging debris, brush, stumps and other obstacles are present. The hydraulic thrust on a skid steer also speeds the augering of planting holes compared to tractor PTO-driven augers. Different size auger bits may be used to more efficiently create planting holes sized to the planting stock. Skid steers are rugged, dependable, maneuverable and readily available as rentals. A less expensive, but more labor intensive, option is the use of an auger powered by a 2-cycle engine. These may work well for planting in remote, inaccessible sites.

Planting Conditions

Good planting conditions occur on most upland tree planting sites in Indiana between March and May, depending on spring weather. Some bottomland soils do not dry out sufficiently until June or July, depending on weather and spring flooding. In southern Indiana, fall planting can be done where adequate ground cover or overhead cover is present to prevent frost heaving in freezing weather. However, some nurseries may not provide fall pickup or delivery.

Ideal weather for tree planting is overcast with temperatures between freezing and 70º F with high humidity. This reduces the chances of seedling desiccation or overheating. Of course, trees can be planted in sunny, dry weather with precautions taken to prevent root drying.

Tree planting should wait until the soil is workable. Planting in saturated soil alters soil structure around tree roots, creating less favorable rooting conditions. Closed and packed machine planting slits in saturated soil with high clay content tend to open up as the soil dries, sometimes exposing tree roots to drying. A simple way to test soil moisture suitability is to squeeze a clump of soil in your hand until it forms a ball. Then gently compress the soil ball between your thumb and fingers. If it readily crumbles, soil moisture is suitable for tree planting. If it stays "gummed up" in a sticky ball, the soil is too wet for tree planting.

Planting Technique

Good planting technique protects the health of the seedling during the planting process and provides the best conditions possible for the seedling to grow quickly. Through all stages of the planting process, roots should be kept cool and moist. While planting, keep seedlings in a bucket, box or tree planting bag with the roots packed in moist sphagnum moss. This can be the same moss the seedlings were packaged in at the nursery.

Whether planting by machine or by hand, the planting hole or slit must be large enough to fully accommodate the seedling root system so no roots are sticking out and exposed to the air, or are too cramped, with the roots turned up in a "J" shape or to the side in an "L" shape (Figure 12). Figure 13 illustrates hand planting, step-by-

Figure 12. *Avoid common planting errors.*

step, using a dibble bar or KBC bar. Larger holes may be made with these tools to accommodate large-rooted seedlings. This is done by inserting the bar two or three times side-by-side and by driving them deeper in to the soil. Figure 14 illustrates hand planting using a garden spade.

Machine planting depth is controlled by the overall size of the machine, the size of the planting shoe, and three-point-hitch adjustments on the tractor. Larger, heavier machines with larger planting shoes can cut a deeper planting slit, provided the tractor has sufficient power and traction to pull the machine at those depths.

The seedling's root collar (Figures 8 and 12) should be planted at about the same depth it was in the nursery bed or up to 1 inch deeper. The planting hole or slit should be closed to provide good root-soil contact without excessively compacting the soil around the roots. No air pockets should remain around the roots. The seedlings should be erect. To test whether a seedling was properly planted, gently grasp the end of the stem between thumb and forefinger and firmly, but not forcefully, tug on it. If planted properly, the seedling will remain firmly planted. If not planted properly, it will slip out of the ground when tugged on in this manner.

The proper closing of a slit with a tree planter is accomplished with the weight of the planter and its rider(s) on the packing wheels. Where grass sod has not been removed in site preparation, proper slit closure and packing may not occur, thus exposing roots to drying.

Cuttings are planted using any tree planting tool. They should be planted 8 to 10 inches deep, so that not more than 1 inch of the cutting is above ground. Orient the cuttings so that the buds are pointing upward. Pack the soil firmly around the cutting.

9. Post-Planting Care

New tree plantings require follow-up maintenance to ensure their establishment and success. Follow-up maintenance may include:

- Weed control
- Protection from insects, disease, and mammals
- Thinning and pruning

Weed Control

Good weed control should be maintained for the first two to three years. The information on weed control under the Preparing the Site section in this publication is equally applicable to follow-up weed control. FNR-220 and FNR-224 provide more information on weed control.

Protection

Most people think of controlling insects and disease when they think of forest protection. There are too many potential insect and disease pests of trees to attempt to describe them in this publication. *Environmental and Management Injury in Hardwood Tree Plantations* (FNR-217), *Insects Affecting Hardwood Tree Plantings* (FNR-227-W), and *Diseases in Hardwood Tree Plantings* (FNR-221) give more information on diseases and

Figure 13. *Dibble and KBC bar planting steps.*

Figure 14. *Garden spade planting instructions.*

herbicide and environmental injury in new tree plantings. Contact your local county Cooperative Extension Service for help in diagnosing tree pest problems and in collecting specimens for diagnosis.

While insects and disease may threaten a tree planting, certain mammals, including voles, rabbits and deer, more commonly pose a threat to new tree seedlings. Where deer populations are high, newly planted tree seedling survival and growth will suffer unless measures are taken to protect seedlings. Deer browse on tree twigs and buds, reducing seedling vigor and causing the tree to grow more like a bush.

Deer browse damage.

Fencing, repellents, tree shelters and wire cages are all methods for protecting tree seedlings from deer damage. Reducing deer populations through hunting is the most practical and economical solution and the only long-term solution to deer damage in forest environments. See FNR-136, *Electric Fences for Preventing Browse Damage by White-tailed Deer*, *Controlling Wildlife Damage in Hardwood Plantations* (FNR-216) and *How to Build a Plastic Mesh Deer Exclusion Fence* (FNR-486-W) for more information on deer damage control and control of other forms of animal damage. For a more in-depth discussion of how deer are impacting our forests and how to manage deer damage, see Purdue Forestry & Natural Resources Deer Impact Toolbox, https://extension.purdue.edu/pondwildlife/deer-impact.html.

Figure 15. *Thinning in a plantation.*

Thinning and Pruning

Depending on the initial spacing and the number of seedlings naturally seeding in, thinning may be necessary sooner or later to prevent slow tree growth. The initial thinning in a plantation is usually needed at sometime between 10 and 20 years of age. Pruning is not essential to the health of trees and is done primarily to make better-formed trees that produce more valuable timber. Slower-growing trees will likely be dead by the time the stand reaches maturity. The more widely spaced the trees are, the more pruning is required to obtain good timber form. Close spacing encourages vertical growth and the natural self-pruning of lower limbs and reduces the need for you to prune. Of course, spacing must be balanced with thinning to promote optimal tree health and growth. Talk with a forester before attempting to thin or prune your trees. FNR-215 and FNR-IDNR-414, *Forest Improvement Handbook*, provide more information on thinning and pruning.

10. Take a Break! … a Tax Break

Expenses incurred for tree and shrub planting for conservation purposes may be eligible as a federal income tax deduction on farm income under Sec. 175 of the Internal Revenue Code. The *Reforestation Tax Deduction and Amortization* provision of the federal income tax code recognizes the long-term nature of the tree planting investment for timber production. You may expense or deduct 100% of your tree planting costs, up to a maximum of $10,000 per year if the trees are being planted for timber. The balance of your tree planting

National Timber Tax Website:
www.timbertax.org

costs may be amortized over a seven-year period. Tree planting costs include plan preparation, site preparation, seedlings, planting labor and equipment, weed control, and protection costs. Eligible costs include the services of a forester.

For the most up-to-date information on tree planting tax provisions, see the National Timber Tax Website (www.timbertax.org). FNR-214, *Financial and Tax Aspects of Tree Planting*, provides detailed information.

Tree plantings are also eligible to be enrolled in the *Classified Forest and Wildlands* program. If your tree planting qualifies, the enrolled acreage will be assessed at a significantly reduced value per acre for property tax purposes. Contact your state district forester for more information on *Classified Forest and Wildlands*.

References

Jacobs, D.F., Ross-Davis, A.L., Davis, A.S. 2004. Establishment success of conservation tree plantations in relation to silvicultural practices in Indiana, USA. *New Forests* 28:23-26.

Ross-Davis, A.L., Broussard, S.R., Jacobs, D.F., Davis, A.S. 2005. Afforestation behavior of private landowners: an examination of hardwood tree plantings in Indiana. *Northern Journal of Applied Forestry* 22:149-153.

Additional Information on Tree Planting

The tree planting series referenced in this Extension publication is titled *Planting and Care of Fine Hardwood Seedlings*. It is a cooperative production of the Hardwood Tree Improvement and Regeneration Center in Purdue University's Department of Forestry and Natural Resources, Purdue Cooperative Extension Service and the Northern Research Station of the U.S. Forest Service. The entire series may be ordered as Purdue Extension Publication FNR-235 from:

Purdue Extension, The Education Store

301 S. 2nd St.
Lafayette, IN 47901
Ph. 765-494-6794
email: edustore@purdue.edu
web: https://edustore.purdue.edu

Titles in the series:

Planting Hardwood Seedlings in the Central Hardwood Region, Paula M. Pijut. FNR-210

Regenerating Hardwoods in the Central Hardwood Region, Felix Ponder Jr. and Phillip E. Pope. FNR-211

Nursery Production of Hardwood Seedlings, Douglass F. Jacobs. FNR-212

Designing Hardwood Tree Plantings for Wildlife, Brian J. MacGowan. FNR-213

Financial and Tax Aspects of Tree Planting, William L. Hoover. FNR-214

Fertilizing, Pruning, and Thinning Hardwood Plantations, James McKenna and Keith Woeste. FNR-215

Diagnosing and Controlling Wildlife Damage in Hardwood Plantations, James McKenna and Keith Woeste. FNR-216

Environmental and Management Injury in Hardwood Tree Plantations, John Seifert and Keith Woeste. FNR-217

Native Hardwood Trees of the Central Hardwood Region, Paula M. Pijut. FNR-218

Importance of Hardwood Tree Planting, Douglass F. Jacobs. FNR-219

Site Preparation for Tree Planting in Agricultural Fields and Hardwood Forests, Charles H. Michler and Ron Rathfon. FNR-220

Diseases in Hardwood Tree Plantings, Paula M. Pijut. FNR-221

A Guide to Legal and Genetic Terminology Used in the Sale of Hardwood Seeds and Planting Stock, Keith Woeste and Victoria Saker Woeste. FNR -222

Planning the Tree Planting Operation, Richard Meilan. FNR -223

Weed Competition Control in Hardwood Plantations, John R. Seifert, Marcus F. Selig, and Robert C. Morrissey. FNR-224

Enrichment Planting of Oaks, Robert C. Morrissey, John Seifert, Nathan King and Marcus Selig. FNR-225

Resources and Assistance Available for Planting Hardwood Seedlings, Lenny D. Farlee. FNR-226

Insects Affecting Hardwood Tree Plantings, Bradley D. Barnd, Paula M. Pijut, and Matthew D. Ginzel. FNR-227-W

Causes of Gummosis in Black Cherry (*Prunus serotina*), Bradley D. Barnd and Matthew D. Ginzel – FNR-229-W

Invasive plant species in hardwood tree plantations, Rochelle R. Beasley and Paula M. Pijut – FNR-230-W

Related Extension Publications:

FNR-114, *Spray Equipment Calibration*

FNR-136, *Electric Fences for Preventing Browse Damage by White-tailed Deer*

FNR-IDNR-414, *Forest Improvement Handbook*

FNR-486-W, *How to Build a Plastic Mesh Deer Exclusion Fence*

Appendix

Tree and shrub seedling nurseries

IDNR, Division of Forestry

Vallonia State Nursery
2782 W. County Road 540 S.
Mail: P.O. Box 218 Vallonia, IN 47281-9729
Phone: (812) 358-3621
Fax: (812) 358-9033
www.in.gov/dnr/forestry/tree-seedling-nurseries/

Private Nurseries

Reforestation, nurseries, genetics resources: rngr.net/resources/directory

Buy Natives Directory: indiananativeplants.org/landscaping/where-to-buy/

Herbicides Used for Weed Control in Forestry and Conservation Tree Plantings in Indiana

Herbicide Type[1]	What it Controls[2]	Herbicide Common Names	Herbicide Trade Names[3]
Pre-emergent	annual broad spectrum	simazine	Princep
	annual grass + some annual broadleaf	pendimethalin	Pendulum
		oryzalin	Surflan
Post-emergent	annual + perennial broad spectrum	glyphosate	Roundup Pro, Accord, Glypro
	annual + perennial broadleaf selective	2,4-D	AM-40, Weedar 64, Weedone
		triclopyr	Garlon
		clopyralid	Transline
		metsulfuron	Escort
	annual + perennial grass selective	sethoxydim	Poast
		fluazifop	Fusilade
Pre- and Post-emergent	annual + perennial broad spectrum	sulfometuron	Oust
		hexazinone	Velpar

[1] Pre-emergent means the herbicide kills the weed as it germinates, before it emerges from the soil. Post-emergent herbicides kill weeds already established.

[2] Broad spectrum means the herbicide controls both grass and broadleaf weeds.

[3] Reference to specific trade names does not imply endorsement of those products by Purdue University. Other companies may manufacture and market listed herbicides under different brand names.

The United States Forest Service RNGR team (Reforestation, Nurseries, and Genetics Resources) has a Web site that provides a search function for nurseries and other plant material providers at http://www.rngr.net/

About the Authors:

Ron Rathfon, Extension Forester
Department of Forestry and Natural Resources
Purdue University
11371 Purdue Farm Road
Dubois, IN 47527-9666
(812) 678-5049
ronr@purdue.edu

Douglass Jacobs, professor,
van Eck Chair of Forest Biology
Purdue University Department of
Forestry and Natural Resources
Hardwood Tree Improvement and Regeneration Center
Pfendler Hall
715 W. State St.
West Lafayette, IN 47907-2061
(765) 494-3608
djacobs@purdue.edu

Lenny D. Farlee, Extension Forester,
Hardwood Tree Improvement and Regeneration Center
Purdue University Department of Forestry and Natural Resources
Pfendler Hall
715 W. State St.
West Lafayette, IN 47907-2061 (765) 494-2153
lfarlee@purdue.edu www.htirc.org