Department of Forestry and Natural Resources, Purdue University, and the
Indiana Department of Natural Resources, Division of Forestry

FNR-IDNR-36

Indiana Department of Natural Resources
Division of Forestry

PURDUE UNIVERSITY

Planting Forest Trees and Shrubs in Indiana

10 Steps to Success

Ron Rathfon, Extension Forester
Doug Jacobs, Associate Professor of Forestry, Forest Regeneration Specialist
Lenny Farlee, Extension Forester

There are many reasons to plant trees and shrubs, including providing or improving wildlife habitat; providing future timber production; improving or protecting environmental quality; carbon sequestration; windbreaks; landscape beautification; Christmas trees; and more. Successfully planting trees and shrubs is much more than sticking the right end in the dirt. It requires proper planning, preparation, technique, and follow-up maintenance. This publication provides an abbreviated 10-step approach to successfully plant and establish healthy, productive forest and conservation plantings in Indiana. The Department of Forestry and Natural Resources at Purdue University, the USDA Forest Service, and the Hardwood Tree Improvement and Regeneration Center have cooperatively produced a series of publications on hardwood tree planting in the North Central states entitled *Planting and Care of Fine Hardwood Seedlings*. 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

Seventy-five percent of the annual tree plantings in Indiana are planted by first time tree planters (Ross-Davis and others, 2005). Planting your own trees may be feasible if 1) you are planting a small area (no more than 2 – 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 for making your tree planting plans, as well as assist in securing government cost-share funding to help pay for tree planting expenses. Purdue Extension Foresters provide information, offer tree planting workshops, and refer landowners to other sources of assistance.

Contact Information for Foresters

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

Directory of Professional Foresters:

Indiana Forestry & Woodland Owners Assoc.
1007 N 725 W
West Lafayette, IN 47906
(765) 583-3501
www.ifwoa.org

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

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 also 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. Purdue Cooperative Extension Service publications FNR-87 *Forestry and Wildlife Management Assistance Available to Indiana Landowners: Providers, Organizations, and Programs* and FNR-226 *Resources and Assistance Available for Planting Hardwood Seedlings* provide more detailed information on landowner assistance.

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! Successful tree planting is much more than just buying the trees and sticking them in the ground. 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 the questions, "Why are you planting trees?" and "What do you hope the tree planting will do for you, others, future generations, and the environment?" Other 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; and planting maintenance, including weed control and animal damage control. A budget should also be included showing how the 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.

Step 3. Select the Right Species

Indiana has over 100 native tree species. This diversity of tree species 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. Although exotic species, like Asian bush honeysuckle and autumn olive, were more commonly planted in the past, their use today is strongly discouraged because of their invasiveness and disruption of native plant and animal habitats.

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) 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

There are many different 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, available from your local Natural Resources Conservation Service office, describes the soil of 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.

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

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.

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.

More commonly, however, the 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, fine textured soils that are well drained and not subject to prolonged flooding. It grows very slowly on dry upland sites (Figure 1).

Doug 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.*

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	Bayberry Crabapple Dogwood – flowering Hawthorn 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 Chestnut – **American** Gum – black Hickory – pignut, shagbark Oak – black, bur, **chinkapin**, northern red, shingle, scarlet, white	Oak – chestnut, post Pine – shortleaf, **Virginia** Persimmon Sourwood	Bayberry Blackhaw Crabapple Dogwood – flowering Hawthorn 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	Ash – white Cherry – black Chestnut – American Gum – black, sweet Hemlock – eastern 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 Cranberry – highbush Dogwood – flowering, silky, gray Hawthorn Hazelnut Ninebark Pawpaw Plum - American Redbud Serviceberry Witch-hazel

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

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	
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.	Ash – black Birch – yellow Cedar – northern white Tamarack	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 Cranberry – Highbush 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.	Ash – black Tamarack	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 Cranberry – 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)

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 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, meeting government cost share assistance requirements, and achieving the highest likelihood of success.

Species Mixes

After deciding on which species are best suited for the planting site, you must 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 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.

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.*

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).

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 over 1000 trees acre (8 ft x 8 ft. to 5 ft. x 8 ft.), are desirable. However, higher plant-

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

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

$$No.\ Trees\ Needed = \frac{A_p \times 43560\ ft^2/A}{Space_{wr} \times Space_{br}}$$

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 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

ing 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 following planting, so 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 following 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 102, *Woodland Wildlife Management*, and FNR 213, *Designing Hardwood Tree Plantings for Wildlife*, provide tree planting design principles and ideas for improving wildlife habitat.

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 Agricultural Fields and Hardwood Forests*, provides more information on preparing the site for planting.

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

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.

Jack Seifert

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*

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. Non-chemical alternatives may be considered.

Broad spectrum herbicides such as glyphosate (Roundup®, Glypro®, Accord®, and 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 simazine (Princep®) may be applied at the time of planting or shortly thereafter to control weed seedlings before they emerge from the soil. 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.

Pesticides should not be applied over or within 25 feet of streams, ponds, lakes, sinkholes, or springs.

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

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

Tillage

Soil compaction and the presence of a hard pan in the soil limit tree root development. Plowing or subsoiling helps to improve soil aeration and water drainage, and enhances tree root growth. 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 to planting site with equipment, and increased risk of soil erosion. In most cases tillage is not essential. See FNR-220 for more information.

Non-herbicide alternatives for weed control in tree plantings:

- **Tilling**
- **Mulches**
- **Weed cloth or mats**
- **Tree-compatible groundcovers**
- **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 your 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.

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 ft. 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 *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 your 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 list of nurseries). State nurseries use a lottery system to fairly distribute the seedlings. Orders should be sent prior to the lottery drawing deadline in October. After the lottery, orders are filled on a first-come-first-serve basis.

Seedlings purchased from Indiana's state nurseries are grown 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 onset of dormancy in the fall, seedlings are lifted

Jack Seifert

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

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-sized container stock, usually grown in one- to five-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

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

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 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 inches (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

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.*

9 to 18 inches and stem caliper should range from 1/8 to 3/8 inches. 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 5-15% 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 seedlings up 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. If temperatures are less than about 70º F, seedlings may be left outside in a shaded area that is also sheltered from the wind for very short-term storage. 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 re-wrap the packages tightly. Stack seedling bags no more than one to two deep and two high, or use spacers in 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

Only bring 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, re-wrap 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 are planning to return the next day to finish planting.

Preparing Seedlings for Planting

Usually, there is nothing additional that needs to be done to prepare bare-root seedlings for planting after removing them from bundles. 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, there may be some seedlings with unusually long roots that will need to be pruned to properly fit them into the planting hole. However, root pruning should only be done when absolutely necessary. It is always preferable to use the appropriate planting tool to create the proper sized

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 re-hydrate 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 2 to 5 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.

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 9. *Hand tools commonly used for tree planting. Left to right are a mattock, a garden spade, and a KBC bar.*

Machine Planting

Machine planters improve tree planting efficiency many fold over hand planting where larger acreages are being planted. A three-person hand-planting crew may be able to plant 2000 moderately-sized 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 being 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 following a timber harvest. Some foresters and professional tree planters in Indiana own machine planters.

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

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

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.*

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. Fall planting can be done in southern Indiana 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.

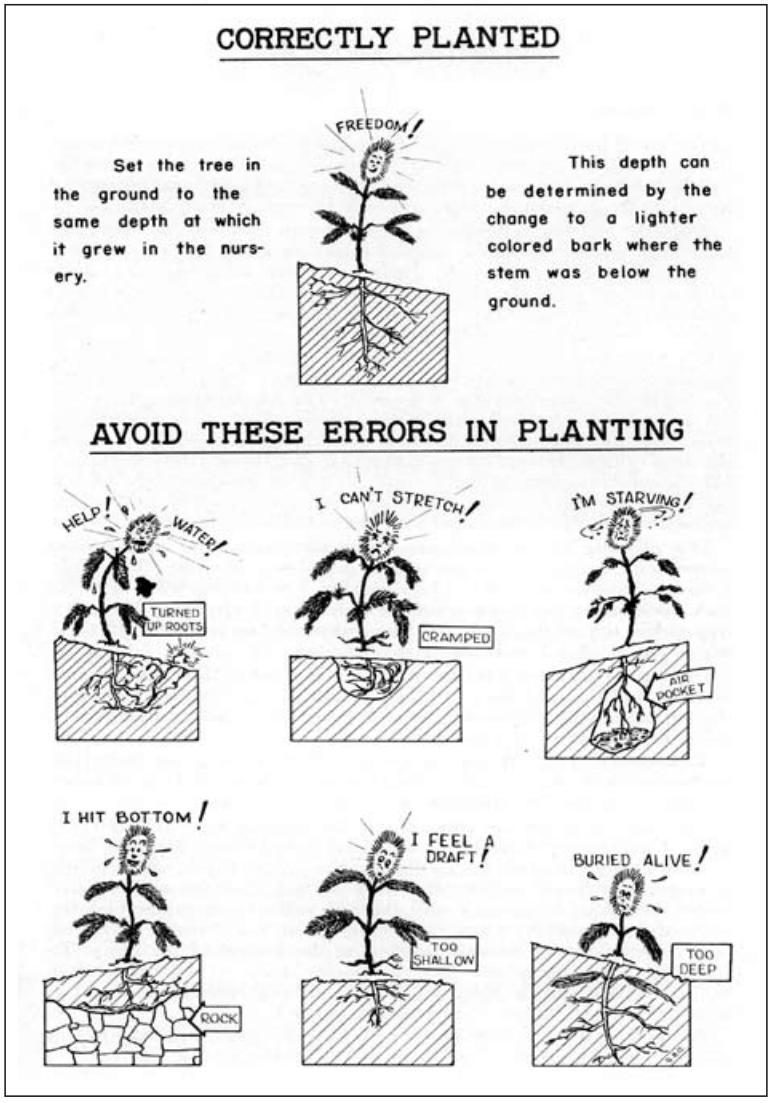
Ideal weather for tree planting is overcast with temperatures between freezing and 70° F with high humidity. This reduces the chances of seedling desiccation or overheating. Of course, trees can be planted in sunny, dry weather with precautions taken to prevent root drying.

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

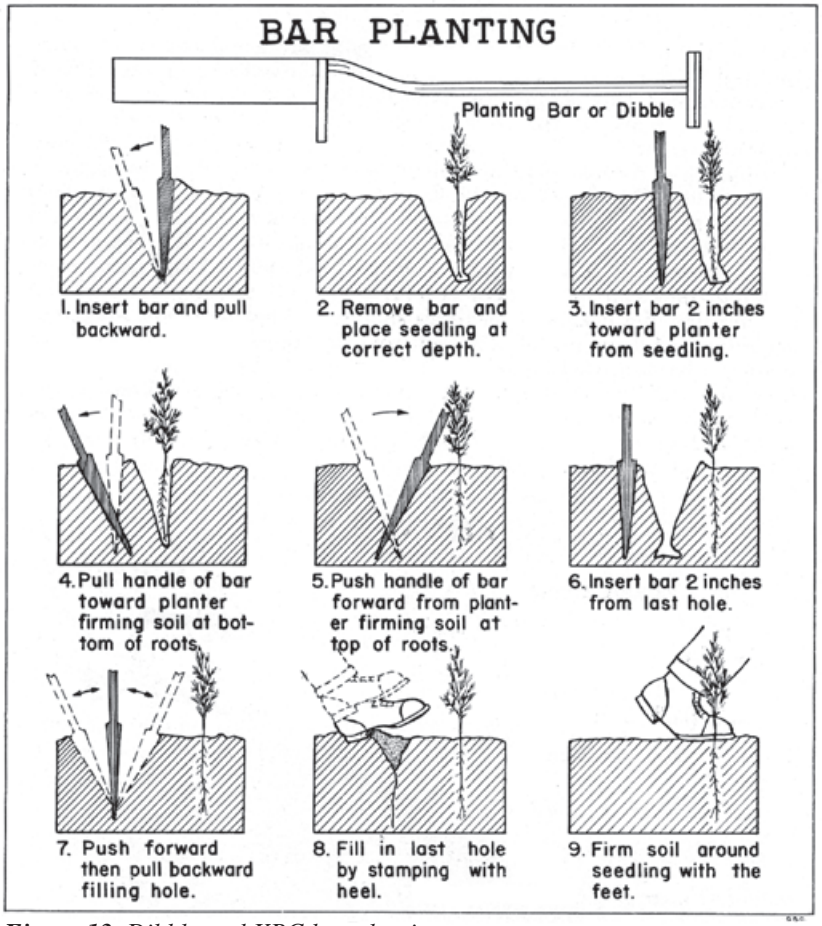
Good planting technique protects the health of the seedling during the planting process and provides the best conditions possible for the seedling to grow quickly. Through all stages of the planting process, roots should be kept cool and moist. While planting, keep seedlings in a bucket, box, or tree 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-step, using a dibble bar or KBC bar. Larger



Pennsylvania Bureau of Forestry

Figure 12. *Avoid common planting errors*



Pennsylvania Bureau of Forestry

Figure 13. *Dibble and KBC bar planting steps*

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 one 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 eight to 10 inches deep, so that not more than one inch of the cutting is above ground. The cuttings should be oriented so that the buds are pointing upward. The soil should be packed 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:

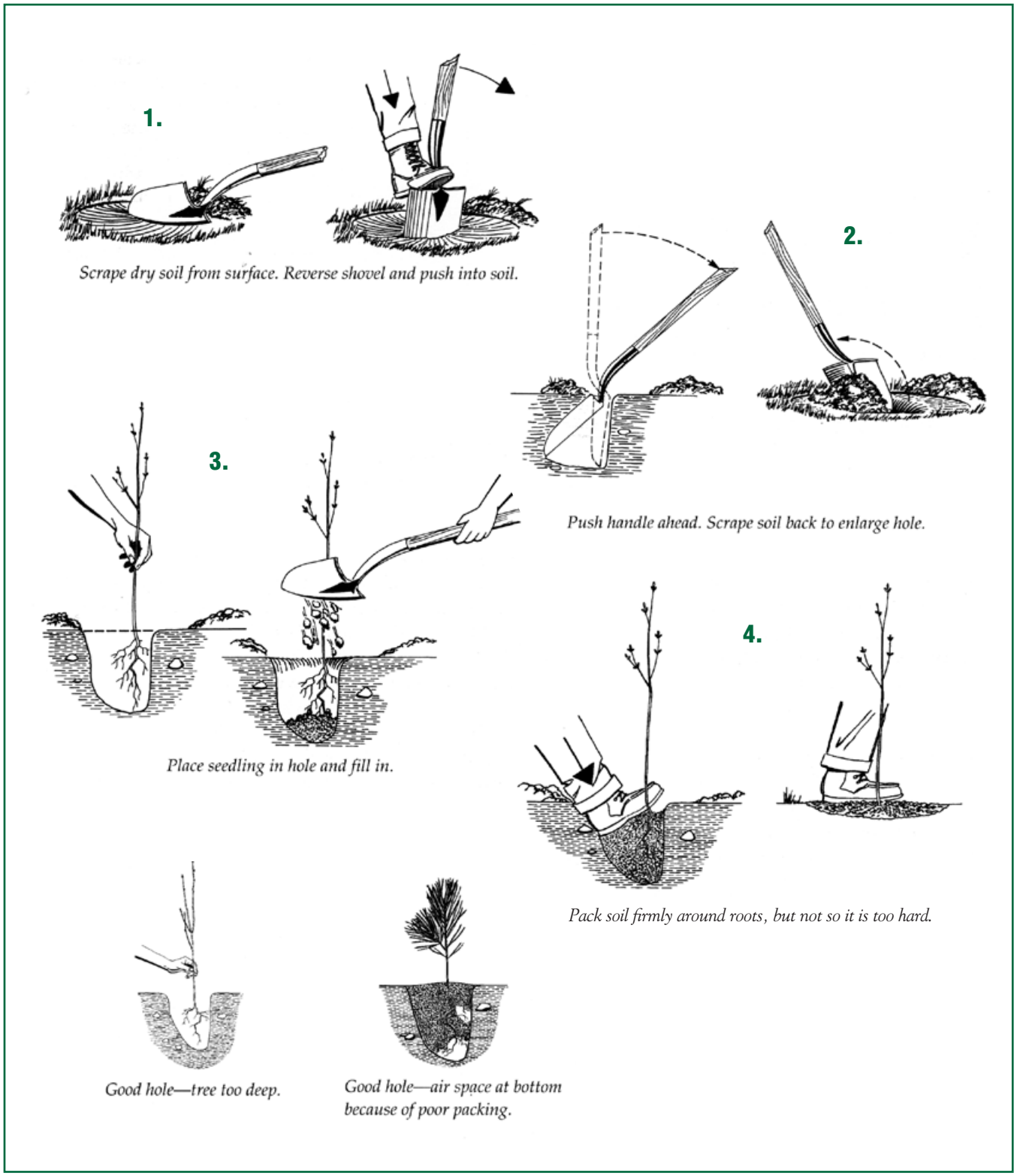
- Weed control
- Protection from insects, disease, and mammals
- Thinning and pruning

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 herbicide and environmental injury in new tree plantings. Contact your local county Cooperative Extension Service for



USDA Natural Resources Conservation Service

Figure 14. *Garden spade planting instructions*

Wildlife Conflicts Information Hotline
Indiana Residents: 1-800-893-4116
Lafayette, IN and outside Indiana:
765-496-3968

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. Fencing, repellents, tree shelters and wire cages are all methods for protecting tree seedlings from deer damage. Reducing deer populations through

Deer browse damage

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* and *Diagnosing* and *Controlling Wildlife Damage in Hardwood Plantations* (FNR-216) for more information on deer damage control and control of other forms of animal damage.

Thinning and Pruning

Depending on the initial spacing your trees were planted at 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 provides more information on thinning and pruning.

10. Take a Break! . . . a Tax Break

The *Reforestation Tax Deduction and Amortization* provision of the federal income tax code recognizes the long-term nature of the tree planting investment. 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 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.

National Timber Tax Website:
www.timbertax.org

Figure 15. *Thinning in a plantation*

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 value of $1 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., and A.S. Davis. 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 entitled *Planting and Care of Fine Hardwood Seedlings* (FNR-210). 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
231 S. University St.,
West Lafayette, IN 47907-2094 Ph. 1-888-398-4636
email: media.order@purdue.edu
web: https://secure.agriculture.purdue.edu/store/

Titles in the series include:

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

Other Related Extension Publications:

FNR-87 *Forestry and Wildlife Management Assistance Available to Indiana Landowners: Providers, Organizations, and Programs*

FNR 102, *Woodland Wildlife Management*

FNR 114, *Spray Equipment Calibration*

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

Appendix

Tree and shrub seedling nurseries

IDNR, Division of Forestry
Vallonia State Nursery
2782 W. Co. Rd. 540 S.
Mail: P.O. Box 218
Vallonia, IN 47281
Phone: (812) 358-3621
Fax: (812) 358-9033
ValloniaNursery@dnr.IN.gov

Private Nurseries

Blanks Nursery
0382 W. 250 S.
0448 East 500 South
LaPorte, IN 46350
(219) 393-5414
Fax: (530) 745-9817
blanksnursery@excite.com

Duncan Nursery and Seed Co
6311 Ferstel Road
Newburgh, IN 47630
(812) 853 - 2053
Fax: (812) 963 - 0977
warhawk@sigecom.net

Hensler Nursery Inc
PO Box 58
5715 North 750 East
Hamlet, IN 46532
(219) 867 - 4192
Fax: (219) 867 - 4960
henslernursery@skynet.net

JF New Native Plant Nursery
128 Sunset Dr.
Walkerton, IN 46574
(219) 586 - 2412
Fax: (219) 586 - 2718
info@jfnew.com

Woody Warehouse Nursery
P.O. Box 259 • 3216 W. 850 N.
Lizton, IN 46149
Ph: (866) 766-8367 or (317) 994-5487
Fax: (317) 994-5494
sales@woodywarehouse.com

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/

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 annual grass + some annual broadleaf	simazine pendimethalin oryzalin	Princep Pendulum 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 clopyralid metsulfuron	Garlon Transline Escort
	annual + perennial grass selective	sethoxydim fluazifop	Poast Fusilade
Pre- and Post-emergent	annual + perennial broad spectrum	sulfometuron hexazinone	Oust 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.

NOTES

About the Authors:

Ron Rathfon, Extension Forester
Department of Forestry and Natural Resources
Purdue University
12000 Purdue Farm Road
Dubois, IN 47527
(812) 678-5049
ronr@purdue.edu

Douglass Jacobs, Associate Professor
Purdue University Department of Forestry and Natural Resources
Hardwood Tree Improvement and Regeneration Center
Pfendler Hall
715 W. State Street
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 Street
West Lafayette, IN 47907-2061
(765) 494-2153
lfarlee@purdue.edu
www.htirc.org

This publication is printed on recycled paper using soy-based inks.

Purdue Extension
Knowledge to Go
1-888-EXT-INFO

PURDUE AGRICULTURE

NEW 4/09