

## **CHAPTER 15** **Reforestation and** **Afforestation**

## CHAPTER 15 REFORESTATION AND AFFORESTATION

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**Reforestation** is the practice of regenerating and growing healthy trees on previously forested sites. Reforestation can include both natural and artificial methods.

- **Natural regeneration methods** include root suckering, stump sprouting, or natural seeding as a result of the application of one of the silvicultural systems as described in Chapter 2: Generally Accepted Silvicultural Principles.
- **Artificial regeneration methods** include aerial and ground seeding, or planting seedlings and cuttings by hand or with a planting machine.

This chapter provides an overview of the planning, design, site preparation, and planting methods needed to successfully establish forest stands in Wisconsin.

### Integrated Resource Management Considerations

- A written reforestation plan will increase the likelihood of success by clarifying all of the site preparation and planting details, and the measures needed to minimize any impacts on other important resources.

#### AFFORESTATION

The practice of planting and seeding trees to create a young forest on non-forested land such as a fallow agricultural field.

#### TYPE CONVERSION

Changing the dominant species composition of a forest from one forest cover type to another.

#### RESTORATION

The process of reintroducing and maintaining native flora on a given site.

- Landowners should analyze their available budget, time constraints, and access to reforestation resources (e.g., nursery stock, equipment and labor) when considering a reforestation project. **A realistic budget must account for the cost of establishment and follow-up care**, such as controlling competing vegetation. Many plantings fail or have less than desirable results due to inadequate planning or to limited capital assets needed to support establishment of a fully stocked forest. Cost-sharing programs are available to assist landowners in completing reforestation efforts. More information on cost-sharing can be found at: [dnr.wi.gov](http://dnr.wi.gov) – keyword **“WFLGP”** or by contacting your local DNR forester.
- Species selection, site preparation and planting methods, and plantation design can affect 1) visual quality, 2) the degree of soil disturbance, and 3) wildlife habitat values.
- When planning and performing mechanical or chemical site preparation in advance of establishing a new stand, maintaining good soil conditions is critical. Practices that result in excessive soil exposure, compaction, rutting, or removal of surface soils may reduce tree survival and growth, or create the need for additional treatments. Site preparation methods, timing and intensity should be evaluated for potential soil erosion and impacts on soil productivity.
- Reforestation considerations should be evaluated as part of any harvesting plan when managing stands at or near rotation age.
- Protection of cultural resources may require modification of reforestation efforts.
- Endangered, threatened and special concern species can be impacted by reforestation projects.
- Consider the impact planting trees can have to non-forested natural communities (e.g., fragment open landscapes, provide predator habitat).



*Figure 15-1: Artificial regeneration methods include machine planting which is quite appropriate when old farm fields are planted, in this case, to red pine.*



*Figure 15-2: Natural regeneration methods, like the shelterwood harvest that resulted in these young red oak seedlings, are described in Chapter 2: Generally Accepted Silvicultural Principles.*

## PLANNING AND DESIGN

### Setting Goals


**The first step in planning a reforestation or afforestation project is to evaluate how it relates to both short- and long-term landowner goals.** Such goals might include producing income from timber, improving habitat for specific wildlife species, restoring a natural plant community, reducing soil erosion, improving water quality, or enhancing the aesthetics of the land.

**Remember that many goals are compatible with each other, allowing a single forest planting to serve multiple purposes.**

### Site Evaluation

Planning reforestation or afforestation activities begins with evaluating the planting site. Knowledge of likely limiting site factors such as soils, existing vegetation, topography, wildlife browse damage, presence of invasive species, fire risk, and productivity potential will aid in selecting suitable species, preparing the site, and prescribing post-planting management practices.

### CLIMATE

Tree species are adapted to a specific range of climatic conditions. Since Wisconsin has a wide range of climates, our state hosts a wide variety of native tree species (some with wide habitat ranges and others with narrow soil or climate preferences). Therefore, it is important to select species that are adapted to the climatic conditions of the planting site. For example, several species reach the northern limit of their range in Wisconsin. Species like black walnut are limited to the southern portion of the state by climatic factors such as minimum winter temperature. Other climatic factors to consider when initiating a plantation are timing and amounts of precipitation, the potential for ice storms and snow loads, and risks associated with early or late frosts (see  6.4).

### SOILS

Soil properties affect the moisture and nutrients available for tree growth. Therefore, a careful analysis of the soil characteristics and uniformity is a critical step in selecting tree species that are well-adapted to the planting site. The USDA Natural Resource Conservation Service's (NRCS) soil survey information is available online and can be used to better understand the site's soil characteristics and to match tree species with appropriate soils. The NRCS Web Soil Survey can be found at: [websoilsurvey.nrcs.usda.gov/app](http://websoilsurvey.nrcs.usda.gov/app).

If possible, examine the soil to a depth of two to five feet with a test hole or auger, paying particular attention to:

- Soil texture – is it too coarse or sandy?
- Organic matter – how much is present?
- Depth of topsoil – what is the available rooting depth?
- Parent material – is high or low soil pH a potential problem?
- Available moisture – is there adequate organic matter in the soil?
- Internal drainage – does water drain freely or puddle following rain?
- Nutrients – does current vegetation appear lush or chlorotic?
- Bulk density – is the soil compacted or have a hard pan due to past land use?
- Erosion patterns – has original topsoil been heavily eroded?

**A careful soil examination is the best way to evaluate the potential of any site to support tree growth.**

Site quality is almost impossible to change significantly once trees are planted, so a careful assessment of soil and site characteristics is essential. Some nutrient deficiencies can be adjusted with fertilizers and other soil amendments but such treatments are expensive and logistically challenging. Soil uniformity can also be checked so that species recommendations can be customized to fit the site. Alternative methods of soil evaluation include the use of published soil surveys, and completion of soil lab analysis. Soil survey reports and/or soil maps offer a general assessment of landscape soil features, but may not be sufficiently detailed to help with small plantings. Also, older soil surveys may not reflect current conditions if intensive agriculture or other development has reshaped the local soil resource. A soil lab analysis provides information on selected soil properties, and can identify possible nutrient deficiencies. For information on how to submit soil samples for testing to the University of Wisconsin Soil and Forage Lab visit: [uwlab.soils.wisc.edu](http://uwlab.soils.wisc.edu).

### COMPETING VEGETATION

Existing and potential vegetation will compete with young seedlings for moisture, nutrients and light. **Not all vegetation is alike in its ability to compete with young trees**, and must be evaluated in order to determine the timing and extent of appropriate control measures. Vegetation existing on the planting site is an obvious consideration, but other plants that regenerate readily from dormant seeds or from well-established root systems also pose potential problems. The types and amounts of competing (or potentially competing) vegetation (native and nonnative) must be considered when selecting appropriate planting stock, site preparation treatments and maintenance activities. Nonnative invasive plants are typically more aggressive than other undesirable plants and may require more effort to control (see [3.2](#), [6.1](#) and [6.5](#)).

### TOPOGRAPHY

Elevation, slope, aspect (north, south, east or west), and surface drainage affect the local environmental conditions of a planting site. For example, northern aspects generally have lower evaporation rates, and therefore, greater available soil moisture to support plant growth. Topographic affects may influence more than just growth potential. Occurrences of white pine blister rust can be worse in certain landscape positions (e.g., certain drainage channels, or some ridges) where humidity and the aerial movement of spores increase.

### PRODUCTIVITY

Site productivity is the capacity of a site to yield a given forest product in a specified period of time, and has traditionally been measured as gross volume per acre per year. Evaluation of productivity levels will help in the selection of species that will exhibit optimal growth on the planting site. Productivity can be evaluated in several ways:

- **Site Index:** Examining the growth rates of existing or adjacent forest trees.
- **Habitat Type Classification:** Using other plant community information.
- **Site Productivity History:** Examining the records of past yields or performance.
- **Soil Surveys:** Using soil information to project stand growth rates.

Some of these measures are indirect, and provide estimates of potential productivity rather than precise measurements. Keep in mind that productivity generalizations from one species to the next vary greatly – what may be viewed as adequate productivity for one species may prove to be inadequate for others.



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*Figure 15-3: Promoting a mixture of species encourages and maintains diversity – which also provides wildlife habitat diversity – and the positive visual impact of a natural-appearing landscape.*

## LANDSCAPE POSITION

The benefits of a forest planting can be enhanced if it is compatible with and complimentary to the surrounding forest cover types and ecological communities.

Examine the broader landscape within a one to five mile radius or larger to assess existing cover types, habitat needs, and management trends. For example, tree planting may be used to establish mast-producing species, such as red oak, in areas where the oak resource is declining due to natural succession or species conversion. Alternatively, past development practices may have fragmented a landscape that can now be coalesced via a successful planting. Regenerating a stand in a fragmented landscape will require different considerations than a site that is within a primarily forested landscape.

## INSECTS, DISEASES AND ANIMALS

Insects, diseases and animals can have locally devastating impacts on young plantings, and hamper reforestation success. Proper site evaluation must include an assessment of these risks. The key to recognizing potential pest or predation problems is to examine the following:

- Site history – were earlier forest stands disease or predation prone?
- Current conditions - are insect or disease populations present in residual trees, in the soil or on decaying woody material that pose a threat to regeneration?

- Vulnerability of tree species to browse – is there a high deer population? Does the species being planted have a history of browse problems?
- Population trends – are new pests/pathogens present that influence the survival of regeneration?
- Evidence of alternate hosts on the planting site – are site conditions conducive to problems?
- Vulnerability of tree species to infection based on site characteristics – does the preferred reforestation species have a history of pest/predator problems?

Timing site preparation and regeneration activities to avoid invasive insect and disease issues is critical to the survival of regeneration.

## SUCCESSION

Forest plantings can have long-term effects on the landscape. Planted species may begin to regenerate naturally, affecting the future species composition on the current and nearby sites. Landowners may wish to purposely introduce a seed source into a new planting, in the expectation that it will create natural regeneration opportunities at stand rotation. A mixed red and white pine plantation that has developed an understory of white pine seedlings is a good example of the long-term effects of seed source introduction. Or a planting can help provide shade-intolerant or mid-tolerant species (e.g., jack pine, white birch or northern red oak) that are being lost to natural succession in the landscape around the site.

## ENDANGERED RESOURCES

**Endangered, threatened and special concern species can be impacted by site preparation activities, by altering the existing vegetation, or by introducing new species.** Perform a Natural Heritage Inventory (NHI) screening prior to reforestation activities in order to identify and address potential impacts. You may need to alter your choice of species or regeneration technique (see Chapter 3: Wildlife Habitat and Biodiversity for more information on NHI).

## Planting Design

A planting design will provide specific details for the creation and management of a planting including acreage, species, number of trees, spacing, row alignment, nursery stock type, arrangement, site preparation and planting method, layout of roads and firebreaks, and any post-planting cultural treatments. A written reforestation plan and map should be

developed to help clarify all these details, and facilitate any modifications prior to planting. A plantation map can help show precise planting locations, species arrangement, and access roads. Maintaining records of treatments is valuable to future landowners and managers as they evaluate future stand treatments.

A planting design is directly tied to a landowner's goals, and the resources and capabilities of the planting site.

### EXAMPLES OF GOALS AND THEIR ASSOCIATED DESIGN CONSIDERATIONS

#### Timber Management

- Match species with potential future market demands and opportunities.
- Provide equipment access for release, thinning, pruning, and harvesting.
- Include harvest roads and firebreaks.
- Manage to encourage and maintain tree species diversity. Add species that will create future natural regeneration opportunities.
- Leave space around power lines, underground cables and gas lines.
- Avoid steep slopes and wet areas.
- Provide closer spacing of hardwoods to improve sawtimber quality by limiting branch size and persistence.
- Reserve an open area to use periodically for storage of cut forest products and equipment when harvesting occurs.

#### Aesthetics

- Use a variety of species, including wildlife shrubs.
- Use non-row plantings, curved rows and irregular edges for a more natural effect.
- Plant species with desirable fall color.
- Leave openings or islands of various sized and aged trees.
- Retain landmarks and distinct features.
- Create or retain scenic views.
- Locate trails or roads to take advantage of scenic quality.

#### Wildlife Management

- Enhance biological diversity and complement habitat in the surrounding landscape, especially habitats that benefit Species of Greatest Conservation Need.
- Offer habitats that are in locally short supply.
- Choose species which provide preferred food for desired wildlife, unless browsing will negatively impact establishment of trees.
- Establish or expand wildlife travel corridors so they connect habitats.
- Create irregular boundaries for more habitat options.
- Enhance interior forest habitat by planting artificial openings, such as isolated fields.
- Plant around existing "wolf" trees.
- Leave frost pockets and odd corners unplanted to improve habitat variety.
- Leave wildlife openings.

#### Erosion Control

- Establish forested or grass buffers (or riparian management zones) near lakes, streams and wetlands to help slow runoff and prevent siltation.
- Plant trees along contours to help control runoff.
- Leave drainage pathways covered in grass.
- Concentrate trees in "problem" areas.
- Plant long-lived tree species in riparian management zones.
- Plant highly erodible upland fields to decrease runoff.



## Species Selection

**The tree species selected for reforestation and afforestation must be compatible with the landowner’s management goals, and biologically-suited to the planting site.** After determining the potential advantages and limitations of the planting site, select a species or combination of species that emphasize the advantages and overcome the limiting factors. Consider the following (see also 🍃 6.4):

- Site requirements, especially soil factors and habitat type.
- Climatic suitability, both short- and longer term (i.e., 75 to 100 years or more into the future).
- Potential growth rate on site.
- Compatibility of growth rates in mixed species plantings.
- Sunlight requirements.
- Potential competition problems.
- Potential for herbivore browse damage as well as insect and disease problems.
- Wood and fiber properties and potential markets.
- Encourage and maintain tree species diversity. Add species that will create future natural regeneration opportunities.
- Timber, wildlife, erosion control, and aesthetic values.

Detailed information on individual tree species’ characteristics is available in the Wisconsin DNR *Silviculture and Forest Aesthetics Handbook*, 2431.5. The handbook can be found at: [dnr.wi.gov](http://dnr.wi.gov) – keyword **“silviculture.”**



*Figure 15-4: Successful planting requires vigorous seedlings of sufficient size with a healthy root system. Notice the invasion of celandine in these woods. The plantings will survive competition with celandine; however, natural regeneration may be hindered. The invasive plant should be considered in management plans.*

## Spacing

**Initial spacing will affect both the productivity and the management of a plantation.** The choice of spacing will depend on the species selected, product desired, need for and intensity of intermediate stand treatments, expected initial survival, and cost.

**Height growth can be reduced at extremely high or low densities.** Fortunately, the most commonly used tree planting densities fall within a range that does not reduce dominant tree height (see Table 15-1). In Wisconsin, commonly recommended planting densities range from 500 to nearly 1,000 seedlings per acre.

Generally, for quality hardwood tree production, choose a closer spacing to encourage straight boles, and small, lower branches that self-prune easily. Hardwood plantings for wildlife purposes can use wider spacing to encourage crown development and earlier seed production. Note that plantation spacing requirements may be specified by some cost-sharing and tax law programs.

	4'	5'	6'	7'	8'	9'	10'
4'	2,722	0	0	0	0	0	0
5'	2,178	1,742	0	0	0	0	0
6'	1,815	1,452	1,210	0	0	0	0
7'	1,556	1,244	1,037	889	0	0	0
8'	1,361	1,089	908	778	681	0	0
9'	1,210	968	807	691	605	538	0
10'	1,089	871	726	622	545	484	436
12'	907	726	605	518	454	403	363
15'	726	581	484	415	363	323	290

Table 15-1: Number of trees per acre by spacing (in feet). The blue numbers represent the more commonly recommended spacings for reforestation purposes.

## ADVANTAGES AND DISADVANTAGES OF WIDE AND CLOSE SPACING

### Wide Spacing Advantages

- Planting costs are less.
- Increased tree diameter growth rates.
- Trees may produce greater quantities of seed/mast at an earlier age.
- Increased understory growth will provide wildlife food and habitat, and increased plant species diversity.

### Wide Spacing Disadvantages

- Increased vegetation competition and maintenance.
- Reduced stem quality due to larger branch diameter, and longer branch retention.
- Fewer crop tree choices.
- Increased fire hazard.

### Close Spacing Advantages

- Faster crown closure which shades the understory resulting in less vegetation competition and maintenance.
- Partial mortality less likely to result in understocked conditions.
- Potential to reduce size and persistence of branches on lower bole.
- Reduces ladder fuels and fire hazard for some species.
- Large wood volumes accumulate in early years.
- Greater number of trees to select from during thinning operations and more crop tree choices.

### Close Spacing Disadvantages

- Increased site preparation, planting and seedling costs.
- Early timber stand improvement may be needed to reduce crown competition.
- Access during initial thinning operations may be difficult.
- May lead to weaker boles and potential for stem bowing or damage due to heavy snows or ice if initial thinnings are delayed.

## Planting Arrangement

**Planting arrangement** refers to the pattern or distribution of tree and shrub species across a planting site. The arrangement of species may be varied to match topographic features, changing soils or site conditions. For example, a mixed hardwood plantation may concentrate black walnut seedlings on the deeper topsoils of the lower slope, and place red and white oak seedlings near the ridge tops and convex slopes. The arrangement should also consider the growth characteristics and compatibility of species planted next to each other. For example, due to the fast juvenile growth of shagbark hickory, an alternating pattern with red oak or black walnut may result in suppression of the hickory. One solution is to group the species within the planting to minimize problems associated with very different juvenile growth rates.

Conifer and hardwood mixtures have been recommended for afforestation in Wisconsin. The benefits of these conifer-hardwood mixtures include:

- Conifers assist in early crown closure and capturing the site.
- Cost of plantation establishment is less than for a pure hardwood plantation.
- Conifers improve the quality of hardwoods by shading out lower branches, and forcing hardwoods to grow straight.
- Conifers provide wind protection and offer an easy alternative for a first thinning.
- Conifers reach merchantable size faster and may help provide earlier income than a pure hardwood planting.
- Increased species diversity and future natural regeneration opportunities.



(WDNR, Greg Edge)

*Figure 15-5: In addition to other benefits, mixtures of hardwoods – planted here in tree shelters – and conifers may be more resistant to insect and disease pests than monocultures.*

One disadvantage to this mixture is that, once established, the options for chemical release of the plantation are more limited than pure conifer plantings. **Initial site preparation treatments are critical for successful conifer-hardwood plantations.** In addition to making future thinning more difficult, alternate row plantings may encourage increase browsing of the hardwoods, as the conifers offer concealment for deer.

Mixed conifer plantings have become more common, typically mixing red and white pine together either in single species rows or randomly mixed during planting. Other mixed conifer species planting include spruce and tamarack or white cedar.

**Interplanting** is the practice of planting new seedlings between or among existing forest growth. Sometimes forests fail to regenerate as expected after a harvest, and interplanting provides a way to supplement natural regeneration. The planting arrangement in this situation will depend on an evaluation of the number, size and spatial distribution of desirable advanced reproduction. Do not forget to factor in the contribution of stump or root sprouts to fill all or part of the reproduction deficiency. Interplanting is almost always accomplished by hand planting. Interplanted trees will be in competition with other vegetation so their success can be measured against the growth of dominant competing vegetation. Generally, larger sized seedlings (e.g., 2-0 or 3-0 hardwoods and 3-0 or transplant conifers, see “Planting Stock Age Classes – What Do Those Numbers Mean?” sidebar on page 15-13 for clarification) are needed to compete with the advanced reproduction and sprouts. These types of plantings generally require some type of release early in the establishment phase.

**Underplanting** is similar to interplanting but is done prior to the final harvest of a mature forest stand in an attempt to establish a species desired in the next forest stand. Often aesthetic concerns adjacent to important visual travel corridors prompt this effort. Underplanted species must be able to tolerate shade for several years until established and the overstory is removed. Attempt to limit damage to planted trees when the overstory is removed. An example is underplanting white pine in an oak stand adjacent to a major road right-of-way with the intent to develop a white pine understory that will provide some visual relief when the oak harvest is scheduled.

### Direct Seeding Versus Seedlings

One of the initial planning decisions when planning artificial stand regeneration is whether to plant seeds or seedlings. Each method has advantages and disadvantages in terms of ecology, site preparation needs, operational logistics, and expense.

#### The advantages of direct seeding include:

- Less expense for conifer plantings or small areas.
- Applicable on difficult terrain or shallow soils.
- Good root development with no transplant shock.
- Potential for a more uniform stocking than in a naturally regenerated stand.
- Natural stand appearance; no rows or uniformly spaced trees.
- Improved hardwood stem quality in high density plantings.

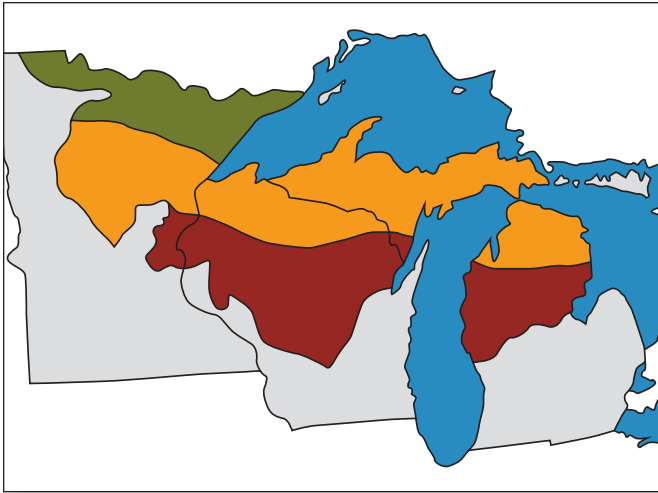
Direct seeding is often times not successful due to improper planning or inadequate germination conditions. Many factors influence seed germination, and careful planning is critical in highly variable field environments.

#### Other disadvantages include:

- Necessity for intensive site preparation and follow-up competing vegetation control.
- Difficulty controlling stand density.
- Greater costs for hardwoods depending on the quantity of seed used.
- Small planting areas may be subject to heavy seed predation.
- Hardwood seed production is unpredictable and highly variable in most years and does not store well.

#### Proper seed collection, handling and storage are critical to the establishment of direct seeded plantations.

Seed collected during an abundant seed year is usually higher quality, especially if mature seeds are collected just before, or simultaneously with, seed fall. Always consider seed source by collecting from quality trees that are within 200 miles of the planting site, or from sources that have proven performance through genetic testing. Properly store, stratify and treat seed to maximize germination rates. For additional seed handling information on particular species, refer to the *USDA Forest Service Woody Plant Seed Manual* found at: [www.fs.usda.gov/nsl/nsl\\_wpsm.html](http://www.fs.usda.gov/nsl/nsl_wpsm.html).



*Figure 15-6: Jack Pine Seed Source Trial (20-year Results). Seed zones established for the appropriate movement of jack pine seed sources in Wisconsin. Tree performance is generally best when seed sources are kept within a particular zone. (Adapted from Jeffers and Jensen, 1980)*



*Figure 15-7: Interplanting spruce seedlings by hand in a harvested hardwood stand to augment natural regeneration, and provide species diversity. The presence of celandine, an invasive plant, in this stand may hinder natural regeneration and should be considered during planning.*

## Seed Source Selection

Seed source is an often overlooked but critical component in a successful reforestation program. **Selecting appropriate seed sources will improve the overall productivity of the plantation, since the trees will be adapted to the environment of the planting site.** Appropriate seed source selection will also reduce catastrophic plantation losses due to poorly adapted genetic material. Poorly adapted seed sources can survive and grow for many years, until an environmental event, such as an early frost or extremely cold winter, results in catastrophic losses.

**Local seed sources (e.g., Wisconsin) are the most appropriate unless proven otherwise through genetic testing.** For example, genetic testing has revealed that southern Ontario white spruce sources are well-adapted to Wisconsin's environmental conditions, and also offer improved growth rates over local sources. Tree improvement efforts by the Division of Forestry and other agencies continue to examine seed source performance across Wisconsin in order to identify appropriate sources and seed zones (see Figure 15-6). Advanced tree improvement practices include 1) the establishment of seed production areas to facilitate the collection of seed from quality native stands, 2) the establishment of progeny tests where individual families are tested and selected for high performance, and 3) seed orchards for the production of high quality seed with superior genetic potential.

## Planting Stock Type Selection

Selection of the best nursery stock type for a given situation depends upon the identification of planting site factors that influence seedling establishment and early growth. Consider the relative advantages and disadvantages of containerized versus bare-root stock versus cuttings in order to select the planting stock that will meet the landowner's goals, and overcome any limiting factors of the planting site.

**Containerized stock** is usually less than one-year-old and is grown, shipped and planted in a soil "plug" of peat, perlite (or vermiculite) and sand. Usage in the Lake States has been restricted primarily to conifer seedlings, but recent advances in pot sizes have allowed some production of containerized hardwoods. The advantages of containerized stock include the fact that seedlings can be grown in six to 15 weeks, they have high survival rates, superior initial height growth, more uniform size, and good plantability, especially on rocky sites where it may be difficult to open a large hole for bare-root seedlings. In addition, these seedlings are less likely to experience transplant shock since the tree is planted in the rooting medium, and the process makes more efficient use of seed. Finally, containerized stock extends planting seasons, and seedlings can perform well on adverse sites. Containerized seedlings also are more resistant to heat and drying stress, so transportation and storage are less problematic. Containerized stock, however, is more expensive than bare-root stock, more bulky to transport and handle, less able to compete with weeds, susceptible to deer browse, prone to frost heaving when planted on bare mineral soil, and often smaller in size.

**Bare-root stock** is seeded and grown in nursery beds for one to three years, and may be moved to a transplant bed to improve root development. Conifer seedlings should have a four to six millimeter caliper, and a 2:1 shoot to root ratio (i.e., a shoot twice the length of the root). Hardwood seedlings should have

good lateral root development with a minimum of five primary lateral roots (greater than one millimeter in diameter) for optimal seedling survival and growth. Advantages of bare-root stock include lower costs, ease of transportation and storage, competitive advantage over weeds, less susceptibility to deer browse, and faster root regeneration. Bare-root stock, however, takes longer to grow, can dry out quickly due to exposed roots, is prone to root damage and deformity during planting operations, and may require special planting considerations due to the larger seedling size.

**Cuttings** are practical for only a few tree species in Wisconsin, typically hybrid poplar, cottonwood and willow. The cuttings are typically six to 10 inch pieces of the previous year's stem growth and do not have any root development present. The cuttings or "sticks" have one to five dormant lateral buds and are planted buds-up directly into the soil. Root tissue develops on the buried cut surface and terminal growth originates from one of the buds on the cutting.

### PLANTING STOCK AGE CLASSES – WHAT DO THOSE NUMBERS MEAN?

Bare-root stock is often sold using an age class designation, such as 1-0, 2-0, 3-0 or 2-1. The first numeral refers to the number of years grown in a seedbed. For example, a 2-0 designation means the tree was grown for two years in a seedbed. The second numeral refers to the number of years grown in a transplant bed. For example, a 2-1 designation means the seedling was grown for two years in a seedbed and was lifted and replanted in a transplant bed for one year (transplanting improves root development).

## OPERATIONAL CONSIDERATIONS

### Site Preparation

**Site preparation is the creation of favorable growing conditions to encourage the establishment, survival and growth of the preferred tree seedlings.** The biggest obstacle facing seedling establishment is competition from other vegetation. Effective site preparation will temporarily reduce competing vegetation, and create a sufficient number of suitable germination and growing sites without causing excessive soil disturbance. Site preparation can be accomplished through mechanical means, the use of chemicals, prescribed fire or a combination of these approaches. Select a technique or combination of techniques based on specific species regeneration requirements and site characteristics including soil, topography, vegetation, access, and distance to surface waters. Consider targeted methods (low-intensity, spot or band) and equipment that minimizes site disturbance.

### MECHANICAL

**Mechanical site preparation** accomplishes two major goals: providing a planting site for seedlings or a microsite for seed germination; and providing initial control of the vegetation competing with the preferred tree species for sunlight, moisture, nutrients, and growing space. Mechanical site preparation typically disturbs the soil and can be accomplished by scalping, disk trenching, disking, root raking, roller chopping, furrowing/plowing, rotovating, or any other method that removes some or all of the existing vegetation from the planting site. Herbicides are often used in conjunction with or as a follow-up to mechanical site preparation. In some situations such as clay or organic soils, mechanical methods can be used to prepare soils for planting or seeding and to prevent soil cracking and frost heaving. The exposure of bare soil increases the risk of erosion and the establishment of invasive plants. Consider the nonnative invasive plants in the vicinity to get a sense of what may take hold after the disturbance (see 4.3). Each site needs to be evaluated and measures taken to minimize these risks.

There are three basic situations where mechanical site preparation is normally used. The first is to **reforest an existing forest site that has been harvested**, leaving

stumps, tops and varying amounts of woody debris. These sites are normally reforested through natural seeding, hand planting, or in some cases, direct seeding. In most cases, heavy machinery is needed to create planting or seeding sites and to allow planters to move between individual planting sites. Tracked or wheeled tractors are commonly used to pull site preparation equipment. Erosion can be an issue if work is done on slopes.

The second situation for mechanical site preparation is during **afforestation of former agriculture lands**, such as cropland or pasture. An herbicide treatment is commonly recommended and may be used in combination with the mechanical site preparation methods (see pages 15-15 and 15-16). Generally, herbicide application is necessary for several years to keep grass and weeds in check until the seedlings are fully established and above the competing vegetation.

The third situation for mechanical site preparation is for **spot or interplanting of existing stands**. Trees are planted in scattered locations.



*Figure 15-8: Soil scarification with a spiked anchor chain is a type of mechanical site preparation that prepares a seed bed for acorns in oak forests.*

## COMMON MECHANICAL SITE PREPARATION METHODS

### Previously Forested Sites

- **Patch scarification** with a Bracke or Leno scarifier provides parallel rows of patches eight feet apart and six to eight feet within rows. The scarifier paddles gouge a shallow depression in the ground surface which removes vegetation and creates an exposed soil bed 12 to 18 inches in diameter where the seedling can be hand planted or seed deposited. Planting density is mechanically set by timing of paddle rotation. Sites may be treated in advance with herbicide or after planting to control competing vegetation. Scalps may be skipped or incomplete on sites with rocky soils and/or heavy woody debris. Patch scarification results in minimal soil disturbance. This method is used for site preparation for hand planting or seeding.
- **Disk trenching** produces parallel trenches eight to nine feet apart using a large diameter disk/wheel with large metal teeth. A rotating disk rakes debris away from the trench and creates a shallow planting trench in which seedlings or cuttings are hand planted at desired spacing within the row. Sites may be treated in advance with herbicide or after planting to control competing vegetation. Trenches may be incomplete or skipped on sites with rocky soils and/or heavy woody debris. Disk trenching is typically done the year prior to spring planting on non-frozen soils. This is the preferred site preparation treatment on large, tough sites following a harvest. This method is used primarily for site preparation for hand planting.
- **Straight blade scarification** of the soil to remove duff layer and reduce competing understory plants. Exposes mineral soil to provide desirable seed bed and germination conditions. Often done prior to harvest on unfrozen soils in mature jack pine stands with serotinous cones. Target one-third to two-thirds surface treatment. Leaves small mounds across the site but compaction of sands helps provide soil moisture contact for germinating conifer seeds.
- **Root/rock raking** involves using a crawler/tractor with a toothed blade to remove woody debris and rocks and reduce ground vegetation. Debris is raked into piles or windrows on the planting site either to be burned or left to decompose on site. There are potentially high impacts to soil and existing vegetation, but timing with frozen soils can reduce these impacts. Stumps may or may not be removed. Piles and windrows occupy site space and reduce acreage available for planting. This method is used for site preparation for hand or machine planting or seeding.
- **Furrowing or trenching** using a Hester plow or fire plow to produce a two to three foot wide planting/seeding space where surface vegetation has been peeled to the side. Furrows or trenches are spaced six to eight feet apart and parallel. Furrows are hand planted at spacing intervals within the furrow to meet desired stocking levels. There are potentially moderate to high impacts to the soil. For natural regeneration methods, scarification patches may be more random in size and spacing. This method is used for site preparation for hand planting or seeding.
- **Anchor chain scarifiers** are generally used to disturb the surface soil and vegetation in preparation for natural or direct seeding. This method is often used in conjunction with a natural regeneration system, such as a shelterwood or seed tree for white pine or oak. A crawler/tractor is used to drag heavy, spiked anchor chains across the site. Sites may be treated in advance with herbicide to aid in seed bed preparation. Work is typically done shortly before or during seed fall. This method is used primarily for site preparation for seeding.



## COMMON MECHANICAL SITE PREPARATION METHODS

### Previously Forested Sites (continued)

- **Salmon blade scarification** of the soil surface to remove duff layer and reduce competing understory plants. Exposes mineral soil to provide desirable seed bed and germination conditions. Often done prior to harvest on non-frozen soils in mature white birch or northern red oak stands.
- **Disking** stand area prior to harvest to create seed bed, to incorporate seed, and/or to reduce competition. Often timed with seed/acorn fall. This method is used for site preparation for hand or machine planting or seeding.
- **Tree or pole length skidding** during harvest to expose mineral soil and reduce shrub layer competition. This method is used primarily for site preparation for seeding.
- **Trench seeder or torpedo tube** is dragged across the site to expose mineral soil and release seeds as the seeder/torpedo spins in trench.
- **Roller chopping** to crush/sever existing vegetation and create exposed mineral soil in advance of direct seeding.
- **Fecon (brush land) mowing** to remove understory and other competition and create a seed bed for direct or natural seeding.

### Former Agricultural Lands

- **Tree planting machines** pulled by tracked or wheeled tractors prepare the site as trees are being planted. A combination of coulter and scalper attachments on the planting machine cut sod away from a narrow trench in which the seedling or cutting can be planted and which can remain free of vegetation for several months. Rows are spaced six to 10 feet apart to allow for equipment between the rows (i.e., mowers, sprayers) until seedlings are established. This method is typically used on sites converted from agricultural fields. Sites with heavy woody debris may require a larger crawler/tractor with v-blade to clear planting patch for towed planting machine.
- **Disking, plowing and rotovating** are commonly used site preparation methods when converting agricultural fields to hardwood stands.

### Spot or Interplanting of Existing Stands

- **Hand scalping** is used in areas where machine access is not possible or practical. A small bare soil patch is created using a shovel or mattock. Normally the radius of a hand scalp should be at least as big as the height of the surrounding vegetation. In some cases, this type of scalp is done chemically. This method is used for site preparation for hand planting or seeding.
- **Bracke scarifiers** can be used where machine access is possible (see details above). This method is used for site preparation for hand planting or seeding.
- **Straight blade scarification** can be used where machine access is possible (see details above). This method is used for site preparation for hand planting or seeding.



*Figure 15-9: A Two-row Leno scarifier set up to create scarified patches in a clearcut. This approach causes minimal site disturbance, yet provides exposed soil for ideal planting conditions.*



*Figure 15-10: A disk trencher provides row scarification to prepare a harvested area for tree planting or direct seeding. Patch or row scarification methods like this one reduce competition for the new tree seedlings while minimizing soil disturbance on the site. Here, the mechanical and chemical site preparation are combined in one operation nine months prior to spring hand planting.*

## BMPs: Protecting Resources

- ◆ Operate mechanical site preparation and tree planting equipment on the contour where necessary to minimize erosion into lakes, streams, and wetlands.
  - ◆ Avoid operating mechanical site preparation and tree planting equipment on slopes greater than 30 percent, where the slopes drain directly into lakes, streams, and wetlands.
  - ◆ Minimize raking in areas, or under conditions, in which soil could erode and enter lakes, streams, and wetlands. Two preferred practices are:
    - (a) shear and rake when soil is frozen and
    - (b) rake lightly to remove only slash.
  - ◆ Suspend operations during wet periods if equipment begins to cause excessive soil disturbance that will increase erosion into lakes, streams, and wetlands.
  - ◆ Deposit site preparation residues in stable locations outside riparian management zones and filter strips.
  - ◆ Use patch scarification, low-intensity prescribed burns, or manual site preparation in areas that are adjacent to lakes, streams, and wetlands, or areas that have steep slopes, erosion prone soils, or saturated soils that drain to surface water. Consider hand planting in these areas.
  - ✍ 4.4 Prior to moving equipment onto and off of an activity area, scrape or brush soil and debris from exterior surfaces, to the extent practical, to minimize the risk of transporting propagules.
  - ✍ 4.5 Take steps to minimize the movement of invasive plants, insects, and diseases to non-infested areas, during forest stewardship activities.
- NOTE:** Prescribed burning and herbicides are also used for site preparation; BMPs for these tools are listed in Chapter 14: Pesticide Use and Chapter 17: Fire Management.

## DESIGN CONSIDERATIONS FOR MECHANICAL SITE PREPARATION

- Design mechanical treatments of regenerating stands to protect reserve areas and structural habitat components retained in previous stand treatments.
- Design practices to avoid funneling water or directing runoff or sediment into water and wetlands.
- Minimize soil disturbance by favoring practices that do not remove surface soils or only remove enough soil as needed to effectively accomplish tree establishment.
- Time site preparation activities and use proper equipment to minimize rutting and compaction of soils.
- Identify occurrences of nonnative invasive plants, and if necessary, treat infestations prior to mechanical site preparation to help prevent spread. Monitor and control new infestations after site preparation activities are completed (see ✍ 3.2, ✍ 3.5, and ✍ 4.2).
- Favor practices that allow for dispersed slash or slash in small piles on the site, rather than piling or windrowing, in situations where residual slash does not conflict with management objectives or reforestation.
- Time site preparation work to coincide with a good seed year in order to maximize the chances of success when regenerating a stand by natural seeding.

## CHEMICAL

**Chemical site preparation** can be an effective method to temporarily control competing vegetation, and increase the amount of sunlight and water available for plant growth. Chemical methods may involve simple equipment, can be less expensive, and provide longer control than mechanical site preparation. **However, chemical effectiveness depends on the appropriate herbicide selection, the timing of application, application rate, and weather conditions.** Herbicide applications may need to be repeated for several years to ensure stand establishment. All herbicides must be applied in accordance with label recommendations and their registered use. Detailed forestry herbicide information is available at: [dnr.wi.gov](http://dnr.wi.gov) – keyword **“herbicide”** or see Chapter 14: Pesticide Use, for additional information on the safe use of herbicides.

## BURNING

**Prescribed burning**, or controlled ground fires, can be an effective and inexpensive means of removing or reducing vegetation, and preparing a suitable seedbed in advance of planting or seeding. Burning can also improve soil nutrient levels and ectomycorrhizal development. Prescribed burning, however, can reduce the effectiveness of pre-emergent herbicides, may stimulate growth of some annuals that compete with seedlings, and can increase solar heating at the groundline, leading to seedling mortality. The use of fire as a vegetation management technique is very appealing to many small landowners because it appears “natural” – but it can be dangerous and may be costly if fire escapes from the planting site onto adjacent stands and ownerships. **Effective and safe use of prescribed fire requires proper design of the firebreaks, appropriate suppression and personal protective equipment, careful evaluation of weather conditions on the day of the burn, and training.**

For more information on prescribed burning visit: [dnr.wi.gov](http://dnr.wi.gov) – keywords **“prescribed burn”** or see Chapter 17: Fire Management and Appendix G: Resource Directory for sources of technical assistance and information on any permits required. Permits and site review by Wisconsin DNR fire control personnel are required in high hazard areas of Wisconsin.

**Cover crops** are appropriate for afforestation sites where they are grown to prevent establishment of nonnative invasive plants and other competing vegetation. Cover crops can also control soil erosion, improve soil condition, and increase water-holding capacity. When selecting a cover crop, choose a species that will accomplish the site preparation objectives, but not adversely impact tree growth. Legumes are sometimes selected as cover crops because they can enhance soil nitrogen. Small grain crops, such as winter wheat and rye, can inhibit nonnative invasive plants and other competing vegetation, and add organic matter to the soil while providing limited competition for tree seedlings. Winter wheat can be spring seeded to produce a less vigorous but effective cover crop.



*Figure 15-11: Herbicide strips free seedlings from competition for water and nutrients, harmful allelopathic chemicals produced by grasses, and potential girdling by rodents that use grass as cover.*

**Former agriculture fields present a unique set of site preparation challenges.** Fields that were in row crops the previous year, such as corn or soybeans, generally require a pre-emergent herbicide to control germination of dormant seed from competing vegetation. Herbicides can be very effective in this situation. Cover crops may also be used to control competing vegetation. Alfalfa, clover or some perennial grasses provide fierce competition for tree seedlings and seeds. Alfalfa and sod are easiest to control during the year prior to planting, with an early fall application of herbicide when the plants are still actively growing. Alternatively, rotation into a row crop or other desirable cover crop at least one year prior to afforestation, followed by planting of seedlings, has been especially effective for hardwood plantings on heavy soils.

## Planting

### PACKAGING

Plastic-lined boxes or bags are preferred for shipping bare-root seedlings because they help prevent physical damage and keep seedlings moist. Paper bags or burlap bales provide less protection from physical damage. Bales will suffice for very short storage or transport periods, but bales leave the shoots exposed and subject to drying. All packaging methods can slow air circulation when stacked. Containerized seedlings are shipped in the plastic or styrofoam container in which they grew at the nursery, therefore, the roots are protected. However, care should be taken to protect the exposed shoots during transportation. Also, regularly monitor the moisture level in the containers.

### SEEDLING CARE AND HANDLING

**Reforestation surveys indicate that the most common problems facing seedling survival are moisture stress, poor handling, and physical damage before planting.** From the time seedlings are lifted from the nursery bed to the time they are planted, it is critically important to keep the seedlings moist (relative humidity 90 to 95 percent) and cool (34°F to 36°F). Seedlings must remain in a state of dormancy during this period.

As temperatures rise, plants begin to respire, and can quickly deplete their energy reserves. Seedlings that exhibit mold growth indicate storage at above optimum temperatures. This improper storage may ultimately impact seedling vigor and survival. Buds can break dormancy and begin to grow, placing the new growth at risk of breakage or damage prior to planting. If seedlings are allowed to dry out, the root hairs become permanently damaged, and are unable to absorb adequate water and nutrients. Physical damage from handling can impair root hairs, shoot tips and buds which will slow initial growth of the seedlings.

### ROOT PRUNING AND CULLING

**Root pruning** may be necessary for seedlings with long fibrous root systems in order to facilitate proper planting. **Remember that the key to seedling establishment and survival is a vigorous root system, so approach root pruning conservatively.** Severe root pruning can quickly lead to seedling mortality after planting because seedlings will not have sufficient root area to absorb water. Recommendations for pruning 2-0 conifer nursery stock are to clip the root system eight to 10 inches below the root collar. Larger conifer nursery stock, such as 3-0 or transplants, require a larger root system in order to maintain a proper shoot to root ratio. Most hardwood nursery stock can be pruned to eight to 10 inches below the root collar, and the lateral roots can be pruned at four inches from the main taproot. Remember that larger hardwood stock must be pruned more conservatively, and may require specially designed planting equipment to prepare adequate planting holes. Root pruning must be done in a cool environment where the seedlings will not be exposed to the drying effects of wind and sun, therefore, the planting site is often the worst place to conduct root pruning. Sharp and sanitary root pruning equipment must be used. Roots damaged by ripping, stripping or crushing reduces moisture availability to the seedling at a critical period.

It may be necessary to cull weak, small or root damaged seedlings at this time. Bulk orders include extra seedlings to allow for (or offset losses from) culling. The nursery often provides specifications on what should be culled from a bulk order. Eliminate the wilted, discolored, damaged, decayed (roots or stem will be soft and spongy) or galled seedlings. Galled seedlings (or seedlings with unusual round or oblong swellings) may be infected with a fungus that will ultimately kill the seedling (see Figure 15-12). Keep seedlings moist during the entire pruning and culling process. Place the seedlings back into their packaging, remoisten and reseal the packages tightly to keep in moisture.



Figure 15-12: Jack pine seedling with a small gall. This seedling should not be planted.

## MACHINE PLANTING

Machine planting is well-suited for large orders, planting on even terrain, heavy soils, and planting hardwoods with large root systems. Planting machines generally require a 30 to 50 horsepower tractor. A minimum of three people are recommended – one to drive the tractor, another to ride the planting machine, and a third to provide seedlings to the planter and check for proper planting technique. The same stock handling principles listed previously apply to machine planting. Do not load too many trees in the machine's storage bins at one time or hold too many seedlings in hand to feed the planting machine. Instead, supply stock in small amounts to keep seedlings moist and cool. The average machine planting crew can plant 5,000 trees per day.

## HAND PLANTING

Hand planting is necessary when the terrain is rough, steep, the seedlings are too small or large for machine planting, or when interplanting within an existing stand or plantation. The most common tools used for hand planting include a shovel, planting bar ("dibble"), or hoedad. The average inexperienced tree planter can hand plant about 500 seedlings per day, depending on site conditions and stock type. A professional tree planter can often hand plant 1,000 or more seedlings per day. For an instruction sheet regarding proper hand planting techniques, refer to: [dnr.wi.gov](http://dnr.wi.gov) – keywords "tree planting."

When planting by hand, remember to keep the seedlings shaded, cool and moist at all times. Do not leave packages of seedlings exposed to sunlight and warm temperatures at the job site. Utilize a reflective tarp, and consider delivering the stock in stages during the workday. Carry seedlings in a planting bag or bucket along with wet burlap to keep the root systems moist. **Handle the roots as little as possible, and do not carry the seedlings exposed to the air or immersed in water.** The roots should hang freely in the planting hole and not be twisted or crooked. The new soil line should be slightly above the seedling's root collar. The soil should be packed firmly around the seedling to maintain good soil to root contact and eliminate air pockets.

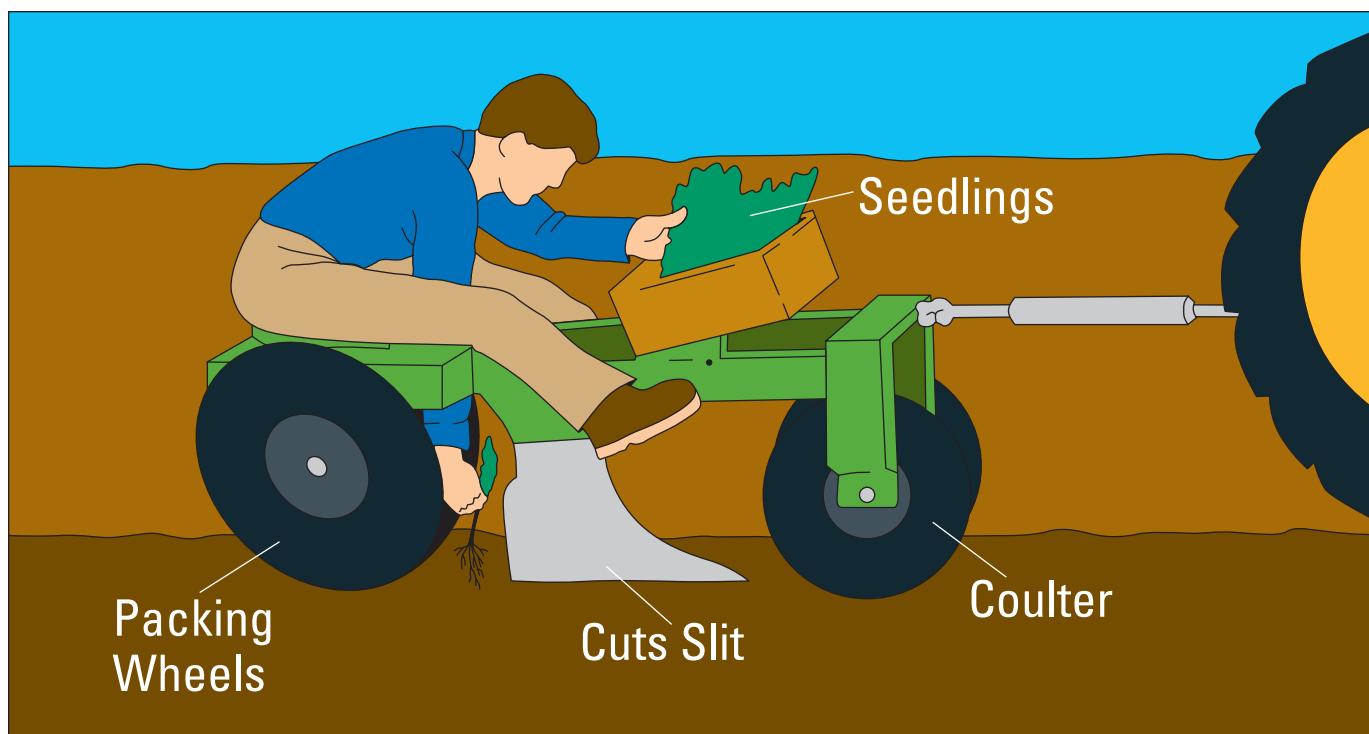


Figure 15-13: A planting machine. It works by opening a slit about 10 inches deep into the soil. A person on the machine inserts a seedling into the slit, and holds it at the appropriate planting depth until the rear packing wheels close the slit. Hardwoods often require a wider and deeper planting slit than conifers to accommodate the large, fibrous root systems.



Figure 15-14: Machine planting hardwood seedlings along the edge of a farm field found in southern Wisconsin.



Figure 15-15: This tree planter is using a hoedad to hand plant jack pine seedlings on this harvested and site-prepped area in the Black River State Forest.

## TRANSPORTING

Seedlings are most at risk from overheating, moisture stress, and physical damage during transportation and immediately before planting at the field sites. Plants must be kept cool and free from wind and sunlight exposure. For large orders, a refrigerated truck is recommended. If a pickup truck is used, place a foam sheet on the truck bed, and spacer boards between the foam and boxes for ventilation. Cover the packages with a solar reflective tarp (reflective side down) to prevent heat build-up. Consider transporting seedlings early in the day to take advantage of cooler temperatures or use insulation, ice packs, snow, or large coolers to help keep the seedlings cool.

Do not place seedlings in a hot car trunk or leave them in a sunny location. If you suspect the seedlings have not been kept consistently cool since leaving the nursery, sprinkle cool water on the roots and reseal the packages.

## SEEDLING STORAGE

Most people do not have access to truly adequate long-term cold storage. Always minimize storage time and plant seedlings as soon as possible after delivery. Storage only allows more time for problems to develop. If seedlings must be stored for short periods of time (one to two days), seek out local cold storage facilities such as produce businesses or orchards. Keeping a constant temperature below 40°F is the key to proper storage. Unheated basements and root cellars may work for very short periods, if the temperature is constant and below 40°F. Do not use storage sheds or similar buildings because the temperatures can fluctuate greatly during the day. Do not immerse seedlings in water for long periods of time as this can damage fine root hairs. Heeling in or planting in a shallow trench can also lead to root damage and additional transplant shock.

## DIRECT SEEDING

Seed can be sown with a variety of equipment, such as seeding sticks, dribblers, broadcast seeders, or seed drills. The most effective means of direct seeding will depend on the species and seed size, and the

planting site characteristics. Seed treatments may be needed to discourage predation by animals. Detailed information on seeding equipment and techniques is available in the Wisconsin DNR *Silviculture Handbook*, 2431.5.

## REFORESTATION AIDS

There are a wide variety of products available to aid in the survival of a plantation.

**Tree shelters** protect trees from animal browse and improve initial height growth by creating a greenhouse effect. They make seedlings easier to locate, and protect the trees from herbicide damage. Tree shelters do not eliminate the need for vegetation control and require annual maintenance. Netting should be placed on the top of shelters to prevent the accidental death of birds in search of nesting sites. Shelters block a significant quantity of incoming light, so they should be used in full sun conditions. Tree shelters are used primarily with high value hardwoods, and the cost may not be economically justified for many landowners. Other problems associated with the use of shelters include stem dieback and rodent nesting. After a few years, tree shelters may actually inhibit sapling growth, so they should be removed once terminal shoots have emerged from the shelter top, and the sapling becomes rigid enough to stand on its own.

**Mulches and vegetation mats** are used to suppress competing vegetation growth, retain soil moisture and reduce erosion. Mulches can include bark, sawdust, straw, wood chips or other materials. Mulches must be applied to a depth adequate to suppress weed growth (i.e., two to three inches), but should not be heaped or mounded immediately next to the seedling. Mulches are labor intensive to apply and can attract rodents seeking nesting areas. Vegetation mats are typically made from plastics or natural fibers. They suppress weed growth while still allowing water infiltration. The primary disadvantage of mats is the high cost.

**Root dips and gels** are hydrating gels used to coat seedling roots prior to handling and planting operations. Their primary purpose is to prevent drying of the seedling's roots during the planting process.



## POST-OPERATIONAL ACTIVITIES

### Monitoring Program

**Some monitoring process should be used to evaluate plantation survival and assess maintenance needs.** A regular program of monitoring helps ensure the success of a reforestation project. Minimally, plantations should be evaluated during the first growing season, four to five months after planting (although earlier evaluations may make problem diagnosis easier), and again during the second, third and fifth growing seasons to verify survival and establishment. During the evaluation process make note of symptoms, including discoloration or the loss of foliage, injury from animals, and presence of damaging insects, diseases, and nonnative invasive plants and other competing vegetation problems.

**Survival counts** are a quick way to determine if replanting is necessary in order to meet management goals. Estimating survival on random 1/100 acre plots throughout the plantation can assess seedling survival. To survey seedling survival attach an 11.8 foot length of cord to a stake to represent the radius of a 1/100 acre plot. Place the stake in the center of each plot and count the number of live and dead planted trees within 11.8 feet of the plot center. Each tree counted represents 100 trees per acre, multiply the number of live and dead planted trees by 100 to determine the number of trees planted per acre. The number of live trees per acre divided by the total number of trees per acre equals the survival percentage. Average the values from all the plots to determine the survival for the whole plantation. The number of plots required to obtain a reliable survival estimate depends on the size of the plantation and the variability of survival. A rule of thumb is to do one plot per acre for the first 10 acres, and one additional plot for each additional five acres of plantation. An alternative method (faster, but potentially less accurate) is to select a row and count the number of live and dead trees to estimate survival and stocking. Switch rows periodically to sample across the entire plantation.

### Vegetation Control

The success of a planting will often be determined by the control of competing vegetation before and after the trees are planted. **Good site preparation will get seedlings off to a fast start, but competing vegetation**



*Figure 15-16: Rapid tree growth results from proper care and planning (e.g., grass control when seedlings were young and adding white pines to help trees grow tall and straight) as evidenced by this 30-year-old black walnut plantation in Dane County.*

**may need to be controlled for at least three growing seasons, or until the trees are well-established.**

Herbicides are often the most effective method for follow-up control of competing vegetation. The proper choice of herbicide, timing and method of application are critical to ensure that planted trees are not damaged. More information on herbicides for forest management is available at: [dnr.wi.gov](http://dnr.wi.gov) – keyword “herbicide” or see Chapter 14: Pesticide Use, for more information on the use of herbicides.

**Mechanical control** of competing vegetation may be suitable for some post-planting situations. Shallow disking or rototilling between rows is effective if care is used to avoid damaging the trees and their root systems. Mowing can reduce competing vegetation maturation and seed production, and minimize rodent habitat, but it may also stimulate grass root growth and intensify competition for soil nutrients and water. Mowing can prevent the physical smothering of trees (i.e., lodging as grasses and broadleaf plants die and fall over in the winter). Hand or mechanical cutting of woody vegetation using brush saws and brush mowers, may effectively release young seedlings, but repeated treatments may be needed due to stump sprouting.

## Animal Control

Most forest plantings will experience some type of animal damage (e.g., browsing, rubbing, rodent bark feeding), however, the severity of that damage will vary across planting sites and between tree species. Many different techniques can be employed to discourage severe wildlife damage.

## POPULATION CONTROL

Hunting can be an effective way to reduce local deer and rabbit populations. **Rodenticides have been used to control mice, pocket gophers and meadow voles, however, these baits are hazardous and can affect non-target organisms.** Rodenticides may be restricted and require a license (see the Resource Directory for sources of assistance).

## HABITAT MANIPULATION

Wildlife damage can be minimized by manipulating the habitat in and around the plantation. Mowing and other grass control measures will reduce rodent damage by removing their habitat, and increasing access by predators such as hawks. Constructing raptor perches (posts that are placed throughout the plantation to allow raptors to sit above the plantation) can also improve rodent predation. The removal of brush and hedgerows virtually eliminates rabbit damage, since they do not venture far from shelter. Manipulating the planting design can protect high hazard areas and discourage animals from entering the plantation. For example, plant several rows of less palatable trees, such as spruce, next to existing woodlands or along obvious travel corridors.

## PROTECTION DEVICES

There are a wide variety of products available to protect seedlings. Electric fences, tree shelters, bud cap protectors, and bud nets create a physical barrier between the seedling and animal. **These devices must remain intact to be effective and maintenance is often required.** Repellents rely on fear, conditioned avoidance, or taste to discourage animal browse. Repellents can work for short periods, but their effectiveness is reduced with time.

## Insect and Disease Control

All plantations will experience some degree of insect and disease damage. If local pockets of damage develop, or problems persist, carefully identify the pest organism and assess the degree of damage prior to developing control recommendations. Once trees are damaged and weakened, they become susceptible to further attacks by pests. Proper identification becomes complicated when more than one organism or injury is present (see the Resource Directory for sources of assistance in insect and disease identification). Additional information on pests that affect young plantations is available in the Wisconsin DNR *Silviculture Handbook, 2431.5*.

Information on insects and diseases can be found in Chapter 8: Threats to Forest Health.



(WDNR, Jolene Ackerman)

*Figure 15-17: Pine plantations hold an allure for rural builders, but such settings pose problems. Soil compaction and root injuries commonly lead to tree mortality near homes. Thinning to keep trees healthy is often impractical in housing developments. Poor air circulation, mold and extreme fire hazard are troubles experienced by homeowners.*

## Weather and Environmental Damage

### DROUGHT

Adequate soil moisture is crucial when the trees are young and lack fully developed root systems. Trees damaged by drought appear wilted and have yellow or brown foliage. The symptoms should appear similar throughout the plantation. Recovery is possible if seedlings get water before extensive damage is done. Drought will weaken seedlings and predispose them to insect and disease attacks.

### FROST/FREEZE INJURY

Frost damage generally occurs in depressions or low areas where cold air settles. The foliage and/or young shoots will curl, turn black and die. Freeze injury can cause hardwood stems to dieback the following growing season. Trees from inappropriate southern seed sources, and species on the edge of their natural range, are particularly susceptible. Frost damage rarely kills trees, but it does slow growth and predispose the seedling to insects and diseases.

### HERBICIDES

Improper application or timing of a herbicide can damage or kill seedlings. Foliage and shoots will usually appear yellow and have distorted growth (see Chapter 14: Pesticide Use).

### POLLUTANTS

Damage from pollutants can resemble many different problems, and is difficult to identify. Sulfur dioxide, ozone, and road salt are common tree damaging pollutants. White pine is particularly susceptible and should not be planted in areas frequently exposed to air pollution or road salt.

### FIRE

The best way to prevent a fire is to reduce the amount of fuel in and around your plantation. Establish and maintain disked firebreaks and mowed access roads in order to prevent the spread of a fire, and provide easy access by fire control equipment.

## DESICCATION

Dry winter winds may cause desiccation of conifer seedlings, and turn needles reddish brown. This damage is mostly an aesthetic concern.

## BMPs: Invasive Species

The following are Forestry BMPs for Invasive Species (IS-BMPs) that should be considered during planning and implementing reforestation and afforestation activities.

- 3.2 Prior to implementing management activities, scout for and locate invasive species infestations, consistent with the scale and intensity of operations.
- 3.5 Plan for post-activity management of highly damaging invasive species.
- 4.2 If pre- or post-activity control treatments are planned, ensure that they are applied within the appropriate time window.
- 4.3 Consider the likely response of invasive species or target species when prescribing activities that result in soil disturbance or increased sunlight.
- 4.4 Prior to moving equipment onto and off of an activity area, scrape or brush soil and debris from exterior surfaces, to the extent practical, to minimize the risk of transporting propagules.
- 4.5 Take steps to minimize the movement of invasive plants, insects, and diseases to non-infested areas, during forest stewardship activities.
- 6.1 Limit the introduction and spread of invasives during reforestation or revegetation site preparation activities.
- 6.4 Select plant materials that are site appropriate to favor establishment and vigor.
- 6.5 Plan for post-planting management of invasive species.

## RESOURCES FOR ADDITIONAL INFORMATION

### HERBICIDES FOR FOREST MANAGEMENT

*dnr.wi.gov* – keyword “herbicide”

### SILVICS OF NORTH AMERICA

*Silvics of North America*, U.S. Department of Agriculture Forest Service.

[www.na.fs.fed.us/spfo/pubs/silvics\\_manual/table\\_of\\_contents.htm](http://www.na.fs.fed.us/spfo/pubs/silvics_manual/table_of_contents.htm)

### SILVICULTURE HANDBOOK

*Silviculture Handbook*, Publication Number 2431.5, Wisconsin DNR, Madison, Wisconsin, 2002.

*dnr.wi.gov* – keyword “silviculture”

### UNIVERSITY OF WISCONSIN INSECT DIAGNOSTIC LAB

[www.entomology.wisc.edu/diaglab/entodiag.html](http://www.entomology.wisc.edu/diaglab/entodiag.html)

### UNIVERSITY OF WISCONSIN PLANT DISEASE DIAGNOSTIC CLINIC

[pddc.wisc.edu](http://pddc.wisc.edu)

### UNIVERSITY OF WISCONSIN SOIL AND PLANT ANALYSIS LABS

[uwlab.soils.wisc.edu](http://uwlab.soils.wisc.edu)

### UNIVERSITY OF WISCONSIN-MADISON FORESTRY EXTENSION

[forestandwildlifeecology.wisc.edu/extension-about\\_us](http://forestandwildlifeecology.wisc.edu/extension-about_us)

### WEB SOIL SURVEY

U.S. Department of Agriculture, Natural Resource Conservation Service.

[websoilsurvey.nrcs.usda.gov/app/](http://websoilsurvey.nrcs.usda.gov/app/)

### WISCONSIN DNR REFORESTATION PROGRAM

*dnr.wi.gov* – keywords “tree planting”

### WISCONSIN NURSERY DIRECTORY

Wisconsin Nursery Directory, Forestry Fact Publication Number 14, University of Wisconsin Extension.

[forest.wisc.edu/sites/default/files/pdfs/publications/14.PDF](http://forest.wisc.edu/sites/default/files/pdfs/publications/14.PDF)

### WOODY PLANT SEED MANUAL

*Woody Plant Seed Manual*, U.S. Department of Agriculture Forest Service.

[www.fs.usda.gov/nsl/nsl\\_wpsm.html](http://www.fs.usda.gov/nsl/nsl_wpsm.html)

### NOTES

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## WISCONSIN DEPARTMENT OF NATURAL RESOURCES NOTICE OF FINAL GUIDANCE & CERTIFICATION

*Pursuant to ch. 227, Wis. Stats., the Wisconsin Department of Natural Resources has finalized and hereby certifies the following guidance document.*

### DOCUMENT ID

FA-20-0005

### DOCUMENT TITLE

Wisconsin Forest Management Guidelines

### PROGRAM/BUREAU

Forest Economics and Ecology, Applied Forestry Bureau

### STATUTORY AUTHORITY OR LEGAL CITATION

S. 823.075, Wis. Stats. & NR 1.25, Wis. Admin. Code

### DATE SENT TO LEGISLATIVE REFERENCE BUREAU (FOR PUBLIC COMMENTS)

2/10/2020

### DATE FINALIZED

4/6/2020

### DNR CERTIFICATION

*I have reviewed this guidance document or proposed guidance document and I certify that it complies with sections 227.10 and 227.11 of the Wisconsin Statutes. I further certify that the guidance document or proposed guidance document contains no standard, requirement, or threshold that is not explicitly required or explicitly permitted by a statute or a rule that has been lawfully promulgated. I further certify that the guidance document or proposed guidance document contains no standard, requirement, or threshold that is more restrictive than a standard, requirement, or threshold contained in the Wisconsin Statutes.*

*Carmen Hardin*

March 27, 2020

Signature

Date