

WISCONSIN FOREST MANAGEMENT GUIDELINES

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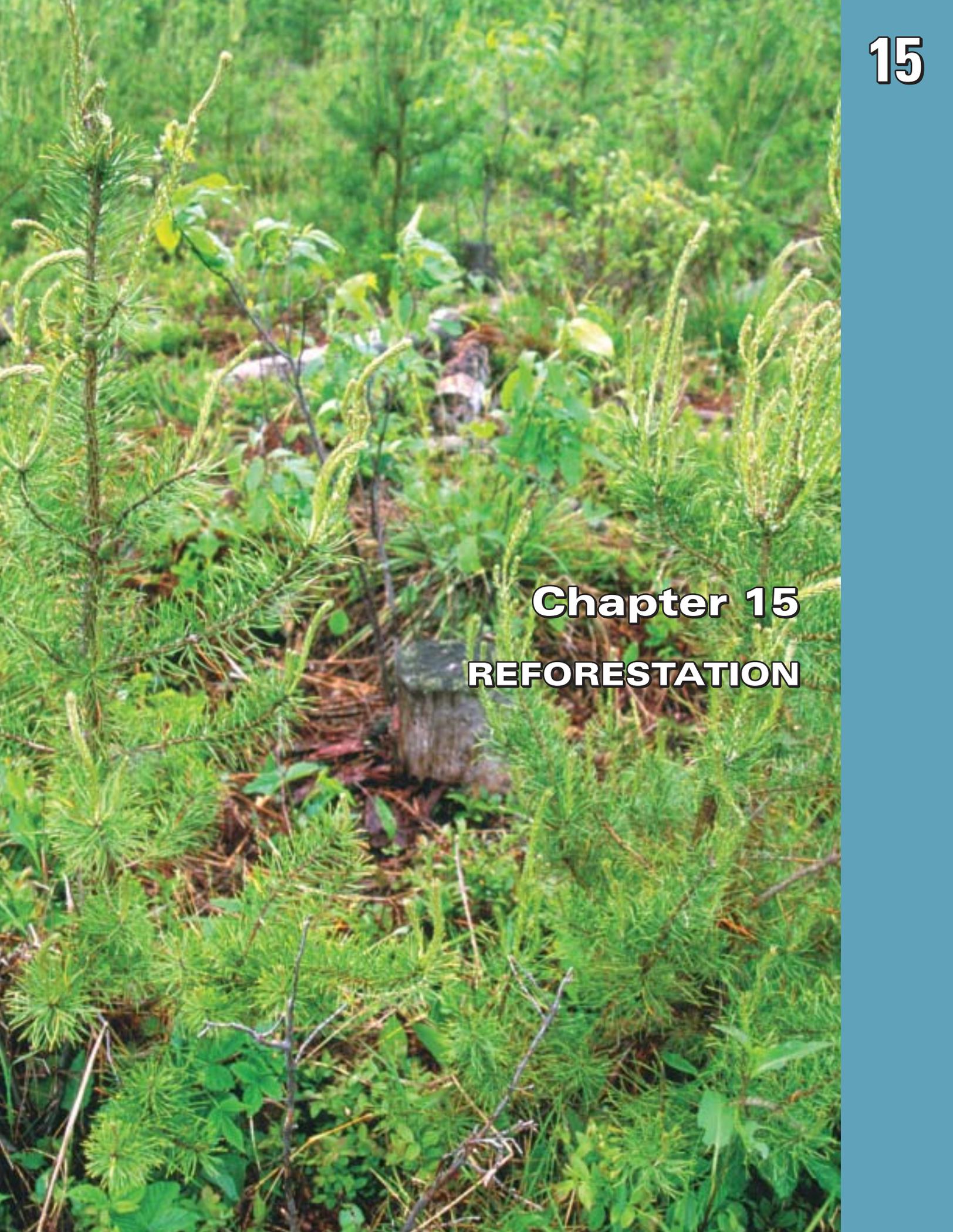
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Chapter 15
REFORESTATION

CHAPTER 15 — REFORESTATION

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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** involve aerial or ground seeding, or planting seedlings 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 tree plantings in Wisconsin.

Afforestation is the practice of planting trees to create a forest on non-forested land.

Species conversion is changing the species composition of a forest from one forest cover type to another.

Restoration is the process of reintroducing and maintaining native flora on a given site.

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 identifies measures needed to minimize any impacts on other important resources.
- 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 weed control treatments.
- 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.
- Reforestation considerations should be part of any harvesting plan.

- Protection of cultural resources may require modification of reforestation efforts.
- Endangered, threatened and special concern species can be impacted by reforestation projects.



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 project is to think about 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 activities begins with evaluating the planting site. Knowledge of potentially limiting site factors such as soils, existing vegetation, 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. 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.

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 trees species that are well-adapted to the planting site. **If possible, examine the soil to a depth of two to five feet, paying particular attention to:**

- Soil texture – is it too coarse or sandy?
- 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. 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 (see the Resource Directory for sources of both soil survey reports and a soil lab analysis).

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 must be considered when selecting appropriate planting stock, site preparation treatments and maintenance activities.

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.

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.

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 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.

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?
- Population trends – are new pests/pathogens present?
- Evidence of pests and 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?

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.

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 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, nursery stock type, arrangement, site preparation and planting method, layout of roads and firebreaks, and any post-planting maintenance. 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.

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



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.

EXAMPLES OF GOALS AND THEIR ASSOCIATED DESIGN CONSIDERATIONS

Timber Management

- Match species with area market demands and opportunities.
- Provide equipment access for thinning, pruning, and harvesting.
- Include harvest roads and firebreaks.
- Add species that will create future natural regeneration opportunities.
- Leave space around powerlines, underground cables and gas lines.
- Avoid steep slopes and wet areas.
- Provide closer spacing of hardwoods to improve sawtimber quality.

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.
- Offer habitats that are in locally short supply.
- Choose species which provide preferred food for desired wildlife.
- Establish or expand 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

- Leave grass buffer zones near streams to help prevent siltation.
- Plant trees along contours to help control runoff.
- Leave drainage pathways covered in grass.
- Concentrate trees in “problem” areas.
- Plant tree species in riparian zones that have a long life expectancy.
- Plant highly erodible upland fields to decrease runoff.

Species Selection

The tree species selected for reforestation 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:

- Site requirements, especially soil factors
- Climatic suitability
- Potential growth rate on site

ADVANTAGES AND DISADVANTAGES OF WIDE AND CLOSE SPACING

WIDE SPACING ADVANTAGES

- Planting costs are less.
- Trees attain larger diameters and become merchantable sooner.
- Trees may produce greater quantities of seed/mast at an earlier age.
- Increased understory growth will provide wildlife food and habitat.

WIDE SPACING DISADVANTAGES

- Increased weed competition and maintenance.
- Reduced stem quality due to greater taper and longer branch retention.
- Increased fire hazard.
- Reduced erosion control.

CLOSE SPACING ADVANTAGES

- Faster crown closure resulting in less weed competition and maintenance.
- Improved stem quality (straighter boles and small, self-pruning branches).
- Large wood volumes accumulate in early years.
- Greater number of trees to select from during thinning operations.

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.

- Sunlight requirements
- Potential competition problems
- Potential for insect and disease problems
- Wood and fiber properties and potential markets
- Compatibility with other species
- 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.

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.



Figure 15-4: Successful planting requires vigorous seedlings of sufficient size with a healthy root system.

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).

	4'	5'	6'	7'	8'	9'	10'
4'	2,722						
5'	2,178	1,742					
6'	1,815	1,452	1,210				
7'	1,556	1,244	1,037	889			
8'	1,361	1,089	908	778	681		
9'	1,210	968	807	691	605	538	
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 shaded areas represent the more commonly recommended spacings for reforestation purposes.

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 (see the Resource Directory for information on these programs).

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 green ash, an alternating pattern with white oak may result in suppression of the oak. One solution

is to group the species within the planting to minimize problems associated with very different juvenile growth rates.

Recently, 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.

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, alternate row plantings may necessitate the removal of all conifers during the first thinning, unless other thinning methods are designed into the plantation.



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.

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 206 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.

Direct Seeding vs. Seedlings

One of the initial planning decisions is whether to plant seeds or seedlings. Each method has advantages and disadvantages in terms of ecology, operation and expense.

The advantages of direct seeding include:

- Less expense for conifer plantings or small areas.
- Quick establishment of tree cover to “capture” the site.
- Applicable on difficult terrain or shallow soils.
- Good root development with no transplant shock.
- More uniform stocking than in a naturally regenerated stand.
- Improved hardwood stem quality in high density plantings.

Direct seeding is often times not successful, although many such instances can be attributed to improper planning. Multiple factors influence seed germination, making careful planning critical in highly variable field environments.

Other disadvantages include:

- Necessity for intensive site preparation and follow-up weed 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 is difficult to obtain 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 100 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. Additional seed handling information on particular species is available in the *USDA Forest Service Woody Plant Seed Manual*.



Figure 15-6: Interplanting spruce seedlings by hand in a harvested hardwood stand to augment natural regeneration, and provide species diversity.

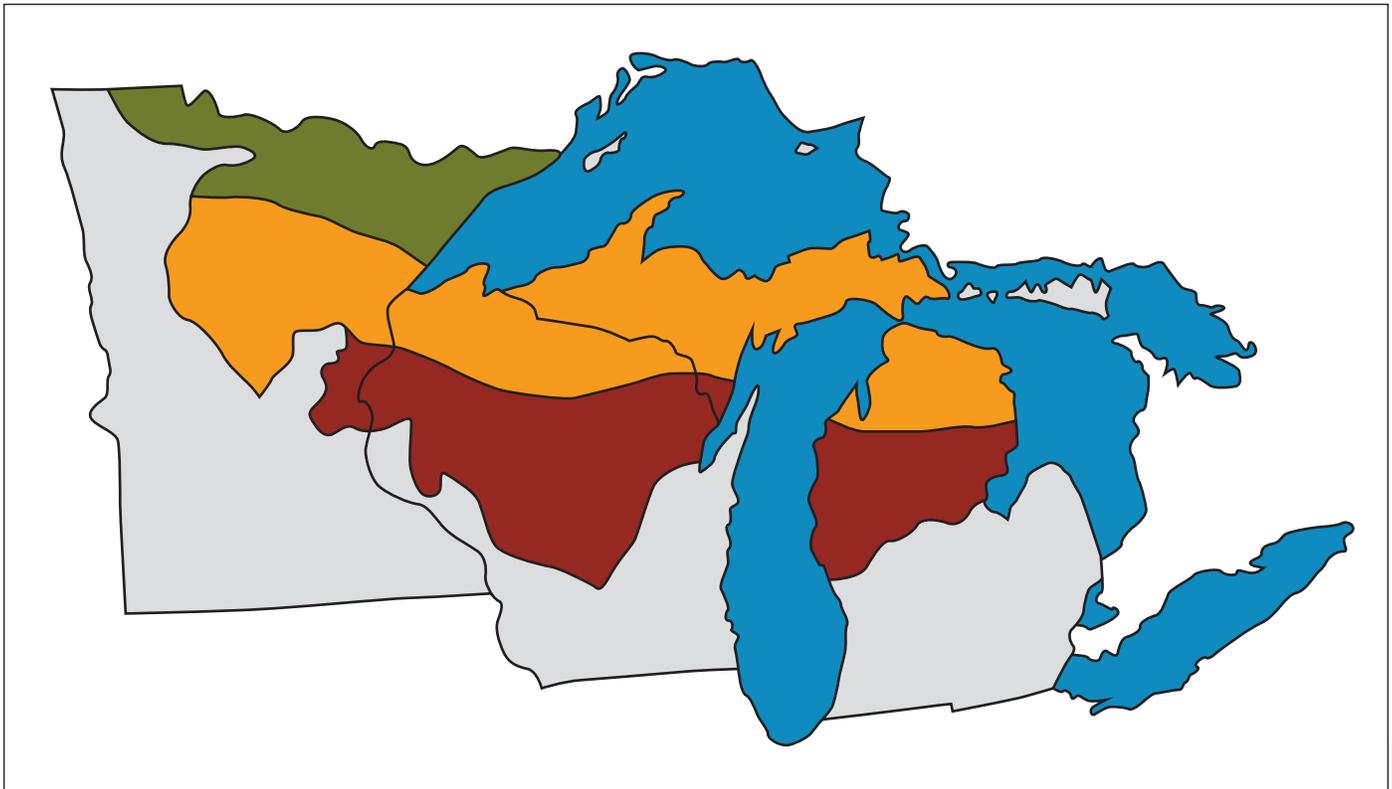


Figure 15-7: Jack Pine Seed Source Trial (20-year Results). Seed zones established for the appropriate movement of jack pine seed sources in Wisconsin. Tree performance is generally best when seed sources are kept within a particular zone.

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 continue to examine seed source performance across Wisconsin in order to identify appropriate sources and seed zones (see Figure 15-7). 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.

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 bareroot stock** in order to select seedlings 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 bareroot 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 bareroot 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.

PLANTING STOCK AGE CLASSES – WHAT DO THOSE NUMBERS MEAN?

Bareroot 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 spent in a seedbed. For example, a 2-0 designation means the tree spent two years in a seedbed. The second numeral refers to the number of years spent in a transplant bed. For example, a 2-1 designation means the tree spent two years in a seedbed and one year in a transplant bed (transplanting improves root development).

Bareroot 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 bareroot stock include lower costs, ease of transportation and storage, competitive advantage over weeds, less susceptibility to deer browse, and faster root regeneration. Bareroot 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.



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.

OPERATIONAL CONSIDERATIONS

Site Preparation

Site preparation is the creation of a favorable growing environment for tree seeds or seedlings. The biggest obstacle facing seedling establishment is competition from other vegetation. Effective site preparation will reduce competing vegetation, and create a sufficient number of suitable growing sites without causing excessive soil disturbance.

Mechanical site preparation typically disturbs the soil and reduces competing vegetation by plowing, disking, raking, chopping, scalping, and trenching, among other approaches. In some cases, mechanical site preparation can be valuable, as exposing and disturbing mineral soil can have the added benefits of increasing root zone temperatures, aerating the soil, and improving drainage. **However, when mechanical site preparation is done incorrectly, it can result in soil erosion, compaction and rutting.** Also consider the potential competing vegetation that may develop from dormant seeds after the soil is exposed. A combination of both mechanical and chemical techniques can be used for added control. Chapter 13: Mechanical Site Preparation provides additional guidance on mechanical site preparation techniques, and the considerations involved in the selection of a particular method.

Chemical site preparation can be an effective method to control 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 in Forestry Facts Sheet #76, University of Wisconsin Extension (see Chapter 14: Pesticide Use, for additional information on the safe use of herbicides).

Prescribed burning, or controlled ground fires, can be an effective and inexpensive means of removing or reducing vegetation, and preparing a suitable seedbed. Burning can also improve soil nutrient levels and ectomycorrhizal development. Prescribed burning, however, can reduce the effectiveness of pre-emergent herbicides 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. **Effective and safe use of prescribed fire requires appropriate equipment and training** (see Chapter 17: Fire Management and the Resource Directory for sources of technical assistance and information on any permits required).

Cover crops are appropriate for afforestation sites where they are grown to prevent invasion by noxious weeds, non-native invasive species, or 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 weed growth, 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 15-9: 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 after planting to control germination of stored weed seed. Cover crops may also be used to control invasive weeds. 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, 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 bareroot 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. Damaging molds can also grow on seedling roots under warm conditions.

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.

It may be necessary to **cull weak 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, or “scraggly” seedlings. 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 15-10: Machine planting hardwood seedlings along the edge of a farm field found in southern Wisconsin.

MACHINE PLANTING

Machine planting is well-suited for large orders, planting on even terrain, and planting hardwoods with large root systems. Planting machines generally require a 30 to 50 horsepower tractor. 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. Instead, supply stock in small amounts to keep seedlings moist and cool. The average machine planting crew can plant 5,000 trees per day.

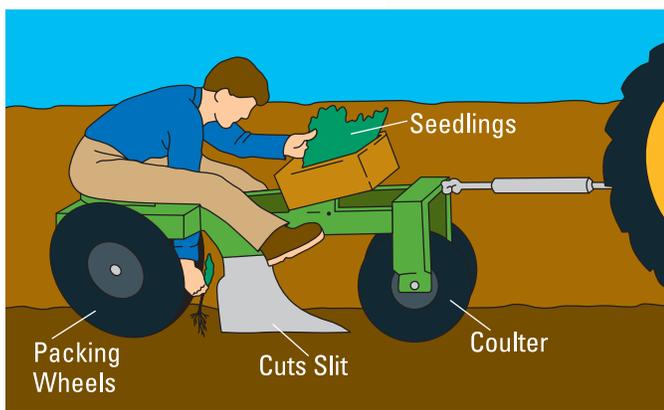


Figure 15-12: A planting machine. It works by opening a slit about 10 inches deep into the soil. A person on the machine inserts a seedling into the slit, and holds it at the appropriate planting depth until the rear packing wheels close the slit. Hardwoods often require a wider and deeper planting slit than conifers to accommodate the large, fibrous root systems.



Figure 15-11: 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.

HAND PLANTING

Hand planting is necessary when the terrain is rough, the seedlings are too 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, contact your local DNR office.

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.

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. For small orders, use a refrigerated van or well air conditioned car. 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 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. Detailed information on seeding equipment and techniques is available in the Wisconsin DNR *Silviculture and Forest Aesthetics 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 weed 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. At a minimum, 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 third growing season to verify survival and establishment. During the evaluation process make note of insect, disease, animal, and/or 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. This can be accomplished in a few easy steps. First, attach an 11.8 foot length of cord to a stake to represent the radius of a 1/100 acre plot. Then place the stake in the center of each plot, and use the cord to determine which trees fall within the plot. Count the number of live and dead trees within each plot. Since each tree counted represents 100 trees per acre, multiply the number of live trees by 100 to determine the average number of live trees per acre. The number of live trees per acre divided by the total number of both live and dead trees per acre equals the survival percentage. Average the values from all the plots tallied 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 within the plantation. A rule of thumb is to do one survival 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. 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 weed competition 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 weed control. The proper choice of herbicide, timing and method of application are critical to insure that planted trees are not damaged. Detailed forestry herbicide information is available in Forestry Facts Sheet #76, University of Wisconsin Extension (see Chapter 14: Pesticide Use, for more information on the use of herbicides).

Mechanical weed control 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 weed 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 the winter. Hand or mechanical cutting of woody vegetation may effectively release young seedlings, but repeated treatments may be needed due to stump sprouting.

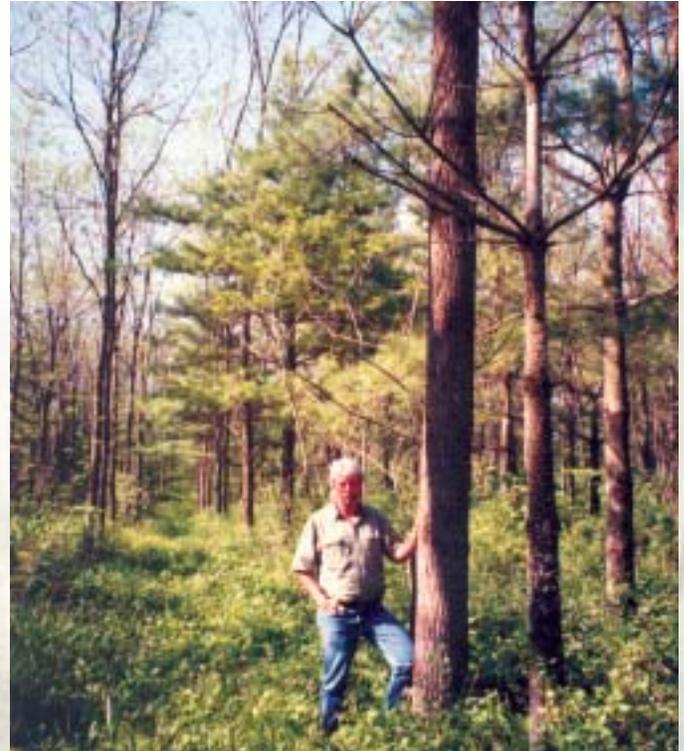


Figure 15-13: Rapid tree growth results from proper care and planning (e.g., grass control when seedlings were young and adding white pines to help trees grow tall and straight) as evidenced by this 30-year-old black walnut plantation in Dane County.

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 and Forest Aesthetics Handbook*, 2431.5.

Insects causing the most damage to young tree plantations fall into three categories:

- **Main stem and root pests**, such as weevils and white grubs, feed on the main stem or root system, and can cause serious tree mortality.
- **Shoot or branch pests**, such as scales and spittlebugs, feed on or within the shoots, causing branch damage or death.
- **Defoliators**, such as caterpillars and sawflies, feed on the leaves or needles.

Diseases can also be grouped into three categories:

- **Root rots** cause slowed leader growth and yellowing of the crown. Mushrooms may be evident around the base of an infected tree. Direct contact between roots will cause the spread of the disease and infection pockets will occur.
- **Cankers, stem rusts, and shoot blights** are seen as lesions and/or swellings on stems and branches. These lesions will eventually cause dieback by girdling the stem.
- **Foliage diseases**, such as anthracnose and needle casts, appear as spots or lesions on needles and leaves.



Figure 15-14: 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 and die. Freeze injury can cause hardwood stems to die back 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.

DESICCATION

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

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.

RESOURCES FOR ADDITIONAL INFORMATION

HERBICIDES FOR FOREST MANAGEMENT

Herbicides for Forest Management, Forestry Fact Publication No. 76, University of Wisconsin Extension
<http://forest.wisc.edu/extension/publications/76.pdf>

SILVICS OF NORTH AMERICA

Silvics of North America, USDA Forest Service
www.na.fs.fed.us/spfo/pubs/silvics_manual/table_of_contents.htm

SILVICULTURE AND FOREST AESTHETICS HANDBOOK, PUBL. NO. 2431.5

Wisconsin Department of Natural Resources. (2002). *Silviculture and forest aesthetics handbook*. Madison: Wisconsin Department of Natural Resources.
www.dnr.state.wi.us/org/land/forestry/publications/2431_5/index.htm

UNIVERSITY OF WISCONSIN PEST DIAGNOSIS LAB

www.entomology.wisc.edu/entodiag.html

UNIVERSITY OF WISCONSIN PLANT DISEASE DIAGNOSTIC CLINIC

www.plantpath.wisc.edu/pddc/index.htm

UNIVERSITY OF WISCONSIN SOIL AND PLANT ANALYSIS LABS

<http://riprock.soils.wisc.edu/>

UNIVERSITY OF WISCONSIN-MADISON FORESTRY EXTENSION

<http://forest.wisc.edu/extension/forfact.htm>

WISCONSIN NURSERY DIRECTORY

Wisconsin Nursery Directory, Forestry Fact Publication No. 14, University of Wisconsin Extension.
<http://forest.wisc.edu/extension/publications/14.pdf>

WOODY PLANT SEED MANUAL

Woody Plant Seed Manual, USDA Forest Service
<http://wpsm.net/>

These resources are specific to the information in this chapter only. Refer to the Resource Directory for additional resources related to this chapter.