Chapter 22

Artificial Regeneration

Last Full Revision: 2/11/04
Note- this chapter has not been fully revised since the restructuring of the Wisconsin Silviculture Guide, therefore some subject areas may be missing in the current version of this chapter.

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1 ARTIFICIAL REGENERATION

1.1 Statement of Purpose

The purpose of this chapter is to aid foresters in their efforts to successfully establish forest tree plantings in Wisconsin. Whether it be to start new forest plantations, or to develop specialty plantings, the chapter will give suggestions and stimulate ideas on the details of reforestation/afforestation. Artificial regeneration can be a tool to reduce soil erosion, improve wildlife habitat, air quality, land value, watershed protection, enhance aesthetics when properly applied, introduce improved seed sources and return previously deforested land to a forest ecosystem.

This chapter will help identify landowner goals, select the best areas for reforestation/ afforestation, determine if the site has the potential for strong tree growth and what type of site preparation and regeneration scheme will work best. It will detail the costs and benefits of seeding versus planting, as well as bareroot versus containerized stock. In addition, it will discuss the planning, planting, and maintenance of plantations. It will provide a list of the labeled herbicides at your disposal to establish and protect newly planted trees. Different tree species native to Wisconsin will be profiled to help determine which species to plant on a site and appropriate regeneration schemes.

1.2 Definitions

Afforestation: the practice of planting trees with the intent of creating a forest on presently non-forested land.

Biological Diversity: the spectrum of life forms and the ecological processes that support and sustain them. Biological diversity is a complex of four interacting levels: genetic, species, community, and ecosystem.

Conversion: the changing of the species composition of forested land from one forest type to another.

Landscape scale: the appropriate spatial and temporal scale for planning, analysis, and improvement of management activities to sustain ecosystem capability and achieve integrated resource management activities.

Reforestation: the practice of regenerating and growing healthy trees on previously forested sites.

Restoration: the process by which natural flora is reintroduced into an area and maintained to prevent repeated extirpation.

2 PLANNING

2.1 Goals

The first step in plantation establishment is deciding why to start a plantation. Many of the subsequent management decisions will be based on this initial premise. Both spatial and temporal landscape characteristics should be considered when planning for potential plantations. Long-term goals and short-term objectives for the plantation need to be developed with the landowner. In defining the goals, multiple goals are possible because many of them may be compatible with each other. The more specific the goals and objectives are, the more useful they will be in fine tuning management decisions.

Know how much time and resources can be devoted to plantation establishment and care. This will allow for realistic decisions about the plantation, subsequently choose treatments and species that will fit with the intended resources and time available. Try to evaluate the initial establishment costs and eventual returns of the plantation. It is important to note however that monetary returns are not the only reason to promote reforestation. Determine the steps necessary to meet goals while staying within budget.

After you have decided what your goals for the plantation are, you need to determine which species will work toward those goals and will grow well on the site. Bear in mind that plantations can serve many different purposes at once, but that the characteristics of the plantation will change through time. The species initially planted may only serve to capture the site. The long-term goal may be to allow succession to proceed into a mixture of species.

2.2 Site Selection

When planning reforestation activities, it is important to know what you have to work with. Knowledge of the soil and topography will aid in species selection, site preparation, fertilization and other management decisions. Your site may also possess features such as wetlands, riparian management zones, or the presence of endangered species which may limit or alter your management activities. A list of endangered and threatened species can be obtained from the DNR Bureau of Endangered Resources.

2.2.1 Site Characteristics

When choosing or evaluating a site for artificial regeneration there are several things about the site to consider. They include the following:

a) <u>Climate</u>: total precipitation, drought, frost timing, insolation, ice storms, and snow loads.

b) <u>Soil</u>: parent material, texture, depth, rock content, compaction, frost heaving, organic matter, available moisture, nutrients, erosion patterns and internal drainage.

c) <u>Topography</u>: elevation, slope, aspect, surface drainage of moisture and air.

d) Institutional environment: access, labor, equipment, seed, or seedling availability, federal and state cost-share incentives (e.g., stewardship), taxes, regulations, and constraints.

e) Existing vegetation: seeds and advanced regeneration, competition (allelopathy) and endangered resources.

f) Animals: domestic, wild - rodents (rabbits, voles, mice), ungulates, endangered species.

g) Insects: previous history, current population trends.

h) Disease: site history, vulnerability to future infection and presence of alternate host plants.

i) Productivity: productive history and overall site quality

j) Landscape: surrounding cover types in the broad geographic area, location of site in broader landscape picture and management trends.

k) Succession: trends and probable future species composition on the site.

Consider the importance of each of these factors. Is the site still appropriate for reforestation? Is a certain species no longer appropriate? How do these factors effect potential site preparation treatments?

2.2.2 Specific Limiting Site Characteristics

When developing your regeneration prescription take a step back and look at the big picture. You will see that there is an interaction of site quality, owner objectives, economics, and difficulty of establishment. They all affect each other and will ultimately affect how you proceed. The success of your plantation will be determined by the weakest link in the series of events including site evaluation, species evaluation, site preparation, planting stock, planting or seeding, and maintenance.

While developing your prescription you should investigate the history of successful and unsuccessful plantings in the area. Why were they successful or unsuccessful? The following is a list of specific site limiting factors:

a) Frost and winter desiccation - initial damage/mortality occurs in the first growing season. Avoidance through species selection, site preparation, site avoidance, planting season, choosing well-hardened seedlings and microsite selection. Avoid planting valley bottoms prone to cold air drainage and radiative frost until later in the season.

b) Lack of Soil Moisture - determined by season, soil characteristics (organic matter, texture, density, excessive internal drainage, depth), vegetation, slope, elevation, aspect, and evapotranspiration. Avoidance through selection of drought tolerant species, spots prepared to minimize drought effects, plant during periods of sufficient soil moisture, selection of shaded/sheltered microsites (excessive transpirational demand may be placed on seedlings), use of well-hardened seedlings with well-branched woody stems to minimize transpirational losses. Avoid stock with large shoots coupled with poorly developed or small root systems. A well-balanced tree is necessary for droughty sites.

c) Lack of Soil Aeration/Excessive Soil Moisture - due to poor internal soil drainage or abundance of moisture because of surface drainage patterns. Determined by season, soil characteristics (organic matter, texture, density, depth, impeded drainage), slope, elevation, aspect, and evapotranspiration. Avoidance through selection of appropriate species, raised planting spots, and plant later in the planting season.

d) Physical Damage - snow effects (press, creep, abrasion, glide), vegetation press (herbs, grasses), animals (browsing, trampling) and falling debris. A large and robust seedling will be most able to deal with these damaging factors. Large diameter will resist trampling and are less palatable and better able to endure small mammal browsing. Planting during low cycles of rodent populations may be an effective avoidance strategy. Reduction of vegetation cover also removes rodent habitat/shelter and will assist in stock type selection. Erection of perch poles for predators has proven effective. If physical damage does occur, a well-branched stem will re-express apical dominance.

e) Vegetation Competition - potential for mechanical and physiological damage. Extraneous vegetation can damage by vegetation press and will compete for moisture, nutrients, and light. Large and vigorous seedling will fare better against competition. Appropriate site preparation treatments and routine plantation checks and releases will minimize problem.

f) Natural Range - species planted outside their natural range will have low vigor, stunted growth, will be especially susceptible to insect and disease attacks, spring and fall frosts, and winter desiccation or cold temperature damage (e.g., walnut winter kill).

g) Insects and Diseases - Recognizing and evaluating the potential for disease and insect caused losses on proposed planting sites is necessary to realistically estimate productivity and investment returns. Although precise estimates are not possible, valuable information can be gained from on-site evidence (e.g., white grubs and alternative host species), proximity to relevant problems, and historical reference. This information may forewarn of potential problems and open up other management possibilities. The likelihood that your planting will develop serious insect or disease problems can be reduced with mixed plantings, using genetically variable species, and avoiding growing the species on unsuitable sites. Planting stock survival and disease control depend upon selection of low disease-risk sites, appropriate site preparation, and use of healthy planting stock suited to the local environment and adapted to local pathogens.

2.2.3 Site Potential

2.2.3.1 Soils

If possible, you should examine your soil to a depth of 2-5 feet for information on soil texture, depth of the topsoil and organic matter, type of substrate, internal drainage (mottling), and bulk density (hardpans). These are characteristics that affect rooting depth and moisture relations. You can have your soil tested if you suspect nutrient deficiencies. If your soil is not uniform throughout the site, different tree species may have to be planted to accommodate these soil changes.

There are two additional methods for using soils information in determining the suitability of different species for reforestation. The first involves determining the soil series from soil survey reports or soil keys. Tracts in question can be identified on individual map sheets in the back of the soil survey reports. On-site verification should be conducted since soil surveys may contain site specific inaccuracies, especially for the woodland soils. If no soil survey report is available, soil mapping units can be determined from a key available from the Natural Resource Conservation Service (NRCS). Mapping units are determined by the physiographic province, landscape position, nature of the soil parent material, key soil profile characteristics, and drainage class.

The second involves submitting soil samples from specific areas for lab analysis. This requires that soil samples from the upper 6 inches be collected. Soil samples should be collected from throughout the field. The University of Wisconsin Soil and Plant Analysis Lab offers a special test for pH, organic matter, total nitrogen, extractable phosphorous, exchangeable potassium, calcium and magnesium, and provides interpretations for seven tree crops. A forester following a field check can determine which species are appropriate based on aspect, exposure, depth to groundwater, pH, silt plus clay content, and organic matter content.

The soil test is helpful because it will aid in determining the following:

1) <u>Production potential</u>: Not all soils will support trees. Tree growth rates are quite variable on differing soils and moisture regimes.

2) <u>Limitations of equipment and use</u>: If your soil has a high bulk density or has the potential to be compacted or puddled, your management options will be narrowed because heavy equipment will exacerbate the problem. Compacted soils have reduced water infiltration, lowered hydraulic conductivity, and reduced oxygen availability.

3) Insect and disease hazard: Certain soil factors such as poor nutrition and poor aeration have been linked to insect and disease problems. The site itself may have a history of insect or disease problems.

4) Species selection: Match planting stock to sites to fully utilize the productive capacity of the site. Start by selecting the best adapted species and then select the appropriate individual sources within that species.

5) Fertilizer requirements: These will vary depending on the nutrient content presently in the soil.

6) Pesticide use: Soil moisture, texture, and organic matter affect performance and application rates.

7) Goals: Review original goals and confirm that site is appropriate for initially established goals

2.2.3.2 Forest Habitat Type Classification System

This site classification and evaluation tool, when appropriately applied and interpreted, can help evaluate forest establishment and management alternatives. Applicable management considerations include inherent site capability (biological potential), relative soil moisture and nutrient availability, suitability and productivity for specific tree species, potential cover types, competition, successional trends, and potential responses to disturbance. Specific applications for artificial regeneration include site selection, species selection (ecological characteristics and silvicultural options), plantation design and spacing, site preparation, and plantation maintenance.

The preferred method to determine the forest habitat type class is on-site evaluation of summer vegetation within a mature forest. This may not be possible for many sites where artificial regeneration is being considered. The following procedures can be utilized to **estimate** the habitat type for non-forested sites:

1) evaluate and identify the vegetation currently on site; depending on management history some diagnostic species may be present,

2) identify the soil type and landform type, and then determine associated habitat types, and

3) identify habitat type in nearby woodlots if soil, topography, and landform are similar.

The Forest Habitat Type Classification System is defined, discussed, and referenced in another chapter of this Handbook. Each cover type chapter identifies the range of associated habitat types, along with potential productivity and competition.

The Field Guide for Forest Habitat Types of Northern Wisconsin and the Guide to Forest Communities and Habitat Types of Central and Southern Wisconsin are published by the Dept. of Forestry, University of Wisconsin -Madison and the WDNR. Copies may be ordered from: Department of Forestry, University of Wisconsin-Madison, 1630 Linden Drive, Madison, WI 53706.

2.3 Plantation Design

Plantation design will detail the specifics of your plantation, including the placement of the access roads, fire breaks, fences, etc. Your final plantation design plan should include acreage, species, number of trees ordered, spacing, arrangement, site preparation, and method of planting. Ideally, a plantation should be designed to provide financial return, aesthetics, wildlife needs, and diversity through proper design. Examples of goals and design considerations are as follows (remember these design considerations are not mutually exclusive):

If your goal is *timber management* you may want to consider some of the following:

- provide access to the trees through spacing to facilitate thinning, pruning, and harvesting
- include 20 feet wide harvest roads and firebreaks in larger plantings
- buffer powerlines, underground cables and gas lines
- match area markets with species planted
- avoid steep slopes and wet areas
- avoid frost pockets
- include some semi-shade tolerant species to serve as seed source for future natural regeneration
- enhance biological diversity and complement the surrounding landscape
- assess future regional wood marketing opportunities

Those also interested in *wildlife management* should consider the following suggestions:

- enhance biological diversity and complement the surrounding landscape
- offer habitats that are in short supply in the area
- choose tree and shrub species which are preferred food for various species
- choose tree and shrub species which provide cover (e.g., nesting habitat and winter thermal cover)
- leave islands unplanted that are encroaching to other tree and shrub species
- establish travel corridors to connect habitats
- plant around existing wolf trees
- create wildlife openings in the planting
- use a wide variety of species in the plantation, including wildlife shrubs
- create islands of differing sized/aged trees
- frost pockets and odd corners should be left unplanted to improve habitat and biodiversity

- plant artificial openings, such as isolated old fields, to create larger blocks of "interior" forest habitat

The following suggestions will help with *erosion* control:

- leave buffer zones near streams to prevent siltation
- plant trees along contours to prevent runoff
- don't use site preparation that might increase erosion
- concentrate trees in trouble areas
- keep drainage pathways covered with grass
- plant tree species in riparian zones that have a long-life expectancy

To improve the *aesthetic* quality of the plantation you can:

- vary layout and location of plantings
- use a wide variety of species in the plantation, including wildlife shrubs
- plant along contours
- use non-row plantings or curve rows for more natural effect
- create irregular plantation edges
- leave openings within the planting
- create islands of differing sized/aged trees
- planting parallel to roads reduces 'fiber factory' appearance
- frost pockets and odd corners should be left unplanted to improve habitat and biodiversity
- create or retain scenic views
- retain landmarks, distinct features (wolf trees)
- locate hiking trails to take advantage of scenic quality
- plant species with desirable fall color

2.4 Spacing

Spacing will be dependent on:

1. the product desired
2. the likelihood and intensity of intermediate stand treatments
3. the expected initial survival and spatial distribution of seedlings.

Be aware that initial spacing will affect both the biological and the operational factors of the plantation.

Height growth is reduced at extremely high and low densities. Most decisions about the spacing of trees is based on an assumption that 'normal' densities fall in a range that does not reduce dominant height. Diameter growth is unaffected by spacing until competition begins. The period of fast, early diameter growth is longer at wider spacings. But trees will have a large amount of taper; this may not be a desirable form. Wide spacing will also result in branch retention leading to knotty woods.

Spacing may also be affected by which species you select to regenerate. Relative shade tolerance and the species growth pattern will affect initial spacing. Additionally, spacing may be affected by the equipment available for planting, maintenance, thinning and harvesting.

Spacing will affect your thinning schedules. Wide spacings provide little selection opportunity for removing low-quality trees. Close spacing allows undesirable trees to be removed. The advantage of close initial spacing is that larger volumes accumulate in the early years. Also, close spacing will mean faster crown closure. This will reduce the need for weed control and may disrupt the life cycle of some harmful insects. Though crowded, stagnated stands will be more susceptible to insect and disease attacks. Vigor needs to be maintained through stocking control. Establishment costs are also a factor. Close initial spacing will have higher site preparation, planting, and seedling costs.

A general rule for spacing is to plant closer on higher quality sites and further apart on less fertile sites. Tight spacing helps to control competing vegetation and fully utilize the site. Generally, for high quality hardwood tree production seedlings should be spaced closer together to encourage straight boles and smaller lower branches that self-prune. Table 22-1 lists the number of trees per acre by spacing. The shaded areas are the more commonly recommended spacings.

Table 22.1. Number of trees per acre by spacing.

	4 feet	5 feet	6 feet	7 feet	8 feet	9 feet	10 feet	12 feet	15 feet
4 feet	2722	2178	1815	1556	1361	1210	1089	907	726
5 feet		1742	1452	1244	1089	968	871	726	581
6 feet			1210	1037	908	807	726	605	484
7 feet				889	778	691	622	518	415
8 feet					681	605	545	454	363
9 feet						538	484	403	323
10 feet							436	363	290

Advantages of wide spacing: planting costs are less, trees will attain larger diameters and become merchantable sooner, competition from other trees is reduced, they may produce seed earlier, undergrowth will provide food for wildlife.

Disadvantages of wide spacing: increased fire hazard, weed competition is extended longer into the rotation, erosion control is reduced with less crown areas, more biomass is allocated to branches and foliage reducing stem quality, poor drainage problems may be exacerbated.

2.5 Species Selection

When selecting a species, it must meet your management goals and suitable sites must be available. After determining the potential positives and limitations of your site, select a species or combination of species that can emphasize the positives and overcome the limiting factors. Along with selecting the best species, you should select the best seed source and stock type for your needs. With these goals in mind, the factors that should be considered when selecting species include growth rate, site requirements, climatic suitability, genetic variability, wood and fiber properties, aesthetics, wildlife value, biological diversity, erosion control and potential insect and disease problems.

The use of tree species not native to Wisconsin should be contingent on credible evidence confirming that the species in question is not invasive, will not create significant risk to forest health, and is from appropriate provenances that are well adapted to the site. If non-native trees are used, their provenance and the location of their use should be documented, and their ecological effects monitored.

Recently conifer and hardwood mixtures have been recommended for afforestation in Wisconsin. The benefits of these conifer-hardwood mixtures include conifers assist in capturing the site earlier, the cost of plantation establishment is less than a pure hardwood plantation, conifers improve the quality of hardwoods by shading out lower branches and forcing hardwoods to grow upwards, provide wind protection for the planting and the conifers offer a easy alternative for a first thinning. The real disadvantage to this mixture is that once established the options for chemical release of the plantation is narrowed significantly. Subsequently, initial site preparation treatments are critical for successful conifer-hardwood plantations.

Appendix 22- A contains a profile of species commonly utilized in Wisconsin's reforestation program.

2.6 Seeding vs. Planting

The first thing to decide when dealing with stand establishment is which method of artificial regeneration is appropriate. Planting is generally considered more expensive than direct seeding of conifers, but for hardwoods the reverse may be true depending on the cost and quantity of seed used. However, by using seedling several years of development are realized with a new planting.

Seeding is an excellent technique to inexpensively regenerate small areas, or to quickly reforest large acreage. Direct seeding is attractive because if successful, it will establish a more uniformly stocked stand, as opposed to a naturally regenerated stand. Direct seeding is more flexible, faster, less expensive, and since there are large numbers of seed spots per acre, successful trees will benefit from the best available microsites. It can be used where access, terrain, or soil conditions make planting difficult. Seeded trees often have better developed root systems and are often better suited to their environmental niche than planted seedlings. On old-field sites the additional benefits of planting seedlings versus direct seeding often does not justify the additional cost. Direct seeding can be an economically viable alternative to planting, although success with seeding requires knowledgeable selection of species/site combinations and proper seed handling and storage. Additionally, conifer seeds can be stored for a long time and used when needed.

The disadvantage with direct seeding is that often times it is not successful, though many of these cases can be attributed to improper planning. This uncertainty has led many to choose either natural regeneration or artificial regeneration through planting. Seeding is not an efficient use of genetically improved seed. Density is difficult to control. Losses of seeds and small seedlings can be high. Hardwood seed is difficult to obtain in most years and does not store very well. Another concern is that the likelihood of successful establishment of oaks with direct seeding is less because openings need to be large (2.5 acres), intensive site preparation is often necessary and follow up weed control is critical.

Sites to be avoided when considering direct seeding are areas where seeding has already failed. Avoid sites prone to frost or frost heaving. Avoid sites where grazing could occur, standing water may cover seed, soils are deep excessively drained sands (except for the direct seeding of jack pine), and highly erodible soils or steep slopes where seed could be washed away. Always use seed of appropriate seed sources that has been properly stored, stratified, and treated with the necessary repellents.

The ideal sites for seeding are where regeneration would have occurred if seed had been present. Direct seeding of sites can also be accomplished when planting is not feasible. Direct seeded oaks develop roots on site so there is none of the root injury associated with bareroot stock. On shallow-soiled sites direct seeding is easier than planting large bareroot stock. When seeds are purchased, those harvested in a good seed year are best. Collect from the best phenotypes. Try to use seed collected from within 100 miles from the eventual planting site to optimize an individual tree's potential for growth. If possible, select seed from trees on sites similar to those on which you intend to seed. Collect mature seeds just after, or right before they fall. Avoid trees that are isolated because pollination may have been poor. Proper seed collection, handling and storage is critical to successful establishment of a direct seeded plantations. Also, seed crops vary in quantity and quality, for example with red oak a good seed crop generally only occurs once every three to seven years.

2.7 Seed Source Selection

Seed source selection is an often overlooked, but critical component in a successful reforestation program. Selecting appropriate seed sources for the reforestation site will improve overall growth rate of the plantation since the trees are planted into an environment in which they are adapted. Appropriate seed source selection will also reduce catastrophic plantation losses due to maladapted genetic material. The literature and experience have demonstrated numerous times that these maladapted seed sources often survive and thrive for many years prior to a catastrophic event (e.g., frosts, cold winter weather, drought, flooding, etc.). All your efforts can be wasted by ignoring the importance of selecting the appropriate seed sources for a reforestation project.

The general rule of thumb for reforestation is that unless proven otherwise local seed sources (e.g., Wisconsin) are the most appropriate to use for reforestation. Genetic tests have revealed that certain non-local seed sources are adapted to Wisconsin's environmental conditions and can offer improved growth characteristics over local seed sources. Examples of this include southern Ontario white spruce and southern Appalachian white pine in southern Wisconsin. Additional seed source recommendations are made in Appendix 22-A, Individual Species Planting Considerations.

2.8 Stock Type Selection

Selection of the stock type is a biologically and economically crucial phase of the reforestation process. Selection of the stock type allows land managers to exert some control over the morphology of their seedlings. Selection of the most effective stock type for a given situation depends upon the identification of the site-specific factors that determine seedling establishment and growth.

This section provides advice for selecting stock type, stock quality and maintaining vigor throughout the planting process. Proper seedling stock type selection will have the greatest influence on the establishment and early growth phases. Proper seedling selection will also help to minimize the early limiting factors of the site.

The following is a list of stock selection factors that need to be addressed during the stock selection process:

1. Review the original goals and confirm that goals and site are still appropriate.

2. Select species/ seed lot. Species selection should be based on ecological acceptability; production goals; silvicultural system; forest health; and local experience. The use of less expensive stock may save on initial costs, but there are risks and expenses that come with variable performance. Seed lot selection should be based on availability, quality, and local seed lot performance.

3. Determine site preparation requirements to overcome limiting factors that the stock type alone cannot. It can help by customizing microsites and improving plantability.

4. Determine the limiting factors stock will have to overcome.

5. Decide which seedling characteristics are needed to surmount the identified limiting factors.

6. Evaluate historical stock type performance and experience.

7. Identify the stock type most likely to overcome limiting factors.

8. Look for a stock type that is appropriate for several or all limiting factors.

9. Consider altering the species or site preparation prescription if no stock type is suited to overcoming limiting factors.

10. If multiple stock types appear equally suited to the site, examine costs, desired stocking, and the logistics of handling and planting.

In addition, the following is a list of operational factors that could affect the stock type selection and the planting operation:

1. Stock cost

2. Stock availability

3. Planting cost

4. Site location, accessibility, and conditions

5. Storage facilities and handling - Prolonged storage reduces a seedling carbohydrate reserves and reduces overall vigor, though spring lifted and shipped seedlings are less sensitive to this type of deterioration of stock quality.

6. Transportation availability and cost (due to site accessibility) - If refrigerated transport cannot be assured it is wise to ship only what is necessary. Storage under ambient conditions is not advised for extended periods.

7. Planter availability and experience - If experienced planters are not available provisions for training and supervision should be made.

The next step in stock type selection is whether to use containerized or bareroot seedlings. The following is a list of attributes, advantages, and disadvantages of containerized and bareroot stock. It should help you decide which type of stock is best suited to your needs.

2.8.1 Containerized Stock

Containerized stock can be less than one-year-old, and trees are grown, shipped, and planted in a medium of peat, perlite (or vermiculite), and sand. Average stem caliper is 2-3 mm and height 10-15 cm. Historically, primary usage has been with conifers in the Lake States, but recent advances in pot sizes has allowed the production of containerized hardwoods.

Advantages of containerized stock include: can be grown in 6-15 weeks; outplanting in the rooting medium; high productivity due to plantability; extends planting season, reducing peak demands on labor; can be planted on rocky sites where it may be difficult to open a hole for bareroot seedlings; higher survival rates at outplanting; more efficient use of seed; superior initial height growth; more uniform seedlings; greater flexibility with tree planting machines; less likelihood of transplant shock; perform well on adverse sites. Containerized seedlings are more resistant to the heat and drying stress than bareroot seedlings so 3-5 days' worth can be shipped at once and a cool van is not as necessary.

Disadvantages of containerized stock include: less able to compete with weeds; more vulnerable to browse damage; lower survivorship when insolation is high; more prone to frost heaving when planted on bare mineral soil; need transport designed for the bulky containers; more expensive than bareroot stock; paper containers can fail to decompose fast enough; paper needs to be covered or it will wick away needed moisture; require more attention while growing; often smaller in size; may need more intense site preparation; the conditions that speed development are also conditions conducive to disease development and nutritional imbalances; fewer can be transported to the field at a time. Moisture level in the root masses needs to be checked regularly.

2.8.2 Bareroot Conifer Stock

Bareroot conifer stock is obtained as 1- to 3-year-old trees and either as seedlings or transplants. A designation such as 2-0 means the tree spent two years in a seedbed, while a designation of 2-1 means the tree spent 2 years in the seedbed and 1 year in the transplant bed (transplanting improves root development). In general, this stock should have a 4-6 mm caliper and a 2:1 shoot/root ratio. Seedlings intended for dryer sites should have smaller tops to reduce transpirational losses.

Advantages of bareroot conifer stock include better able to compete with weeds and survive both browse damage and sites with high insolation; easily transported and stored; less prone to frost heaving on heavy soils; less expensive. Bareroot seedlings are more readily available than containerized seedlings in Wisconsin. In addition, with the availability of differing age classes and nursery cultural regimes there is a wider selection of stock type attributes.

Disadvantages of bareroot conifer stock include takes longer to grow; exposed roots dry out very quickly; lower planting productivity; shorter planting season; prone to root damage and root deformity during planting.

2.8.3 Bareroot Hardwood Stock

Bareroot hardwood stock is generally produced as 1- to 3-year-old seedlings. Recent studies have demonstrated the importance of lateral root formation as the most critical factor in hardwood seedling survivability and future growth. Generally, a minimum of five primary lateral roots (>1 mm in diameter) are required for hardwood nursery stock.

Advantages of bareroot hardwood stock include regenerate roots rapidly; not subject to lodging by competition; sprouts readily; mast for wildlife.

Disadvantages of bareroot hardwood stock include large seedling size requires special planting considerations; requires large storage area; site preparation and follow up maintenance required to ensure success; more expensive than conifers.

2.9 Seedling Quality Characteristics

a. Shoot height is the most obvious and easily determined seedling attribute. Alone this measurement is of little value, but along with root-collar diameter and shoot architecture it becomes important.

b. Root-collar diameter is one of the most useful morphological measures of seedling quality. Diameter often reflects seedling durability and the size of the root system. A larger diameter will mean a seedling is supported better, resists damage better and can sustain higher levels of insect and animal damage. It will also be better insulated.

c. Root architecture is an important attribute when selecting high quality stock. An expansive, fibrous root system that contacts multiple soil layers upon planting is a sign of quality nursery stock. The more fibrous the root, the greater hydraulic conductivity the seedling will have, and it will be less susceptible to various stresses.

d. Shoot architecture should be an appropriate size for the root system. Leaf arrangement should provide adequate sunlit leaf area, but too much leaf area can cause transpirational demands to be excessive.

e. Shoot to root ratio is the most widely used parameter in determining seedling quality. A 2:1 ratio is often recommended for conifer nursery stock, but it can be of limited usefulness since the ratio changes with time and tree age. On drier sites you will want a lower shoot to root ratio, and on moist sites the opposite may be true.

f. The physiological condition and carbohydrate reserve of a seedling is important in determining its resistance to stress and its ability to establish quickly.

g. Presence of mycorrhizae on the roots. Mycorrhizae increase the surface area of the roots and the ability to provide water and nutrients to the seedling.

2.10 Stock Health and Condition

Stock health and condition must be considered when selecting a stock type and when accepting planting stock. The following should be evaluated when receiving nursery stock or removing stock from storage conditions:

a. <u>Succulence</u>: Succulent shoots are more sensitive to handling stress than hardened-off stock and should not be shipped; it is better to wait for them to re-harden.

b. <u>Root dieback</u>: Root dieback can persist on stock and cause reduced growth and mortality. A conservative strategy should be used to reject stock that displays dieback symptoms.

c. Foliage and stem diseases: Stock displaying symptoms should not be accepted. Selection of larger stock types can help minimize the impact of foliage diseases.

d. Heating: Stock that has been improperly stored, handled or transported will heat, causing damage to the seedlings. A conservative strategy should be used to reject stock that displays heating symptoms.

3 SITE PREPARATION

Site preparation is the creation of a favorable growing environment for tree seeds or seedlings. The main objective is to establish plant communities of desired quantity (# trees/acre) and quality (species and form). A successful plantation establishment depends on accurate assessment of the site, biotic and abiotic factors, and the site specific prescription.

Plants are affected by sunlight, relative humidity, foliage and soil temperatures, soil moisture, fertility, bulk density, animals and plant pests. Site preparation has the potential to address all the plants requirements and influences which factors will ultimately affect survival and plantation development. Site preparation must create sufficient numbers of suitable, well-spaced growing sites for the establishment and growth of tree seedlings without causing excessive soil disturbance. Site preparation should also be done in a manner which facilitates subsequent management and achieves results at the lowest cost.

Effective site preparation often will alter residual vegetation, alter slash load, expose mineral soil, increase root zone temperature, reduce the risk of frost damage, reduce competing vegetation, reduce the risk of insect damage, increase oxygen in the soil, and enhance nutrient availability. When site preparation is done incorrectly it can cause increased soil erosion and water quality degradation, increase soil compaction, create landslides, aggravate moisture problems, and negatively impact biodiversity and wildlife habitat.

When choosing a method of site preparation, stacking treatments can become very expensive quickly. There is a need to keep costs reasonable without selling out the seedling's chances of surviving. If you are planning to do your site preparation after a harvest, consider making the site preparation part of the logging activities. For example, the skidding of large trees can expose mineral soil and drop seed. Combining the activities can reduce total expense, but it does require increased planning, development of contract specifications and requirements to meet objectives, an experienced labor force and possible reduced timber sale revenue.

If seedlings are not provided a proper microsite through site preparation they can be vulnerable to short-term changes in their environment. If conditions are severe, just a few hours of certain conditions can be damaging, especially immediately after out planting.

It is crucial that you get the right number of quality planting spots/acre or the result will be an understocked stand that may not have the form you desire. Check the operator's work daily. You have to communicate your desires for all aspects of the operation; people are not mind readers. Understand the site characteristics and match the site preparations accordingly. Costs are variable depending on the site and operator's skill.

The are many different types of site preparation including manual, mechanical, chemical, and burning. Manual is rarely used as it is appropriate for only the smallest plantings or most difficult sites. The method and extent of site preparation can leave long lasting effects which can impact future management decisions.

3.1 Mechanical Site Preparation

Mechanical site preparation includes blading, raking, plowing, ripping, mixing, chopping, scalping, mounding, dragging, trenching and rotovating.

1. Blading is the use of an angled blade to scarify the soil prior to a harvest or to clear a path through slash and small residual trees. The process is best on boulder-free flat terrain. Rocks protruding from the soil bend and dull the blade edges making it ineffective. Depending on the management objective, the process may expose mineral soil. For scarification purposes, blading works best in frost free conditions. For shearing purposes, blading works best in cold weather (better shearing ability) and when there are < 250 trees/ac. and trees are < 10 in. DBH. Blading may produce scarified patches, windrows and nicely prepared strips depending on management objectives. For scarification work in a forest understory, the process requires a skilled operator and a large prime mover (270 HP). Windrows on treated sites can be attractive to rabbits which feed on seedlings. Blading prepares the site for planting but does little for competition. Depending on the depth of blading, the action does not deter sprouting.

   An example of a blading implement is the KG Blade. The KG blade is 12'4" wide and weighs 11,380 pounds. It needs a D8 tractor with a 300 HP engine. It can be used when amounts of slash are high (>50 tons/acre). Slopes >15% can cause problems for the shearing action.

2. Raking removes brush and medium-heavy slash loads and can be used on slopes. Some mineral soil exposure is possible depending on the skill of the operator. Fixed teeth are easy to install and require less maintenance than a flexible tooth rake. They also require a trained operator and have lower productivity. Flexible tooth rakes yield cleaner piles, don't catch stumps and the rake can be fine-tuned to the site. Daily maintenance is required.

3. Plowing is the use of a front mounted V-plow on a prime mover. Plowing controls competing vegetation, removes slash, and exposes mineral soil. It works to prepare for hand planting, or it can coincide with mechanical planting. It works on level to slightly rolling sites. It is good with medium-heavy slash loads. Sites with large residual trees, shallow soils, and thin humus layers should be avoided. Wet sites should also be avoided as the furrows may fill with water. Furrows should follow natural contours to minimize erosion. It can be difficult to regulate the depth of scarification with plowing.

4. Ripping is used to rehabilitate compacted skid trails, roads, and landings. Hydraulic mounted tines with wings rip through the soil reducing bulk density. A large (D7-D9) prime mover is required. Ripping should be done with the contours and can be done when the ground is frozen, but not if the soil is wet. A skilled operator is needed.

5. Mixing is the mechanical blending of mineral and organic soil layers. It controls competing vegetation and exposes mineral soil but does not mend compacted soil. Mixing provides an excellent growing environment for seedlings. It provides good soil aeration and lowered bulk density for root development and better soil/water relations, while nutrients are retained in proximity to the seedling.

   Coarse mixing involves large (1,500-2,000 pound) disks and heaps the mixture in a raised bed which is dryer, has better aeration and is warmer. It works best on flat loams and fine textured soils. It does not work on rocky sites or sites with residuals or stumps. A large (D6-D9) prime mover is required. It works best in dry or slightly frozen soil. It provides vegetation control that lasts, but it is expensive and has low productivity, especially if a prior treatment is required. Equipment is also limited and requires high maintenance.

   Fine mixing chops all surface vegetation and mulches it with mineral and organic soil. It produces a high-quality product, but the process requires a large PM and is expensive because the mixing is very slow, and a pretreatment may be necessary.

   Spot mixing uses an implement on a boom such as an auger screw to produce individual planting sites. This can be used on a wide variety of sites and can be highly productive. It works best with dry to lightly frozen soil. A skilled operator is needed who knows the microsite needed. Treatments may need to be followed with herbicide to control competing vegetation.

6. Chopping is the cutting or flattening of brush, shrubs, and small trees. Chopping is best on even terrain with loamy or sandy soils that are not wet or thin because it requires heavy equipment. Chopping is limited on sites where the residual trees or stumps are large or where large rocks/exposed bedrock are present. Chopping is not appropriate for aspen regeneration because the blades reduce sucker vigor, but if the objective is increase stand diversity by reducing the aspen component a roller chopper would be an appropriate site preparation treatment.

   The Marden roller chopper is equipped with cutting blades and partially filled with water (the sloshing effect provides more effective cutting action). The Marden roller chopper is pulled by a D5 crawler tractor.

   The 2-drum roller features opposed rolling drums for better chopping action. It is best when used on vegetation that is a few years old so that it doesn't spring back easily. This chopper is not very maneuverable, can only be turned in one direction and is best on large tracts of land.

These rolling brush cutters reduce slash and competing brush to facilitate planting machines or scarifiers of sod for hand planting. Rolling brush cutters are often used where slash or residual brush is medium to heavy, rocks are absent, stumps are low, residuals over 6 in. DBH are few, and on areas where seed area or fire hazard reduction are needed.

A third type of chopper is the Pettibone Slashmaster which features highly effective front-mounted cutting hammers. The Slashmaster reduces slash, debris, and standing unmerchantable stems to small manageable pieces. The Slashmaster is faster and more maneuverable with its articulated frame, but it is only for controlling slash and brush. It works best in conifer slash at a rate of about 1 acre/hour. In principle the machine performs between a rake and a roller chopper though it won't remove organic matter as raking does or ride up on green material as roller choppers can. It is good on dry or frozen ground and little operator training is necessary, but daily maintenance is necessary.

7. Scalping or patch scarification is the creation of intermittent patches of exposed soil for direct tree planting or manual seeding. Scalping provides access to layers of both mineral and organic soil and leaves unused land unaffected. Scalping works well on dry sites with thin humus layers. Scalps must be of good size or competing vegetation will take over. Wet sites should be avoided to prevent the submersion of seedlings. It is preferable to scalp in the late summer or fall preceding planting and allow the scalp to stabilize over winter.

   The Bracke scarifier is an example of a scalper. It works best on flat to rolling hills with <25% slope and can handle light/medium slash. Stumps and heavy slash cause problems because the scalper will ride above the soil. Thick duff can also reduce penetration. The Bracke is rugged, creates regular patches and mounts easily. Unfortunately, it is not maneuverable and wheel slippage can disrupt scalp spacing. The Bracke scarifier needs a 90-130 HP prime mover with rubber tires or a JD450.

   It has a productivity range of 2-4 acres/hour. Its good in areas where erosion may be a problem because the scalps do not create a water travel way.

   The Leno scalper mounts directly to a 160-180 HP prime mover and is highly maneuverable and compact. The scalping action is independent of the prime mover. It produces a shallow scalp and is highly productive. It also requires regular maintenance. Patch size should be monitored closely. It is not for use on rocky terrain, shallow soils, thick organic matter, heavy clay, frozen soils, contours with >30% slope, or on sites with a high water table. The Leno works in light to medium slash.

   The Quicktatch scalper is a four-tined shield mounted on a small (90 HP) prime mover. Scalps are created through the periodic raising and lowering of the tines. It works wherever the prime mover can go. Thin soils, rocks, and stumps do cause problems. A skilled operator is necessary, but it is portable, easy to mount and relatively maintenance free.

8. Mounding is the production of raised intermittent mounds with deeper pits and higher mounds than scalps. They make good planting sites in cold moist environments or on soils with thick organic matter. The mounds are aerated, above the water table and handle competing vegetation if they are high enough. Mounds are typically 4-6 inches though they can be higher on wetter sites.

9. Dragging of chains or drums across a site is used to control brush, expose mineral soil (if organic layer is not too thick) and to crush older slash. Dragging works on flat to rolling terrain and is not limited by rocks or soil depth. It is often used with raking and can enhance natural regeneration.

   Sharkfin barrels are an effective piece of dragging apparatus which create trenches or patches of mineral soil. They do require a more powerful (150 HP) prime mover and are limited to sandy sites.

10. Trenching produces continuous trenches of exposed mineral soil with multiple planting sites along the wall of the trench, increasing planter productivity. Seedlings can then be planted where the microsite will be best. For example, seedlings can be planted in the bottom of trenches on dry sites. It works best on dry to medium sites. Trenching with discs removes competition. Avoid heavy soils, rocky soils and heavy slash.

    Trenching with discs can be an effective tool to reduce woody tree and brush competition because the disc penetrates the soil to a sufficient depth and severs the root system. This 'discing' requires a D8 tractor and can treat 2-3 acres per hour. Heavy slash reduces efficacy and should be raked from the site. Material <3 inches in diameter will not reduce operations greatly. Slopes greater than 20% can be difficult. Stumps can be limiting if they are high and fresh. Wet soils should be avoided as well as very grassy areas because the discing can stimulate further grass and weed development.

11. Rotovating produces a continuous band of tilled soil. Used generally on old agricultural sites. Need to let soil settle prior to planting as air introduced into the soil by rotovating can cause seedling desiccation. Ideal to do rotovating in the fall prior to planting the following spring to allow for the soil to settle. Avoid heavy soils, rocky areas, wet soils, and areas with slash.

    Rotovators come in varying sizes, ranging from 18 inches to 6 feet in width. The type of tractor required to power a rotovator is strictly dependent on the size of the rotovator.

3.2 Chemical Site Preparation

The use of chemicals in site preparation does not alter the slash load or expose mineral soil the way mechanical site preparation does, but it can be an effective means to control competing vegetation and improve tree growth. The use of herbicides for weed removal will increase the amounts of sun and water available to seedlings. It will stimulate growth by increasing foliar and root zone temperatures. Herbicides will also kill plants that may be providing shelter for seedling-feeding pests thereby reducing tree mortality and disease.

See Appendix 22-B for the Herbicide Effectiveness Chart and the Herbicide Comparison Table. They are meant to be used in conjunction with each other. They contain large amounts of information on herbicides labeled for forestry uses and are updated annually.

The first step is determining your need for chemical site preparation. The Effectiveness Chart will tell which herbicides are effective on a certain weed species or group of species as derived from the pesticide label. It is important to note that an herbicide label rarely notes all the weed species that a product is effective on. The Comparison Table will help if you are looking for a herbicide to apply by a particular application method or for a particular use. The information in the tables and charts about this section are likely to be dated so they should only be used as a guide and should not be considered recommended treatments.

Always read the label and material safety data sheet (MSDS) before recommending, purchasing or handling any pesticide. Pesticide labels have the force of federal law and directions must be followed precisely. Persons using any of the products listed assume responsibility for their use in accordance with label directions.

When making a pesticide recommendation always inform the individual to read and follow the label directions and to adhere to the MSDS.

The tables in Appendix 22-B provide a cross reference of tree species and herbicides. They are meant to encourage those intending to plant in the spring to plan weed control before trees are in the ground.

3.3 Fire as a Site Preparation Tool

Site preparation burns can be an effective treatment for artificial or natural regeneration because it accomplishes multiple objectives. Prescribed burning prepares a suitable seedbed by reducing organic layers; access for planters is facilitated by the removal of slash; plantable microsites are created; competing vegetation is removed or reduced; access for secondary site preparation is facilitated; the soil nutrient regime is often temporarily positively affected through increased levels of cations and accelerated mineralization rates; and soil temperature is improved through altered surface albedo and reduction in the insulating organic layers. Burning prior to planting has also been shown to positively affect ectomycorrhizal development, and seedling health and survival. Burning of dead grasses on farm fields can be helpful in controlling mouse and meadow vole habitat and reducing the girdling of planted seedlings.

A word of caution though, on sites that have been burned and immediately planted, soil temperatures at the ground line near the seedling can be significantly higher then the ambient air temperatures due to the absorption of heat by the black ash. This can lead to increase seedling mortality on these sites if daily air temperatures exceed 90 degrees shortly after planting. Subsequently, plan ahead and burn in the fall or at minimum a month prior to planting seedlings.

Prescribed burning is a regular occurrence in the regeneration of a number of species. Jack pine with its serotinus cones is adapted to regeneration following fire. A helpful hint is don't burn jack pine slash expecting to prepare a mineral seedbed for the seed contained in the cones on the slash. The cones and seed are also burned up in the prescribed fire. Possible alternatives include to prescribe burn the site and then direct seed jack pine or to mechanically scarify the site lightly to expose mineral soil and scatter the jack pine slash uniformly across the site. Prescribed burning has been used to stimulate oak regeneration, while controlling species not adapted to fire ecosystems. The mineral soil seedbed and reduced organic layers provided by burning provides excellent conditions for natural white pine, red pine, white spruce, black spruce and aspen regeneration.

Prescribed burning is a tool but is by no means a cure-all for forest management problems. It requires extensive training and experience to effectively plan, implement and control prescribed fires. Other disadvantages associated with prescribed fire include escaped fire scenarios, increased deer browse and reduced effectiveness of herbicides. In areas where fire has never played a natural role, its use may be inappropriate and detrimental.

4 COVER CROPS

Cover crops are appropriate for afforestation sites where they are grown to replace or build soil organic matter levels, increase soil aggregation, structure, and water holding capacity. They can aid in soil-stabilization, reclaim nutrients that have moved to lower soil levels, reduce leaching losses, and break up hard pans when their roots penetrate these layers. Cover crops also prevent invasion by competing vegetation, provide erosion control and additional wildlife habitat. They may also aid in breaking insect and disease cycles.

When selecting a cover crop, choose a species that will not adversely affect the growth and development of trees. Grasses can compete fiercely with trees. Legumes on the other hand have a number of advantages that can benefit seedlings. Legumes add nitrogen to the soil, increasing the fertility level; conserve moisture and nutrients; improve the soil physical condition; build up the soil organic matter; enhance microbial activity; decrease erosion; and provide a mulching effect. Most legumes have shallow roots that are not as finely branched as grasses making them less able to compete with tree roots for water and nutrients. Cool season legumes (such as hairy vetch) complete most of their growth during the early spring before moisture becomes limiting. Stems and leaves then form a mulch during the summer, conserving moisture and releasing nutrients. The disadvantage of hairy vetch is that it can smother smaller seedlings.

Small grain crops such as winter wheat, rye and oats can be useful cover crops. Generally, these grain crops can be planted directly into with seedlings. On sites prone to erosion, herbaceous legumes have been seeded in to reduce weed competition and bolster soil nitrogen.

5 OLD FIELD SITE PREPARATION (AFORESTATION)

5.1 Grass fields

The more intense site preparation you use the less weed control will be necessary immediately following planting. Plowing, disking and herbicide application are often used in combination for sod and woody vegetation control. The site preparation chosen will depend on the composition of the soil, topography, accessibility, density and composition of the existing cover, and cost.

For spring planted areas a proven method of site preparation consists of vegetation eradication with herbicide (glyphosate) in the previous autumn followed by plowing or disking 1 to 2 weeks after spraying. This kills deep rooted perennials, improves soil aeration and water movement, and stimulates microbial activity while incorporating organic matter into the soil. It is important that the site be plowed in the fall, not the spring. Spring plowing can create excessive soil aeration just prior to planting causing seedling mortality. Fall plowing allows the soil to settle through the winter and provides for excellent planting conditions in the spring. Simazine can also be a useful herbicide for site preparation.

Another common method of site preparation is the fall application of glyphosate and then an application of simazine, a pre-emergent herbicide, in the spring immediately following planting. Simazine seems to be the most effective in controlling the re-invasion of weed competition on a site when it is applied to a site that has had the existing weeds previously killed.

Spot treatments on open fields should be at least 5 feet in diameter. Spot treated sites never fair as well as sites that receive full treatment due to encroachment of neighboring weeds on the planting spot.

An intermediate treatment between broadcast herbicide and spot herbicide treatment is a strip herbicide treatment. The advantages of strip treatments are the reduction of erosion on sloping fields and the reduction in amount of herbicide required when compared to broadcast applications. This has proven an effective treatment when incorporated with between row maintenance (e.g., mowing) to prevent annual weed problems. The major disadvantage is the eventual encroachment by perennial weed species from the neighboring un-sprayed strips.

Knowledge of herbicide dosage is critical because too much herbicide can cause injury to seedlings while too little won't control vegetative competition. Always read the label and material safety data sheet (MSDS) before recommending, purchasing or handling any pesticide. Pesticide labels have the force of federal law and directions must followed precisely. Persons using any of the products listed assume responsibility for their use in accordance with label directions.

WHEN MAKING A PESTICIDE RECOMMENDATION ALWAYS INFORM THE INDIVIDUAL TO READ AND FOLLOW THE LABEL DIRECTIONS AND TO READ THE MSDS.

5.2 Former row crop fields (previous year)

Site preparation on fields that were in row crop production (e.g., corn, soybeans) the previous year generally involves the use of a pre-emergent herbicide following planting in the spring. Generally, the site will be bare soil with crop residue on the surface. Additional items that should be considered when planting trees on fields that were in agricultural production the previous year include the presence of a plow layer (hardpan) at 8 to 9 inches deep, topsoil erosion patterns, soil fertility levels, soil pH, and the presence of weeds. Site preparation possibilities to deal with these items include soil ripping to break up hardpans; sowing of a cover crop to stabilize soil, prevent soil erosion and weed invasions; and the addition of soil amendments to the site prior to tree planting to adjust fertility and pH.

The downside of these former agricultural fields that were in row crops the previous year, is that loam and clay soils in the springtime can be very muddy sites to mechanically plant trees. When scheduling tree planting, consider planting these agricultural fields with heavier soils towards the end of the tree planting season. Additionally, on agricultural fields formerly treated with atrazine, simazine may not be sufficiently effective due to resistant weed populations. So, anticipate the potential of a late summer annual weed problem.

5.3 Alfalfa fields

Alfalfa can be an extreme competitor with young seedlings for moisture and nutrients. It grows to about three feet in height and can completely shade out young seedlings. More important is that alfalfa lives many years and develops a deep, heavy root system which makes it difficult to control with conventional herbicides.

In order to control alfalfa, the root system must be killed. Moldboard plowing and rototilling are effective site preparation treatments for controlling alfalfa, but these mechanical methods can expose the site to soil erosion. Herbicides are effective on alfalfa when applied during the active growing season when the plant is translocating nutrients to the root system. Ideally, the tops of the alfalfa should be greater than 6 inches in height and in the early bud to flower stage. Alfalfa that has already reached the stage where seed has been set should be harvested and allowed to resprout prior to treatment. Additionally, alfalfa that is growing slowly because of stress from environmental conditions (e.g., drought) will not be effectively controlled by herbicide applications. In droughty conditions alfalfa has little translocation occurring, even though the top will dieback and the plant will look dead, the root system will still be alive and resprout vigorously.

Test results have shown late summer (mid-September in southern Wisconsin) applications of herbicides are effective in controlling alfalfa. Herbicides that have proven to be effective include glyphosate, dicamba and 2,4-D. Especially with dicamba and 2,4-D fall treatment is recommended since these growth hormones prevent the plant from becoming cold hardy. Even if the herbicide fails to kill the alfalfa, the cold winter temperatures will kill the plants.

An herbicide with a 24(c) special label for Wisconsin that is effective in controlling alfalfa and other broad leafed weeds is clopyralid. It is registered for use either initial site preparation treatments or for release. The label states that it can be used over the top of white pine, red pine, white spruce, white ash, red oak, black walnut, sugar maple and other species at any time during the growing season when weeds are actively growing.

6 DIRECT SEEDING

Seeding is an excellent technique to inexpensively regenerate small areas, or to quickly reforest large acreage.

6.1 Direct Seeding Equipment

1. Seeding Sticks - essentially a long tube with handles, a seed metering and release mechanism and a seed storage reservoir. The seed release mechanism injects the seeds into the soil from the bottom of the tube and can be adjusted based on the number of seeds desired per planting spot and the type of seed. Often used in areas too rocky for conventional seedling establishment. Advantages are they are simple mechanical devices, light weight and require little maintenance. Disadvantages include that site preparation (usually scalping) must be done in a separate step, they are not appropriate for larger direct seeding areas and changing species to be sown requires changing bushing within the seed metering device

2. Shelter Sowing Sticks - similar to seeding sticks in that it places a small quantity of seed in each planting site, but in addition a small, conical, degradable plastic shelter covers the seed. The shelter protects the seed from birds and rodents and provides favorable microsite for seed germination and seedling growth. Advantages include the protection of seed from animals and provide a favorable microsite. Studies have shown germination to be improved by as much as 60 percent. The main disadvantages are that the plastic shelters must be carried by the operator, the shelters can be removed from the planting site by strong winds or animals and the increased cost of the shelters.

3. Seed Dribblers - distribute seed from prime movers directly during the site preparation operations. Seed dribblers consist of a seed reservoir, seed metering/trip device and a long tube to aim the seed to the desired locale. Types of equipment that seed dribblers are made to attach to include Bracke scarifiers, fire plows, harrows, dozers and dozer blades. Advantages of this system include the automatic dispensing of seed during site preparation, little additional cost associated with seeding, and the prepared seed microsite is generally favorable for plant establishment. The main concern is that it is difficult to tell how uniformly the seed has been distributed across the site and ultimately to predict the results.

4. Hand Broadcast Seeders - consist of a seed hopper, a hand crank operated distribution device and an adjustable metering slot. Operation consists of filling the hopper and turning the hand crank while walking across the site to broadcast the seed. Advantages

include the simplicity of operation, reliability, and inexpensive mechanisms that require little maintenance and are useful to seed small areas rapidly. Disadvantages are that it is slow and labor intensive. In addition, it is difficult for operators to achieve uniform seed distribution, requires an enormous amount of seed and seed is exposed to damaging agents (animals, insects and disease) or may be removed from the target site by environmental conditions (wind and water).

5. Mechanical Broadcast Seeders - are mounted on various prime movers, including crawler tractors, skidders, wheeled tractors, ATVs or snowmobiles. Similar in design to hand broadcast seeders but these mechanical seeders are powered by electric motors or vehicle PTOs. Advantages include the rapid seeding on sites accessible to vehicles and that they can be attached to prime movers involved in site preparation treatments. Disadvantages include the enormous amount of seed required and the greater exposure of the seed to damaging agents and environmental influences.

6. Aerial Broadcast Seeders - similar to other broadcast seeders but are utilized on helicopters or fixed-wing aircraft and usually powered by an electric motor or by the aircraft's hydraulic system or PTO. Can be economically feasible for seeding very large sites. Advantages include the ability to easily seed rough or inaccessible terrain and large areas rapidly. Disadvantages include the difficulty in obtaining uniform application rates across the site, small hopper capacities, large amounts of seed required and again the seed is exposed to damaging agents and environmental influences.

7. Direct Seeding Hardwood Seed Drills - similar in design to a tree planting machine in that a shallow furrow is opened up and the seed is placed into the furrow then packing wheels close the furrow. Being used for direct seeding of large seeded hardwood species like oaks and walnuts.

6.2 Direct Seeding Methods for Conifers

6.2.1 Broadcasting (shotgun approach)

a. Aerial application provides good dispersal, but helicopters and planes are expensive. In reality, it may only be practical on large inaccessible plots.

b. Barrel seeders can be attached to sharkfin barrels to simultaneously accomplish scarification and seeding. It is best done in the late spring or early fall.

c. Cyclone spreaders are designed for small woodlots. Productivity is low but they are easy to use and transport.

d. Hand spreading has very low productivity.

e. Requires large quantities of seed and seed efficiency (number of seed required to produce an established seedling) is very low.

f. Seed is exposed to damaging agents and environmental influences.

6.2.2 Spotting (rifle approach)

a. Generally done in conjunction with spot scarification, like a Bracke scarifier.

b. Is a more efficient use of seed.

c. Controls the number of seed and eventually seedlings and stocking better.

6.3 Direct Seeding of Oaks

With the difficulties and expenses associated with regenerating oak forests, land managers are seeking information on why past regeneration efforts have sometimes failed and what can be done to ensure oak forests remain in a position of prominence in the future. Direct seeding is one possible method of regenerating oak and other hardwoods in Wisconsin, especially on old agricultural field sites.

6.3.1 Seed tree selection

Priority should be given to selecting seed from trees that are either on site or from sites as near and as similar to the planting site as possible. This will reduce the chance of an introduction of foreign and potentially deleterious genes into oak populations neighboring the planting site and will increase adaptability to the planting site. If oaks are absent from the site and nearby areas, one should collect from oak species that can be identified from reliable historical information as relevant to the restoration site.

In order to maximize the genetic diversity of seed harvested, avoid collecting acorns from closely related individuals. This may be difficult, though acorns rarely travel far from their maternal tree (usually from one to perhaps two adult-crown diameters). Theoretically, acorns should be collected from trees separated by at least two crown diameters.

6.3.2 Acorn collection

Acorns should only be picked when ripe. While on the tree the acorns are undergoing developmental processes that are vital to seedling survival. Premature harvesting may reduce viability or cause potentially disastrous early germination. Ripening dates can vary tremendously among species as well as within a species in a single population. For example, southern Wisconsin bur oak usually ripens in mid-August, white oak in late August to early September and red oak in mid-September.

Acorns with signs of parasite damage should be discarded because seedlings of low vigor are usually produced. Diagnostics of insect damage include premature acorn drop, softening of the acorn, tiny oviposition holes, and larger larvae exit holes. The oviposition holes may be located just below the lip of the cap and bacteria can enter the hole and cause disease.

Neither mean stand diameter nor mean basal area of the stand is correlated with acorn yield. Acorn production in oak is sporadic, infrequent, and unpredictable. This makes accurate acorn seed crop forecasts nearly impossible until shortly before seed-crop maturity. White oak and bur oak acorns are produced the same year as the flower. Red oak acorns however mature the year after flowering and an estimate of the acorn seed crop for the upcoming fall can be determined from the one year nutlets on branches in the previous winter.

Mature acorns are denoted by the following characteristics:

a. The pericarp of mature acorns turns from green to tan or brown at maturity.

b. Caps of mature acorns separate easily from the pericarp without being forced and without leaving pieces of the cap attached to the acorn. An exception is bur oak, where the cap can almost enclose the pericarp and doesn't separate easily even when ripe.

c. The cap scar is "bright" in appearance after cup removal. Fresh cup scars are bright yellow or orange for red oak, though this color soon fades after cup removal.

d. The cross-section of mature oak acorns show light creamy white to yellow cotyledons.

e. Floating acorns in water is good method for separating quality acorns from damaged or immature acorns. Sound, mature acorns sink in water. Defective acorns will generally float. Defects include parasite damage, cracked pericarps, rodent damage, mold, deformed pericarps, black spots on the pericarp, and acorns with dull-brown or gray cap scars or difficult to remove cups. Water flotation also facilitates the removal of leaves, acorn cups, and other debris making sowing of the acorns easier.

Hints to collecting quality acorns:

a. The first acorns to fall are usually defective, either due to incomplete development or exposure to a damaging agent.

b. Acorns can be collected from the tops of felled trees if they were felled when the acorns were ripe. Do not pick immature acorns, they cannot be artificially ripened.

c. Acorns should be collected from dominant oaks with tall, straight boles, good diameter growth rates and well-developed crowns.

d. Light acorn crop years usually have a higher percentage of insect infested acorns.

e. A sample from each seed source should be inspected and evaluated for soundness, maturity, and quality by cutting the acorns in half.

f. Acorns on the ground are subject to predation and rapid decline, especially in dry weather. If collecting from the ground, do so shortly after the main release of acorns occurs.

g. If there is ever a choice, choose the larger acorns. It only makes sense that the larger acorns will have larger nutrient reserves and some studies have indicated a positive relationship between acorn size and subsequent acorn germination, seedling survival and height growth.

6.3.3 Germination

An acorn's ability to germinate is often used as a diagnostic to estimate the potential of seed lots and determine sowing rates. White oak acorns lack embryo dormancy and begin germinating in the fall, subsequently they must be sown almost immediately after collection. Germination tests also are not feasible to perform on fall sown red oak acorns. A cutting test can be used to estimate the number of sound seed in a seedlot for white oak and fall sown red oak acorns.

Germination will drop off sharply once weight loss of the acorn exceeds 10%. Weight loss also dramatically reduced respiration of the acorns. This weight loss in acorns is generally associated with the loss of moisture during storage, even short-term storage. Acorns must be kept damp throughout germination and especially just prior to radicle emergence because the imbibed water provides the turgor necessary to push the radicle through the pericarp.

Assuming sound acorns, germination between 30 and 40 percent is common. In the state nurseries oak acorns are sown at a rate of approximately 200 sound acorns to produce 100 plantable seedlings. Germination may be significantly reduced due to damage caused by low temperatures (less than 5 degrees C), desiccation and fungal infections. White oak acorns will not germinate though after a loss of 30 to 50% of seed moisture content.

6.3.4 Acorn storage

White oak acorns should be sown immediately following collection. Red oak acorns should be sown as soon as possible after collection, but if you desire to temporarily store red oak acorns, the following should provide direction on the requirements needed.

Conditions coinciding with successful red oak acorn storage after seed fall include continually high moisture content of the acorn; opportunity for gas exchange with the environment; temperatures near freezing and no fluctuations of temperature during storage. These conditions walk the fine line between causing cold injury and permitting germination once dormancy requirements are met.

Polyethylene bags of 4 to 10 mil thickness without any packing medium work well for stratification and storage of acorns. They are permeable to carbon dioxide and oxygen, while remaining largely impermeable to water. Container tops should not be completely sealed to allow for adequate aeration. Bags should be stored on shelves for good air circulation.

The key to maintaining acorn quality is to avoid desiccation. Seed moisture content should be determined at the time of collection as well as periodically throughout the storage of the acorns. If moisture content drops below 35%, soak acorns in water at room temperature until moisture contents are above 40%. Seed moisture contents must be kept high (>40% based on oven-dry weight) and adequate aeration for the acorns must be provided. Water immersion for 24 to 48 hours before storage results in acceptable acorn moisture content.

Storage temperatures that go much higher than the recommended range of 1 to 3 degrees C will result in increased germination in storage of white oak. Microorganisms can kill radicle tips during storage and radicles can be broken. This may be advantageous however, as a damaged radicle may result in a multiple-rooted seedling which will survive out planting better.

When deciding if acorns will be germinated under refrigeration or in the ground, note that under refrigeration, germination can be delayed until field conditions are ideal for seeding, herbivore and pathogen damage is reduced, and monitoring of the germination process can take place. On the negative side, refrigeration can desiccate acorns and result in losses of seed viability. Prolonged storage should be avoided because it increases the risk of infection and adds to the loss of energy reserves through respiration.

6.3.5 Site preparation

Direct seeding of acorns requires site preparation for the same reasons that site preparation is needed for planted seedlings (i.e., reduce vegetative competition, reduce slash loads, create a favorable growing environment, reduce rodent habitat, and increase nutrient and water availability). Adequate site preparation is critical to insure a successfully established oak stand by means of direct seeding acorns.

Soil preparation and vegetation control should be carried out before sowing acorns, though it does not seem to have any great influence on the initial emergence of seedlings, it is critical to the seedling's initial growth and survival. Although many seeds germinate best in a mineral seedbed, the removal of the humus layer during site preparation does have an adverse effect on seedling emergence and should be avoided. Soil preparation often increases soil temperature which positively influences root growth and water uptake of young seedlings. Soil preparation also reduces the mechanical resistance to the growth of the young roots.

In preparing the site, eliminate rodent habitat over large areas by removing or reducing forest litter, logging slash, and vegetation. Methods for accomplishing this include prescribed burning, mechanical scarification, and chemical weed control. Without site preparation, sown acorns can be totally eaten by herbivores within a week. Acorn predation will be directly influenced by the size of the opening made. Vegetation and litter removal directly around the seed spot only will not reduce predation. Generally, an opening of 2.5 acres or larger is required to have an impact on rodent predation.

6.3.6 Sowing

Those that advocate spring sowing of acorns do so because there are lower rodent populations and the length of time that seed is exposed to predation is reduced. Spring sowing is only possible with acorns from species in the red oak group, acorns from white oak, swamp white oak and bur oak germinate in the fall after falling from the tree. Fall sowing may be beneficial because the germination rate is higher, overwinter storage is eliminated, at sowing time food alternatives are present for rodents, germination happens earlier than with spring sowings, and germination is less likely to be affected by a dry spring. Sowing an abundance of seed, such as occurs naturally during a good acorn crop year, may be a successful strategy due to predator satiation.

A covering of litter or soil will prevent desiccation and is necessary for good germination. Most research reports recommend sowing acorns to a depth of 2.5 to 5 cm unless rodents are problematic, or soil moisture and temperature are a concern. The rule of thumb in the state nursery is to plant seed to a depth twice the diameter of the seed.

Broadcast sowing results in poorer germination rates, costs are much greater than spot or row seeding, and is generally felt to be a waste of a value seed resource. Rates that have been used in broadcast direct seeding trials in Wisconsin are 8 bushels of acorns/acre.

Density of sowing is a factor of the desired stocking, the germinative capacity, and the level of predation. A 35-50% germination is typical for red oak and 1000 to 1500 acorns per acre can be expected to produce 300 to 485 one-year-old seedlings per acre. Recommend sowing rates are twice as many spots as trees desired and plant 3 to 4 acorns per spot. There is no upper limit on sowing density if the strategy is to provide acorn predators with more acorns than they can eat. It has been hypothesized that bumper crop years are an evolutionary response to cope with heavy seed predation.

Assuming sound acorns, germination of sown acorns between 30 and 50 percent is attainable. A seeding rate of 1500 acorns per acre in 500 well-spaced seed spots should be adequate for most objectives. Acorns should be sown about 1 foot apart at each seed spot. One study found that seed spot spacing of between 3 and 5 feet should allow for adequate stocking on areas with moderate to light mouse populations.

An additional idea is to sow a seed mixture of varying hardwood species appropriate to the site along with the acorns. This also benefits diversity in the future planting and reduces seed costs.

Other ideas being implemented include alternating rows of planted conifers and of direct seeded hardwoods. A hardwood seed drill has been used to sow acorns in bands 20 feet apart and within these bands in three parallel rows 15 inches apart. Within these bands a row of conifers is planted to act as a nurse crop for the hardwoods. Seeding rates of 2 bushels of acorns/acre were used. Early results look promising, and this seems to be the best use of the limited hardwood seed resource.

6.3.7 Rodents

Most oak seeding efforts fail due to rodents digging and destroying acorns. There is a relationship between rodent activity and amount of forest or grass cover. Seeding under a canopy is often victim to predation while seeding in a 2.5 acre or larger forest opening is more likely to be successful and rodent damage insignificant. Predation of acorns may be substantially reduced if covered by 5 cm of mineral soil.

Mice, voles, chipmunks, and squirrels usually damage acorns before they germinate and during the early stages of seedling development. In one study seedling survival was better on bare areas because of the reduced mouse damage as compared to litter-covered areas. Mice pilfered acorns before germination and after germination while seedlings were still persisting on food reserves stored in the acorns. Seeding was almost a complete failure when litter remained in areas highly populated with mice. Where mouse populations were not high, the improved germination did not justify the expense of litter removal.

Poisoned baits, chemical repellents and scent-treated acorns have been unsuccessful in reducing acorn predation. Plastic tree shelters and wire screens provide protection to oak acorns if they are installed immediately after sowing and are set below the soil surface. Unfortunately, such measures are prohibitively expensive. The use of diversionary foods such as sunflower seeds and oat kernels has not yet been used for oak reproduction, but it has been successful in aiding in the regeneration of some western conifers.

In old field situations it may be critical to the establishment of the plantation to first reduce the mouse and vole population by eliminating the protective grass cover and using rodenticides in rodent bait stations. In addition, raptor poles can be established in larger fields to assist in rodent control. In one experiment, oaks benefited from mowing between rows in the early years to control rodent habitat and reduce vegetative competition.

7 PLANTING

Planting seedlings may have a higher initial cost than seeding, but the chance of success is also higher. Planting also gives you a head start of several years over seeding. It can also be designed to facilitate future management activities.

7.1 Seedling Handling

Before the actual planting of seedlings, they need to be handled carefully. Keeping them healthy requires minimizing physical damage and keeping them at a constant low (33-40 degrees) temperature with a high relative humidity. They must remain in a state of dormancy from the time of lifting to the time of planting. If temperatures rise, so will respiration and young seedlings can quickly lose their energy reserves.

To prevent desiccation, keep relative humidity between 90% and 95%. If root hairs become damaged, they will never properly uptake water and nutrients.

Seedlings are often packaged and shipped in plastic-lined boxes that provide both physical and moisture protection for the seedlings. Bags are used for smaller quantities of seedlings. They do not protect seedlings from physical damage. Bales are seedlings packaged with a moisture-retaining material such as saw dust or sphagnum moss. They are used for very short storage or transpiration.

Until you are ready to plant, do not handle your seedlings individually. Leave them in their packaging to minimize physical damage.

Transportation is a vital consideration for all sizes of orders. For large orders (>1000 seedlings) a refrigerated truck is optimal. If one is not available, the following steps should be taken with a pickup truck:

1. place foam sheets on the bed and spacer boards between the foam and the boxes for ventilation.
2. with bags, or bales, build a frame to allow for air flow about the packages.
3. cover packages with a damp canvas tarp.
4. cover the canvas tarp with a solar-reflective tarp
5. fasten the load securely.

If the order is small, a refrigerated van is still the best way to go. If this is not possible, and the packages fit into your car, air conditioning on maximum along with insulation and ice packs is advised. Only a few minutes in a hot trunk can damage seedlings permanently. If you suspect that the seedlings have not been kept cool since leaving the nursery, you may want to open the package and sprinkle the roots with water.

Seedlings should not be 'heeled-in' or planted in shallow soil pits for long-term storage. Do not immerse seedling in water as this can drown root hairs. Do not delay planting while waiting for optimal soil conditions. Since most people do not have truly adequate long-term storage, seedlings are better off in the ground. If your planting job is large, consider receiving staggered seedling shipments to minimize storage time. The less time your seedlings spend out of ideal storage, the more vigorous they will be.

Root pruning of seedlings is a necessary process for seedlings with long fibrous root systems. Recommendations for root pruning 2-0 conifer nursery stock is to clip the root system off at 8 to 10 inches below the root collar of the seedlings. Remember, the shoot to root ratio is critical for conifer stock survival and performance, subsequently for larger conifer nursery stock, like 3-0 and transplants, a larger root system is required. For hardwood nursery stock the root system can be pruned to 8-10 inches in length and the laterals can be pruned at 4 inches in length from the main tap root. Again, the key to hardwood establishment and survival is to plant as large and vigorous root system as possible. If severe root pruning is required to plant hardwoods with the current equipment available, it would be wise to invest in new tree planting equipment designed specifically to plant hardwood seedlings.

Root pruning should be done in a controlled environment where the seedlings root system will not be exposed to drying effects of the sun and wind, where water is available to re-moisten the seedlings and the ambient air temperature is relatively cool (e.g., 40-50 degrees Fahrenheit). The worst place to do root pruning of seedlings is on the tree planting site itself.

7.2 Planting Procedures

7.2.1 Hand Planting

When planting by hand be sure to:

– keep seedlings shaded and cool until planting
– minimize handling of the seedlings.
– carry seedlings in a bucket or planting bag along with wet burlap to keep seedlings moist.
– never carry seedling exposed to the air or immersed in water.
– seedling roots should hang freely and just touch the bottom of the hole.
– long anchor roots may need to be pruned back.
– the new soil line should be just above the old soil line.
– pack the soil after planting

A rough estimate is that an inexperienced, but physically fit, tree planter can plant by hand 500 seedlings per day.

7.2.2 Machine Planting

Mechanical planting is suitable for especially large orders to be planted on even terrain. Generally, a 30-50 horsepower tractor and a crew of three is sufficient. The principles of seedling protection listed above certainly apply. Experience in operation of tree planters comes quickly and a crew can usually plant 5000 seedlings a day. The plantings should be checked early and often to make sure they are done correctly. Become intimately familiar with the tree planting machines and their adjustment. Routine maintenance of hydraulic system and other mechanical parts can prevent disastrous breakdowns in spring planting season.

If involved in scheduling of tree planting machines for private landowners a couple of pointers to remember including:

a. Do not schedule the tree planter for use each day of the week, spring weather and breakdowns will ruin the schedule in a hurry. For example, leave Wednesdays and Sundays free.

b. Find an individual or organization to provide movement of the equipment from landowner to landowner.

c. Stick with the schedule, even if the landowner who has the machine currently is not completed.

d. Schedule bare fields with heavier soils and lower lying areas later in the tree planting season.

e. Inform the landowners to pick up their trees at least the day prior to arrival of the tree planting machine.

f. Try and meet with the landowners on the first day the tree planting machine arrives if they are unfamiliar with the tree planting equipment to get them started properly.

7.3 Seedling Ordering

For seedling order forms or for general questions you can write or call your nearest state nursery:

Griffith Nursery, 473 Griffith Avenue, Wisconsin Rapids, WI 54494 (715) 424-3700

Hayward Nursery, 16133 Nursery Road, Hayward, WI 54843 (715) 634-2717

Wilson Nursery, 5350 Hwy. 133 E, Boscobel, WI 53805 (608) 375-4123

Seedlings for reforestation purposes are also available from private nurseries. The Wisconsin Nursery Stock Source Guide (DNR publication FR-095) lists by species and stock type the nurseries that produce or provide these trees.

8 PLANTATION MANAGEMENT AND MAINTENANCE

8.1 Monitoring

Monitoring is the operational practice of evaluating the outcome to improve its effectiveness. Successful plantations are identified for repetition and failures are evaluated to determine why objectives were not met.

8.1.1 Characteristics of a successful monitoring program:

a. Incentives. Without benefits to be gained by improving regeneration performance monitoring becomes inconsequential and inefficient.

b. Linkages. Evaluate how the interactions of climate, site factors, and seedling condition and timing factors affect the outcome of the regeneration treatments.

c. Stratification. Differences in site and stand conditions as well as treatments should be distinguished to explain the effects of a treatment on the site, seedlings (species, age, stock type), and planting practices.

d. Objectives. Program objectives must be defined before the effectiveness of the activity can be evaluated.

e. Evaluation. Determine effectiveness of the treatment in terms of the objectives set.

f. Records. Keep clear, concise, and current records.

g. Feedback. Monitoring results should be passed to those setting objectives and performing treatments to alter treatments.

h. Adaptive design. Activities change as knowledge improves objectives and treatments.

8.1.2 Survival Checks

One of the most important things to do after planting is to evaluate survival. This is a necessary step because you may need to replant to ensure that you meet your management goals. It also provides an opportunity to observe signs of animal, insect, disease, or competition problems. If adequate stocking of regeneration is not present, then supplemental planting should be implemented.

Survival counts are done 4-5 months after planting, and again after three years. The preferred method of conducting survival counts is to use random plots to evaluate survival. The common plot size utilized is 1/100 acre. You need a stake and a rope 11' 10" long (the radius of a 1/100-acre circle). Select a plot randomly and circle the rope around as you count the number of live trees and total number of trees both live and dead. The number of live trees multiplied by 100 is the average trees/acre. The number of live trees/acre divided by the number of total trees planted/acre is the survival percentage. Sample randomly throughout the plantation and average the values from all the plots tallied to determine the survival of 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 ten acres and one additional plot for each additional five acres of plantation.

Another method is to randomly select a row and walk down it while counting the live and dead trees. Switch rows periodically to sample across the entire plantation. Survival percentages can then be calculated.

8.2 Maintenance

8.2.1 Vegetation Control

To help your seedlings to continue growing vigorously post-planting weed control with the use of herbicides may be necessary until the trees are the dominant vegetation. Weed competition control is necessary for at least 3 years following establishment in hardwood plantings to give the hardwoods time to reach a competitive height. Refer to Appendix B for proper herbicide selection.

Post planting weed control and seedling growth can be maximized by shallow disking or rototilling between rows. Mowing will reduce weed seeding and rodent shelter, but it can also stimulate weed root growth and intensify competition for soil nutrients and moisture.

8.2.2 Animal Control

To control the damage done by browsing to your plantation you will need to discourage wildlife. Elimination of damage is not possible. There are two approaches to dealing with animal damage: prevention and containment.

Prevention is done by manipulating the environment to discourage invasion or controlling the target animal population. An example would be to plant a stretch of unpalatable vegetation, i.e., spruce, around the primary planting to dissuade animals from entering. The use of human hair clippings, perfumed soap, and sprays can be effective as temporary repellents, but their effectiveness is reduced with time. Population control methods include encouraging hunting for whitetails and rabbits and the use of rodenticides for control of rodent populations. Baits are hazardous and can affect non-target organisms. Rodenticides and repellents should only be used as a last resort.

Another method for controlling rodent browse is to remove their shelter. By keeping grass down, you reduce rodent access to seedlings and provide opportunity for predators to control the population. If the dens, nests, and perches of foxes, coyotes, owls, and hawks are left undisturbed it will naturally limit pest numbers. To encourage raptors perch poles can be erected throughout the plantation. For rabbits, the removal of brush and hedgerows virtually eliminates damage since they do not venture far from their shelter.

Containment includes devices such as electric fences, tree shelters, bud cap protectors, and bud nets. The key is to make sure that they remain intact.

8.2.3 Insects

Insects will affect every part of your plantation trees. Those causing the most damage fall into three categories: stem and root pests; shoot or branch pests; and defoliators. Common insects that can affect young plantations during the establishment phase include the following:

8.2.3.1 Main stem and root pests

1) <u>white grubs</u> - conifer planting sites should be checked prior to planting for presence of white grubs. White grub densities that are above 2 grubs for every 10 square feet of soil may cause heavy seedling losses due to feeding on the root systems. Old farmland with heavy grass sod is often infested with white grubs, especially on sandier sites. Control alternatives include delay planting of site for 2 to 3 years until the grub population declines or plan on accepting some losses and adjust planting densities appropriately.

2) <u>pine root collar weevil</u> - jack and red pine planted on nutrient deficient, sandy sites are susceptible to root collar weevil attack and subsequent death by girdling of the stem in the root collar region. Other hazardous conditions include planting a seedling with the root collar well below the soil surface, understocked stands, and

proximity to infested scotch pine stands. Prevention measures include not planting red pine and jack pine within 1 mile of infested scotch pine stands, planting seedlings with the root collar no deeper than 1 inch below soil surface, planting stands at densities greater than 800 trees per acre and controlling competing vegetation during early development stages of the stand.

3) pales weevil - red pine and white pine seedlings planted on sites with recently cut pine stumps are susceptible to feeding injury and death by pales weevil. Prevention measures include the removal of freshly cut pine stumps during site preparation, delay planting for two years after harvesting pines to allow stumps to dry out so they no longer can support pales weevil and treat pine stumps in early spring with an insecticide to preclude pales weevil egg laying in them.

8.2.3.2 Shoot or branch pests

1) Saratoga spittlebug - hazardous situations are sites where red pine (primary host) and the combination of sweet fern, willow and berry bushes (alternate hosts) cover 20% or more of the site. Prevention measures include adequate site preparation treatments to remove alternate host species or do not plant red pine on sites where the alternate hosts cover more than 20% of the site.

2) European pine shoot moth - Open stands of young red pine trees with lower branches extending below snow line are susceptible to European pine shoot moth attack. The hazard zone in Wisconsin extends from southern Door County to southern Lake Winnebago to Walworth County. To avoid problems with European pine shoot moth, promote early stand closure by planting 800 or more trees per acre and controlling competing vegetation in early development phases of the stand.

3) Pine Tortoise Scale - a sap-sucking insect of jack pine that can cause branch and seedling mortality. Prevention measures include insecticide spraying in severe infestations during June or July and planting or at least 800 trees per acre to promote stand canopy closure.

4) *Acrobasis* sp. - Two species of *Acrobasis* damage black walnut by mining the expanding buds in the spring; one of the two species then bores in and kills the new shoots. Rarely, populations become high enough to kill young trees less than 3 feet in height. Monitor local Acrobasis populations in young walnut stands during the winter months when small gray eggs are located near the buds. Spray with a registered insecticide if population becomes high enough to kill reproduction.

5) Kermes oak scale - Full grown female Kermes scales have the appearance of a gall about 3/8 inch in diameter. They are sapsucking insects that weaken and kill twigs when they attach in groups of three or more. They occasionally cause moderate twig damage in planted red oaks. On higher quality sites, the red oak usually will outgrow the problem. On very poor sandy sites, planted red oaks can

be kept in a perpetual bush stage by repeated attacks. Avoid planting red oak on poor quality, sandy sites. On high quality sites, spraying has been effective in reducing the scale population but is seldom necessary.

8.2.3.3 Defoliators

1) gypsy moth - gypsy moth caterpillars kill mainly oak reproduction by defoliating seedlings. The caterpillars originate in nearby heavily infested hardwood stands and individual trees. The problem can be prevented by establishing new stands at least L mile from susceptible stands. Where this is not possible, monitor the gypsy moth population in nearby hardwood stands and spray with a registered insecticide when population is high enough to threaten high-value reproduction.

2) redhead pine sawfly - red pine and jack pine trees are susceptible to redheaded pine sawfly defoliation. Hazardous conditions to avoid include shallow, disturbed, or eroded soils; proximity of northern hardwood stands (esp. sugar maple); and heavy competition from grasses, bracken fern or sweet fern. Prevention in future plantations can be accomplished by avoiding planting red pine on disturbed, eroded, or shallow sites. Leave at least a 50 foot buffer strip between red pine plantings and northern hardwood stands. Do appropriate site preparation and follow up releases to control competing vegetation. Plant 800 or more seedlings per acre to promote early canopy closure.

Additional information concerning insects can be obtained from this Handbook in the specific cover type chapters.

8.2.4 Diseases

Diseases can be classified into two broad categories: root rots; and cankers, rusts and shoot blights. Root rots cause trees to have slow twig and leader growth and a yellowing of the crown which may be especially evident in the leader. Mushrooms or fruiting bodies can be found about the base of the stem and disease often occurs in distinct infection pockets. Cankers and rusts cause dieback and the tell-tale sign is the presence of a swelling and/or lesion on stems and branches. Foliage diseases cause mottled spots on the affected foliage. Other foliage diseases cause browning or curling of foliage. Common diseases that can effect newly established and young plantations include:

8.2.4.1 Root rots

Armillaria root rot - this root rot is caused by a fungus that feeds on and decays hardwood and conifer stumps. Pines planted on previous hardwood forest sites are susceptible to this disease. Preventative measures include avoidance of planting red pine or white pine stands on or near previous hardwood sites with known root rot infestations or delay planting these sites for 7 to 10 years after harvest to allow the fungus to die out. Another option, though definitely more costly, is to remove hardwood stumps during site preparation.

8.2.4.2 Cankers, rusts and shoot blights

1) Sirococcus shoot blight - a fungus disease spread from older red pine to younger trees by raindrops in northern Wisconsin. Sirococcus causes mortality of young seedlings and saplings. Prevention can be accomplished by planting new red pine stands with a buffer zone of 150 feet from existing red pine stands.

2) White pine blister rust - a fungus which requires white pine (primary host) and gooseberry or current bushes (alternate hosts) to complete its life cycle. Statewide avoid small forest opening, bases of slopes, V-shaped valleys, and other topographical depressions. Other preventative measures include planting white pine on dry or sandy hilltops, steep slopes, or open fields; and use white pine blister rust resistant seedlings or consider alternative species.

3) Diplodia shoot blight - red pine seedlings under stress due to poor site, drought or frost are susceptible to infestation by diplodia shoot blight. Preventative measures include the avoidance of planting red pine on dry sites or sites that have a history of serious Diplodia infection.

4) Eastern gall rust - a fungus which requires jack pine (primary host) and oaks (secondary host) to complete its life cycle. Jack pine seedlings growing in the vicinity of oak trees are susceptible. Improved jack pine seedlings from DNR seed orchards have had resistance to jack pine gall rust as a criterion in the selection process.

8.2.5 Weather and Environmental Damage

It is important to be able to recognize tree injury caused by weather and environmental injury.

1) Drought - trees damaged by drought have wilted and yellow/brown foliage. The symptoms should be similar throughout the plantation. Recovery is possible if seedlings get water before extensive root damage is done. Drought will weaken seedlings and predispose them to biotic attacks.

2) Frost - damage occurs commonly in "frost pockets" and will curl foliage and kill it quickly. Frost damage is also a precursor for the tree to other biotic attacks.

3) Desiccation - dry winter winds cause desiccation of conifers, especially white pine. This causes the needles of the tree to turn reddish brown in color. Usually just an aesthetic concern.

4) Herbicides - improper application or timing of herbicide can cause damage. Signs are usually yellowed needles and distorted growth of the needles or leaders.

5) Pollutants - damage from pollutants can resemble many different problems and are extremely hard to identify. Sulfur dioxide and ozone are the major pollutants.

Remember to avoid planting white pine in areas frequently exposed to air pollution and along major highways.

6) Fire - to deal with the risk of fire on your plantation your only option for prevention lies in reducing the amount of fuel. Keep vegetative debris to a minimum and see that a ready supply of water for fire suppression is available. The presence of weed-free firebreaks and access roads will allow fire trucks to reach fires and will make it more difficult for flames to spread.

9 OTHER REFORESTATION AIDES

9.1 Tree Shelters

Shelters protect trees from animal browse and improve initial growth rates by creating a 'greenhouse effect' around each tree. The 'greenhouse' traps carbon dioxide and moisture around the tree while light passes through. There are literature reports of height growth being increased from 100-200% versus non-sheltered trees after three seasons, but trials in Wisconsin have shown mixed results. This increase in height growth is generally associated with a reallocation of resources within the tree. Trees growing within a tree shelter have increased height growth, reduced stem caliper growth and decreased root system growth.

The best test results with tree shelters have come from use on open-field plantings, the shelters block a significant quantity of incoming light so use of tree shelters in shelterwood is questionable. Remember, shelters do not alter site quality, poor planting, or inappropriate species selection!

The tree shelters are used mainly on high value hardwood seed or seedlings such as black walnut and red oak. Shelters will generally increase survival and make the seedlings easier to locate for follow up maintenance. They also protect trees from herbicides, windblown sand and debris, and careless workers. Shelters do not however eliminate the need for vegetation management. Weeds in and about the shelters should still be controlled.

The decision to use a shelter should be based on initial shelter and stake cost, installation, site quality, species planted, the extent of competition, animal browse damage expected and future return on investment. Generally, for operational reforestation programs use of tree shelters cannot be economically justified.

Netting should be added to the top of shelters to reduce accidental bird deaths. Bluebirds and indigo buntings investigate the inside of the shelters for possible nest sites and then are not able to escape the shelter.

Recommended stakes include treated southern pine, plastic, cedar, oak and redwood heartwood. Stakes should be placed 2 inches from the seedling on the windward side. The base of the tube should be driven 1 inch into the soil.

Shelters require yearly maintenance, generally to re-attach shelter ties to the stakes, replace bird netting, and replace broken stakes.

9.2 Mulches

Mulch is also a valuable tool in the regeneration effort. Mulch protects seeds, seedlings and seedbeds from sun, wind, and excessive rainfall. Mulch can be made of straw, sawdust, bark, or wood chips. Anything that reduces erosion and competition while helping to maintain a beneficial microsite can be used as a mulch. Mulches must be applied to a depth adequate to suppress weed growth, generally 2-3 inches deep. The mulch should be deeper toward the outside of the tree and less near the base of the seedling. The disadvantages of natural types of mulch is that they can be attractive to rodents for nesting.

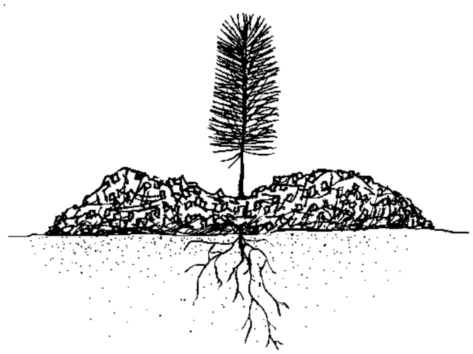

Figure 22.1. Diagram showing proper mulching technique.

Sometimes mulch mats made of polypropylene, polyethylene, kraft paper, wood fiber, grass mats, or polyester are used around new seedlings for protection. Mulch mats form a protective barrier around seedlings that blocks out competition without negatively affecting water relations. They can be expensive, but are invaluable if neither chemicals or fire are an alternative for vegetation management.

9.3 Root Dips and Gels

These products generally consist of a hygroscopic starch polymer that gels when wet. Coating of a seedling root system with a hygroscopic gel is done to reduce dessication of the seedling during handling and planting operations. It is used often as a preplanting dip to reduce transplanting shock and mortality caused by short duration droughts immediately following planting. However, their effectiveness is uncertain and appears to decline with severe and long-term droughts.

10 SPECIALTY PLANTINGS

10.1 Windbreaks

A windbreak is a tall, dense, continuous wall of vegetation. A windbreak will generally reduce wind speeds to a distance of 10 times its height and reduce wind speed by 70% immediately inside the barrier. They are generally located to the north and west of areas that need protecting as that is the direction of the most damaging winds.

People use windbreaks because they can reduce heating and cooling costs by 10-15%. Windbreaks also provide a sound barrier from machinery, traffic, and animals. Windbreak plantings can beautify property and benefit wildlife. They also trap snow and act as a living snow fence, reducing maintenance costs and making roads safer. A windbreak is a valuable asset to any property.

The reduction in wind velocity reduces soil erosion and improves irrigation effectiveness, soil productivity and the quantity and quality of crops. Evaporation is reduced, soil moisture is conserved, and soil temperature is moderated. Windbreaks protect plants from abrasive and drying winds.

Multiple-row plantings can be used along with grass plantings to help filter animal wastes, pesticides, and fertilizers from irrigation water before entering streams and reservoirs. Windbreaks also serve as a valuable tool in the protection of livestock. Trees can moderate the chilling and drying effects of the wind. This results in animals needing less water in hot months and less feed in the cold winter months. Use of windbreaks can also reduce the occurrence of udder damage.

For the typical farm, windbreaks offer energy conservation, muted wind chills, beauty, snow control, reduced noise, wildlife sanctuary and potential wood products.

Mass plantings are an alternative to windbreak row plantings. Trees are planted at random intervals are often very close to each other. This type of planting works because the closely spaced plants protect each other from wind, sun and reflected heat. Species must be selected on their shade tolerance, root competition and moisture availability.

Along roadsides, mass plantings provide visual improvement, traffic control, and privacy. Along streams they are used to stop sheet and rill erosion or to filter sediments. Grass and forb cover may supplement the soil retention capacity of the trees. The barrier effect created by the addition of trees also reduces erosion by reducing the overland traffic of animals and vehicles.

Mass plantings are affective as buffers and can be aesthetically pleasing. They provide visual privacy, attenuate noise, diminish air pollution, reduce and slow storm runoff, maintain water quality, increase property values, benefit wildlife, moderate microclimates, and reduce heating and cooling demands.

10.1.1 Windbreak Planning and Design Considerations

The standard DNR windbreak packet contains 200 spruce and 100 white pine. This is enough for a 3-row planting, 800 feet long. Leaving 10-15 feet between rows is a good guideline. The second row should be staggered or offset from the first and third rows to provide better wind protection. The windward and leeward edges of the planting should be planted with a shade tolerant species that won't self-prune. White spruce or Norway spruce are good candidates for this position because they will provide a barrier near the ground even as they grow taller. The inner trees should be a species with considerable height. White pine, red pine, Imperial

Carolina poplar or green ash would be good choices. Be cautious of establishing windbreaks along roadways with white pine due to salt toxicity.

Adding addition rows can greatly improve the wildlife holding capacity of your planting by adding shelter, food, and nesting habitat.

Windbreak plantings have a high individual value because each tree will eventually play a role. For this reason, each tree needs to be given a favorable microsite in which to grow. The way to do this is through proper site preparation. Competing vegetation can choke out young seedlings by robbing light and water or through the production of harmful chemicals. You can reduce grass competition by rototilling, fall plowing, and/or discing between rows. Do not plow in the spring, as too much air in the soil dries the young seedling's delicate root systems. Mowing can also knock back competing vegetation. Competition can be controlled with selective herbicides.

You may even want to consider protecting it with a fence in the early years. Weed control will continue to be necessary to remove both vegetative competition and mice and vole habitat.

Replace dead trees every year until every spot that should have a tree does.

10.1.1.1 Location of Windbreaks

- Position the planting as close to perpendicular to the prevailing winds or noise as possible.

- For wind protection place the row with the tallest growing trees species from 2-5 tree heights (estimated at age 20) from the protection area. If the area to be protected is uphill, the planting must be move closer.

- When wind and noise are coming from multiple directions, two legs rather than one will improve protection.

- Roads or paths through row plantings need to be oriented at an angle to the prevailing winds or wind will be funneled through the gap in the trees. No access roads should go through plantings in snow drift hazard areas. In these areas, the access roads should be placed 100-500 feet from the ends of the windbreaks to minimize problems.

- If soil differences exist within the planting strip, you should consider planting different species.

- Incorporate existing tree into your windbreak plan only if space is limiting.

10.1.1.2 Number of Rows

This number of rows will vary depending on the situation. Where wind, snow and noise are a factor, 3-5 rows are recommended. It is recommended that two to three rows of different species be used since one species could be decimated through insect or disease damage. Though the actual number of rows is important to note, the key is the density. Different species have different densities, and this will affect the number of required rows. Be sure you maintain density through proper species selection.

10.1.1.3 Row Arrangement

Shrubs, short trees, and slower growing trees should be located in the outer rows while the inner rows should have the taller growing species. If rows are going to be cultivated in between, the rows must be spaced far enough apart for the equipment to pass through. Common row spacing is from 12-20 feet.

Another type of row arrangement is called twin-row high density where narrow and wide spacings between rows are combined. Each twin-row contains two rows of the same species 4-6 feet apart and each twin-row is 25-50 feet from the next twin-row. This spacing leaves many options open for future renovation without damaging trees. Within row spacing will depend on the density and light and nutrient requirements of the species used.

10.1.1.4 Snow Management

A properly located shelterbelt can deposit snow on the lee side and prevent drifting. The snow is "trapped" in the wind shadow or dropped in front of the barrier.

The outside row must be 100-200 feet from the area of protection. All areas needing protection should be in the 2-5H zone. Locate any new roads at least 100 feet from the ends of the windbreaks to minimize drifting problems. For snow trapping, multiple row and twin-row high density plantings work best. The barrier length is simply determined by the size of the area to be protected. The length of the snow fence should extend 100 feet past either side of the area to be protected. The addition of 1 or 2 shrubs 500 feet from the windward side of the planting will benefit the snow management aspect of your planting. By trapping snow on the windward side of the shrubs as well as between the shrubs and the first trees you can count on snow removal being that much easier.

As trees grow, they can cause hazards, so plantings must be at least 30 feet away from the edge of a roadway to reduce ice on roads due to shading. Plantings should also be at least 20 feet away from power lines.

There are several characteristics of trees and shrubs that affect the quality of the windbreak. Wind movement and velocity are affected by leaf character, branching pattern, and stem form.

10.2 Noise Buffer Plantings

One potential benefit of buffer plantings is the reduction of noise pollution. Reduction of noise pollution can lower stress, anxiety, and can improve productivity. Buffers can improve health, happiness, and quality of life by reducing audible noise levels by 50%.

Sound is controlled by plants through absorption, reflection, deflection, or refraction. Trees and shrubs are effective as noise barriers because they can absorb sound energy. Trees also deflect sound toward the ground which should be covered with a thick grass layer which is an effective sound absorber.

Key points in designing a noise reduction buffer planting are:

1. Put barriers as close to the source as possible; they will be more effective.

2. Row plantings are not necessary, but they do aid in maintenance. If row plantings are used, use at least three rows with the narrowest row to row spacing possible.

3. Year-round effectiveness is most dependable when evergreens are used.

4. Shrubs should go on the source side of the planting.

5. Center trees should reach at least 45 feet at maturity.

6. Planting length should equal twice the length as the distance from the noise source to the receiver.

7. A diverse group of trees, shrubs, and grasses should be used for noise barriers

10.3 Plantings for Riparian Management Zones (RMZ)

The DNR defines RMZ as the areas next to lakes and streams where management practices are modified to protect water quality, fish and other aquatic resources. RMZ are one of the most important ecotones and deserve special consideration. RMZ plantings help filter sediments and nutrients, improve water infiltration, improve stream structure, stabilize banks and shores, shade streams, and provide food and habitat for wildlife. Research indicates in areas where conifers are indigenous that long lived conifers should be planted within one tree length of streams to eventually restore in-stream large woody debris structure. Species composition plays an important role in habitat next to water and the riparian use for bird and mammal travel corridors.

Plantings in these areas should be to enhance compositional features of the landscape. Additionally, in areas dominated by hardwood species planting or seeding of alder, willow, cottonwood, elm, or other mesic species is recommended to preserve water quality.

10.4 Interplanting

Sometimes forests will fail to regenerate as expected after canopy removal. Problems like this and other regeneration failures are potentially solvable through supplemental interplanting. Interplanting is defined as "establishing young trees among existing forest growth, planted or natural." Two factors determine the conditions that justify hardwood interplanting. The first is an absence of adequate advance reproduction of desirable species and the second is site quality. Good quality sites are obviously better candidates for interplanting. Evaluation criteria should consider the number, size, and spatial distribution of desirable advance reproduction. Don't forget to factor in the contribution of expected sprouts to fill all or part of the reproduction deficiency. It is conceivable that if there is little desirable advance reproduction that an herbicide treatment to re-capture the site may be required.

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, subsequently existing vegetation control may be required. Generally, larger sized seedlings (e.g., 2-0 or 3-0 hardwoods and conifer 3-0 or transplants) are needed in interplantings situations in order to compete with this advance reproduction and stump sprouts. These types of plantings generally will require some type of release early in the establishment phase.

10.5 Underplanting

Another tool is to underplant seedlings in mature stands. Underplanting establishes desirable species without the cost of site preparation. This may allow the root systems of the planted trees to become well established before competition escalates after cuttings. Underplanting eliminates the difficulty associated with planting in slash. With underplanting, understory and overstory density control may be required to produce the light and soil moisture conditions necessary for adequate development of planted trees prior to the final cut.

Factors to consider in determining whether to underplant a stand is the time prior to removal of the overstory and the damage caused to the seedlings due to removal of the overstory. Generally, the time to schedule an underplanting of an existing stand is three to five years prior to expected final overstory removal. Depending on treatments to the stand prior to the underplanting (e.g., establishment of a shelterwood harvest) control of the existing vegetation may be required prior to planting.

As with any planting effort the size, physiological condition and overall quality of the planting stock can determine success or failure. Generally, larger sized seedlings (e.g., 2-0 or 3-0 hardwoods and conifer 3-0 or transplants) are required in underplantings situations.

10.6 Restoration Plantings

The purpose of restoration planting is to bring back landscapes that thrived in the past but today are dwindling due to human pressures on the land. Whenever possible, the chance to diversify the landscape with restoration plantings should not be overlooked. If you can feasibly restore a prairie, a pine barren, or an oak savanna it should be considered as part of your land use plan. Not only will you be adding aesthetic and biological variation you will be benefiting a unique or rare community type.

10.7 Wildlife Plantings

Woody wildlife cover in Wisconsin along roadsides, fencerows and field borders has rapidly disappeared. Wildlife cover plantings placed in any odd corner of a farm or property will attract some form of wildlife during the lifetime of the planting. However, if the placement of these plantings is done with recognition given to existing travel corridors; surrounding topography; potential nesting cover; proximity to wetlands; and food and watering areas - then the payoff in diversity and quantity of wildlife using the planting will be great.

One type of wildlife planting is the creation of hedgerows that provide travel corridors between habitats, wildlife cover and food. These are easily created along existing fencerows by just increasing the width of the fencerow with 2-3 additional rows of small trees and wildlife shrubs. Species that are ideal in this situation include silky dogwood, red osier dogwood, ninebark, hawthornes, elderberry, sumac, wild plum, American highbush cranberry, nannyberry, American hazelnut and wild grape.

One of the primary benefits of well-located wildlife planting is providing relief for wildlife from mid-winter winds and extreme cold temperatures. In Wisconsin, severe northerly and westerly winds are a concern in winter, subsequently winter cover plantings on southern and eastern facing slopes that receive direct sunlight should be preferred locales. The arrangement of these plantings is critical to provide the intended benefits of wind protection and thermal protection. Planting designs with depth are preferable to long, thin planting. The planting should provide an area to catch snow on the west and north sides of the planting with inner rows of conifers to provide shelter and fruit bearing trees and shrubs on the downwind side. It consists of two rows of dense shrubs on the windward side to catch snow, a 35–50-foot grassy space for the snow to be deposited and then rows of small hardwood trees, conifers, and shrubs.

Another consideration to take into account in these types of planting is to incorporate a wildlife food plot near the wildlife cover planting. A few smaller scattered food plots, one-half to one acre in size, are preferable to one large food plot.

Also, please remember that it is not always appropriate to plant trees. Some types of wildlife, like prairie chickens, prefer wide open grassy areas. Good intentioned wildlife plantings in these areas can actually be detrimental to certain species by breaking up the habitat or providing perches for raptors. Remember to consider the entire landscape when developing prescriptions or management plans for a landowner.

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12 APPENDIX 22-A: INDIVIDUAL SPECIES PLANTING CONSIDERATIONS

12.1 Conifer Species

12.1.1 TAMARACK, Larix laricina

12.1.1.1 Introduction

Tamarack is capable of tolerating a wide range of sites and exhibiting rapid growth. Tamarack is more tolerant of poorly drained soils than other *Larix* species and can be found naturally in bogs and similar areas. Its best growth occurs on well-drained upland loams and sandy loam soils, though it will do surprisingly well on sandy sites with a high water table.

12.1.1.2 Planting Considerations

In lowland situations mounding is a common site preparation treatment for tamarack establishment. Tamarack seedlings are sensitive to many herbicides so existing vegetation control is best implemented either chemically or mechanically prior to planting.

Note that tamarack is sensitive to close spacing; when crowns close, diameter growth is considerably reduced. A spacing of 8' x 8' is common in artificial reforestation.

12.1.1.3 Nursery Stock

In most situations a 2-0 bareroot seedlings is utilized in Wisconsin's reforestation program.

12.1.1.4 Direct Seeding

Direct seeding of tamarack has not been utilized extensively mainly due to the difficulty in obtaining suitable quantities of seed and the low germination rates associated with tamarack seed. Research in Minnesota has shown that sites that were burned or sites where full tree skidding exposed mineral soil provided the best sites for naturally regenerated tamarack. This is an important consideration if planning to direct seed tamarack, seed it into bare mineral soil.

12.1.1.5 Seed Source Considerations

A genetic test of several tamarack seed sources in Forest County, Wisconsin demonstrated local Wisconsin sources, a Maine source and a Nova Scotia, Canada source performed well in height growth and survival, while sources from Minnesota and Michigan did not perform as well as these sources.

12.1.2 WHITE SPRUCE, *Picea glauca*

12.1.2.1 Introduction

White spruce can tolerate a range of moisture conditions, but good growth depends on a reliable supply of well-aerated water. Spruce does not tolerate poorly aerated soils which reduce rooting volume. It will grow on dry sites if they are fertile; in general fertility needs are high. Spruce grows best on well-drained loamy soils and has higher minimum soil-fertility requirements than other conifers. Spruce grows in soils from pH 4.7 - 7.0 and higher. The potential height and diameter of white spruce on good sites are trees 100 feet tall and 2-3 feet in diameter.

12.1.2.2 Planting Considerations

Full sun is required for adequate diameter growth of white spruce. Planting sites need to have good cold air drainage to prevent spring frost damage which new growth is susceptible to at the time of flushing. Slow initial root growth makes young seedlings and transplants susceptible to frost heaving especially on soils with adequate water for ice formation. Plantings should also be avoided on shallow soils because windthrow will likely be a future problem.

Site preparation for white spruce is critical to ensure survival and growth. White spruce seedlings do not compete with other vegetation as effectively as other conifers after establishment, so vegetation control at time of establishment and follow up releases are required. White spruce seedlings planted in fields with heavy grass competition commonly experience what is described as "planting check". This condition is where the seedling basically survives but does not exhibit anywhere near its growth potential. Research has indicated controlled burning; mechanical or chemical site preparation are all effective in the establishment of white spruce seedlings. If the site preparation is not going to be accomplished, select another species to plant.

12.1.2.3 Nursery Stock

Commonly, 2-0 and 3-0 white spruce nursery stock is utilized in Wisconsin's reforestation program. With the smaller 2-0 being commonly hand planted or machine planted, and the larger 3-0 machine planted on heavier soils. White spruce seedlings can be sensitive to transplant shock. Through proper planting, root pruning, and competition control you can reduce the likelihood of shock.

12.1.2.4 Direct Seeding

For direct seeding purposes germination of white spruce is optimal at 50-75 degrees. Prechilling or stratification of seed at 36-39 degrees for 60 days may improve germination rates for spring seeding. The seed to seedling ratio varies from 5 to 30 depending on the amount of mineral soil exposed and the amount of vegetative competition and leaf litter present. Late fall, early winter or early spring direct seeding are recommended.

12.1.2.5 Seed Source Considerations

Genetic tests of white spruce in the region have shown the superiority of local Wisconsin selections and white spruce from Ontario's Ottawa Valley region. These seed sources are represented in Wisconsin's seed orchards and the nursery stock from the state nursery program is all from seed orchard origin.

12.1.3 BLACK SPRUCE, *Picea mariana*

12.1.3.1 Introduction

Black spruce usually grows as pure stands on wet organic soils, though they will grow in mixed stands on mineral soil sites. In Wisconsin, black spruce grows in peat bogs and swamps that have formed on old glacial lake beds and in muck-filled seepages on peat deposits that range in thickness from 20 inches to 20 feet. Productive stands are on dark brown to blackish peats. Good sites will yield trees 40-65 feet tall and 9 inches in diameter.

12.1.3.2 Planting Considerations

Black spruce is shade tolerant. Seedlings can develop in as little as 10% of full sun, though survival improves in the open.

12.1.3.3 Nursery Stock

Black spruce is a relatively slow grower, even in a nursery situation. Subsequently, 2-0 nursery stock is generally only 3-4 inches in height. This can be utilized on sites that will be hand planted and in which competing vegetation can be controlled. For machine planting a 3-0 seedling is recommended. Though more expensive, nursery grown transplants or larger seedlings will survive better on difficult sites.

12.1.3.4 Direct Seeding

Seedbed scarification will increase stocking of your young black spruce stand. Sowing 32,000 viable seeds/acre in the spring should result in 60% stocking of receptive seedbed sites which should be adequate for regeneration.

12.1.3.5 Seed Source Considerations

There are currently no definitive genetic tests in Wisconsin in which to base seed source recommendations on. Subsequently, local seed sources are recommended.

12.1.4 JACK PINE, *Pinus banksiana*

12.1.4.1 Introduction

Jack pine has rapid growth rates, low site requirements, good pulp properties, and is easily established and genetically variable. Jack pine is a pioneer species that rapidly invades sites after fire or other disturbances that expose mineral soil. Mature trees are generally 55-65 feet tall with a DBH of 8-10 inches.

Jack pine is usually found on sandy soils. Well stocked stands in central Wisconsin have a moisture holding-capacity of 3 to 17% in the top foot of soil. Site index is improved with the presence of fine sand, silt and clay in the upper soil layer due to improved water holding and cation exchange capacity. Jack Pine is generally considered a drought tolerant species.

12.1.4.2 Planting Considerations

Optimal conditions for seedling establishment are where mineral soil has been exposed, competition is not fierce, the water table is high and there is some shade. The organic matter layer should not be greater than 0.5 inches thick.

Normally, 750-900 seedlings per acre are planted.

12.1.4.3 Nursery Stock

For hand planting on sites where the competition has been controlled or lacks significant competition 1-0 jack pine seedlings are preferred. On higher quality jack pine sites, where competition is greater and where machine planting is to be utilized, 2-0 jack pine seedlings are recommended.

12.1.4.4 Direct Seeding

When direct seeding it is important to note that germination takes from 15 to 60 days (though 100 days may be required for some seed) when air temperatures reach 64 degrees. Germination will be markedly reduced if light isn't ample. Though shade cast by slash and snags on cut-over areas can reduce surface temperatures and drying to improve germination on harsher sites.

Drag scarification with simultaneous redistribution of the cone-bearing slash is one of the most dependable methods of regenerating jack pine. The object is to produce well-distributed patches of mineral soil totaling 40-50% of the area and having a light cover of cone-bearing branches over them. Direct seeding can also be used with drag scarification. A rate of 1/4 pound of seed per acre is recommend in direct seeding operations. Burning and seeding can be used on problem sites where mechanical scarification is too expensive or difficult.

12.1.4.5 Seed Source Considerations

The Wisconsin State Nursery system at this time is procuring seed from first generation seed orchards of jack pine for seedling production. Estimated genetic gains in height, volume, stem form and pine-oak gall rust are significant with this material. Genetic tests have shown seed sources which are acceptable in Wisconsin are local sources and those from lower peninsula Michigan. These sources are recommended for direct seeding purposes.

12.1.5 RED PINE, *Pinus resinosa*

12.1.5.1 Introduction

Red pine's high yield and variety of products make it an attractive species for artificial regeneration. They are straight-growing trees with little taper and strong wood. Mature red pines reach (depending on the site) 70-80 feet in height and 36 inches DBH. Red pine is one of the most drought resistant conifers in the region. Because of shade intolerance red pine grows best in even-aged groups or stands.

Best growth is on acidic sandy-loam soils. Natural stands of red pine are most often found on sandy soils that are low in fertility. It grows especially well on soils that are naturally sub irrigated with a well aerated surface layer and a water table at a depth of 4 to 9 feet. Red Pine needs soils with a pH of 4.5 to 6 in the upper 10 inches. Red pine grows sporadically on heavier soils due to heavy competition from more aggressive species. In southern Wisconsin, health problems with red pine on heavier soils develop about twenty years after planting.

12.1.5.2 Planting Considerations

Plantations of red pine are normally established at a rate of 750-900 seedlings per acre.

Red Pine seedlings are fairly resistant to herbicides used to control competing vegetation, though caution must be used with the herbicide Oust. There is a need for release usually with red pine two to three years after planting since young stands can be quickly out competed - competition needs to be controlled early on.

12.1.5.3 Nursery stock

Planting is usually done at the rate of 700-1200 trees per acre. Bareroot stock should be planted in the spring. Container-grown seedlings can be planted throughout the growing season but fall planting can be risky on fine-textured soils where frost-heaving can kill the seedlings. For hand planting 2-0 stock is preferred, while machine planting of 2-0 and 3-0 nursery stock is acceptable. The 2-0 red pine nursery stock generally is a seedling with a better shoot to root ratio.

12.1.5.4 Direct Seeding

For direct seeding red pine seeds should be sown in mineral soil 1/8 to 1/4 inch deep. However, they are often broadcast after site preparation at the rate of 15,000 viable seed per acre. Because germination requirements are difficult to meet and impossible to control planting red pine is more popular. Most seedlings emerge after temperatures reach 70-86 degrees where there is high moisture and some shade. Germination is inhibited when full sun exceeds four hours per day. Seedlings grow best on a soil media with good water retention, a high CEC and a pH from 5.1-5.5. Establishment is possible with 35% full sun and only 45% full sun is necessary for maximum height growth to the age of 5.

12.1.5.5 Seed Source Considerations

Red Pine is noted for its lack of genetic variation as compared to other conifers. Genetic variations within the species is small, so care should be taken to plant in strategic locations to diversify age classes and forest cover types as part of an IPM (integrated pest management) program.

The state nurseries currently procure red pine seed from northern and central Wisconsin. In addition, there is three seedling seed orchards of red pine. It is recommended to use Wisconsin seed sources for reforestation purposes.

12.1.6 EASTERN WHITE PINE, *Pinus strobus*

12.1.6.1 Introduction

White pine is one of the faster growing conifer species in Wisconsin and as such it is an excellent candidate for artificial reforestation.

White pine will grow on nearly all soils within its range, but it does best on well-drained loamy sand soils of low to medium site quality where it regenerates naturally, competes readily, and can be managed most economically. White pine can also grow on fine sandy loams and silt-loams when there is no hardwood component during establishment. Avoid planting in heavy clay soils and poorly drained bottom land sites.

12.1.6.2 Planting Considerations

There is a concern with white pine with white pine blister rust (*Cronartium ribicola*). Trees are susceptible to this highly virulent fungus throughout its lifetime and throughout the range of white pine. The fungus is fostered by cool wet weather and the presence of its alternate host, plants of the genus *Ribes*, also known as gooseberry or currant. Reforestation opportunities exist even within the high hazard zones for blister rust, either by utilizing blister rust resistant seedlings available from the state nurseries or through individual site evaluation you can determine that blister rust can be managed. See additional details in the White Pine chapter of this Handbook.

Sites selected for white pine should maximize tree vigor and have a low incidence or potential for blister rust. Sites to avoided include bottom land of narrow valleys; bases of slopes; and small openings which have low daytime temperatures and prolonged daytime wetness.

White pine is subject to heavy browse damage by whitetail deer and is a preferred browse species of rodents. Browsing can cause severe loss of productivity and potentially plantation failure. Plantation maintenance strategies must recognize this potential problem.

12.1.6.3 Nursery Stock

If planting, site preparation and follow up maintenance usually is necessary to reduce competition. For hand planting on lighter soils, sites with little competition or excellent site preparation, 2-0 nursery stock is generally utilized. For machine planting on heavier soils 3-0 nursery stock is preferred.

12.1.6.4 Direct Seeding

Germination of white pine does not require mineral soil; seeds can germinate on both disturbed and undisturbed litter layers. Favorable seedbed conditions include full sunlight and moist mineral soil, polytrichum moss, or a short grass cover of light to medium density. While some shade is beneficial, dense shade can be detrimental to young stands. Overstory shade from a shelterwood-type cut provides protection during germination and early seedling stages of growth (at least 20% of full sun is required to keep seedling alive). Direct seeding rates of 1/4 pound of seed per acre have been used successfully in the Lake States to regenerate white pine.

12.1.6.5 Seed Source Considerations

The state nurseries currently have seedlings available from the White Pine Blister Rust Resistant Seed Orchard and are distributing these to the high hazard counties in northwest Wisconsin. Genetic studies in Wisconsin have shown the benefit of local seed sources. In southern Wisconsin, southern Appalachian white pine has performed quite well, though during the initial years of establishment it winter burns excessively.

12.1.7 NORTHERN WHITE CEDAR / ARBORVITAE, *Thuja occidentalis*

12.1.7.1 Introduction

White cedar is native to Wisconsin's north and as well as the eastern shoreline. It grows on a wide variety of organic and mineral soils. It does not develop as well on excessively wet or excessively dry soils. It is most often associated with cool, rich, moist sites, particularly on organic soils near streams or other drainageways or on calcareous mineral soils.

12.1.7.2 Planting Considerations

Northern white cedar is a compact tree with thick branches and foliage making it a good windbreak species as well as a good cover for birds. Seedlings do best on neutral to slightly acidic soils. A soil pH from 5.5 to 7.2 is common. Northern white cedar grows rapidly on well-drained sites, but also does well on moist soils.

White cedar seedlings may need extra attention when they are young because they are a favorite food for deer. If deer populations are high, you may want to use an alternate species.

12.1.7.3 Nursery Stock

The state nurseries offer 3-0 white cedar seedlings which generally are fairly large. Transplants can be obtained from private sector nurseries if a very large plant is required.

12.1.7.4 Direct Seeding

Germination is best at high temperatures (84 degrees), so it may not occur until July or August. Seeds will germinate on a variety of surfaces, but seedlings require constant moisture and warm temperatures to become established.

12.1.7.5 Seed Source Considerations

There are no definitive genetic tests in Wisconsin, so the state nurseries believe local seed sources are the best to utilize at this time.

12.1.8 HEMLOCK, *Tsuga canadensis*

12.1.8.1 Introduction

Hemlock is the most tolerant of the conifers in Wisconsin and regenerates well under heavy shade conditions. Hemlock restoration efforts have been mainly driven by wildlife and fisheries concerns. It provides a long-lived species next to riparian corridors and winter thermal cover for wildlife. Hemlock stands in large northern hardwood forest stands are ideal for wildlife.

12.1.8.2 Planting Considerations

Hemlock is a species that is highly susceptible to drought and browsing pressures. Numerous studies have indicated that in areas of high deer populations an enclosure is needed to protect the hemlock seedlings from browse.

Hemlock seedlings should be established under an existing canopy to provide shade which will help in alleviating moisture stress. Hemlock is not considered established until it reaches 5 feet in height.

12.1.8.3 Nursery Stock

Hemlock seedlings are very slow in growth initially. Subsequently, the state nurseries produce 3-0 and occasionally 4-0 hemlock seedlings. Larger seedlings are required due to extreme browsing pressures from rodents and deer.

12.1.8.4 Direct Seeding

Direct seeding of hemlock has not been tried extensively throughout the Lake States. Most likely due to the difficulty in collecting cones and obtaining viable seed.

Research has indicated that mechanical disturbance of the soil in stands with a basal area of 60-160 square feet/acre and a significant hemlock component increased natural regeneration of hemlock seedlings in the scarified plots. Subsequently, hemlock direct seeding sites will require a high density overstory, 70-80% crown cover, and a continuous availability of moisture in the upper soil horizons throughout the growing season. Operational seeding rates for hemlock direct seeding in Wisconsin are yet to be determined, but an initial estimate would be 6-8 ounces/acre.

12.1.8.5 Seed Source Considerations

Locally adapted Wisconsin seed sources are currently recommended.

12.2 Hardwood Species

12.2.1 SILVER MAPLE, *Acer saccharinum*

12.2.1.1 Introduction

Silver Maple is a specie associated with riparian forests. Its rapid growth rate has made it an ideal specie for research on biomass plantations. One of several hardwood species that produces seed in the springtime.

12.2.1.2 Planting Considerations

Quality silver maple sites require adequate moisture throughout the growing season.

12.2.1.3 Nursery Stock

Common age-classes produced are 1-0 and 2-0 silver maple seedlings. The 1-0 seedlings can be difficult for machine planting and the 2-0 can be too large for hand planting. Survival generally is quite excellent with silver maple seedlings if planted in early spring when the soils are moist.

12.2.1.4 Direct Seeding

There is not a considerable amount of information available on direct seeding silver maple. Factors to consider would include the site would require adequate moisture throughout the growing season, soil disturbance prior to seeding and seeding will have to be done in early June. Seeding rates for silver maple should be at a rate of 4-6 pounds/acre.

12.2.1.5 Seed Source Considerations

Local seed sources should be utilized in Wisconsin.

12.2.2 SUGAR MAPLE, *Acer saccharum*

12.2.2.1 Introduction

Sugar maple grows on sandy loams, loams, and silt loams, but it does best on well-drained loams and silt loams. It does not grow well on dry shallow soils. The soil pH for sugar maple ranges from 5.5 - 7.3.

12.2.2.2 Planting Considerations

Planting or other regenerative methods are rarely needed if a seed source of sugar maple is nearby. Open field plantings of sugar maple can be susceptible to sun scalding in the first few years following establishment. Sugar maple seedlings do not compete very well with grass on old field sites; therefore, sugar maple seedlings require excellent weed control for the first three years following planting to become established.

12.2.2.3 Nursery Stock

Commonly 2-0 and 3-0 sugar maple seedlings are utilized for reforestation in Wisconsin. The height and caliper of sugar maple seedlings vary more than any other hardwood species, both within and between years.

12.2.2.4 Direct Seeding

No information is available.

12.2.2.5 Seed Source Considerations

Local seed sources of sugar maple should be utilized for reforestation in Wisconsin.

12.2.3 WHITE ASH, *Fraxinus americana*

12.2.3.1 Introduction

White ash is native throughout Wisconsin. Its wood is strong, durable, and is highly resistant to shock. It is rarely the dominant species in the forest. White ash seed is a source of food for many wildlife species.

12.2.3.2 Planting Considerations

White ash grows best on rich, moist, well-drained soils, as it has demanding soil fertility and moisture requirements. White ash grows commonly on soils with a high nitrogen content and a moderate to high calcium content. Depth to bedrock or a hardpan should be at least 18 inches. It should only be planted on the best of sites for moisture and nutrients.

12.2.3.3 Nursery Stock

White ash is commonly available as 2-0 and 3-0 nursery stock. White ash seed does not all germinate in the first year so it is very common to have multi-aged nursery stock in a single bed (1-0 and 2-0), thus white ash generally will have a fairly high cull rate associated with it.

12.2.3.4 Direct Seeding

Natural germination is fostered if the soil, humus, or leaf litter is wet in the spring. Seedlings develop well in just 50% of full sun, so direct seeding under a shelterwood is a possible silvicultural system for white ash. White ash seed can lay dormant on the forest floor for several years prior to germination.

12.2.3.5 Seed Source Considerations

Local seed sources of white ash are recommended for Wisconsin.

12.2.4 BLACK ASH, *Fraxinus nigra*

12.2.4.1 Introduction

Black ash is a species found along stream banks, lakes, and lowlands.

12.2.4.2 Planting Considerations

Requires moisture throughout the growing season, especially as a young seedling. Relatively slow grower requiring vegetative control for first couple of years.

12.2.4.3 Nursery Stock

Black ash seedlings are currently grown to a 2-0 or 3-0 age class. Black ash seed never germinates all in the same year, subsequently you have multi-aged nursery stock in the same nursery bed. Therefore, black ash has a fairly large cull percentage when ordered bulk from the state nurseries.

12.2.4.4 Direct Seeding

No information is available.

12.2.4.5 Seed Source Considerations

Local Wisconsin seed sources should be utilized for reforestation efforts.

12.2.5 GREEN ASH, *Fraxinus pennsylvanica*

12.2.5.1 Introduction

Green ash is a small hardwood (50-60 feet) whose seed is the preferred food of wood ducks, cardinals, and grosbeaks. They can grow on dry upland sites, but more often they are found along streambanks, floodplains, and wet upland sites.

12.2.5.2 Planting Considerations

Moisture is a critical factor in selecting green ash planting sites.

12.2.5.3 Nursery Stock

Available as 1-0 and 2-0 seedlings. Very hardy seedling, with excellent survival and juvenile growth characteristics.

12.2.5.4 Direct Seeding

Green ash seed can lay dormant on the forest floor for several years prior to germination.

12.2.5.5 Seed Source Considerations

Local Wisconsin seed sources should be utilized for reforestation plantings.

12.2.6 BUTTERNUT, *Juglans cinerea*

12.2.6.1 Introduction

Butternut has been dramatically affected by butternut canker throughout most of Wisconsin. This disease has rendered butternut to a minor component in most stands. The value of butternut currently is in the hard mast production for wildlife.

12.2.6.2 Planting Considerations

Butternut should not be established in pure plantings but should be inter planted throughout a hardwood plantation. Butternut should be planted on the best of sites, high in moisture holding capacity and nutrient availability.

12.2.6.3 Nursery Stock

Butternut is available as a 1-0 or 2-0 seedling. Characteristics of a quality seedling would be more than 5 first order lateral root greater than 1mm thick and a stem caliper of 1/4 inch.

12.2.6.4 Direct Seeding

Seed of butternut is difficult to procure in significant quantities, but direct seeding would be similar to black walnut direct seeding. Direct seeding of pure stands of butternut is not advised due to disease considerations. Recommend just mixing butternut seed into a direct seeding mixture, possibly to as high as 10% of the seed mix.

12.2.6.5 Seed Source Considerations

Local Wisconsin seed sources are recommended.

12.2.7 BLACK WALNUT, *Juglans nigra*

12.2.7.1 Introduction

Black walnut is a valuable lumber and veneer species native to southern Wisconsin and areas along the Mississippi River. Black walnut is sensitive to soil conditions and develops best on moist, fertile, deep, well-drained, and nearly neutral soils. Walnut grows best on moisture retaining soils such as sandy loam, loam, or silt loam textured soils but decent growth is often possible on silty clay loam soils. Walnut is common on limestone soils and grows exceptionally well on deep loams, loess soils, and fertile alluvial deposits. Agricultural soils that do not have a fragipan are also good black walnut soils. Greatest size is often reached along streams and on the lower portion of north or east facing slopes.

12.2.7.2 Planting Considerations

Black walnut is intolerant of shade. Young walnuts develop a large taproot and planted seedlings typically survive well.

Excellent results have come from planting black walnut along other species, especially conifers or with nitrogen fixing species to bolster soil fertility. They do require weed control during the first 2 or 3 years to grow well.

12.2.7.3 Nursery Stock

The most commonly utilized reforestation nursery stock in Wisconsin is the 1-0 age class. Target seedling research in Wisconsin has identified the following seedling characteristics as being critical to successful black walnut plantation establishment:

1) First order lateral root development is critical to seedling survival and subsequent growth. The minimum number of first order lateral roots, greater than 1 mm in diameter, that an acceptable black walnut seedling should have is seven to nine. A seedling with greater than ten first order lateral roots is the best.

2) First order lateral roots should be trimmed to 3-4 inches in length prior to planting

3) Minimum root collar diameter of 1/3 inch

4) Main tap root of 8-10 inches in length

5) Seedlings should have been grown in a nursery at a density of 4-6 seedlings per square foot to encourage proper root development

12.2.7.4 Direct Seeding

Direct seeding of black walnut has become a fashionable alternative to planting seedlings. The current recommendations are to use a hardwood seed drill as opposed to broadcast seeding of walnut due to economics and seed needs. Current sowing rates with a seed drill of eight bushels hulled walnuts per acre seem to be adequate. In several planting a bushel of red oak acorns was added to the mix to sweeten the seeding. Broadcast seeding rates of 20 bushels of hulled walnuts per acre have been done successfully.

12.2.7.5 Seed Source Considerations

Genetic tests in Wisconsin have shown that seed sources from southern Wisconsin and northern Illinois have performed the best in regards to survival, height growth and form. Current recommendations are for black walnut to be obtained from counties adjacent to the Wisconsin River and south to northern Illinois.

12.2.8 HYBRID POPLARS (Cottonwood), *Populus sp.*

12.2.8.1 Introduction

There has been a resurgence in the interest of planting hybrid poplars for biomass production. Potential yields are reported between 3 to 6 dry tons of wood plus bark per acre per year.

12.2.8.2 Planting Considerations

Poplar clones should be established on deep, fertile sandy loam to clay loam soils with a pH between 5.0 and 7.5. The site should have a high water holding capacity or be shallow to groundwater (1 to 6 feet). They should be considered almost as an agricultural crop in initial establishment. Requiring clean tillage, excellent weed control, fertilization (especially nitrogen) and potentially irrigation.

Several different clones should be planted to reduce the potential impact from insects and diseases. Spacing is typically 8 feet by 8 feet. Prior to planting, with the buds pointing upwards, immerse 3/4 the length of the cutting in water for five to seven days. Cuttings are ready to plant when the buds just begin to elongate. The soils should be moist when planting. Cuttings are planted with one bud exposed above the soil surface.

12.2.8.3 Nursery Stock

Nursery stock available is of unrooted cuttings and rooted cuttings. Cuttings should be 10 inches in length and have a caliper between 3/8 inches and 1 inch. The cuttings should have several well-developed buds and be free from disease or bark damage. The ends of the cuttings should be wax coated to prevent desiccation of the cutting.

12.2.8.4 Direct Seeding

Not recommended.

12.2.8.5 Seed Source (Clone) Considerations

The following clones are currently recommended for the Lake States area: NM-6, DN-1, DN-2, DN-5, DN-17 (Robusta), DN-34 (Eugenei, Imperial Carolina), DN-182 (Raverdeau) and Bucky.

Additional clones are being developed and tested by the USDA-Forest Service and the University of Wisconsin-Madison. Release of new materials should be occurring in the next couple of years.

12.2.9 QUAKING ASPEN, *Populus tremuloides* and BIGTOOTH ASPEN, *Populus grandidentata*

12.2.9.1 Introduction

Aspen can be found on a variety of soils ranging from shallow and rocky to deep loamy sands. Good aspen soils are usually drained, loamy, and high in organic matter, calcium, magnesium, nitrogen, and potassium. Sandy soils offer poor growth conditions because of low levels of moisture and nutrients. Clay soils are not desirable because of limited available water and poor aeration.

Aspen is quick to pioneer disturbed sites where there is bare, moist mineral soil. The tree is fast growing and short lived. Mature trees are typically from 66-82 feet tall and from 7-12 inches in diameter. Aspen benefits many wildlife species.

12.2.9.2 Planting Considerations

Aspen should be planted into situations where it will receive full sun to become established. It doesn't compete well with grasses or other woody vegetation. Initial site preparation is critical since there are limited chemical release options with aspen seedlings.

12.2.9.3 Nursery Stock

Aspen seedlings are generally available as 2-0 nursery stock. Research has indicated that a larger aspen seedling survives and provides the best growth potential.

12.2.9.4 Direct Seeding

Has not been done to date.

12.2.9.5 Seed Source Considerations

Aspen seed sources should be from local Wisconsin sources.

12.2.10 BLACK CHERRY*, Prunus serotina*

12.2.10.1 Introduction

Black cherry throughout the state of Wisconsin. It is generally considered an early successional species and also a favorable specie for wildlife in Wisconsin.

12.2.10.2 Planting Considerations

Black cherry can survive and grow on a wide variety of sites, but performs best on deep, well drained, fertile soils. It has proven to be a excellent hardwood seedling for regeneration since it competes well with competition due to its rapid juvenile growth.

12.2.10.3 Nursery Stock

Black cherry is commonly available as 1-0 and 2-0 nursery stock.

12.2.10.4 Direct Seeding

Black cherry seed can be used as a component in most hardwood direct seeding projects. The seed is relatively abundant most years and is available early in the fall.

12.2.10.5 Seed Source Considerations

Local seed sources are recommended. Genetic studies in other states have shown that local seed sources perform as good if not better than non-local sources and that there is more stand-to-stand variation, then within stand variation.

12.2.11 WHITE OAK, *Quercus alba*

12.2.11.1 Introduction

White oak is an important lumber species and an important source of mast for many types of wildlife. Its Wisconsin range includes the southern 3/4 of the state. It is found on sandy plains, gravelly ridges, rich uplands, and well-drained loamy soils. Growth is good on all but the driest, shallow soils; poorly drained flats; and wet bottom land. Sites that best favor white oak are north and east facing slopes. Moderately dry slopes and ridges are also good sites. Wetter, mesophytic sites yield somewhat larger oaks than the drier west and south facing slopes, but these drier slopes usually support a greater abundance of oaks.

12.2.11.2 Planting Considerations

Seedlings can be planted under an overstory of about 60% stocking as long as the understory competition is not too competitive. White oak seedlings that are planted at the time of canopy removal often develop too slowly to become a major component of the new stand. Seedlings of white oak should be several feet tall at time of final canopy removal to better insure them a place in the new canopy structure.

There is evidence that the periodic use of fire is an effective tool to regenerate oaks. The oaks are resistant to the fire which kills competing vegetation, freeing up resources for the oaks. Subsequently, an oak planting that is suffering from woody competition can be burned and the oak will resprout vigorously.

12.2.11.3 Nursery Stock

White oak seedlings are commonly produced as 2-0 nursery stock. Seedling quantities are often limited because of a lack of acorns.

Recent research on red oak target seedlings has demonstrated the importance of the following seedling characteristics to ensure successful plantation establishment, it is believed these would also be critical for white oak seedlings:

1) First order lateral root development is critical to seedling survival and subsequent growth. The minimum number of first order lateral roots, greater than 1 mm in diameter, that an acceptable oak seedling should have is five to seven. A seedling with greater than ten first order lateral roots is the best.

2) First order lateral roots should be trimmed to 3-4" in length prior to planting

3) Minimum root collar diameter of 1/4 inch

4) Main tap root of 8-10 inches in length

12.2.11.4 Direct Seeding

See section on direct seeding of oak earlier in this chapter.

Acorns germinate rapidly in the fall after dropping. They do not store for any appreciable length of time and should be direct seeded as soon as possible after collection. Germination is favored at soil temperatures between 50 and 60 degrees. Seedling establishment is best on loose soil where the radicle can penetrate into the soil. Litter cover should be light to moderate and light reaching the seedling should be at least 35% of full sun.

12.2.11.5 Seed Source Considerations

Local Wisconsin seed sources are recommended at present for reforestation in Wisconsin.

12.2.12 SWAMP WHITE OAK, *Quercus bicolor*

12.2.12.1 Introduction

Swamp white oak is predominately found along riparian areas throughout the southern 2/3 of Wisconsin. It occurs on lands that are periodically inundated, such as river valleys, margins of lakes and sloughs. Swamp white oak is an ideal mast specie for wildlife, especially ducks and yet is a commercially viable forest tree species.

12.2.12.2 Planting Considerations

Swamp white oak should be planted along riparian areas.

12.2.12.3 Nursery Stock

Swamp white oak seedlings are commonly available as 1-0 and 2-0. Characteristics of a quality seedling include similar characteristics of oak seedlings in general:

1) First order lateral root development is critical to seedling survival and subsequent growth. The minimum number of first order lateral roots, greater than 1 mm in diameter, that an acceptable oak seedling should have is five to seven. A seedling with greater than ten first order lateral roots is the best.

2) First order lateral roots should be trimmed to 3-4 inches in length prior to planting

3) Minimum root collar diameter of 1/4 inch

4) Main tap root of 8-10 inches in length

12.2.12.4 Direct Seeding

No results of direct seeding with swamp white oak are available, but it is similar to white oak in that the acorns germinate in the fall after falling from the tree.

See section on direct seeding of oaks earlier in chapter.

12.2.12.5 Seed Source Considerations

Current recommendations are for local swamp white seed sources to be used for reforestation in Wisconsin.

12.2.13 BUR OAK, *Quercus macrocarpa*

12.2.13.1 Introduction

Bur oak occurs on a variety of sites throughout its native range, which covers nearly the entire state of Wisconsin. It is considered a highly drought resistant species and is often associated with calcareous soils. In the driftless area bur oak can be found on the limestone ridges. It has the potential to dominate severe sites with thin soils, heavy claypan soils, gravelly ridges, and coarse-textured loessial hills. Bur oak though is also an important bottomland species. As a bottom land species, it is relatively intolerant of flooding and prefers a mesic, fertile environment. In Wisconsin bur oak is most known for being the major tree species associated with oak savannas.

12.2.13.2 Planting Considerations

Height growth in bur oak seedlings is relatively slow when compared to other oaks. Bur oak allocates resources to initially establish a large and deep root system at the expense of top growth.

Bur oak is commonly associated with oak savanna restoration efforts in Wisconsin.

12.2.13.3 Nursery Stock

Bur oak seedlings are generally available as 1-0 and 2-0 seedlings. The important factor in seedling quality of bur oak is the root system. It should have from five to seven first order lateral roots greater than 1 mm thick.

12.2.13.4 Direct Seeding

No long-term results of direct seeding with bur oak are available in Wisconsin. Bur oak is an oddity in the white oak group in that some acorns will germinate immediately in the fall, while others will delay germination to the springtime.

See section on direct seeding of oaks earlier in the chapter.

12.2.13.5 Seed Source Considerations

Local Wisconsin seed sources are recommended for bur oak restoration projects.

12.2.14 RED OAK, *Quercus rubra*

12.2.14.1 Introduction

Red oak is an important lumber species with moderate to fast growth. Mature red oaks grow to between 65 and 98 feet tall and are 2 to 3 feet in diameter. It has good form and dense foliage. Its native range includes the entire state. Red oak is generally found on spodosols. The soils vary from clay to sand. It grows best on deep well drained sandy loams to silty loams, to clay loam soils. Red oak prefers lower and middle slopes with northerly or easterly aspects on soils with a thick A horizon. Growth is most common at altitudes less than 3,500 feet above sea-level.

Red oak is intermediate in shade tolerance. Like white oak, newly planted red oak seedlings cannot compete with other vegetation after clearcutting on the better sites. The amount of red oak in the new stand will be proportional to the amount of advance regeneration of large, well-rooted seedlings before canopy removal, plus the amount of anticipated stump sprouts.

12.2.14.2 Planting Considerations

Larger 2-0 red oak seedlings can be difficult to plant with conventional machine tree planters. Requirements for an acceptable tree planting machine for red oak include a coulter near 36 inches in diameter and shoe width of 3 inches. The machine planter must be able to create a slit in the soil at least 8 to 12 inches deep and then properly pack the soil once the seedling has been planted.

A serious disease of red oak is oak wilt caused by the fungus (*Ceratocystis fagacearum*). Oak wilt can kill a tree in a single year and sites with a recent history or new signs of the disease should be avoided for reforestation with red oak unless proper treatment of infected stems and sprouts is accomplished. In order to plant red oak seedlings in a recently infected oak wilt pockets the following steps need to be accomplished:

1) Root barriers should be installed if the pocket is continuing to expand

2) Healthy red oak trees (>3 inches in diameter) need to be cut within the pocket

3) Infected trees with the bark attached need to be cut and treated to prevent

4) Stumps of cut red oak need to be treated with an herbicide to prevent stump sprouting

Older oak wilt pockets with no active spread of the disease can be planted with red oak.

12.2.14.3 Nursery Stock

Seedlings of red oak in Wisconsin are generally planted as 1-0 or 2-0. For underplanting red oak, you should control undesirable woody vegetation; plant under a shelterwood at 60% stocking; use large caliper (1/2 inch) nursery stock with clipped tops; and remove overstory after 3 growing seasons.

Recent research on red oak target seedlings has demonstrated the importance of the following seedling characteristics to insure successful plantation establishment:

1) First order lateral root development is critical to seedling survival and subsequent growth. The minimum number of first order lateral roots, greater than 1 mm in diameter, that an acceptable red oak seedling should have is five to seven. A seedling with greater than ten first order lateral roots is the best.

2) First order lateral roots should be trimmed to 3-4 inches in length prior to planting

3) Minimum root collar diameter of 1/4 inch

4) Main tap root of 8-10 inches in length

5) Seedlings should have been grown in a nursery at a density of 4-6 seedlings per square foot to encourage proper root development

6) 2-0 seedlings should be undercut in the nursery during their second growing season to encourage production of more and heavier first order lateral roots

12.2.14.4 Direct Seeding

See section on direct seeding of oaks earlier in the chapter.

12.2.14.5 Seed Source Recommendations

Red oak seed source recommendations are for Wisconsin seed sources currently.

12.3 Wildlife Shrub Species

12.3.1 SILKY DOGWOOD, *Cornus amomum*

Dogwoods attain heights of 4-10 feet and the fruit is a favorite food of turkey, grouse, quail, and many songbirds. Dogwoods will grow on moist to well-drained soils and do best in full sunlight.

12.3.2 RED OSIER DOGWOOD, *Cornus stolonifera*

12.3.3 AMERICAN HAZELNUT, *Corylus americana*

A moderate sized shrub that is commonly found along woodland edges, old pastures and thickets. American hazelnut prefers full sun for best growth and development. Though it can grow and persist in partial shade, plant density and fruit production are greatly reduced. It is a medium to fast growing species, that suckers moderately, eventually producing a multi-stemmed, clump appearance. American Hazelnut grows to a height of 8-12 feet and with a crown spread of 10 to 15 feet. The species adapts well to a range of soil pH and types but does best on well-drained loams. The nuts produced by American hazelnut are a preferred mast by squirrels, deer, turkey, woodpeckers, pheasants, and other animals. The male catkins are a food staple of ruffed grouse throughout the winter.

12.3.4 COCKSPUR HAWTHORNE, *Crategus crus-galli*

Hawthornes are small trees, growing 20-24 feet tall. They are attractive to ruffed grouse and numerous songbird species. Hawthornes need full sun and should not be planted on moist, wet, or extremely dry soils. Silt loam soils are best.

12.3.5 PRAIRIE CRABAPPLE, *Malus ioensis*

Is a hardy southern Wisconsin tree that grows to 15-30 feet in height. Its fruit is utilized by many species of birds and animals. The crabapple prefers well-drained loam soils, but it can tolerate a variety of soils.

12.3.6 NINEBARK, *Physocarpus opulifolius*

A multi-stemmed, arching shrub, reaching 10 feet in height at maturity. Small clusters of white flowers develop into brownish capsules in September. Ruffed grouse eat the buds and songbirds eat the small seeds. Ninebark provides excellent wildlife cover. It has the ability to grow on a wide variety of sites from goat prairies to sedge meadows. One of the few shrub species that does well on very droughty sites.

12.3.7 AMERICAN PLUM, *Prunus americana*

A large shrub which can reach 15 feet in height. It forms dense thickets which are good for nesting. The wild plum grows best in full sun on well-drained silt loams.

12.3.8 AMERICAN HIGHBUSH CRANBERRY, *Viburnum trilobum*

Can attain heights of 10-13 feet and requires well-drained to moist sites for proper development.

13 APPENDIX 22-B: HERBICIDES FOR FOREST MANAGEMENT

The herbicide tables contain a large volume of information from the labels of herbicide products that are registered for various forestry uses. To be listed here a product's labeling must contain wording specific to forestry.

The tables can be used in several ways. If you are looking for a product to control a particular species of weed, consult the **Herbicide Sensitivity Table** for herbaceous or woody species. If you are looking for a product to use as a "**broadcast spray"** or "**directed spray**", consult the **Herbicide Comparison Table**.

Two tables, "**Wisconsin Forest Tree Planting Herbicides**", provide a quick cross reference for tree species and herbicide products that are registered for tree planting. They are meant to be photocopied and handed out to encourage land managers who will be planting trees to plan weed control measures before their trees are planted.

Quality improvement: Users of these tables are encouraged to comment and make suggestions to improve their usefulness. Comments can be directed to:

Forest Health Coordinator
Wisconsin DNR
3911 Fish Hatchery Rd.
Madison, WI 53711
608-275-3273 (temporary)
Jane.Cummings-Carlson@dnr.state.wi.us (temporary)

Herbicide products and labels change often, so these tables are updated annualy and should be used as a guide only and not considered a recomendation. The latest version of the tables can be found on the DNR web site at:

http://www.dnr.state.wi.us/org/land/forestry/fh/weeds/index.htm

The latest version of the UWEX Forestry Fact Sheet, Herbicides for Forest Management, is available over the internet at:

http://forest.wisc.edu/extension/publications/76.pdf

Current labels and MSDSs can be found at:

http://www.cdms.net/pfa/LUpdateMsg.asp