

INTRODUCTION

This technical note is intended to be used by resource professionals as a guide for planting and direct seeding tree and shrub species for reforestation, afforestation and the installation of Alley Cropping (311), Tree and Shrub Establishment (612), Early Successional Habitat Development/Management (647), Farmstead and Feedlot Windbreaks (380), Field Windbreaks (392), Hedgerow Planting (422), Restoration and Management of Declining Habitats (643), Riparian Forest Buffer (391), Shoreland Habitat (643A), Wildlife Upland Habitat Management (645), Wildlife Wetland Habitat Management (644), and other conservation practices that include the establishment of trees and/or shrubs. Refer to the previous standards for specific practice purposes and requirements. This technical note is intended to be used for all programs and by resource professionals regardless of agency affiliation.

BACKGROUND

Appendix A to this technical note (found at http://www.nrcs.usda.gov/wps/portal/nrcs/detail/wi/technical/cp/?cid=nrcs142p2_020842) includes most, but not all of the native tree and shrub species for Wisconsin. Other native species may be planted if they serve the intended purpose of the planting and are approved by Wisconsin NRCS State Forester.

Species selection should be based on local site conditions, professional judgment, and availability of planting stock/seed.

The Major Land Resource Area (MLRA) and county-specific tables provided in [Appendix A](#) can be modified by the NRCS State Forester with concurrence from WDNR Division of Forestry and local Resource Professionals.

SPACING AND LAYOUT REQUIREMENTS

Tree/shrub spacing and densities vary depending on the purpose of planting, and the type of stock being planted. Typical ranges are listed below.

Seedlings (bare root or plugs and cuttings):

- » Timber production:
- » Hardwoods - 545-900/ac.
- » Conifers - 600-1000/ac.

- » Wildlife Plantings: 302-1200/ac. Certain wildlife plantings may require densities outside this range.
- » Christmas Trees: 726-1200/ac.
- » Supplemental Underplanting: 200-300 / ac. evenly distributed over the area needing treatment.
- » Erosion control: 1000-1200 /ac.
- » For other applications or approval of planting densities outside these listed ranges, contact the Wisconsin NRCS State Forester or State Biologist.

Larger stock, including air-root pruned, containerized, and balled and burlapped stock:

- » 20+ per acre if natural regeneration is expected.
- » 50+ trees per acre if natural regeneration is not expected.

For minimum planting stock sizes, refer to the next section.

Plan the minimum setback distance from the outside tree or shrub row to adjacent property line or contrasting land use areas to be equal to the 20-year height of the tree or shrub, unless the 20-year height is > than 20' in which case use a minimum setback of 20 feet. Refer to the Conservation Tree/Shrub Guide (CTSG) Tool in eFOTG, Section II for 20-year plant heights.

Where subsurface drains (tile lines) cross through a tree/shrub planting, and where these drains will remain functional, install a sealed conduit through the planting and extending a minimum of 100 feet beyond large trees and 75 feet beyond small to medium sized trees and shrubs.

Additional Layout information for Supplemental Underplanting

Ensure that there is adequate sunlight available for the species to be planted. Use the CTSG tool to determine the shade tolerance of the species to be underplanted.

- » Intolerant tree/shrub species (I) require full sun and require openings $\frac{1}{2}$ to $\frac{2}{3}$ acre in size (diameter of opening: 160-200 feet, measured at tree crown level).



- » Species with intermediate shade tolerance (M) require canopy closure of 30-50%, which can be approximated with openings ¼ to ½ acres in size (diameter of opening: 120-160 feet, measured at tree crown level).
- » Shade tolerant species (T) can grow in full shade, although 60-80% canopy closure will accelerate the growth and development of underplanted trees/shrubs when compared to 100% canopy closure. Small openings of 1/10th acre or less (diameter of opening: 80 feet or less, measured at tree crown level) will favor regeneration of shade tolerant species.

All underplanted seedlings will benefit from additional cutting or killing of overstory trees 2 or more years after establishment to maintain or increase the amount of light reaching the ground.

MINIMUM PLANTING STOCK SIZE

Bare-root Stock

Conifers: Minimum height 9 inches with a minimum root length of 8 inches OR minimum caliper 3/16 inch.

Hardwoods: Minimum height of 12 inches with a minimum root length of 8 inches OR minimum caliper* of ¼ inch. Exceptions: hickory species may have a minimum height of 6 inches and root length of 8 inches OR ¼ inch caliper*.

Containerized Stock

One year old plug container seedlings must have root volumes of at least 7 cubic inches.

Potted Stock

Minimums for potted stock, including air-root pruned: height 3 feet, container size 1 gallon, caliper* 3/8 inch.

Cuttings (Hybrid Aspen, Willow, Cottonwood, etc.)

Minimum 10 in. in length with 3/8 in. caliper*.

Balled and Burlapped Stock

Conifers:

Tree Height	Minimum Diameter Ball
18-24 in.	10 in.
2-3 ft.	12 in.
3-5 ft.	14 in.
5-6 ft.	20 in.

Hardwoods:

Tree Height	Minimum Diameter Ball	Caliper*
5-6 ft.	12 in.	½ in.
6-8 ft.	14 in.	¾ in.
8-10 ft.	16 in.	1 in.

* Caliper (diameter at ground level) shall be measured at the root collar.

ADDITIONAL RESOURCES

Site resource information such as microclimate, soil type, soil drainage classification and moisture regime, exposure and purpose of the planting must be gathered before deciding on species recommendations. Some county soil surveys contain information about the original vegetation for each soil type. Other references include the “Original Vegetation Cover of Wisconsin” map that can be found at www.dnr.state.wi.us/org/at/geo/map_gal/dancov/orgveg. Early Vegetation of Wisconsin map found in Section I of the Wisconsin NRCS Field Office Technical Guide (FOTG), and “Vegetation of Wisconsin”. Also refer to “Forest Communities and Habitat Types of Central and Southern Wisconsin” and “Forest Communities and Habitat Types of Northern Wisconsin”, by John Kotar for information on natural forest communities and the sites on which they developed. These references along with [Appendix A](#) will allow the planner to develop sound planting/seeding species recommendations.

- » Identify the Major Land Resource Area (MLRA) and the county where the practice will be applied. The map titled "Major Land Resource Areas for Wisconsin" can be found in Section I of the Wisconsin NRCS Field Office Technical Guide.
- » Identify the soil type(s) and the drainage classification of the soils on site. Drainage class for each soil series on site can be found in the soil series description in the published County Soil Survey or at <http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx>. Manipulations of the natural drainage class identified in the County Soil Survey must be considered when developing species recommendations.
- » Consider the intended and potential uses of the planting.
- » Determine whether the planting will be in open (cropland or pastureland conversion), partial shade (under-stocked existing stand), or shade (100% canopy-mainly for shrub plantings) and aspect (exposure).



- » Select species based on the criteria identified in steps 1 through 4. See [Appendix A](#), Wisconsin Native Tree and Shrub Guides. Similar common name does not always mean same species. When in doubt, use scientific names to identify species selected.

Method of Establishment (Seeding vs. Planting)

Direct seeding, if successful, allows the establishment of more trees per acre at a comparable cost to planting seedlings. It can be particularly useful on sites that otherwise are difficult to plant due to spring wetness or shallow soils. Areas that are difficult to plant with seedlings because of spring wetness can be seeded at a dryer time of year and areas with very shallow topsoil are easier to seed because of shallow seeding depths versus planting depths. It also allows a more natural-appearing stand of trees to develop which can be further encouraged by planting a variety of species.

Direct seeding is not well suited for under-planting in poorly stocked stands and may not be a viable option every year because many species only produce good seed crops every 3-5 years and seed may not be available. It should not be used on slopes steeper than 6% without considering a cover crop or other measure for erosion control. Direct seeding is not well suited for sites that will be used for specialty plantings (Christmas trees, windbreaks, and alley cropping).

The direct seeding method is best suited to sites being converted from intensive agricultural production because of historic weed control practices. Weed control is very critical to establishment of trees and shrubs using the direct seeding method. Competition must be controlled for a minimum of 3 years after seeding and should be checked for follow up control measures until tree crowns are above the competition.

The large number of seeds per acre increases the chance that trees will benefit from the best available micro-sites. Enough trees will generally escape deer and rabbit browse to develop a stand of trees when heavily planted. Squirrels and other rodents can destroy much of the seed in years when snow cover is light.

Locally collected seed can be used to ensure compatibility with local conditions. However, seed should only be collected from high-quality source trees and at the right time of year. If unsure about seed collecting techniques, check with local resource professionals first.

Planting of nursery stock allows for better density control (specialty plantings such as windbreaks and Christmas trees) and is more desirable for sites that require intensive weed control, especially where

mechanical control is the preferred option. By using seedlings, several years of development are realized with a new planting. Planting of seedlings is a more efficient use of genetically improved seed. Sites that are excessively well drained are usually more successful if planted because the developed root systems have a better chance of obtaining enough moisture to become established. Nursery stock is better suited to slopes greater than 6% than is direct seeding, but additional conservation practices such as cover crops and planting on the contour should be considered when planting fields being converted from intensive agriculture (exposed soil).

For sites that have existing grass/herbaceous cover, planting seedlings is a better choice than seeding if the competing vegetation is controlled by band spraying within rows and/or by mechanical control between the rows. Nursery stock plantings produce a more uniform stand, and are well suited for under-planting in poorly stocked stands. Planting can be designed with future management/land use activities in mind.

TREE PLANTING/DIRECT SEEDING TIMELINE

August/September prior to planting nursery stock, begin site preparation on sites with existing vegetation (on row crop fields site preparation may begin after the crop is harvested). Site preparation will be site and species specific. Direct seeding is not recommended on sites with severe competition from existing vegetation (old hay fields with dense sod and or areas of Reed Canary Grass). Identify commercial or local seed sources for sites to be direct seeded. For commercially purchased seed, make sure the supplier can confirm the seed is from the Lake States Area and purchase from a source as close to the site to be seeded as possible.

- » Order seed or begin collecting seeds in season and plant as soon after collection as possible. If buying commercially available seed, use the supplier's listing of percent sound seed, to determine final seeding rates. Most seed is very difficult to store and self-storage is not recommended.
- » For locally collected seed, collect enough seed to meet the required rates and account for defective seed. Visually inspect seed looking for proper color, form, insect and mechanical damage. Separate debris, caps and wings from seed.
- » The float test may be useful for separating good from poor acorns and nuts; floaters are removed off the top of the tub of water and discarded. However, it is not always accurate to determine that all sinkers are viable, as other factors are also



important. The husks around nuts such as black walnut and hickories, must be removed prior to floating. Always cut a sample of floaters and sinkers to be sure of the effectiveness of flotation to separate them. Seed embryo color should be white or creamy yellow.

- » A cut test can be used to determine the amount of sound seed being collected. Inspect by species, at least 10 randomly selected seeds per 3,000 seeds collected. Cut open the seed to be sure that seed is filled, moist and normal colored.

Site Preparation

The single most important part of planting trees is protecting them from competitive vegetation. All plants compete for light and water and many grasses produce natural chemicals that suppress tree and shrub growth. If not managed, competition from weeds, grasses and unwanted woody vegetation, will choke out the planting. Mechanical and/or chemical site preparation techniques can be used depending on site conditions and client objectives.

Mechanical Site Preparation

Reduce the competition from a thick grass sod by moldboard plowing, disking and establishing a cover crop the year prior to planting. On slopes greater than 6%, leave strips of sod between 6-foot wide tilled strips and plant as near to the contour as possible to prevent erosion. For sites with a clean tilled row crop existing, address weed problems and see "Cover Crop" Standard 340 for ground cover options. Annual rye, winter wheat, and white clover perform well as cover crops for tree planting purposes.

Chemical Site Preparation

Weed and/or grass competition can be controlled with herbicide use. On sites with slopes greater than 6%, band spraying of the row is preferable over broadcast spraying of the entire site. Effective control depends on four factors:

- » Timing of application,
- » Herbicide selected,
- » Weather conditions, and
- » Application rate.

A combination of chemical and mechanical site preparation may be required on very difficult, heavy sod sites. Very dry conditions will limit the effectiveness of most herbicides. Be sure to follow label directions for application rates, as rates differ depending on soil type and herbicide being used.

Direct Seeding

The amount of seed required for direct seeding varies by species and site conditions. Use [Table 1](#) as a guide. Rates are based on single species planting. For drilling of mixed species, the total seeds/acre should be at least 3,000. For broadcasting mixed species, the total seeds/acre should be at least 1,000. Ideal seedings contain a mix of drilled and broadcast species.

The following chart shows the row spacing and seed spacing combinations that will result in 3,000 seeds per acre. Adjust planting rate based on sound seed percentage from seed inspection.

4-foot row spacing = 3.6-foot spacing within row
5-foot row spacing = 2.9-foot spacing within row
6-foot row spacing = 2.4-foot spacing within row
7-foot row spacing = 2.0-foot spacing within row
8-foot row spacing = 1.8-foot spacing within row
9-foot row spacing = 1.6-foot spacing within row
10-foot row spacing = 1.5-foot spacing within row

Heavy seeded species, those suitable for drilling, will usually comprise the main part of the stand. Lighter seeded species, those suitable for broadcast seeding, will be used for diversity and micro-site establishment within the stand.

Plant acorns 1-3 inches deep and nuts 2-5 inches deep. A good rule of thumb is to plant to a depth that is twice the diameter of the seed. For light seeded species that are broadcast, cultipack the site after seeding. Plant seed from seed suppliers or seed collected as close to the site as possible.

White oak, bur oak, and swamp white oak acorns must be planted as soon as possible after collection. It is extremely important that the site is prepared for planting before the acorns are received or collected. These acorns sprout in the fall and begin growing before the ground freezes and do not require the cold stratification that the red oak family, the walnuts, and the hickories require.

Red oak acorns can be stored, if necessary, if kept in cold damp conditions 35 to 40 degrees F. Fall seeding is preferred over storage and seeding should be done immediately after receiving or collecting seed. Many species require cold stratification to stimulate germination in spring and it is difficult to create the required conditions unless climate controlled storage is available. Immersing acorns in water prior to planting will restore any moisture lost during collection. Soak



from 4 to 24 hours. If seeding is delayed more than a few days, seed will be placed in porous bags, such as onion bags, in cold storage, 35 to 40 degrees F. Keep heavy seeded species moist, but not wet until planting. Keep light seeded species dry until planting. Do not allow seed to heat up and never place seed in the sun. Inspect seeds for storage losses prior to planting.

October/November of the year before planting, order nursery stock and/or begin direct seeding as appropriate for the species.

Nursery Stock Spacing

Density of plantings will vary by species, intent of the planting, soil site conditions, and other factors. For most multiple purpose plantings, use [Table 2](#) when planning the amount of planting stock required.

Specific Program requirements (CRP, Managed Forest Law, etc.) may dictate the amount of stock needed and spacing.

For specialty plantings (windbreaks, Christmas trees) consult specific standards and/or fact sheets.

April/May of planting year inspect sites to be planted for weed problems and apply chemical or mechanical weed control as needed prior to planting. Inspect sites direct seeded the previous fall for weed problems and treat as necessary. Plant tree and shrub seedlings from late March until early May as soon as they arrive. Seedlings may be planted by hand using a shovel or planting bar, or with a tree planting machine. Many counties have planting machines available for rent.

Planting Information

Plant seedlings as soon as they arrive. Do not allow seedlings to lay in the sun or dry out. Do not take large amounts of seedlings to the field where they will dry out before planting. Take small amounts and store the rest in a cool, shaded location and keep moist, but not wet until planted. Do not open the shipping containers until ready to plant. If stock in bundles has been exposed to warm temperatures, the bundles should be opened to prevent heating. Wet roots if needed. Keep tops dry.

Stock to be planted in a few days can be stored in a cellar, open shed, or similar cool place. Stock held over a week should be stored in a cooler.

During planting, keep roots wet. Dry roots mean dead trees/shrubs.

Plants developing "J" roots will die. Seedling roots should hang free and just touch the bottom of the hole. When the root length on seedlings exceeds the depth of the planting tool being used, roots may be pruned to the proper length. Use a sharp tool such as a large scissors,

pruning shears, or a machete. Root systems can be pruned at 8-10 inches below the root collar provided a shoot to root ratio of 2:1 or less can be maintained. Dip the roots in water immediately but do not leave roots submerged in water. Moisture enhancers or root gels may be used to keep roots moist and repack the trees in the original containers. Removal of any part of the root system will have an adverse impact on seedling vigor so pruning is not recommended. It is better to modify the depth of planting whenever possible, than to prune roots.

Tree planting machines are available in most counties. If the site is suitable for machine planting, this method is usually cheaper.

Hand planting may be done with shovel, hoe, planting bar, mattock, or other hand tool. The hole should be large enough to avoid doubling of roots.

If cuttings are used, they must be kept moist and cool until planted. Cuttings should be buried, except for exposed tip, with at least two buds above ground.

REFERENCES

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- Harlow, William M., Ph.D., and Harrar, Elwood S., Ph.D., Sc.D., 1969. Textbook of Dendrology, 512pp.
- Kotar, John; Kovach, Joseph A., Burger, Timothy L., Second Edition, 2002. A Guide to Forest Communities and Habitat Types of Northern Wisconsin, 480pp.
- Kotar, John; Burger, Timothy L., 1996. A Guide to Forest Communities and Habitat Types of Central and Southern Wisconsin, 378pp.
- Preston, Richard J. Jr., Third Edition, 1976. North American Trees, 399pp.
- U. S. Department of Agriculture-Forest Service, 1965. Silvics of Forest Trees of the United States, Agriculture Handbook No. 271, 762pp.



Figure 1

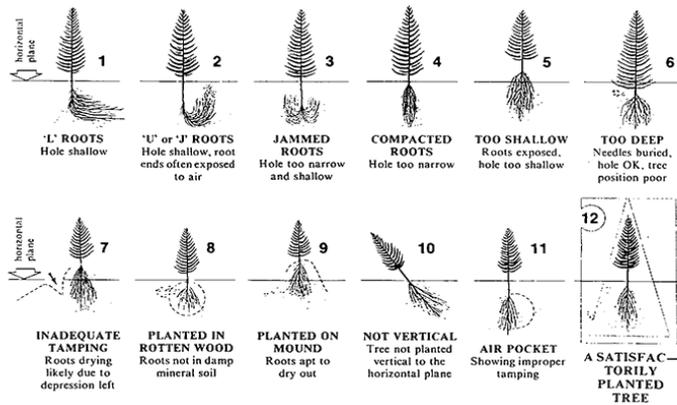
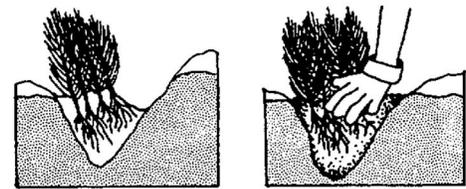


Figure 2



One method of long-term tree storage is the “heeling-in” technique. Roots must be packed tightly in soil and kept moist, and the heel-in trench must be shaded and protected from the wind.

Table 1

Species	Planting Method	Collect	Sound Seeds Per Acre	Pounds Per Acre
Northern Red Oak	Drilled	Sept - Oct	3,000	24 lbs.
White Oak	Drilled	Sept - Oct	3,000	25 lbs.
Bur Oak	Drilled	Aug - Nov	3,000	40 lbs.
Swamp White Oak	Drilled	Sept - Oct	3,000	25 lbs.
Black Walnut	Drilled	Sept - Oct	3,000	75 lbs.
Shagbark Hickory	Drilled	Sept - Oct	3,000	30 lbs.
Ash	Broadcast	Aug - Oct	1,000	.13 lb.
Sugar Maple	Broadcast	Sept - Oct	1,000	.16 lb.
Red Maple	Broadcast	Apr - July	1,000	.04 lb.
Basswood	Broadcast	Oct - Nov	1,000	.2 lb.
Black Cherry	Broadcast	Aug - Oct	1,000	.2 lb.

Table 2: Common Tree/Shrub Spacings

Spacing (feet)	Plants Per Acre
6 x 6	1210
6 x 8	907
5 x 10	871
6 x 10	726
7 x 7	889
7 x 10	622
8 x 8	681
8 x 10	544
8 x 12	453
9 x 9	538
10 x 10	436
10 x 12	363
12 x 12	302

