Tree/Shrub Planting Recommendations

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The following recommendations about planting trees and shrubs are based on scientific research, bulletins published by agency personnel and university professionals who have specific expertise in planting trees and shrubs, and my own experiences planting trees and shrubs and measuring survival as part of research projects and private sector planting projects in Michigan, Indiana, and Florida. The focus of this document is recommendations for planting deciduous trees, coniferous trees, and shrubs, for timber and wildlife habitat. Planting larger trees for landscape projects, orchard management, and Christmas tree plantation management are separate disciplines so are not discussed here. Regardless of your objective(s), it is important to consult with professionals prior to designing and implementing a tree planting project. Finally, it is important to note that many of the following topics are debated and still researched, meaning that in some cases there is no single correct answer. It is therefore important to use the best evidence available prior to making a decision about which trees and shrubs to plant and how to plant them.

Site and Species Selection

First and foremost, **DEFINE YOUR OBJECTIVES AND WORK WITH A PROFESSIONAL TO UNDERSTAND WHAT IS REALISTIC BASED ON THE CONDITIONS AT YOUR PARCEL**. Are you interested in planting trees for ornamental purposes? Are you interested in a forest plantation for timber production? Are you interested in providing food and cover for certain wildlife species? Are you trying to control erosion or stabilize the bank of a lake, river, or stream? These are important questions to ask. Different species of trees and shrubs are suitable for different purposes (Lantagne and Koelling 1997; Ochterski et al. 2009; Table 1).

It is also important to match the appropriate species to the soil type on your property. Please visit the Web Soil Survey at ***https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm*** to examine your parcel for soil types. Refer to Lantagne and Koelling (1997) and Ochterski et al. (2009) for a list of common tree and shrub species and where they grow, in the Midwest and Eastern U.S. For example, certain tree and shrub species are best adapted to sandy soils whereas other species are better adapted to damp, heavy soils (Table 1).

Table 1. A tree selection table, from Ochterski et al. (2009). Please note that for the category "Deer browse likely", a species rated as Good is not as susceptible to being browsed as species rated as Fair and Poor.

Tree Selection Table

	SOIL			LOCATION / USE					Deer browse likely	Pioneer species	Shade / understory planting
	Damp / heavy	Loamy	Sand / gravel	Windbreak / screen	Timber or lumber	Wildlife	Christmas tree	Streambank / riparian buffer			
Native conifers / evergreens											
White pine (*Pinus strobus*)	F	G	P	G	P	G	G	P	G	G	P
White cedar (*Thuja occidentalis*)	G	G	F	G	P	G	P	G	P	G	F
Eastern red cedar (*Juniperus virginiana*)	F	G	G	G	F	G	P	P	G	G	P
White spruce (*Picea glauca*)	G	G	F	G	P	F	G	P	G	G	P
Canadian hemlock (*Tsuga canadensis*)	P	G	P	F	F	F	P	G	P	P	F
Balsam fir (*Abies balsamea*)	F	G	F	P	P	F	F	F	P	P	F
Red pine (*Pinus resinosa*)	P	G	G	G	P	F	P	F	F	G	P
Native hardwoods											
White ash (*Fraxinus americana*)	G	G	P	F	G	F	P	G	F	P	F
Green ash (*Fraxinus pennsylvanica*)	G	G	F	F	F	F	P	G	F	F	F
White birch (*Betula papyrifera*)	F	G	G	G	P	F	P	F	F	G	P
Black cherry (*Prunus serotina*)	P	G	G	F	G	G	P	F	F	F	F
Red (Soft) maple (*Acer rubrum*)	G	G	F	F	F	F	P	G	F	F	F
Sugar (Hard) maple (*Acer saccharum*)	P	G	F	P	G	G	P	F	P	P	G
Red oak (*Quercus rubra*)	P	G	G	F	G	G	P	F	P	F	F
White oak (*Quercus alba*)	P	G	G	F	G	G	P	F	P	F	F
American chestnut (*Castanea dentata*)	P	G	G	F	F	G	P	F	P	F	G
American sycamore (*Platanus occidentalis*)	G	G	F	P	P	F	P	G	F	F	P
Yellow poplar (*Liriodendron tulipifera*)	P	G	F	P	F	F	P	F	P	F	G
Black walnut (*Juglans nigra*)	P	G	P	P	G	G	P	F	F	F	F
Butternut (*Juglans cinerea*)	P	G	G	F	F	F	P	G	F	F	F
Redbud (*Cercis canadensis*)	P	G	F	P	P	F	P	G	P	F	G
Flowering dogwood (*Cornus florida*)	P	G	F	P	P	G	P	F	P	P	G
Trembling aspen (*Populus tremuloides*)	G	G	F	G	P	F	P	G	F	G	P
Big-toothed aspen (*Populus grandidentata*)	G	G	F	G	P	F	P	G	F	G	P
Cottonwood (*Populus deltiodes*)	G	G	F	G	P	F	P	G	F	G	P
Sweetgum (*Liquidambar styraciflua*)	G	G	P	P	P	F	P	G	F	F	F
Water tupelo (*Nyssa sylvatica*)	G	G	P	P	P	F	P	G	F	F	F
Hawthorn (*Crataegus* sp.)	G	G	G	F	P	G	P	F	F	G	F
American plum (*Prunus americana*)	F	G	G	F	P	G	P	F	F	F	F
Black locust (*Robina pseudoacacia*)	F	G	F	G	F	F	P	G	F	G	P
Hazlenut (*Corylus americana*)	F	G	F	F	P	G	P	G	F	F	G

Good	Fair	Poor
G	F	P

Table developed by Shavonne Sargent Morin.

Site Preparation

Preparing the site is a critical step to maximize the survival and growth of tree seedlings (Dickman and Stuart 1983; Ashby 1997; Lantagne et al 1997; Neumann 2001a).

Mechanical site preparation methods include using hand tools or larger equipment to kill or clear competing vegetation. Hoeksema and Peterson (2001) recommend a 24-inch wide area (where the seedling is planted in the center) be scalped (i.e., competing vegetation is mechanically removed with hand tools) prior to planting. The Natural Resources Conservation Service (NRCS) recommends a 36-inch wide area for scalping. Ochterski et al. (2009) suggest, if mowing and/or brush hogging methods are used to clear competition, these practices should be implemented in August and again in October the year prior to the spring when seedlings are planted, and only in the zones where seedlings will be planted. When controlling competing vegetation, it is important to find a balance between controlling the weeds and not removing too much of the beneficial topsoil.

Herbicides can be used to chemically control competition. Beheler and Michler (2013) provide a clear description of the different types used in tree/shrub planting projects: "Pre-emergent herbicides are applied before weed seeds germinate. Post-emergent herbicides are applied to plants that are actively growing. Some chemicals translocate, which means they move within the plant; these are known as systemic herbicides. Other chemicals only affect what they touch; these are known as contact herbicides. Chemicals like glyphosate are non-selective, meaning they are not specific to any species and will kill trees if applied incorrectly. Selective herbicides affect only some plant types or species—some just kill grasses, some only kill broadleaved plants. The label will help identify how the specific chemical works, how and when it should be applied, and what conditions to avoid to prevent damage to your trees." When using herbicides, please remember that THE PESTICIDE LABEL IS THE LAW! Refer to Lantagne et al (1997), Neumann (2001b), and Randall (2013) for common herbicides used in Christmas tree plantations (many conifers planted as Christmas trees are also planted for forestry and wildlife purposes) and forestry plantations (Table 2).

Table 2. Some herbicides recommended for site preparation for deciduous and conifer seedlings. Table taken from Neumann (2001a).

Herbicides recommended for site preparation for hardwood and conifer tree seedlings.[1, 2]

For both hardwood and conifer regeneration:	Quantity
Accord, Glypro, Roundup Pro[3]	3/4 to 4 quarts/acre
Garlon 3A	1/4 to 3 gallons/acre
For conifer regeneration only:	
Velpar DF	1.3 to 6.6 pounds/acre (site preparation only)
Velpar L	4 to 10 quarts/acre (for conifer site preparation only)
Arsenal	1/4 to 2.5 pints/acre (summer applications)
2,4-D ester (2,4-D LV4)	1.5 to 4 quarts/acre (between full leaf development to two weeks before first frost)
Patron 170	1 to 2 gallons/acre (between full leaf development to two weeks before first frost)
Vanquish (Dicamba)	1 pint to 2 gallons/acre (between full leaf development to two weeks before first frost)
Garlon 4	3 to 6 quarts/acre (wait 1 to 2 months after application before planting)

[1] For site preparation on sites with minor patches of woody brush, spot spray with Garlon 4 or a concentrated Roundup solution per the label instructions.

[2] Reference to commercial products or trade names does not imply endorsement by the MSU Department of Forestry or the MDNR Forest Management Division, or bias against those not mentioned.

[3] Roundup Pro is registered for landscape and ornamental uses. Accord concentrate and Accord SP are labeled for forestry site preparation.

Josh Shields has found that using a combination of mechanical site preparation, herbicide, and cover crops can be successful for site preparation. See the section titled "Suggested Timelines for Tree/Shrub Planting Projects" in this document for more details.

Containerized or Bareroot Seedlings?

The question of "containerized versus bareroot" is a hotly debated topic, as is the "type of bareroot".

What do the numbers mean with bareroot stock? Bareroot seedling stock is available in a variety of ages. You will often see numbers such as 1-0, 2-0, 3-0, 2-1, and 2-2 next to seedling names. The first number indicates the number of years a seedling was grown in the nursery seedling bed and the second number indicates the number of years the seedling was grown in a transplant nursery bed (Lantagne and Koelling 1997). For example, a 2-0 seedling was grown for 2 years on the nursery seedling bed and never grown on a transplant bed. Conversely, a 2-2 seedling was grown for 2 years on the nursery seedling bed and 2 additional years on a transplant bed. Seedlings such as 2-2 seedlings are referred to as transplant stock, which are taller and have more robust root systems than seedlings that were grown only on the nursery seedling bed. Survival and growth tend to be better with transplant stock as compared to smaller seedlings, but transplant stock is more expensive and take more time to plant (Lantagne and Koelling 1997).

What about containerized seedlings? In general, seedlings grown in containers are less susceptible to transplant shock than bareroot seedlings because the roots are not disturbed on containerized seedlings when out-planted (Lantagne and Koelling 1997). This often translates to higher survival rates for containerized seedlings (Walter et al. 2013). Containerized seedlings can also be planted during a wider window of the growing season as compared to bareroot stock. However, containerized seedlings tend to be more expensive (McRae and Starkey 2000), although this is not always the case. Containerized seedlings also require more space to transport (e.g, 1,000 containerized seedlings in flats will take up more space than 1,000 bareroot seedlings in a bundle). It is also important to note the importance of "untangling the roots" on containerized stock, whereby the roots on the outside of the root plug should be pulled away from the root plug where they are otherwise compressed against the root plug, prior to putting the seedling in the ground. From an economic perspective, it is important to compare the cost of planting containerized seedlings with a higher initial survival rate to the cost of planting bareroot stock with a lower survival rate followed by a re-planting. In some cases it is still cheaper to plant and re-plant a certain number of bareroot stock (to make up for mortalities during the first planting) to achieve the same level of survival as a single planting of containerized stock.

Spring or Autumn?

Like the question of "containerized versus bareroot", the question of "spring or autumn planting" is a hotly debated topic. Iowa Department of Natural Resources (2003) recommend that trees/shrubs be planted during the spring, from when the frost is out of the ground to the end of May, or in the autumn from October until the ground is frozen. Ochterski et al. (2009) indicate that deciduous and evergreen seedlings are best planted in the spring in the Northeastern U.S. Lantagne and Koelling (1997) suggest that spring is the best time to plant, particularly on heavy loam or clay soils. Lantagne and Koelling (1997) indicate that autumn planting, particularly on heavy soils, can result in higher mortalities due to frost heaving, dry winter winds, and higher levels of damage from rodents. Koelling (2006) indicated that nearly 90% of trees planted for Christmas trees or other purposes are planted in the spring. In spite of this statistic, Koelling (2006) suggests that autumn tree planting may be an advantage because of the expected precipitation that occurs in the autumn, which can translate to higher survival during years when a summer drought follows a spring planting; however, he also emphasizes the importance of planting larger stock and early enough in the autumn (to allow for more root

growth) to ensure survival. Watson (2014) indicated that trees planted in autumn may have more time for new root growth before potential heat stress during the following growing season, but the author also indicated that several weeks of warm soil temperatures (above 50°F) are needed after planting to support such root growth.

Handling Seedlings

After seedlings are removed from the nursery bed and/or after they are purchased from a Conservation District, actions should be taken to avoid overheating, lack of moisture, and physical damage during the transportation of the seedlings. Regardless of what actions you take during transportation, seedlings should be given to you in packaging, with packing material, to help keep the roots moist and cool. Roots should not exhibit a whitish color that is indicative of being dried out, nor should they be over-saturated or waterlogged (Jamie L. Whitten Plant Materials Center 2002). The following actions can help (Wisconsin Department of Natural Resources 2006): 1) Leave gaps around boxes or bags of seedlings to minimize overheating and allow for ventilation. 2) Pick up your seedlings in the morning when temperatures are cooler. 3) If the sun is shining, cover seedlings with a tarp (but keep the air temperature cool!) to avoid excessive drying of the seedlings. 4) If possible, put seedlings in a cooler.

From the time the seedlings are removed from the ground at the nursery, it is best to store the seedlings at temperatures between 33 and 40 degrees Fahrenheit (Wisconsin Department of Natural Resources 2006). Jamie L. Whitten Plant Materials Center (2002) suggest the ideal storage temperatures are between 33 and 35 degrees Fahrenheit. Seedlings can tolerate being stored in temperatures as high as 50 degrees, but storage temperatures higher than this can result in seedling damage due to hot temperatures that cause the root hairs to dry out, making it more difficult for seedlings to absorb water and nutrients once in the ground. Likewise, storage temperatures below 33 degrees can result in freeze damage (Wisconsin Department of Natural Resources 2006).

Seedlings should be planted within 72 hours of being taken out of cold storage (Jamie L. Whitten Plant Materials Center 2002). For longer term storage, “heeling in” is an option, whereby seedlings are placed in a trench, covered in soil, and watered until ready to be planted. It is important to note that “heeling in” causes additional stress to the seedlings as compared to planting them right away so “heeling in” should only be used as a last resort for storage of seedlings (Jamie L. Whitten Plant Materials Center 2002).

During the planting stage, it is critical to keep the roots cool and moist until they are ready to be put in the ground (Jamie L. Whitten Plant Materials Center 2002). For example, do not open bundles of seedlings and allow them to sit in the sun as you are planting other seedlings. Likewise, do not store seedlings in buckets of water for prolonged periods, causing excessive saturation (Jamie L. Whitten Plant Materials Center 2002). It is okay to soak seedlings in water to “give them a drink” for a couple of hours just prior to planting, but saturation beyond that can cause damage to the seedlings. Instead, open one bundle at a time, and keep the roots moist and protected as you are putting the seedlings in the ground.

Planting Methods

If planting by hand, two common methods are the slit method with a planting bar, or the wedge method using a shovel (Wisconsin Department of Natural Resources 2006; Figure 1).

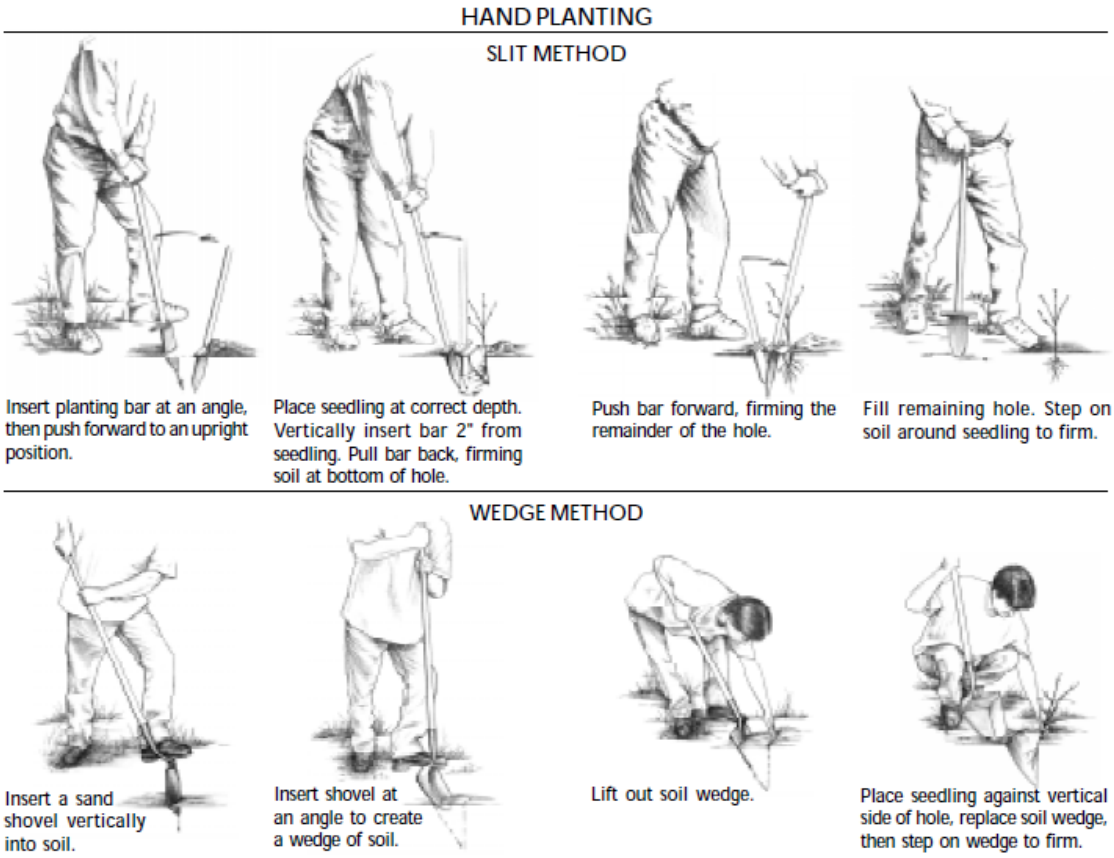

Figure 1. The slit method using a planting bar, and the wedge method using a shovel. Taken from Iowa Department of Natural Resources State Forest Nursery (2002). Illustrations and design by nita at *nitaupchurchstudio.com*.

According to Wisconsin Department of Natural Resources (2006), "Plant a seedling by placing the root collar at the soil line or no more than 1/2 inch deeper. The root collar is a spot located just above the roots identified by a change in color or slight swelling of the main stem. Make the planting hole or slit deep enough to accommodate the seedling's root system. The roots should hang freely in the planting hole and not be bent or twisted. Pack the soil firmly around the seedling to maintain good root-to-soil contact and eliminate air pockets."

Soils with heavy clay can be problematic – a planting bar is not recommended for heavy clay soils since the movement of such a bar can compress pore spaces around the edges of the planting hole and create an impenetrable "wall" that roots cannot grow through easily. One approach for heavy clay soils is to amend the soil with some organic matter and sand to provide pore spaces. It is important, however, to avoid putting the more porous soil at the bottom of the hole with the inherent clay soil at the top; this "layering approach" will not help improve drainage since water will still be slow to infiltrate the clay layer at the top of the hole. Instead, using a spade to dig the hole (making it larger than it normally would need to be and ensuring that the inside edges of the planting hole are "rough" and not smooth impenetrable "walls" like those created by a planting bar) and mixing in some organic matter and sand (not in layers) to improve drainage, can sometimes improve seedling survival in this difficult soil. Watson (2014) indicated that "It is best to eliminate the potential for trouble by using a shovel, hard tine rake, or other hand tool, to break up glazed surfaces before planting". The International Society of Arboriculture (ISA; 2011) recommends digging a hole two to three times as wide as the

root system, and elevating the base of the trunk flare two to three inches above the natural grade using an amended soil.

Soil compaction in general is also an issue and can be stressful on seedling roots and lead to death. Research on this topic is variable (See Ampoorter 2011, Buckley et al 2003, Omi 1986), but it has been linked to seedling mortality and there is much anecdotal evidence of this on fallow fields in Northwest Lower Peninsula Michigan. Cultivating or tilling the planting area is recommended to aerate the soil if compaction is an issue.

It is also important to root prune seedlings with excessively long root systems and be sure not to "J root" seedlings, which occurs when roots are placed in too small of a hole for the root system, resulting in roots growing upward and strangling themselves. Root pruning can be used to avoid "J-rooting" and should not negatively affect the survival or growth of the seedling (Simpson 1992). According to Wisconsin Department of Natural Resources (2006), "In general, seedlings can have their roots pruned 8 to 10 inches below the root collar. The root collar is the point on the main stem identified by a change in color or slight swelling in the stem. Larger seedlings (3-year-old or transplanted seedlings) require a larger root system, so don't over-prune these."

For larger, multi-acreage tree planting projects, machine planting is an option if the site conditions allow for it. As stated by Ochterski et al. (2009), **"**Mechanized planters are usually towed behind a tractor or large ATV. The seedlings are handled carefully and loaded into a covered hopper. Progressing through the prepared field, a small plow opens a furrow, and the seedling is inserted. Packing wheels drive the topsoil back into the hole, planting the tree. Mechanized tree planters are best operated on flat or gently sloping sites of well-drained soil. Rocks, woody debris, and roots interfere with the mechanisms, so they must be removed first. Sites with poor drainage can be damaged by tree planting machines, so be sure to check soil conditions first."

Spacing

The spacing of planted seedlings depends on your objectives. If the objective is to plant conifers, such as red pine (*Pinus resinosa*) for timber, a spacing of 7 feet between rows and 7 feet within rows (~889 seedlings per acre) or 8 feet between rows x 7 feet within rows (~778 seedlings per acre) is typical (Lantagne and Koelling 1997). For deciduous trees planted for timber or wildlife habitat, a 9 feet x 9 feet spacing (~538 seedlings per acre) or 10 feet x 10 feet spacing (~436 seedlings per acre) is typical. Shrubs can be planted at a tighter spacing (as close as 6 feet apart) than deciduous trees. For conifer windbreaks, two or three staggered rows are recommended, with a minimum spacing of 10 to 15 feet between rows and between trees within a row (NRCS recommends a minimum of 20 feet between rows and 8 to 18 feet between trees within a row).

Watering and Fertilizing

Seedlings, during the first two to three years after being planted, are not likely to survive excessive droughts such as two or three weeks of rain-free periods, so watering is necessary if these conditions are anticipated (Ochterski et al. 2009). Berg and McDonnell (2007) provide some irrigation recommendations as follows – Water at time of planting, the next day, three days after that, then three days after that, then seven to 10 days thereafter (less frequently in clay than sand), making sure to water during any anticipated drought periods. In terms of amount of water, University of Minnesota Extension (2018) recommends one gallon of water per one caliper inch for landscape-sized stock (less water would be required for smaller seedlings such as 1-0, 2-0, 3-0, or transplant bareroot seedlings).

For smaller seedlings, fertilizers are typically not needed given that the proper species should be matched to your soil type. Applying fertilizers in this case, particularly quick-release inorganic fertilizers, will

often create a loss of nutrients due to leaching or favor competing, non-native, weedy vegetation (Ochterski et al. 2009). Polomski et al. (2004) indicate that too much fertilizer can result in weakened plant growth, making the seedling more susceptible to being damaged from drought, cold weather, and pests and diseases. Furthermore, Jacobs and Timmer (2005) indicate that improper fertilization can result in chemical changes that prevent the roots from taking in water and nutrients. Having said that, more research is needed on this topic given that fertilizers, when applied according to the recommendations of a soil test, can result in increased growth of seedlings (Polomski et al. 2004). For example, certain organic slow-release fertilizers can sometimes be applied without harming the seedling. Also, biochar as a soil amendment has been shown to increase seedling survival (Juno and Ibanez 2021; Richard et al 2018; Slesak et al 2022).

Planting gel, in the form of hydrogels such as Terra-sorb®, can be used to dip bareroot seedling roots and increase the water-holding capacity of such roots prior to planting. More research is needed to determine under which circumstances this provides a significant advantage in terms of seedling survival, as overall results have been mixed in terms of whether planting gels actually equate to higher survival rates of seedlings (Crous 2017). In one study, Apostol et al. (2009) found that northern red oak (*Quercus rubra*) seedlings treated with Terra-sorb® had 80% higher root moisture content than seedlings not treated.

Protection from Herbivory

Tree tubes (i.e., tree shelters) provide an excellent way to protect seedlings from being browsed by white-tailed deer (*Odocoileus virginianus*) and other herbivores. As indicated by Ochterski et al. (2009), "Tree tubes reduce deer browse and create a favorable growing environment immediately around the seedling. The translucent material allows sunlight to pass through while reducing wind stress, increasing warmth, and protecting the young tree from sudden changes in temperature. They provide mowing protection and make young trees easy to spot in the field." It is also important to note that tree tubes require maintenance. As indicated by Ochterski et al. (2009), "Maintenance and monitoring of tree shelters are necessary. Tree shelters are not a 'stick it and forget it' operation. Tree tubes can tip, become weedy, and fail due to incorrect installation. Landowners should inspect each tree shelter seasonally to make sure it is providing the desired protection. If you cannot monitor the shelters at periodic intervals, it is not worth installing them in the first place."

In the Midwest, tree tubes placed on deciduous trees or coniferous trees should be at least 5 feet tall (the typical "browse line" height of white-tailed deer). While numerous professionals have used 4-feet tall tubes with high seedling survival, it is important to remember that a 4-feet tree tube is still below the typical browse line in the Midwest, meaning that white-tailed deer have access to the terminal buds of seedlings as soon as they get above the 4-feet tree tube. Consequently, whether seedlings survive or have adequate vigor when 4-feet tree tubes are used depends on the densities and feeding behavior of local white-tailed deer – this can be challenging to predict. Using 5-feet tree tubes is therefore the safer approach. Thyroff et al (2022) indicated, by citing other research, that tree shelters (mesh or solid-wall tube) approximately 5 feet tall are sufficient for protection from browsing by white-tailed deer. Regarding their research, Redick and Jacobs (2020) stated "we found that the most effective shelters at reducing browsing were 150 cm (5 feet) tall. Ward and Stephens (1995) observed browse damage on trees growing out of tree tubes that are 4 feet tall.

The purpose is for trees to grow inside the tube until they are taller than the tube, at which point they are much safer from being killed due to over-browsing of the terminal bud. For shrubs, an ideal tube would be wider in diameter than a tree tube for deciduous trees or coniferous trees; this larger diameter allows the shrub to grow like a shrub as opposed to growing like a tree with a single trunk. Shrub tubes should also be 5 feet tall, although 4 feet can also be acceptable given that shrubs have multiple leaders so can therefore withstand some browsing and still survive when reaching a height of more than 4 feet but less than 5 feet (as compared to the browsing pressure put on a single terminal bud of a tree with a single trunk). Ventilation of the tubes is also

important. For deciduous trees and certain coniferous trees, rigid tree tubes with small holes scattered throughout the tube provides adequate ventilation. For certain other coniferous trees and deciduous or coniferous shrubs, mesh-style tubes are a better fit, not just in terms of providing ventilation, but also for encouraging the growth of lateral branches and basal sprouts.

Fencing is another option. As indicated by Ochterski et al. (2009), "One of the most successful tactics to limit the impact of deer is exclusion with fencing. Numerous types of fencing are available depending on deer density, cost, and aesthetics. An 8-feet high fence should be sufficient in most situations. Although deer can jump this high, they are unlikely to take the risk, especially when other food sources are available. It is imperative that the fence goes close to ground level as deer are as likely to crawl under a fence as they are to jump over the fence."

Another option is the use of bud caps to protect the terminal buds of trees. This is especially common with coniferous trees. According to Barnacle (1997), "The idea behind the bud cap is to protect the terminal bud cluster by stapling a small piece of paper around it. Suitable paper products include common lightweight papers such as typing or photocopy paper. The paper should be cut to 4" x 6", folded around the terminal bud of the tree, and stapled to some needles near the top. However, for trees that tend to have very weak terminal shoots such as young eastern white pine (*Pinus strobus*), pieces of paper as small as 3" x 4" are recommended. Wet snow can stick to the paper and cause the weak terminal to bend over. A smaller piece of paper will not catch as much snow as a larger one."

Numerous types of repellents are available to prevent herbivores from browsing and killing tree and shrub seedlings. Wagner and Nolte (2001) examined 20 types of repellents and found that fear-based repellents were more effective than taste or pain-based repellents. Ward and Williams (2010) also examined numerous types of repellents and found that the most effective were those that required the most frequent applications. See ***https://www.plantskydd.com/articles/field-trials/forestry-field-trials*** for a list of forestry field trials conducted using Plantskydd®, a fear-based repellent made from organic dried blood.

Follow-up Competition Control

Hoeksema and Peterson (2001) recommend using mechanical practices such as mowing or smothering competition with mulch, and/or application of herbicides. They suggest that applying herbicides is the most efficient approach. Ochterski et al. (2009) also suggest these practices, as well as synthetic weed mats. With mulching, Ochterski et al. (2009) suggest a 2-inch thick layer in a 12-inch radius circle around each seedling. They also suggest not allowing the mulch to contact the stem of the seedling directly as this can result in the creation of micro-habitat for voles that can and will kill seedlings by girdling the stems.

Follow-up Monitoring for Pests and Diseases

Look for browsed shoot tips, withered shoot tips and/or leaves, excessively eaten leaves, and abnormal discoloration of leaves (Hoeksema and Peterson 2001). While these may be caused by pests and/or diseases, environmental factors such as drought could also be the culprit so it is important to contact a professional if you are noticing issues.

Invasive Species

It is important to avoid planting non-native invasive species! Simply put, non-native (i.e., exotic) species are organisms that are not native to a particular ecosystem and/or geographic area. Such species, when re-located, can and do cause significant ecological and economic harm to the environment and therefore to humans. Non-

native invasive species are the second-most important threat to biodiversity (habitat destruction is first; Wilcove et al. 1998, Mack et al. 2000). Some of the native species that suffer may have economic value (e.g., important merchantable tree species), medicinal value, aesthetic value, cultural value, etc. Annual economic costs incurred by invasive species in the U.S. may be as high as $120 billion (Pimentel et al. 2005). Some native species may have important values that have not been discovered.

Are all non-native species invasive? The Tens Rule published by Williamson and Fitter (1996) indicates that for every 1,000 species that are introduced to a new area, 100 will escape into the wild, 10 will become established, and one of those 1,000 species will actually become invasive. However, which of these species will be the one that becomes invasive is challenging to determine. It can also take many years for such an invasive species to become noticeable and by that point, it often becomes costly to control. It is therefore best to plant native species.

Introducing a non-native invasive species is not the same as slightly shifting the range of a native species already found in a particular region. Introducing non-native invasive trees and shrubs from one continent to another (e.g., introduction of non-native invasive shrubs from Asia to North America) or from one distinct eco-region to another (e.g., introduction of tree species from the Appalachian Mountains to the Midwest) can result in species becoming invasive. However, this is not the same as slightly shifting the current range of a species native to a particular region. For example, the probability is extremely low that planting a species in Northwest Lower Peninsula Michigan that is typically found in Southern Michigan, will result in that species becoming invasive, especially given that such a species is likely moving northward via other dispersal mechanisms.

A major debate that has persisted and will continue to persist is how to define “natural”. Some believe that humans should be excluded from this definition even though we are as much part of this world as any other species. As already mentioned, introducing non-native invasive trees and shrubs from one continent to another or from one distinct eco-region to another can result in species becoming invasive and interfering with the health of the ecosystems upon which we depend for our existence. This has less to do with “natural” versus “not natural” and more to do with environmental harm. However, species shifts not viewed as harmful and caused by "Mother Nature" within major geographic areas have been and are still often an effect of humans (e.g., increases in aspen [*Populus* spp.] and paper birch [*Betula papyrifera*] dominance in certain portions of Michigan due to the widespread logging across the state in the early 1900s). From an objective standpoint, humans as a dispersal mechanism is no less native than wind, water, mammals, or birds acting as dispersal mechanisms. There is a threshold that we must be mindful of, such as moving species such incredible distances as across continents or completely different ecosystems that the result is destruction of the native ecosystem. It is quite likely that Native Americans moved seed, such as acorns, long distances, and these additional propagules, combined with other activities such as planting and prescribed fire (Abrams and Nowacki 2008), resulted in some of the very ecosystems that are labelled "natural", such as oak (*Quercus* spp.) savannahs and oak-hickory (*Carya* spp.) forests. Without the influence of humans, many of these areas in our part of North America are becoming dominated by maple (*Acer* spp.) and American beech (*Fagus grandifolia*) because of the lack of human-induced fire.

Climate Change

According to Handler et al. (2014), “Forests in northern Michigan will be affected directly and indirectly by a changing climate during the next 100 years”. While the exact impacts of climate change can vary depending on which climate change model is used, planning for climate change is becoming an increasingly more common component of tree and shrub planting projects. For example, according to the Michigan Assisted Tree Range Expansion Project (ATREP; ***https://www.atrep.net/***), six species that are predicted to do well (based on multiple

climate change models; see Handler et al. 2014) in the face of climate change in Northwest Lower Peninsula Michigan but that currently have ranges in Southern Michigan, are shagbark hickory (*Carya ovata*), tuliptree (*Liriodendron tulipifera*), sassafras (*Sassafras albidum*), blackgum (*Nyssa sylvatica*), common hackberry (*Celtis occidentalis*), and swamp white oak (*Quercus bicolor*).

Suggested Timelines for Tree/Shrub Planting Projects

Determine your strategy for site preparation and post-planting weed control BEFORE you pick up your seedlings from the nursery or Conservation District!

For small projects (typically where less than ~100 seedlings are planted):

1. Site preparation – At the time of planting, remove competing weeds by scalping (ripping up vegetation with hand tools) or by using herbicide, in an area with a diameter of 36 inches, where the seedling will be planted in the center. Do not remove too much of the beneficial topsoil! Determine if soil compaction is an issue and address accordingly.
2. Plant the tree or shrub seedlings.
3. Post-planting weed control – Use a fabric or coconut weed barrier, use mulch, hand pull weeds within the 36-inch area, or spot treat weeds with herbicide within the 36-inch area, for the entire first growing season when seedlings are planted.

For large projects (typically where hundreds to thousands of seedlings are planted in blocks) where major site conversion is needed, such as converting fallow fields dominated by dense herbaceous layers such as grasses:

1. Late Spring – Use mechanical tilling for herbaceous weeds and a mechanical + herbicide treatment for invasive shrubs (if need be). Repeat tilling every 2-3 weeks until August, never allowing new herbaceous weeds to form seed. Again, do not remove too much of the beneficial topsoil. Also account for soil compaction.
2. August – Treat the last flush of weeds with a foliar herbicide (if need be).
3. September – Plant a cover crop (e.g., oats that will winter kill).
4. April of FOLLOWING YEAR – Lightly disk or rake in the cover crop (cover crop residue can serve as mulch) and plant the tree or shrub seedlings.
5. Post-planting weed control – Use a fabric or coconut weed barrier, use mulch, hand pull weeds within a 36-inch diameter area encompassing each seedling, or spot treat weeds with herbicide within the 36-inch area.

If using herbicides, match appropriate herbicides to appropriate weeds and remember that the pesticide label IS THE LAW!

IMPORTANT DISLAIMER – Using a scalping method for site preparation, as opposed to spending the entire previous year implementing site preparation, can be just as effective if weed competition and soil compaction are not severe, but aggressive post-planting weed control methods are critical if weed competition is severe! An example of a large project where scalping is typically more than adequate for weed control includes the underplanting of tree and shrub seedlings under an existing forest canopy – competing vegetation in this circumstance typically only requires scalping and sometimes requires no weed control.

Tree/Shrub Planting Experiments – Using Seedlings from the Manistee and Mason-Lake Conservation Districts

Ever since the spring of 2015, I have been purchasing tree and shrub seedlings, or using leftover seedlings, from the Manistee and Mason-Lake Conservation District tree/shrub sales, planting them at parcels across Michigan, and tracking survival. Here are the results as of the end of the beginning of the growing season of 2022:

*Ogemaw County site, red pine

- **TAKE-HOME MESSAGE – Certain species do not need protection from browsing (this depends on the feeding behavior of the local population of herbivores).**
- I and family members planted 25, 2-0 bareroot seedlings in excessively drained Rubicon sand in April of 2015.
- For site preparation, I scalped a 3-feet diameter area at the time of planting.
- Neither planting gel nor fertilizer were used.
- Browse protection was not implemented.
- I gave each seedling ~0.25 gallon of water at the time of planting. No watering was done after that.
- By the beginning of the growing season of 2022, 21 seedlings survived (84% survival).

*Ogemaw County site, white oak

- **TAKE-HOME MESSAGE – It is important to protect certain species from browsing; 5-feet tall tree tubes are effective.**
- I planted 10, 1-0 bareroot seedlings in excessively drained Rubicon sand in April of 2015.
- For site preparation, I scalped a 3-feet diameter area at the time of planting.
- Neither planting gel nor fertilizer were used.
- On five of the seedlings, browse protection was implemented by installing 5-feet tall rigid tree tubes.
- I gave each seedling ~0.25 gallon of water at the time of planting. No watering was done after that.
- By the end of the growing season of 2018, all five seedlings with tree tubes were alive (100% survival) and all five seedlings not protected were dead from excessive browsing (0% survival).
- During the autumn of 2018, tree tubes were removed without me knowing it. By the beginning of the growing season of 2019, those same five seedlings that used to be in tree tubes did not survive the excessive browsing.

*Ogemaw County site, American mountain ash (*Sorbus americana*)

- **TAKE-HOME MESSAGE – It is important to protect certain species from browsing; bloodmeal repellent can be effective.**
- I planted 10, 2-0 bareroot seedlings in excessively drained Rubicon sand in April of 2015.
- For site preparation, I scalped a 3-feet diameter area at the time of planting.
- Neither planting gel nor fertilizer were used.
- On five of the seedlings, browse protection was implemented by applying bloodmeal repellent periodically until 2018.
- I gave each seedling ~0.25 gallon of water at the time of planting. No watering was done after that.
- By the beginning of the growing season of 2022, all five seedlings that received repellent were alive (100% survival), but those seedlings are showing evidence of excessive browsing, and all five seedlings not protected were dead from excessive browsing (0% survival).

*Ogemaw County site, wild crabapple (*Malus coronaria*)

- **TAKE-HOME MESSAGE – It is important to protect certain species from browsing; 5-feet tall tree tubes are effective.**
- I planted four, 2-0 bareroot seedlings in excessively drained Rubicon sand in April of 2016.

- For site preparation, I scalped a 3-feet diameter area at the time of planting.
- Neither planting gel nor fertilizer were used.
- On all four of the seedlings, browse protection was implemented by installing 5-feet tall rigid tree tubes.
- I gave each seedling ~0.25 gallon of water at the time of planting. No watering was done after that.
- By the end of the growing season of 2018, all four seedlings with tree tubes were alive (100% survival).
- During the autumn of 2018, tree tubes were removed without me knowing it. By the beginning of the growing season of 2019, those same four seedlings that used to be in tree tubes did not survive the excessive browsing.

*Ogemaw County site, eastern white pine

- **TAKE-HOME MESSAGE – Certain species do not need protection from browsing (this depends on the feeding behavior of the local population of herbivores).**
- I and family members planted 50, 2-0 bareroot seedlings in excessively drained Rubicon sand in April of 2016.
- For site preparation, I scalped a 3-feet diameter area at the time of planting.
- Neither planting gel nor fertilizer were used.
- Browse protection was not implemented.
- I gave each seedling ~0.25 gallon of water at the time of planting. No watering was done after that.
- By the beginning of the growing season of 2022, 40 seedlings survived (80% survival).

*Ogemaw County site, yellow birch (*Betula alleghaniensis*)

- **TAKE-HOME MESSAGE – It is important to protect certain species from browsing; 5-feet tall tree tubes are effective.**
- I planted 10, 2-0 bareroot seedlings in soil transitional between excessively drained Rubicon sand and a lake, in April of 2017.
- For site preparation, I scalped a 3-feet diameter area at the time of planting.
- Neither planting gel nor fertilizer were used.
- On five of the seedlings, browse protection was implemented by installing 5-feet tall rigid tree tubes.
- I gave each seedling ~0.25 gallon of water at the time of planting. No watering was done after that.
- By the end of the growing season of 2018, all five seedlings with tree tubes were alive (100% survival) and all five seedlings not protected were dead from excessive browsing (0% survival).
- During the autumn of 2018, two of the tree tubes were removed without me knowing it. By the beginning of the growing season of 2019, those seedlings that used to be in tree tubes did not survive the excessive browsing, but by the beginning of the growing season of 2022, those that remained in tree tubes were still alive.

*Ogemaw County site, northern white-cedar (*Thuja occidentalis*)

- **TAKE-HOME MESSAGE – It is important to protect certain species from browsing; 5-feet tall tree tubes are effective.**
- I planted 10, 2-1 bareroot seedlings in soil transitional between excessively drained Rubicon sand and a lake, in April of 2017.
- For site preparation, I scalped a 3-feet diameter area at the time of planting.
- Neither planting gel nor fertilizer were used.
- On five of the seedlings, browse protection was implemented by installing 5-feet tall rigid tree tubes.
- I gave each seedling ~0.25 gallon of water at the time of planting. No watering was done after that.
- By the end of the growing season of 2018, all five seedlings with tree tubes were alive (100% survival) and all five seedlings not protected were dead from excessive browsing (0% survival).

- During the autumn of 2018, tree tubes were removed without me knowing it. By the beginning of the growing season of 2019, four of the five seedlings that used to be in tree tubes did not survive the excessive browsing.

*Saginaw County site, American mountain ash

- **TAKE-HOME MESSAGE – It is important to protect certain species from browsing. It is important to consider the impacts of soil compaction on survival and vigor.**
- I planted five, 1-0 bareroot seedlings in poorly drained Parkhill loam, in April of 2018.
- For site preparation, I scalped a 3-feet diameter area at the time of planting.
- Neither planting gel nor fertilizer were used.
- On all five of the seedlings, browse protection was implemented by installing 5-feet tall rigid tree tubes.
- I gave each seedling ~0.25 gallon of water at the time of planting. The landowners watered seedlings subsequently, usually several times throughout each growing season, for the first three growing seasons.
- Tree tubes were removed during the growing season of 2021, due to a lack of white-tailed deer in the area and because no evidence of trunk damage by eastern cottontails (*Sylvilagus floridanus*) had been observed on other susceptible woody plants in the neighborhood.
- Mulch (approximately two inches deep) was added around each seedling in 2021 to reduce encroaching competition from turf grass.
- By the beginning of the growing season of 2022, four of the five seedlings (80%) survived. The seedling that died was not dead due to browsing, but due to disease. The surviving seedlings are showing signs of stress due to compacted soil (the seedlings were planted in a manicured lawn that is regularly mowed).

*Manistee County site, Canadian serviceberry (*Amelanchier canadensis*)

- **TAKE-HOME MESSAGE – If species susceptible to browsing are not protected, high mortality will be the result.**
- I, other Manistee Conservation District staff, and volunteers, planted 25, 1-0 bareroot seedlings in somewhat excessively drained Coloma sand and well drained Spinks sand, in May of 2020.
- For site preparation, we scalped a 3-feet diameter area at the time of planting.
- Seedlings were not watered.
- Neither planting gel nor fertilizer were used.
- No browse protection was used initially. Excessive browsing by white-tailed deer and eastern cottontail was subsequently observed. 17/25 (68%) were alive by the beginning of growing season 2022, and those that survived were exhibiting extreme weakness to the point of possibly dying. Those that were dead had been over-browsed by white-tailed deer or eastern cottontail.
- As of the growing season of 2022, bloodmeal repellent has been applied to surviving seedlings.

*Manistee County site, buttonbush (*Cephalanthus occidentalis*)

- **TAKE-HOME MESSAGE – If the species is improperly matched to the soil type, high mortality will be the result. The same is true if the species is susceptible to browsing and is not protected.**
- I, other Manistee Conservation District staff, and volunteers, planted 10, 1-0 bareroot seedlings in somewhat excessively drained Coloma sand and well drained Spinks sand, in areas close to a ditch, in May of 2020.
- For site preparation, we scalped a 3-feet diameter area at the time of planting.
- Seedlings were not watered.
- Neither planting gel nor fertilizer were used.
- No browse protection was used initially. Drought stress and excessive browsing by white-tailed deer and eastern cottontail was subsequently observed. 2/10 (20%) were alive by the beginning of growing season 2022, and those that survived were exhibiting extreme weakness to the point of possibly dying.

Those that were dead had been over-browsed by white-tailed deer or eastern cottontail, or died due to dry soil conditions (buttonbush is commonly found in wetlands).

- As of the growing season of 2022, bloodmeal repellent has been applied to surviving seedlings.

*Manistee County site, eastern redbud (*Cercis canadensis*)

- **TAKE-HOME MESSAGE – If species susceptible to browsing are not protected, high mortality will be the result.**
- I, other Manistee Conservation District staff, and volunteers, planted 15, 2-0 bareroot seedlings in somewhat excessively drained Coloma sand and well drained Spinks sand, in May of 2020.
- For site preparation, we scalped a 3-feet diameter area at the time of planting.
- Seedlings were not watered.
- Neither planting gel nor fertilizer were used.
- No browse protection was used initially. Excessive browsing by white-tailed deer and eastern cottontail was subsequently observed. 10/15 (67%) were alive by the beginning of growing season 2022, but most were exhibiting extreme weakness to the point of possibly dying. Those that were dead had been over-browsed by white-tailed deer or eastern cottontail, or died from drought stress.
- As of the growing season of 2022, bloodmeal repellent has been applied to surviving seedlings.

*Manistee County site, redosier dogwood (*Cornus sericea*)

- **TAKE-HOME MESSAGE – If the species is improperly matched to the soil type, high mortality will be the result. The same is true if the species is susceptible to browsing and is not protected.**
- I, other Manistee Conservation District staff, and volunteers, planted 10, 1-0 bareroot seedlings in somewhat excessively drained Coloma sand and well drained Spinks sand, in areas close to a ditch, in May of 2020.
- For site preparation, we scalped a 3-feet diameter area at the time of planting.
- Seedlings were not watered.
- Neither planting gel nor fertilizer were used.
- No browse protection was used initially. Drought stress and excessive browsing by white-tailed deer and eastern cottonail was subsequently observed. 3/10 (30%) were alive by the beginning of growing season 2022, and those that survived were exhibiting extreme weakness to the point of possibly dying. Those that were dead had been over-browsed by white-tailed deer or eastern cottontail, or died due to dry soil conditions (redosier dogwood is commonly found in wetlands).
- As of the growing season of 2022, bloodmeal repellent has been applied to surviving seedlings.

*Manistee County site, American hazelnut (*Corylus americana*)

- **TAKE-HOME MESSAGE – If species susceptible to browsing are not protected, high mortality will be the result.**
- I, other Manistee Conservation District staff, and volunteers, planted 10, 2-0 bareroot seedlings in somewhat excessively drained Coloma sand and well drained Spinks sand, in May of 2020.
- For site preparation, we scalped a 3-feet diameter area at the time of planting.
- Seedlings were not watered.
- Neither planting gel nor fertilizer were used.
- No browse protection was used initially. Excessive browsing by white-tailed deer and eastern cottontail was subsequently observed. 1/10 (10%) was alive by the beginning of growing season 2022. Those that were dead had been over-browsed by white-tailed deer or eastern cottontail, or died from drought stress.
- As of the growing season of 2022, bloodmeal repellent has been applied to surviving seedlings.

*Manistee County site, common juniper (*Juniperus communis*)

- **TAKE-HOME MESSAGE – It is important to thoroughly examine the quality of stock from nurseries before planting.**
- I, other Manistee Conservation District staff, and volunteers, planted 25, 3-0 bareroot seedlings in somewhat excessively drained Coloma sand and well drained Spinks sand, in May of 2020.
- For site preparation, we scalped a 3-feet diameter area at the time of planting.
- Seedlings were not watered.
- Neither planting gel nor fertilizer were used.
- No browse protection was used initially. 0/25 (0%) grew any new needles and all were dead before the end of their first growing season, due to the poor condition of the seedlings when they were received by the nursery.

*Manistee County site, white spruce (*Picea glauca*)

- **TAKE-HOME MESSAGE – If the species is improperly matched to the soil type, high mortality will be the result.**
- I, other Manistee Conservation District staff, and volunteers, planted 20, 2-0 bareroot seedlings in somewhat excessively drained Coloma sand and well drained Spinks sand, in areas close to a ditch, in May of 2020.
- For site preparation, we scalped a 3-feet diameter area at the time of planting.
- Seedlings were not watered.
- Neither planting gel nor fertilizer were used.
- No browse protection was used. Drought stress was subsequently observed. 2/20 (10%) were alive by the beginning of growing season 2022, and those that survived were exhibiting extreme weakness to the point of possibly dying. Those that were dead had died due to dry soil conditions (white spruce is commonly found in richer soils than where they were planted).

*Manistee County site, black cherry (*Prunus serotina*)

- **TAKE-HOME MESSAGE – If species susceptible to browsing are not protected, high mortality will be the result.**
- I, other Manistee Conservation District staff, and volunteers, planted 20, 1-0 bareroot seedlings in somewhat excessively drained Coloma sand and well drained Spinks sand, in May of 2020.
- For site preparation, we scalped a 3-feet diameter area at the time of planting.
- Seedlings were not watered.
- Neither planting gel nor fertilizer were used.
- No browse protection was used initially. Excessive browsing by white-tailed deer and eastern cottontail was subsequently observed. 3/20 (15%) were alive by the beginning of growing season 2022, but most were exhibiting extreme weakness to the point of possibly dying. Those that were dead had been over-browsed by white-tailed deer or eastern cottontail.
- In May of 2022 a 5-feet tall mesh-style tree tube was placed on one surviving seedling, and bloodmeal repellent has been applied to the other surviving seedlings.

*Manistee County site, northern red oak and white oak

- **TAKE-HOME MESSAGE – If species susceptible to browsing are not protected, high mortality will be the result.**
- I, other Manistee Conservation District staff, and volunteers, planted 15, 3-0 bareroot seedlings in somewhat excessively drained Coloma sand and well drained Spinks sand, in May of 2020.
- For site preparation, we scalped a 3-feet diameter area at the time of planting.
- Seedlings were not watered.
- Neither planting gel nor fertilizer were used.

- No browse protection was used initially. Excessive browsing by white-tailed deer was subsequently observed, as was evidence of defoliation by spongy moth. 12/15 (80%) were alive by the beginning of growing season 2022, but most were exhibiting extreme weakness to the point of possibly dying. Those that were dead had been over-browsed by white-tailed deer.
- In April and May of 2022, browse protection was implemented on a subset of surviving seedlings by installing 5-feet tall rigid tree tubes on five seedlings and 5-feet tall mesh-style tree tubes on three seedlings. Bloodmeal repellent has been applied to other surviving seedlings.

*Manistee County site, staghorn sumac (*Rhus typhina*)

- **TAKE-HOME MESSAGE – If species susceptible to browsing are not protected, high mortality will be the result.**
- I, other Manistee Conservation District staff, and volunteers, planted 20, 1-0 bareroot seedlings in somewhat excessively drained Coloma sand and well drained Spinks sand, in May of 2020.
- For site preparation, we scalped a 3-feet diameter area at the time of planting.
- Seedlings were not watered.
- Neither planting gel nor fertilizer were used.
- No browse protection was used initially. Excessive browsing by white-tailed deer was subsequently observed. 2/20 (10%) were alive by the beginning of growing season 2022, but most were exhibiting extreme weakness to the point of possibly dying. Those that were dead had been over-browsed by white-tailed deer.
- As of the growing season of 2022, bloodmeal repellent has been applied to surviving seedlings.

*Manistee County site, American witchhazel (*Hamamelis virginiana*)

- **TAKE-HOME MESSAGE – It is important to understand the management history of a site prior to planting. If the soil has been seriously degraded, high mortality may be the result.**
- I planted 10, 1-0 bareroot seedlings in somewhat excessively drained Coloma sand and well drained Spinks sand, in April of 2021.
- For site preparation, I scalped a 3-feet diameter area at the time of planting.
- On two of the seedlings, browse protection was implemented by installing 5-feet tall rigid tree tubes.
- On two of the seedlings, browse protection was implemented by installing 5-feet tall mesh-style shrub tubes.
- For all seedlings in tree or shrub tubes, grass-specific herbicide was applied in 3-feet diameter area, periodically throughout the growing season.
- The remaining six seedlings were not put in tree or shrub tubes; of those six seedlings, three seedlings received both grass-specific herbicide and bloodmeal repellent, two seedlings received neither grass-specific herbicide nor bloodmeal repellent, and one seedling received grass-specific herbicide and no bloodmeal repellent.
- Neither planting gel nor fertilizer were used.
- I soaked each seedling in water for ~1.5 hour prior to planting.
- I gave each seedling ~0.5 gallon of water at the time of planting and watered them using the same amount per watering, periodically throughout the growing season.
- Overall, only 2/10 (20%) survived by the beginning of the growing season of 2022.
- 2/4 (50%) in tree or shrub tubes were alive by the beginning of the growing season of 2022.
- The seedling that was not in a tube, that did receive grass-specific herbicide, but did not receive bloodmeal repellent, was browsed and killed by an eastern cottontail.
- All three seedlings that received both grass-specific herbicide and bloodmeal repellent were dead by the beginning of the growing season of 2022, likely due to extremely poor soils where a weather station previously existed.

- Both seedlings that did not receive grass-specific herbicide or bloodmeal repellent were dead by the beginning of the growing season of 2022, likely due to browsing by eastern cottontails and poor soils.

*Manistee County site, tuliptree

- **TAKE-HOME MESSAGE – If the species is improperly matched to the soil type, high mortality will be the result.**
- I planted five, 1-0 and 1-1 bareroot seedlings in somewhat excessively drained Coloma sand and well drained Spinks sand, in April of 2021.
- For site preparation, I scalped a 3-feet diameter area at the time of planting.
- Neither planting gel nor fertilizer were used.
- On all five of the seedlings, browse protection was implemented by installing 5-feet tall rigid tree tubes.
- I soaked each seedling in water for ~1.5 hour prior to planting.
- I gave each seedling ~0.5 gallon of water at the time of planting and watered them using the same amount per watering, periodically throughout the growing season.
- Grass-specific herbicide was applied in 3-feet diameter area for all seedlings, periodically throughout the growing season.
- Only 1/5 (20%) were confirmed as being alive by the beginning of the growing season of 2022. It is possible this was due to the soil not being mesic enough.

*Manistee County site, eastern white pine

- **TAKE-HOME MESSAGE – It is important to examine the vigor of each seedling prior to planting. Severe drought conditions can lead to mortality (especially on sandy soils), even if proper watering practices are implemented.**
- I planted nine, 2-0 bareroot seedlings in somewhat excessively drained Coloma sand and well drained Spinks sand, in April of 2021.
- For site preparation, I scalped a 3-feet diameter area at the time of planting.
- Four of the seedlings were dipped in planting gel; two of those seedlings received periodic application of bloodmeal repellent and two did not.
- Five of the seedlings were not dipped in planting gel; two of those seedlings received periodic application of bloodmeal and three did not.
- Fertilizer was not used.
- I soaked each seedling in water for ~1.5 hour prior to planting and prior to dipping in planting gel (for those that received planting gel).
- I gave each seedling ~0.5 gallon of water at the time of planting and watered them using the same amount per watering, periodically throughout the growing season.
- Grass-specific herbicide was applied in 3-feet diameter area for all seedlings, periodically throughout the growing season.
- Across all seedlings, 6/9 (66%) were confirmed as being alive by the beginning of growing season of 2022. Two seedlings that died were those that were dipped in planting gel but did not receive bloodmeal repellent, but both seedlings exhibited poor vigor prior to being planted. A third seedling (not dipped in planting gel but did receive bloodmeal repellent) also died.

*Grand Traverse County site, eastern white pine

- **TAKE-HOME MESSAGE – Certain species do not need protection from browsing (this depends on the feeding behavior of the local population of herbivores).**
- I and family members planted 40, 2-1 bareroot seedlings, and 10, 2-0 seedlings in somewhat excessively drained Kalkaska sand, in April of 2021.
- No site preparation was done.
- Neither planting gel nor fertilizer were used.

- No browse protection was implemented.
- I soaked each seedling in water for ~1.5 hour prior to planting. The landowners watered the seedlings semi-regularly for the remainder of the growing season.
- Although all seedlings were not tracked, at least 85% were confirmed as being alive by the beginning of the growing season of 2022.

*Grand Traverse County site, black elderberry (*Sambucus nigra* ssp. *canadensis*)

- **TAKE-HOME MESSAGE – When the soil type does not support the species, it is possible to amend the soil, but this takes much effort.**
- I and family members planted five, 1-0 bareroot seedlings, whereby extra-large holes were dug and filled with organic potting soil, in April of 2021.
- No site preparation was done since large holes were dug.
- Neither planting gel nor fertilizer were used.
- On all five of the seedlings, browse protection was implemented by installing 5-feet tall mesh tree protectors (with a diameter larger than that of rigid tree tubes).
- Mulch (approximately two inches deep) was placed around each seedling.
- I soaked each seedling in water for ~1.5 hour prior to planting. The landowners watered the seedlings semi-regularly for the remainder of the growing season.
- All five seedlings (100%) were alive by the beginning of the growing season of 2022.

*Manistee County site, red maple (*Acer rubrum*)

- **TAKE-HOME MESSAGE – Bloodmeal is an effective repellent, but it will fail if it is not applied frequently enough (per the instructions by the manufacturer).**
- I planted 25, 2-0 bareroot seedlings in somewhat excessively drained Coloma sand and well drained Spinks sand, in April of 2022.
- For site preparation, I tilled the area using a garden tiller.
- Seedlings were not watered.
- Neither planting gel nor fertilizer were used.
- 5-feet tall rigid tree tube was placed on one of the seedlings.
- Bloodmeal repellent was initially applied to the seedlings without tree tubes, but the next application was not done in a timely manner (on purpose, to examine the effects of not applying bloodmeal in a timely manner); excessive browsing by white-tailed deer and eastern cottontail was consequently observed.
- As of June 2022, 17/20 (85%) have survived and those that survived and that are not in a tree tube are being treated with bloodmeal repellent. Those that did not survive either did not ever expand their leaves, or were excessively browsed due to too much of a delay between the initial and second bloodmeal applications.

*Manistee County site, Canadian serviceberry and Allegheny serviceberry (*Amelanchier laevis*)

- **TAKE-HOME MESSAGE – Bloodmeal is an effective repellent, but it will fail if it is not applied frequently enough (per the instructions by the manufacturer).**
- I planted 25, 2-0 bareroot seedlings in somewhat excessively drained Coloma sand and well drained Spinks sand, in April of 2022.
- For site preparation, I tilled the area using a garden tiller.
- Seedlings were not watered.
- Neither planting gel nor fertilizer were used.
- A 5-feet tall rigid tree tube was placed on one of the seedlings.
- Bloodmeal repellent was initially applied to the seedlings without tree tubes, but the next application was not done in a timely manner (on purpose, to examine the effects of not applying bloodmeal in a

timely manner); excessive browsing by white-tailed deer and eastern cottontail was consequently observed.

- As of June 2022, 15/25 (60%) have survived and those that survived and that are not in a tree tube are being treated with bloodmeal repellent. Those that did not survive either did not ever expand their leaves, or were excessively browsed due to too much of a delay between the initial and second bloodmeal applications.

*Manistee County site, wild crabapple

- **TAKE-HOME MESSAGE – Bloodmeal is an effective repellent, but it will fail if it is not applied frequently enough (per the instructions by the manufacturer).**
- I planted 10, 1-0 bareroot seedlings in somewhat excessively drained Coloma sand and well drained Spinks sand, in April of 2022.
- For site preparation, I tilled the area using a garden tiller.
- Seedlings were not watered.
- Neither planting gel nor fertilizer were used.
- 5-feet tall rigid tree tubes were placed on two of the seedlings and a 5-feet tall semi-solid tree tube was placed on another seedling.
- Bloodmeal repellent was initially applied to the seedlings without tree tubes, but the next application was not done in a timely manner (on purpose, to examine the effects of not applying bloodmeal in a timely manner); excessive browsing by white-tailed deer and eastern cottontail was consequently observed.
- As of June 2022, 6/10 (60%) have survived and those that survived and that are not in a tree tube are being treated with bloodmeal repellent. Those that did not survive either did not ever expand their leaves, or were excessively browsed due to too much of a delay between the initial and second bloodmeal applications.

*Manistee County site, eastern white pine

- **TAKE-HOME MESSAGE – Some species may be susceptible to browsing in certain geographic areas, but not in other areas. This is often the case with eastern white pine.**
- I planted 35, 2-0 bareroot seedlings in somewhat excessively drained Coloma sand and well drained Spinks sand, in April of 2022.
- For site preparation, I tilled the area using a garden tiller.
- Seedlings were not watered.
- Neither planting gel nor fertilizer were used.
- A 5-feet tall rigid tree tube was placed on one of the seedlings.
- Bloodmeal repellent was initially applied to the seedlings without tree tubes, and while the next application was not done in a timely manner (on purpose, to examine the effects of not applying bloodmeal in a timely manner), excessive browsing was not observed.
- As of June 2022, 31/35 (88%) have survived and those that survived and that are not in a tree tube are being treated with bloodmeal repellent. Those that did not survive either did not grow new needles and eventually died; evidence of browsing was not observed.

*Manistee County site, trembling aspen (*Populus tremuloides*)

- **TAKE-HOME MESSAGE – Bloodmeal is an effective repellent, but it will fail if it is not applied frequently enough (per the instructions by the manufacturer).**
- I planted 9, 1-0 bareroot seedlings in somewhat excessively drained Coloma sand and well drained Spinks sand, in April of 2022.
- For site preparation, I tilled the area using a garden tiller.
- Seedlings were not watered.

- Neither planting gel nor fertilizer were used.
- 5-feet tall rigid tree tubes were placed on two of the seedlings.
- Bloodmeal repellent was initially applied to the seedlings without tree tubes, but the next application was not done in a timely manner (on purpose, to examine the effects of not applying bloodmeal in a timely manner); excessive browsing by white-tailed deer and eastern cottontail was consequently observed.
- As of June 2022, 5/9 (55%) have survived and those that survived and that are not in a tree tube are being treated with bloodmeal repellent. Those that did not survive either did not ever expand their leaves, or were excessively browsed due to too much of a delay between the initial and second bloodmeal applications.

*Manistee County site, black cherry

- **TAKE-HOME MESSAGE – Bloodmeal is an effective repellent, but it will fail if it is not applied frequently enough (per the instructions by the manufacturer).**
- I planted 10, 1-0 bareroot seedlings in somewhat excessively drained Coloma sand and well drained Spinks sand, in April of 2022.
- For site preparation, I tilled the area using a garden tiller.
- Seedlings were not watered.
- Neither planting gel nor fertilizer were used.
- Bloodmeal repellent was initially applied to the seedlings without tree tubes, but the next application was not done in a timely manner (on purpose, to examine the effects of not applying bloodmeal in a timely manner); excessive browsing by white-tailed deer and eastern cottontail was consequently observed.
- As of June 2022, 6/10 (60%) have survived and those that survived and that are not in a tree tube are being treated with bloodmeal repellent. Those that did not survive either did not ever expand their leaves, or were excessively browsed due to too much of a delay between the initial and second bloodmeal applications.

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