TREE AND SHRUB HANDLING, PLANTING, AND CARE

This document provides guidance for establishing trees and shrubs as part of the following Natural Resources Conservation Service (NRCS) South Dakota Technical Guide (SDTG) Practices:

Hedgerow Planting (422)
Riparian Forest Buffer (391)
Tree/Shrub Establishment (612)
Upland Wildlife Habitat Management (645)
Windbreak/Shelterbelt Establishment (380)
Windbreak/Shelterbelt Renovation (650)

The success of any tree planting is dependent upon proper site preparation, use of quality planting stock, proper planting and handling techniques, and good maintenance. The planner, the vender, the planters, and landowners are important links in the chain of events that lead to a successful tree planting. This document outlines the methods that have proven successful for conservation tree and shrub plantings in South Dakota.

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CONSERVATION TREE/SHRUB GROUPS

Refer to "Expected Tree and Shrub Heights at 20 Years" in Section II of the SDTG for information on expected heights of trees and shrubs in 20 years. Use the groups to select trees and shrubs that are suited for the soils on the proposed planting site.

PLANTING STOCK REQUIREMENTS

Planting stock must be grown from locally adapted seed or cuttings of known origin and will meet height and caliper standards listed below. Locally adapted named varieties are recommended over common stock and should be used when they are available. Planting stock should come from sources less than 200 miles north or south, and less than 400 miles east or west of the planting site, unless long-term replicated field trials or extensive historical data indicate that the stock is hardy for a given location. "Planting stock sources" refers to the location where the plant naturally occurred or were the seed was collected, not the location of the nursery from where it was purchased.

Bare Root Deciduous Seedlings shall not be less than 6/32-inch caliper at one inch above the root collar. Bare root deciduous seedlings shall have a shoot (top growth) of at least 12 inches. Seedlings should not be topped, unless untopped stock is not available. Rooted planting stock must not exceed a 2:1 shoot-to-root ratio (see Figure 1).

Bare Root Coniferous Seedlings shall be two-to-four-year old stock. 2-0 equals 2 years in a seedling bed; 2-2 equals two years in a seedling bed and 2 years in a transplant bed. Coniferous seedlings or transplants will have at least a six-inch shoot and shall have a minimum stem diameter of 3/16 inch at 1 inch above the root collar. Rooted planting stock should have a well-developed fibrous root system and must not exceed a 2:1 shoot-to-root ratio (see Figure 1).

Vegetative Deciduous Cuttings shall be no less than one-half inch diameter at the base, have the apical bud and all lateral side branches removed, and produced in lengths long enough to reach a soil depth that remains saturated throughout the growing season, or the site must be irrigated (see Figure 7).

Depth to the saturated zone must be determined before cuttings are ordered or harvested. In no case will vegetative deciduous cuttings be less than 10 inches in length. Tops of dormant-season-collected cuttings may be dipped in latex paint, paraffin, or sealing wax to prevent desiccation and mark the top.

Vegetative material should be collected while dormant. Dormancy means no bud swell, no green showing on buds, and no separation of bud scales. Actively growing materials can be used, but survival will usually be lower.

Vegetative material works best if planted within two to three weeks of harvest. Willow and cottonwood species can be stored up to six months. Proper storage consists of 34-38°F temperatures with nearly 100 percent relative humidity. Storage in plastic bags will achieve the desired humidity. Care must be taken to prevent mold buildup. Do not allow stock to dry out for even short periods of time, as survival will be greatly reduced.

Container-grown Stock shall have a root mass of at least seven cubic inches. Seedling height will be at least six inches. Container-grown stock must be produced in containers that minimize girdling roots or J-roots.

Bare root seedlings, transplants, or container grown stock shall be dormant when planted. Avoid planting stock after bud break, except for bur oak and hackberry that have been sweated.

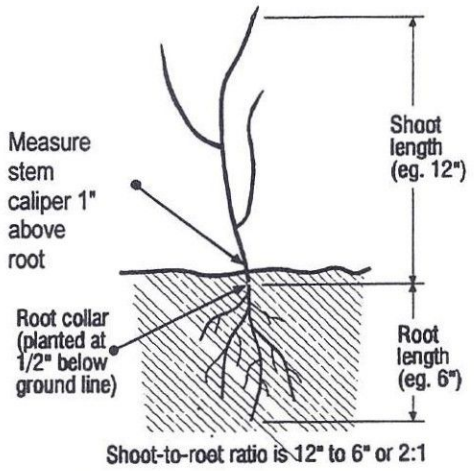


Figure 1: Shoot/Root Ratio

STORAGE OF STOCK

Rooted planting stock and cuttings will be stored in a cool, moist environment (34-38°F) or heeled into the soil. During all stages of handling and storage, keep stock free of mold and roots moist and cool. Keep roots covered at all times. Evaluate stock that has been allowed to dry, heat up (e.g., within a bale, delivery carton, or container), or that has developed mold or other problems. Destroy stock if there is any doubt as to the viability. Live cuttings that are not immediately planted after harvest shall be promptly placed in controlled storage conditions (34-38°F) and protected until planting time.

Landowners may keep stock for up to one week before planting by storing in a shaded, cool, moist place. A basement or fruit cellar works well. Plant bundles should be turned every day when temporarily stored to avoid mold and/or drying problems within the bundle. Ensure that the roots are moist and not exposed to the air. Do not store in a bucket of water.

For longer storage periods, stock may be heeled in. Locate the heel-in bed in good soil in a protected location (see Figure 2 for details).

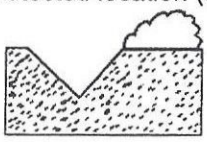


Figure 2A: Dig a trench deep enough for proper root placement.

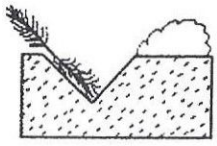


Figure 2B: Break bundles and spread along the trench wall with two-three inches between each plant.

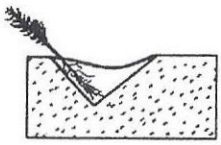


Figure 2C: Immediately cover roots with soil to minimize exposure to sun and air; and lightly pack. Thoroughly soak the trench with water after planting to remove air spaces and improve root soil contact.

Leaving plants in a heel-in bed for longer than one season increases the difficulty of transplanting and decreases survivability.

PLANTING SITE PREPARATION

Planting sites shall be properly prepared before planting trees. Good site preparation is one of the best ways to improve the survival and growth rate of newly planted trees and shrubs. Based on the soil and vegetative conditions encountered, select one of the methods listed below.

Be wary of sites that have had recent applications of pesticides that may be harmful to woody species. Check carryover characteristics and waiting period restrictions of pesticides applied to the planting site in the previous one to two years.

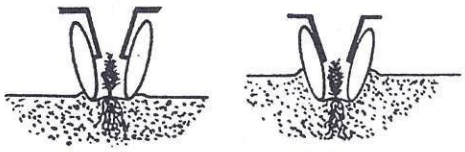
If herbicides are used for site preparation, apply only as needed and within federal, state, and local regulations. Follow label directions and heed all precautions listed on the container.

Site preparation may include the whole site, strips, or patches. Individual site prep for each tree or shrub will provide a minimum four-foot diameter circle, or a minimum four-foot by four-foot square, or a four-foot wide strip at each planting spot (two feet on each side of the planted stock).

The planting area must be free of living sod and weed free before planting. Primary noxious weeds must be controlled in accordance with state and local regulations before the windbreak is planted.

Prior to planting, firm the seedbed, if needed, to reduce drying of the site and to aid in proper depth placement of the plant. A firm seedbed for tree planting should be similar to a firm seedbed for grass seeding where adult human footprints are barely visible and planting equipment leaves a minimal trench (see Figure 3).

Be alert to potential wind and water erosion risks during the over winter period. If needed, seed an annual cover crop of oats or small grains to control erosion while minimizing water usage. Oats or small grains must be seeded early enough to attain a four to six inch height prior to freeze up to provide soil protection.



This
Firm soil, plants at proper depth.

Not This
Soil too loose, plants pressed too deep.

Figure 3: Effects of Seedbed Firmness

Row Crop and Small Grain Sites

If the site is in soybean or small grain stubble, the trees may be planted in the spring without further preparation. To remove sprouted annual weeds, shallow tillage or a chemical burn down immediately prior to planting is appropriate.

If the site is row crop, trees may be planted directly into the crop stubble unless excessive residue levels interfere with the ability of the tree planting machine to operate properly. Residue removal or shallow tillage between harvest and freeze up the year before planting may be necessary to reduce residue levels so the tree planter can successfully plant through it.

If needed, seed an annual cover crop of oats or small grains to control erosion while minimizing water usage. Oats or small grains must be seeded early enough to attain a four-to-six-inch height prior to freeze up to provide soil protection.

If heavy row crop residue is present, consider tilling only 4-6-foot wide strips where the tree/shrubs will be planted (8-10-foot wide strips if weed control fabric is to be installed after planting). This allows the standing stubble between the rows to act as temporary wind protection for the new seedlings.

Avoid excessive tillage prior to planting. Tillage is not needed or effective if there are no weeds present and the crop residue is manageable.

Avoid tilling soils when they are wet, to minimize compaction.

Avoid deep tillage (greater than two inches deep) immediately prior to planting to prevent drying the seedbed.

Another option on cropland is to apply appropriate herbicides, according to label directions prior to planting trees and shrubs.

Sites with grass, alfalfa or other herbaceous vegetation

Perform sufficient tillage or use non-selective herbicides to kill the sod or alfalfa and maintain the entire site in a reasonably weed free condition the year prior to tree and shrub planting.

The sod will be killed or destroyed by tillage or herbicides by July 1 of the year prior to planting.

Avoid tilling soils when they are wet, to minimize compaction.

Be alert to potential wind and water erosion risks during the fallow period if the site is tilled. Seed an annual cover crop of oats or spring grains to control erosion while minimizing water usage. Oats and spring grains must be seeded early enough to attain four-to-six inch height prior to freeze up to provide soil protection.

Follow label instructions so that application technique and timing of herbicide application will lead to a complete control of the vegetation. Repeated applications throughout the fallow year may be necessary.

For erosive sites without aggressive sod forming grasses, such as smooth bromegrass, reed canarygrass, or quackgrass, till or spray out five-to-eight-foot wide strips where the trees and shrubs will be planted while leaving and maintaining the existing vegetation between the rows. This will reduce wind and water erosion, sandblasting, provide easier site access, and provide wildlife benefits. The wider tilled area is appropriate for locations where weed control fabric is to be installed after the tree or shrub planting.

For all sites with aggressive sod forming grasses, such as smooth bromegrass, reed canarygrass, or quackgrass, or alfalfa; completely till or spray the entire area where the trees and shrubs will be planted, including the isolation strips around the outside of the planting.

Very Erosive Sod-covered Sites

Very erosive sites are those with slopes of 7 percent or steeper, or a wind erosion "I" factor of 134 or 250.

On very erosive sites without aggressive sod forming grasses such as smooth bromegrass, reed canarygrass, or quackgrass, or alfalfa; spray out five to eight foot wide strips where the trees and shrubs will be planted while leaving

the existing vegetation between the rows. This will reduce potential erosion, sandblasting, provide easier access and provide wildlife benefits.

Suitable broadleaf trees and shrubs can be planted in undisturbed dead sod on these sites.

Undisturbed dead sod will often provide a season's weed control or suppression after the trees or shrubs have been planted.

For very erosive sites with aggressive sod forming grasses such as smooth bromegrass, reed canarygrass or quackgrass and no plans for cover crops, till only 8-to-10-foot wide strips where the trees and shrubs will be planted. With this option, fabric weed barrier must be installed.

Orient tree and shrub plantings on the contour, when possible, to minimize water erosion risks during the fallow period and subsequent planting and maintenance operations.

Scalp Planting Site Preparation

Scalp planting is a method that places plant material in an area cleared of competing vegetation. The area cleared is usually 2-to-4-inches deep and at least 18 inches wide with the sod thrown to both sides. The furrow shall be prepared immediately prior to or as part of the planting operation.

Do not scalp plant into aggressive sods such as smooth bromegrass, reed canarygrass, or quackgrass; or alfalfa. Follow guidelines for site preparation under Sites with grass, alfalfa, or other herbaceous vegetation above.

Scalping tends to encourage a rapid flush of annual weeds on the freshly exposed soil that will require a post-treatment for weed control.

Plantings on these sites shall be limited to conifers.

When scalping on native range sites, orient plantings in locations that are most conducive to tree growth. Best tree growing sites are often found in toe slope positions, north facing slopes, or in swales and draws.

When possible, orient rows on the contour to harvest runoff moisture and reduce erosion.

Do not scalp plant into tilled sites.

Natural Regeneration Site Preparation

This procedure should only be attempted on sites within the 10-50-year flood plain of stream systems where adequate native seed trees or shrubs are within 200 yards of every part of the planting site and soils are suitable for tree growth. Stream systems where this could be attempted with a reasonable chance of success include:

- All perennial streams and tributaries of the Big Sioux River in the counties within the Major Land Resource Area (MLRA) 102A and 102B.
- Scattered segments of the James River that meet the flooding, soil, and seed tree requirements.

Perennial grasses should be controlled with herbicides and/or tillage prior to attempting this method of tree and shrub establishment.

Once herbaceous vegetation has been controlled, the site should be tilled to expose bare mineral soil just prior to seed dispersal from the tree species desired. Seed dispersal may occur from mid spring to late fall depending upon the species. During the planning phase, determine the dispersal times of the desired species to ensure timely site preparation. Besides direct onsite observation, the following source, "Woody Plant Seed Manual," can be used to determine likely seed dispersal times.

Consider leaving strips of vegetation perpendicular to flood flows to reduce scour erosion.

Installed Fabric Site Preparation

Fabric Site Preparation, All Sites

All instructions concerning fabric installation for weed control after planting apply when fabric is used for site preparation. Refer to Synthetic Mulch (Fabric) Weed Control under the maintenance section of this document.

Installation of weed control fabrics as a form of site preparation can be very effective. When properly applied it can effectively kill vegetation and store seasonal moisture ahead of planting.

Currently, planting trees and shrubs through the fabric must be done by hand; therefore, planting stock with compact root systems is a must. Installing fabric the summer before planting, as a site preparation method, and using container-grown stock, can extend the planting season by two to four weeks.

Minimum fabric widths will be six feet if installed by machine and the edges are anchored by soil. This will result in about four feet of effective

weed control following installation. Fabric that is four feet wide can be used if the edges are stapled down and not anchored by soil.

Rocks, staples and/or soil must hold down fabric edges. It is essential that wind is not allowed to get under the fabric or it will be torn out of the ground. Staples or rocks should be spaced in the center of the fabric close to where the trees/shrubs will be planted the following spring. When not using soil to anchor the fabric edges, staples, pins or rocks must be placed every three to five feet along the edge. Do not use soil to hold down the fabric centers, as weeds will quickly become established on the soil spots, reducing or ruining the effectiveness of the fabric.

After installation, fabric should be taut, reasonably level and well anchored.

Fabric Site Preparation, Tilled Sites

The area to be tilled should be two to four feet wider than the width of the fabric, for those sites where fabric will be installed by machine. If the fabric will be hand placed, tillage need only be as wide as the fabric.

To facilitate hand planting, tillage should be deep enough to accommodate the roots of the species to be planted the following spring.

Fabric Site Preparation, No Till Sites

Large amounts of grass and other herbaceous cover should be mowed and removed from the site before fabric installation to reduce the risks of rodent damage when the trees and shrubs are planted and to allow the fabric to lay flat to the ground.

Equipment modifications may be necessary if installing fabric by machine. Fabric laying machines usually need to be "beefed up" in order to get good fabric placement and soil coverage on the fabric edges.

Fabric may be hand placed by anchoring the edges every three to five feet with staples, pins, or rocks. Every 10-15 feet a staple, pin, or rock should be placed in the middle of the fabric to prevent "billowing" by the wind.

Tools used for planting must be able to easily penetrate untilled soils to the proper depth under the fabric. If easy penetration is not likely, use the Fabric Site Preparation, Tilled Sites method.

CARE AND HANDLING REQUIREMENTS

Roots of bare root stock shall be kept moist at all times during planting operations by placing in a water-soil (mud) slurry, super-absorbent (e.g., polyacrylamide) slurry, or covering with wet peat moss, wet shingle tow, or other equivalent material. Do not cover with dry shingle tow, peat moss, etc., and expect to wet afterwards. No matter how much water is applied, some roots will remain dry.

The rooting medium of container or potted stock shall be kept moist at all times by periodic watering.

Pre-treat bare rootstock by soaking roots in water or polyacrylamide for several minutes before placing on the tree-planting machine.

Sweating Seedlings

Certain species, such as bur oak and hackberry, may require special preparation before planting, especially in cold wet soils. These species have a tendency to not break dormancy without a "sweating" treatment. Trees that do not break dormancy during the first growing season will likely die.

Sweating trees is a simple process that usually requires nothing more than the packing material shipped with the trees and duct tape. One-to-two-weeks before the trees are to be planted, remove them from the cooler. Line the cardboard shipping boxes with a large plastic bag. Place broken bundles of trees loosely in the plastic-lined box. Wet them thoroughly. Fold and tape the plastic together to make an air tight seal. Store the wrapped trees at room temperature, away from direct sunlight, for one to two weeks, checking to ensure they do not dry out.

Condensation should form on the inside of the plastic within hours, indicating a tight seal and that the process is working.

When properly sweated, the buds of these species will have swollen and in some cases broken open. Use extra precautions when planting sweated stock, especially if leaves are starting to emerge, because they are very sensitive to drying out during handling and the effects of hot dry winds immediately after planting.

PLANTING

Planting - All Sites Except Natural Regeneration

Plant only in the spring of the year after the frost is out of the ground. All stock, except as noted, will be planted by June 1st. Bare root conifers shall be planted by May 15.

Extensions of these planting dates by 10 days may be made by the district conservationist if local soil moisture and temperature conditions justify it and are documented. Before granting an extension, consider the cooperator's ability and willingness to address the greater need for supplemental watering, wind protection and/or shade that may be necessary in the weeks immediately following a later planting.

Keep roots moist and covered throughout the entire planting operation. To further reduce planting shock, stock could be carried during the planting process in buckets of water or slurry. Do not allow rooted conifer stock to be immersed for longer than one hour.

Stock shall not be planted when the soil is frozen or dry.

Do not handle trees or shrubs when air temperatures are freezing or below.

Minimize exposure of bare root seedlings to air and sunshine while loading the planter and during the planting operation. Studies have shown that exposure of Scotch pine roots to air and sun on a 73 degrees day for only 2 minutes resulted in 80 percent mortality.

Do not plant on hot, dry, windy days. Refer to Figure 4, Climatic Stress Chart, to identify conditions suitable for planting.

Cease planting when field temperature and humidity conditions fall above the curved line appropriate for sustained wind speeds at the site. As conditions approach those indicated by the appropriate wind speed line, use extra care to prevent desiccation of roots and tops.

Weather conditions falling below the appropriate wind speed line are generally considered good for tree and shrub planting. Cease planting when sustained wind speeds exceed 30 mph (miles per hour).

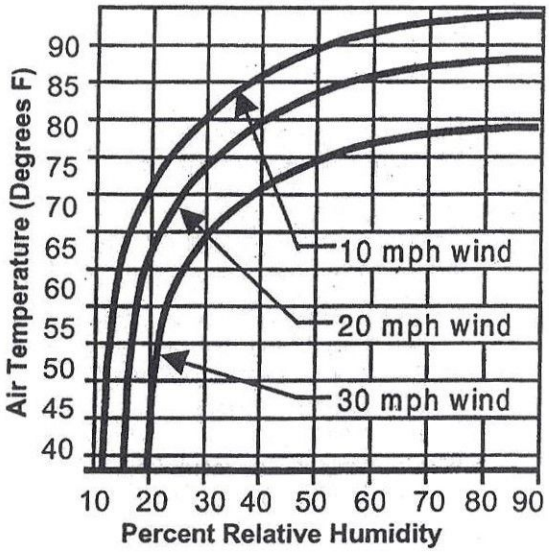


Figure 4: Climate Stress Chart

Remove any wire or plastic ties that encircle the trunk or limbs of planted stock. If left on they can girdle and kill the stem above that point as the stem increases in diameter.

Container-grown stock planted through fabric that has been properly placed a year in advance may be planted up to June 20th. Refer to Installed Fabric Site Preparation for details.

Before initiating a late June planting through fabric (past the cutoff date for all other plantings) ensure that at least a two foot depth field capacity soil moisture is present beneath the installed fabric and the herbaceous wind barriers are at an effective height to protect the new planting.

Immediately after, or during planting of all stock, whether by hand or machine, pack soil firmly around each plant to eliminate air pockets. Proper adjustment and operation of the tree-planting machine will eliminate the need to pack the edges of tree rows with tractor tires or feet.

Planting – Bare Root Stock (Seedlings, Transplants, Rooted Cuttings)

Rooted stock will be planted in a vertical position with the root collars approximately one-half inch below the soil surface (see Figures 1, 5, and 6)

The planting trench or hole must be deep and wide enough to permit roots to spread out and down without J-rooting or L-rooting. Trim straggly roots of bare-root stock as needed to prevent J-roots, L-roots, broken roots, or wadded roots that may result from "stuffing" too many roots into the planting shoe. Do not over trim roots.

Figure 6 illustrates some examples of improperly planted trees. The only acceptable way to plant a tree is shown in the lower right corner.

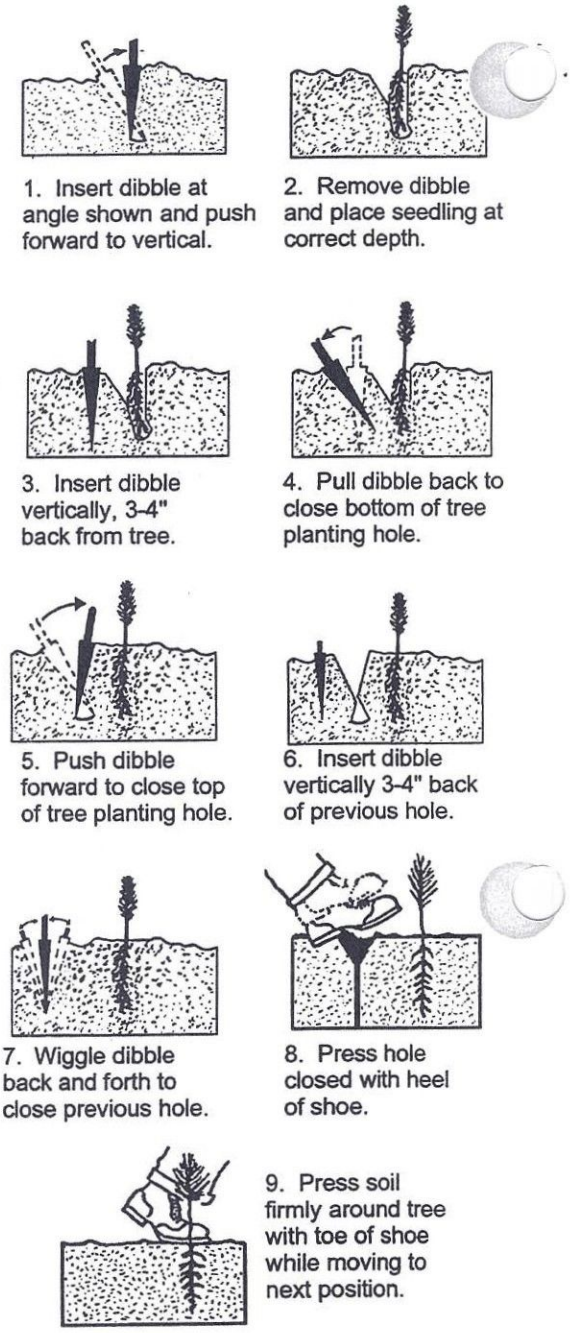


Figure 5: Hand Planting

Planting - Unrooted Cuttings (Willow, Poplar, and Dogwood Species)

Base ends of longer cuttings, or the entire cutting if smaller, should be soaked for 10-24 hours before planting. If cuttings have been stored for more than one week, recut the base end at a 45-degree angle to maximize water uptake. Cut back until the cut is in green tissue.

Planting may be by hydraulic jetting, hand dibbles, shovels, tree planters, or probes.

Insert cuttings to the depth required to reach adequate soil moisture with one to two buds sticking above the soil surface. Note: depth to growing season water table must be determined before obtaining cuttings to ensure cuttings are sufficiently long to reach the water table. Make sure that the base end is planted down (see Figure 7).

When using shorter cuttings through a traditional tree-planting machine, ensure the soil is firmly packed against the cutting. Shorter cuttings may require supplemental watering to ensure survival and establishment during the first year.

When planting by hand, ensure that the planting hole is large enough to prevent stripping or damaging the bark and buds.

Once the cutting is in the hole, ensure that voids are eliminated either by packing around the cutting or by using hydraulic jetting to prepare the planting hole.

When planting by hand avoid excessive force that may kink or break the cutting.

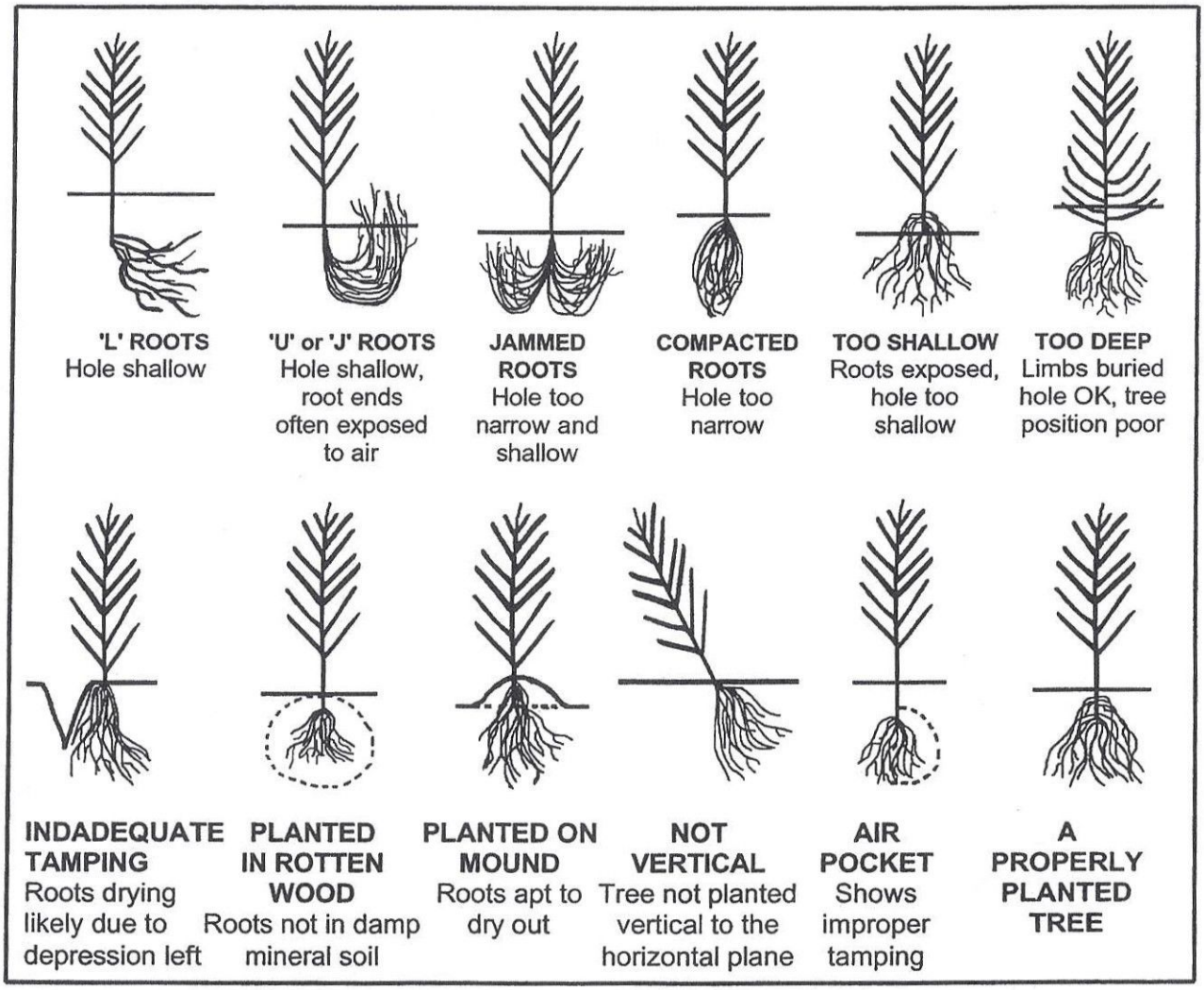


Figure 6: Examples of Improperly Planted Trees.

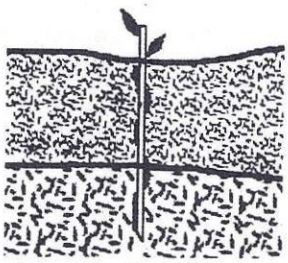


Figure 7: Unrooted Cutting

Planting - Container-grown Stock

Remove container stock from the pots or blocks, wire baskets, etc. in which they were grown, if not already done by the nursery. Balled and burlap stock can remain in the burlap ball but all ties must be removed from around the trunk and the burlap rolled back off the top of the ball, once placed at the proper depth in the planting hole.

Container-grown stock should be planted so the top of the root ball or plug is covered with one-half inch of soil (see Figure 8).

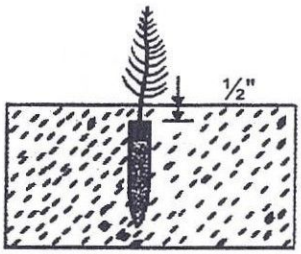


Figure 8: Container-grown planting depth

During planting ensure that the root ball stays moist. Do not soak in water.

If containers did not prevent formation of girdling roots, tree or shrub roots should be gently manipulated to straighten them out.

Planting - Natural Regeneration

This method should only be attempted within the 10-50 year flood plain of the following stream systems.

- All perennial streams and tributaries of the Big Sioux River in the counties within MLRA 102A and 102B.
- Scattered segments of the James River.

At least 2 species of seed trees should be within 200 yards of the seeding site, preferably upwind for ash, boxelder, cottonwood, or basswood. Wildlife or floodwaters will often bring in other species of trees and shrubs.

At least two seed producing (nearly mature or mature) trees, within 200 yards of the planting site, are needed for each acre of the planned seeding site.

Refer to Natural Regeneration - Site Preparation for guidance in preparing the planting site prior to seed dispersal.

Planting - Direct Seeding

Until more data on the viability of this planting method in South Dakota becomes available, review and approval of each site, planting plan, and maintenance schedule will have to be obtained from the NRCS state forester.

MAINTENANCE AFTER PLANTING

Control of competitive vegetation after planting

Competitive vegetation shall be controlled for a minimum of three years, and thereafter as needed to successfully establish the tree planting. Competitive vegetation includes competitive annual and perennial broadleaf and grass weeds, aggressive sod forming grasses, and alfalfa.

Aggressive sod-forming grasses such as smooth bromegrass, reed canarygrass, quackgrass, or deep-rooted legumes such as alfalfa or sweet clover should be kept from the tree or shrub area for the life of the planting.

Utilize herbicides, mowing, or tillage to prevent invasion of aggressive sod-forming grasses and weeds, throughout the planting, and until tree canopies begin to close.

Control of unwanted vegetation should continue until weeds do not threaten the growth and function of the trees and shrubs.

Based on the vegetative conditions encountered and site preparation method used to prepare the tree planting area, select appropriate alternatives from the following.

Row Crop and Small Grain sites shall have competitive vegetation in the tree planting controlled. Select one or more method from each component of weed control below: in-row

weed control, and weed control between the tree rows.

In-row weed control

a) Hand hoeing.

b) Tractor-mounted row hoes, rototiller, or other small tillage device.

c) Use an appropriate herbicide to control competitive vegetation in a two-foot band adjacent to each side of the tree row or a four-foot diameter circle around each tree.

d) Polypropylene fabric mulch in rolls or fabric squares installed according to requirements found in **Synthetic Mulch (Fabric) Weed Control** starting on page 13 of this document.

e) Organic mulch consisting of clean corncobs, woodchips, or bark. Do not use hay or straw mulch as these materials harbor rodents that can girdle the trees. Refer to the Mulching standard (484) for other requirements when installing these types of organic mulch.

Weed control between the tree rows

a) Clean cultivation with a spring tooth harrow, sweep chisel plow (duckfoot), disk (tandem disk only) shovel cultivator, or other tillage implement. Use caution when tilling around trees and shrubs. Poor tillage techniques (too deep, too close to the trunk) can damage trunks, limbs and roots. Tillage depth shall be no more than two-to-three-inches to avoid damage to tree roots.

b) Herbicides may be used on the entire tree planting area to control competitive vegetation. If this method is used, caution must be taken to avoid erosion and concentration of the chemicals from runoff or damage to trees from drift or overspray. When using herbicides, always follow label instructions.

c) If weed control fabric is applied for in the tree row weed control, mow the weeds between fabric strips approximately once each month during the growing season.

d) If soil erosion and/or wind blasting of young trees is a problem, plant a cover crop or herbaceous wind barrier such as grain or forage sorghum. At least four feet shall be left between the cover crop and the tree row. Manage the cover to prevent grain production.

e) If soil erosion and/or wind blasting of young trees is a concern mow the weeds between the rows approximately once each month during the growing season. A sparse cover of annual weeds or grasses, outside the four-foot wide weed free zone, may benefit the windbreak by trapping snow, cooling the soil surface, and controlling erosion.

Sites with grass, alfalfa, or other herbaceous cover (sod) shall have competitive vegetation controlled by a combination of methods as outlined below, depending on the site preparation method used. One or more of the following methods from each component of weed control will be selected: in-row weed control and weed control between the tree rows.

Entire area tilled or treated with herbicides prior to planting

In-row weed control

a) Hand hoeing.

b) Tractor-mounted row hoes, rototiller, or other small tillage device.

c) Use an appropriate herbicide to control competitive vegetation in a two-foot band adjacent to each side of the tree row or a four-foot diameter circle around each tree.

d) Polypropylene fabric mulch in rolls or fabric squares installed according to requirements found in **Synthetic Mulch (Fabric) Weed Control** starting on page 13 of this document.

e) Organic mulch consisting of clean corncobs, woodchips, or bark. Do not use hay or straw mulch as these materials harbor rodents that can girdle the trees. Refer to the Mulching standard (484) for other requirements when installing these types of organic mulch.

Weed control between the tree rows

a) Clean cultivation with a spring tooth harrow, sweep chisel plow (duckfoot), disk (tandem disk only) shovel cultivator, or other tillage implement. Use caution when tilling around trees and shrubs. Poor tillage techniques (too deep, too close to the trunk) can damage trunks, limbs and roots. Tillage depth shall be no more than two to three inches to avoid damage to tree roots.

b) Herbicides may be used on the entire tree planting area to control competitive

vegetation. If this method is used, caution must be taken to avoid erosion and concentration of the chemicals from runoff, or damage to trees from drift or overspray. When using herbicides always follow label instructions.

c) Mow the weeds between the rows approximately once each month during the growing season.

In riparian zones or on erosive sites with native grass, strips are tilled or sprayed with herbicides prior to planting

In-row weed control

a) Hand hoe or weed around each tree.

b) Tractor-mounted row hoes.

c) Use an appropriate herbicide to control competitive vegetation in a two-foot band adjacent to each side of the tree row or a four-foot diameter circle around each tree.

d) Rototill at least a 24-inch wide strip, 2-to-3-inches deep along each side and in the row approximately once each month during the growing season.

e) Polypropylene fabric mulch in rolls or fabric squares installed according to requirements found in **Synthetic Mulch (Fabric) Weed Control** starting on page 13 of this document. NOTE: If the tree planting is strip planted in aggressive sods on very erosive sites, this method must be used.

f) Organic mulch consisting of clean corncobs, woodchips, or bark. Do not use hay or straw mulch as these materials harbor rodents that can girdle the trees. Refer to the Mulching standard (484) for other requirements when installing these types of organic mulch.

Weed control between the tree rows

a) Use appropriate herbicides to minimize weed growth.

b) Mow between the rows approximately once each month during the growing season.

Very erosive sites (slopes = 7 percent or more, or "I"=134 or greater) may utilize existing native grass cover to reduce erosion and runoff, prevent sandblasting, and improve wildlife cover.

If needed, the warm season native grass species: blue grama, buffalograss, and/or sideoats grama may be seeded between tree/shrub rows to control erosion.

When using native grasses between the rows, it is essential that a weed free zone of at least four feet be maintained around each tree or shrub (two-foot radius around the trunk) for the first three years after planting. In western South Dakota, it is best if the weed free zone is maintained by the use of tree mulch fabric.

Warm season native grass species initiate growth after trees and shrubs have leafed out, reducing early season competition for water. These warm season grass species are shade intolerant and will be suppressed as growing tree and shrub canopies shade the ground. In no case should a sod-forming cool season grass be substituted for these species.

Short warm season grasses are particularly effective between fabric strips. Without tillage between the fabric strips, there is no risk of the fabric being hooked and torn out by a tillage implement.

The following pure stand seeding rates are to be used for designing the between row grass seeding. Reduce rates by the appropriate percentage when using a mix of these grasses.

Blue grama 1.3# PLS (Pure Live Seed) per acre

Buffalograss 26# bulk seed per acre

Sideoats grama 5.7# PLS per acre

Mow between the rows at least once a year at the appropriate time of the growing season when non-desirable species begin to invade.

Organic Mulches

Mulches are most effective when maintained to the drip line of the tree or beyond. For newly planted stock, they should be placed in a three to four foot diameter circle around each plant to a depth of about four inches. When mulching shrub rows, mulch can be applied in a contiguous four-foot wide band (two feet each side of the plants).

In situations of higher precipitation, frequent irrigation or on tighter, wetter soils, it may be prudent to maintain a four-to-six-inch mulch-free circle around each trunk to minimize potential trunk problems. In high moisture situations, mulch against the trunk can hold moisture and encourage bacterial growth resulting in bark injury, which can shorten the life of the tree.

Synthetic Mulch (Fabric) Weed Control

Fabric shall be of such quality that the manufacturer warrants complete weed control for at least five years.

Fabric must be black or capable of preventing underlying plant growth.

Fabric may be pin-punched polyethylene, woven polypropylene, or some other rot-resistant material. It must prevent plant shoots from pushing through from below.

The minimum width for continuous rolls of fabric applied by machine will be six feet; nominal four feet width after installation. Roll fabric thickness is a minimum of 14 mil. Individual fabric squares may be as small as a four-foot square since the full four feet, when stapled or pinned, effectively prevents weed growth.

Consider searing fabric edges on home-cut individual squares of woven fabric to prevent fabric edges from running or being hooked by maintenance equipment.

Consider that some types of fabric, in particular some of the pin-punched types and polyethylene are prone to puncturing by animal hooves (deer, antelope, etc.) which allows weeds to emerge, reducing the effectiveness of the fabric.

Consider not using fabric on suckering shrubs where a dense thicket is desired.

Fabric Installation – All methods

Tilled sites should be firmed and leveled in such a way that the fabric will lie flat against the ground across the entire area covered by fabric. Sites should be firmed to barely show an adult footprint, prior to planting (see Figure 9.)

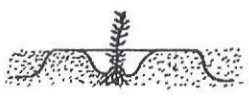
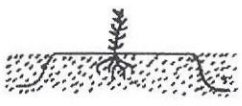
Improper Weed Control Fabric Installation	Proper Weed Control Fabric Installation
	
Tree planted in furrow; Fabric bridged over limbs; this creates an "oven." Plants can be killed by heat.	Fabric flush to ground surface. All limbs above fabric. Soil around tree is cool and moist.

Figure 9: Improper & Proper Fabric Installation

Fabric should not be bridged over ridges or valleys left by planting operations. Fabric not flush to the ground around the tree can provide a runway for rodents and trap summer heat sufficient to damage or kill the young plant.

If fabric is installed under a no-till situation, excessive vegetation should be removed from the area where fabric will be placed, to reduce rodent habitat and to allow the fabric to lie flat against the soil surface.

Fabric mulch installation shall occur no later than 30 days after trees are planted to insure adequate weed control and/or water conservation. For best results, the fabric should be installed right after the trees and shrubs are planted.

Fabric mulch will be centered over planted trees. Openings for trees or shrubs shall be cut with a sharp instrument to avoid tearing of fabric or "running" of individual fabric fibers.

Openings shall be X-, C-, L-, or J-shaped. Length of slit should not exceed 12 inches. Do not use straight slits as abrasion of tree bark can occur.

When fabric is placed over plants before openings are made, use care to avoid cutting the plant when making the opening. Trees and shrubs must be pulled through the fabric as soon as possible (within five minutes) after installation to avoid damaging temperatures created by the fabric "oven."

Ensure that edges of fabric are firmly anchored either by soil or staples placed every 3-to-5-feet along the edge.

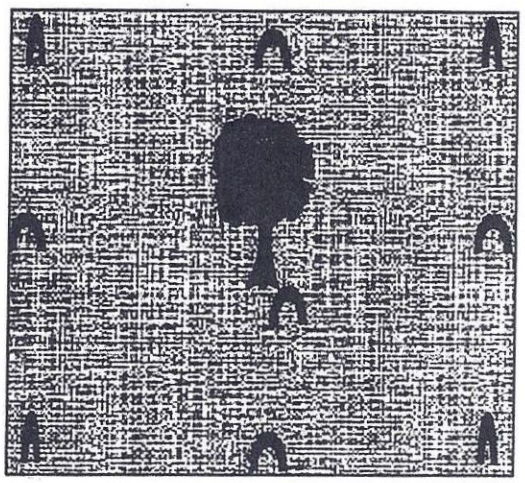
Fabric is not recommended within flood plains. One flooding event could cover the fabric with silt, eliminating its effectiveness, or flood flows could tear out the fabric.

Do not cover weed control fabrics with organic mulches or gravel. These materials will delay the breakdown of the fabric, possibly causing girdling damage to the plant, and providing a medium in which weeds can flourish.

Installation of Individual Fabric Pieces

Individual fabric pieces shall be at least four-foot square or four-feet in diameter.

Individual Fabric Square



Position of pins, staples, or rocks for all fabric sizes.

Positions of additional pins, staples, or rocks for five and six foot fabric sizes.

Figure 10: Positions of staples, pins or rocks for individual fabric squares.

Use landscape fabric staples, pins, or rocks to anchor fabric. Do not use soil to anchor individual fabric pieces. Individual rocks should weigh at least five pounds to resist being moved by wind or water.

Four-foot fabric squares shall have each corner anchored. Five-and six-foot squares shall have each corner and the midpoint of each side anchored, as well as an anchor point near the tree or shrub (see Figure 10).

Pins or staples shall be of sufficient length to resist movement, based on soil textures. Follow manufacturer recommendations for staple length.

Installation of Continuous Fabric Strips.

Site preparation, if tilled, shall be at least eight feet wide to allow enough loose soil to properly anchor fabric.

Fabric strip splices shall be anchored with staples, pins, or rocks. Staples and pins shall be of a length recommended by the manufacturer for the particular soil texture. Rocks must weigh at least five pounds. Do not anchor splices with soil. When splices are made with field-cut fabric ends consider tucking a few inches of the cut end under itself to reduce the risk of snagging the fabric with maintenance equipment.

About every 10 feet, or between each tree, whichever is greater, the fabric should be anchored with pins, staples or rocks. In lighter soils, or in high wind areas, an additional pin staple or rock may be needed near each opening in the fabric (see Figure 11).

Machines must be adjusted to ensure 10-12-inches of fabric edge are firmly anchored in the soil (see Figure 9). After installation, it is often necessary to run a tractor wheel over the edge of the fabric to get a firm seal.

Check-dams across the furrow or slight grading of the site may be necessary on sloping land to prevent water from running along the edge of and uncovering the fabric.

Where fabric crosses larger waterways or areas of concentrated flows, the fabric shall be spliced on either side of the waterway. This is to prevent heavy runoff events from washing out an entire strip of fabric and potentially damaging 300-500 feet of tree row. The smaller spliced section may still wash out but only a small amount will have to be repaired or replaced.

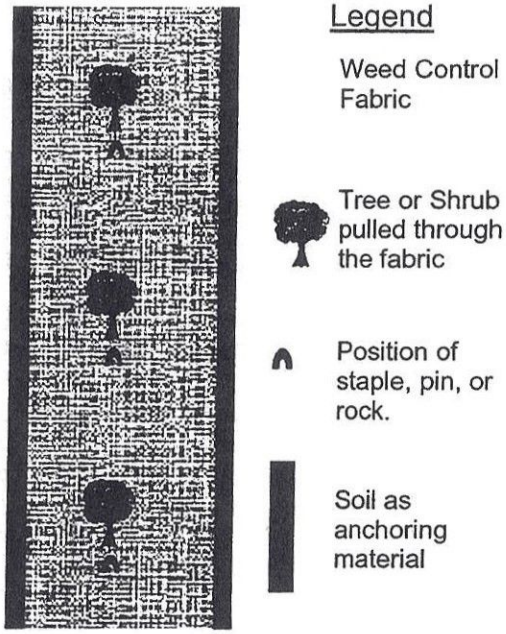


Figure 11: Position of staples, pins, or rocks for continuous fabric strips.

Pins or staples, instead of soil, may be used to anchor the fabric edges. The fabric must lay flat against the soil and the pins or staples must be placed every three to five feet along the fabric edge.

On sites exposed to extremely high winds or on loose soil, the pins or staples may need to be closer than three feet.

When installing fabric on curves, use extra care to ensure that 10-12-inches along each edge gets covered and packed with soil. Ensure that the fabric is not so tight that temperature changes pull the fabric loose. Use pins, staples, or rocks to tack excessively large "puckers" to prevent wind damage.

Where fabric is desired on a curved planting with a short radius, it may be better to break the curve into short, straighter segments to ensure better quality and easier fabric installation.

Management of Fabric Following Installation

While annually checking the survival, vigor, and form of the trees and shrubs, inspect the fabric to:

- Ensure all fabric edges are firmly anchored.
- Ensure openings in fabric are not damaging trunks.
- Remove weeds, soil, or clippings that may have accumulated on the fabric before they become a rooting medium for weeds.

If tilling between fabric pieces, use extreme caution to avoid hooking fabric with tillage tools. Damage to trees and/or fabric may result. Control erosion in the tilled areas to prevent silt from accumulating on fabric.

If mowing between fabric pieces, do not allow herbaceous matter to accumulate on the fabric. Such accumulations will initiate germination of weeds and grasses, reducing the usefulness of the fabric.

Strongly rhizomatous grasses, such as smooth brome, quackgrass, or reed canarygrass along the perimeter of the fabric piece must be suppressed or controlled with tillage, or herbicides. If not controlled, their extensive root systems will suppress tree growth, even with fabric.

Every few years closely examine the areas where plants grow through the openings to ensure the fabric is not girdling the plant. Fabric in the shade of the plants will last much longer than the manufacturer's minimum life span. Fabric openings may have to be enlarged as tree stem diameters increase to prevent girdling and death of the tree. A linoleum knife or a utility knife on a long handle using hooked shingle blades, or a similar tool, will work well to enlarge the openings.

Replanting

Any tree or shrub that fails within the first three years should be replaced with a similar plant. Replanting is essential to maintain the intended function of the planting and should be compatible with soils and climate. Growth rates of most replants (when replanted within 3 years of the original planting date) are usually such that little if any size difference is noted, across the planting, after 10 years. Delays in replanting of longer than three years will allow adjacent established tree roots to create greater competition to the replants, resulting in slower growth. On some sites with older established plantings (over 15 years old), replants rarely put on substantive growth or function as desired.

Figures 13a and 13b illustrate two different ways of staking trees. The wires and ties used in staking should not be so tight that the tree can not move at all. Some movement is desirable. The stakes are to restrict movement during high winds that could uproot the tree.

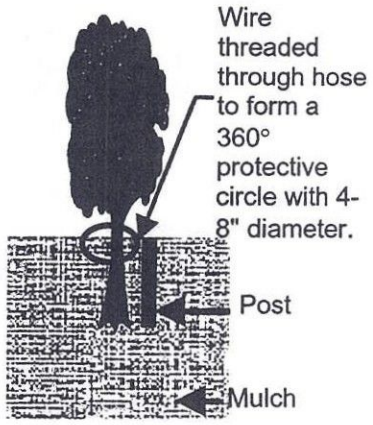


Figure 13a: Staking with One Post

Ties and posts should be positioned in such a way that the tree trunk or limbs will not be abraded against the post(s). When using steel fence posts, orient the steel plate on the posts parallel to a line between the tree and the post to minimize damage to roots when the post is removed. When using the single post method, place the post on the prevailing wind side of the tree.

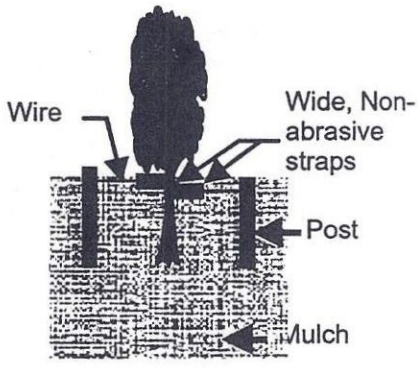


Figure 13b: Staking with Two Posts

Tipped Trees

Trees older than two-to-five-years that have been tipped due to high winds and saturated soils can rarely be pulled back straight, nor will they likely develop a strong, supportive root system. Establish a new planting near the one that has been damaged. Once the new planting is established and functioning as intended, the damaged planting can be removed. Younger trees, not older than 5 years and not tipped more than 30 degrees, may be pulled back straight immediately after the storm event while the soil is saturated and staked for 1-2 years. These straightened, young trees may develop a root system strong enough to withstand future strong winds. Trees tipped more than 30 degrees will most likely never develop wind hardiness.

REQUIRED SURVIVAL PERCENTAGE

To determine when a planting can be labeled a success, refer to Table 1. Required survivability of individual plants will vary as the purpose of the planting varies. Wildlife plantings can function perfectly well with considerably more missing trees and shrubs than can a windbreak. Table 1 presumes that the proper numbers of trees were planted originally, according to a sound design.

Table 1 - Required Survival Percentages For a Successful Tree Planting

Inventoried after "leaf out" during spring or summer of the second year (% of number planted)

Practice	Percent Survival
380 - Windbreaks / Shelterbelt Establishment Sound Barrier Visual Screen Airborne chemical drift Wind borne dust barrier Living snow fence	85 percent of all trees or shrubs planted with no two adjacent plants missing
391 Riparian Forest Buffer	75 percent of all trees or shrubs planted
422 Hedge Row Planting	
612 Tree / Shrub Establishment	
580 Streambank/Shoreline Protection 644 Wetland Wildlife Habitat Management	50 percent of all trees or shrubs planted, unless specific sites require a higher survival percentage
645 Upland Wildlife Habitat Management	

ADDITIONAL INFORMATION:

"Common Insect Pests of Trees in the Great Plains," Great Plains Agricultural Council Publication No. 119.

"Diseases of Trees in the Great Plains," Rocky Mountain Forest and Range Experiment Station, General Technical Report RM-129.

"Windbreaks for Conservation," USDA Natural Resources Conservation Service, Agricultural Information Bulletin 339.

Please note that all the Internet links included in this document were current at the time of publication. Since then, some sites may not be currently maintained.

"Pruning Trees and Shrubs"
http://www.ext.nodak.edu/extpubs/plantsci/trees/h1036w.htm

"Deciduous Tree Diseases"
http://www.ext.nodak.edu/extpubs/plantsci/hortcrop/pp697-1.htm

"Common Insect Pests of Trees and Shrubs in North Dakota
http://www.ext.nodak.edu/extpubs/plantsci/trees/e296w.htm

"Diseases and Related Problems of Evergreens"
http://www.ext.nodak.edu/extpubs/plantsci/trees/pp789-1.htm

"Insect and Disease Management Guide for Woody Plants in North Dakota"
http://www.ext.nodak.edu/extpubs/plantsci/trees/f1192w.htm

"Windbreak Establishment", University of Nebraska Extension EC 91-1764-B.
http://www.unl.edu/nac/brochures/ec1764/ec1764.pdf

"Windbreak Management", University of Nebraska Cooperative Extension EC 96-1768-X.
http://www.unl.edu/nac/brochures/ec1768/ec1768.pdf

"Windbreak Renovation" University of Nebraska Cooperative Extension EC.98-1777-X
http://www.unl.edu/nac/brochures/ec1777/ec1777.pdf

For the most complete reference on wildlife damage and control in North America, refer to "Prevention and Control of Wildlife Damage" by Hygnstrom, Timm, and Larson, and published by the University of Nebraska Cooperative Extension Service. A version that can be downloaded can be found at
http://wildlifedamage.unl.edu/