CONSERVATION PRACTICE SPECIFICATION
Windbreak/Shelterbelt Renovation – 650

When properly applied, windbreak renovation can:

- Restore the function of an existing windbreak
- Modify the function of an existing windbreak
- Increase the health and vigor of selected windbreak plants
- Increase the longevity of a windbreak

Depending upon the renovation method chosen, some or all of the following practice standards or technical documents may be required when developing a windbreak/shelterbelt renovation plan.

- County-specific windbreak suitability groups for each soil type are found in county specific Interpretive Tables in FOTG – Section II – Soil Information.
- "Tree Care and Management" is found in FOTG – Section I – Reference Subjects – Windbreaks and Woodland.
- "Expected 20-Tree Heights" by Windbreak Suitability Groups is found in FOTG – Section II – Windbreaks and Forest.
- "Tree and Shrub Characteristics" is found in FOTG – Section I – Reference Subjects – Windbreaks and Woodland.
- "Tree/Shrub Pruning – 660." All conservation practices are located in FOTG – Section IV – Conservation Practices.
- "Windbreak/Shelterbelt Establishment – 380."

Caution: Several windbreak renovation methods involve substantial soil disturbance at depths below typical agricultural tillage. If the depth of disturbance will exceed 18 inches, notification of various utility companies via the North Dakota One Call System at 1-800-795-0555 is required.

Several of the windbreak renovation methods are considered undertakings per Section 106 of the Federal Historic Preservation Act and will need to be investigated and assessed accordingly.

Detailed purposes, descriptions and techniques for each renovation method are described below. Following the windbreak renovation descriptions and techniques is a symptom key that can be used to determine which renovation method may be most applicable for a particular windbreak.

Windbreak Renovation Purposes

Coppicing can be used to:

Increase windbreak density or hasten within-row closure on newly established shrub rows. Rejuvenate broken-down shrubs that have become "leggy" but retain a healthy root system. Rejuvenate many species of deciduous trees that are experiencing top dieback but still have a healthy root system.

Gap Planting can be used to:

Restore windbreak function or effectiveness.

Natural regeneration can be used to:

Maintain age and species diversity.
Maintain or improve windbreak densities.
Maintain or improve windbreaks for wildlife.

Pruning can be used to:

Reduce the density of a windbreak.
Correct improper branching on newly planted stock.
Correct storm, animal, or agricultural damage to trees or shrubs.
Provide agroforestry products.

Root pruning can be used to:

Reduce windbreak competition to crops immediately adjacent to the windbreak.
Provide a temporary zone of reduced competition for replacement trees within or adjacent to an existing windbreak.

Row removal and replacement can be used to:

Remove dead and dying tree and shrub rows.
Provide a site for replacement plantings within an existing windbreak.
Remove part of an even-aged planting to allow for a diversity of age classes.
Provide agroforestry products.
Alter windbreak composition or density.

Shearing can be used to:

Increase windbreak density.
Reduce spread or extent of the windbreak.
Shape the windbreak to meet a specific objective.
Shape conifers for Christmas trees (agroforestry products).

Sod release and management can be used to:

Release trees and shrubs from herbaceous competition.
Extend the life of the windbreak.
Prepare the site for other renovation methods.

Supplemental planting (intra-planting) can be used to:

Improve windbreak density.
Improve species and age class diversity.
Improve wildlife habitat.
Expand a windbreak.

Thinning can be used to:

Alter windbreak density.
Reduce competition to adjacent trees.
Provide agroforestry products.
Manage snow moisture more effectively.

Underplanting (interplanting) can be used to:

Increase species diversity.
Increase windbreak density, especially lower densities.
Improve windbreak characteristics without expanding windbreak acreage.

Windbreak Renovation Descriptions and Techniques

Renovation recommendations will be site-specific to match landowner objectives, site potential, and the composition and condition of the existing windbreak. Some renovation methods may

only need to be applied on an infrequent basis, while others will need regular repetition in order to maximize the benefits.

Coppicing

Coppicing is the removal of the top growth on deciduous trees and shrubs in order that the root systems can initiate healthy vigorous sprouting to improve or restore the function of the windbreak. This technique is applicable to most deciduous shrubs and many of the deciduous trees. Care must be taken to prevent injury to stem, root collars and roots. Cuts should be clean with no ragged ends. Bark of the residual stumps should not be damaged or stripped. Do not use rotary mowers, as they do not produce a clean, non-torn cut. The clipping operation should be done in mid to late winter before any leaf emergence.

For newly planted shrubs, 1-2 years old, existing above-ground stems may be cut off at a 6-8 inch height. This will encourage faster row closure and increased density within the planting. A wide variety of tools can be used to cut off above-ground stems including; sickle bar mowers, hedge clippers, etc.

For older shrub rows, coppicing is an effective way to remove the old, "leggy" material that has lost its windbreak effectiveness. The most commonly used tools to remove older stems are chain saws and power pole pruners. When working on larger shrubs try to leave 6-8 inch stumps above the root collar.

For most shrubs with healthy root systems, re-growth the first year will often reach 30-50% of the precut height.

Figure 1 illustrates 3 different phases of a coppiced shrub renovation.

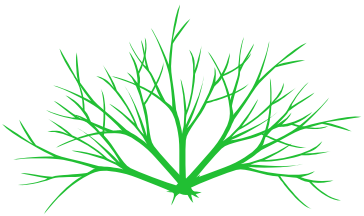


Figure 1a: Leggy, over-mature shrub prior to coppice renovation.

Figure 1b: Top growth removed. 6-8 inch stump remains.

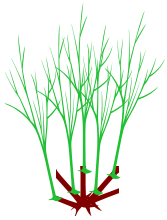


Figure 1c: First year coppice re-growth.

Successful coppicing of older shrubs is dependent upon the shrubs having a reasonably healthy root system. Shrub rows with many gaps, evidence of diseases, and exhibiting minimal annual growth for the past several years may not be suitable candidates for coppice renovation. In these situations coppicing, if used, will need to be supplemented with new plantings.

When using pole pruners or chainsaws, be sure to understand the safe operation requirements of these tools. Wear proper safety equipment. When uncertain of personal skills and abilities, rely on trained professionals to perform the task.

Because of the nature of old shrub rows, chainsaws and pruners will often "bind" in the cut. Using wide loader buckets or other means to take the tension off the stems and "lean" them all one direction will reduce the amount of binding that will occur. Cutting can then proceed on the "up" side of the leaning material. Exercise caution when using saws and pole pruners around tractors and loaders.

Certain deciduous trees exhibit strong tendencies towards coppicing after the main stem has been removed. To determine which species have the greatest chance of being successfully renovated via coppicing, see "Tree and Shrub Characteristics". Deciduous trees shall be cut off to a height of 1-4 inches to encourage a strongly attached sprout arising from the root collar rather than as an advantageous sprout arising from higher locations on the stump.

As with shrub coppicing, care must be taken to prevent injury to the tree stem, root collars and roots. Cuts should be clean with no ragged ends. Bark of the residual stumps should not be damaged or stripped.

Removing the top growth from trees is usually accomplished with chainsaws or specialized tools mounted on skid loaders or tractors. When using chainsaws to fell larger trees, ensure that proper techniques and safety equipment are used. If in doubt, hire someone with the necessary skill, experience, and equipment.

One main difference between coppice regeneration on shrubs versus coppice regeneration on trees is the required maintenance during the first few years after re-growth. In most cases, regenerated trees will require pruning multiple stems to leave only one or two stems per stump prior to the second to fourth growing season.

Select the stem(s) with the best form for the particular species that will meet landowner objectives. Remove remaining sprouts using proper pruning methods. Properly attached sprouts are usually those closest to the ground or arising from the root collar or immediately adjacent roots. Avoid keeping sprouts that are attached high on the stump as they tend to break easily with wind or snow. Waiting a year or two before pruning will allow weather and other site conditions to naturally prune out some of the weaker stems and make it easier to determine which sprouts are the best to leave.

Proper pruning techniques are illustrated and described in "Pruning Trees and Shrubs" http://www.ag.ndsu.edu/pubs/plantsci/trees/h1036.pdf and in Tree/Shrub Pruning - 660.

See figure 2 for illustrations of coppicing deciduous trees.

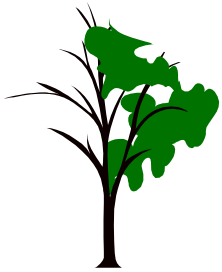


Figure 2a: Tree in a state of decline needing renovation.

Figure 2b: Top removed, leaving 4-6" stump with healthy roots.

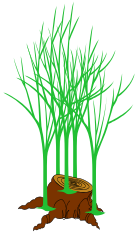


Figure 2c: Stump with multiple sprouts first or second year after main tree removal.

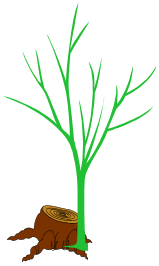


Figure 2d: Best sprout selected. Other sprouts pruned in year 3 or 4 after main tree removal.

Gap Planting

Gap planting is the planting of trees or shrubs to fill openings in otherwise healthy windbreaks. Successful gap planting is dependent upon effective weed control, species selection, and water management.

- For all windbreaks needing gap planting:

  Select species appropriate for the soils at the location of the opening in the windbreak. It may have been a soil-related problem that caused the original plants to die.

  Control herbaceous vegetation for one growing season before planting. Be especially diligent in killing perennial sod.

  Establish replacement stock at a spacing appropriate for the species being replanted. See Table 1 of "Windbreak Shelterbelt Establishment" for within-row spacings.

Control weeds after planting with fabric, herbicides, mulch, or tillage. Weed control on plantings to fill gaps is critical since nearby trees and shrubs are competing with the new plant for moisture and nutrients. The newly planted tree or shrub often will not withstand losing additional moisture to weeds. Refer to pages 11-15 of Tree Care and Management for weed control details. Control of aggressive sods and weeds may be needed for many years until replants reach a size to effectively compete with the larger windbreak trees or shrubs.

- For windbreaks less than 5 years old needing gap planting:

  Plant the desired species, either conservation grade stock or larger, at spacings appropriate for the species and the windbreak purpose.

  Refer to pages 3-11 of "Tree Care and Management" for stock handling and planting guidelines.

  Add 10-20 gallons of water every 2 weeks for the first year, when soil around the new plant is dry. Apply in such a way as to thoroughly saturate the root zone of the new tree or shrub.

- For windbreaks over 5 years old

  If site conditions allow, consider root pruning to reduce competition from existing trees or shrubs.

  Pruning or coppicing existing trees may be necessary to reduce shade on new plants.

  Plant new trees or shrubs at a spacing appropriate for each species and windbreak purpose.

  Supplemental water is essential to the successful establishment of replacement trees or shrubs in older windbreaks. Check soil moisture weekly and, provide 20-50 gallons water to each tree or shrub if the soil is dry. Apply in such a way as to thoroughly saturate the root zone of the new tree or shrub.

Natural Regeneration

Natural regeneration is managing the naturally occurring seedlings that develop within the understory of some windbreaks to improve windbreak function. Species such as green ash, basswood, eastern redcedar, honeysuckle, chokecherry, Russian-olive, and buffaloberry will often regenerate naturally within windbreaks.

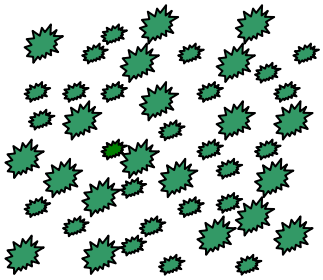
Presence of naturally regenerated trees and shrubs is largely dependent upon the site. Natural regeneration rarely occurs in single-row windbreaks. Full shade, thick sods of grass, or long-term aggressive tillage will often limit the extent of natural regeneration. In North Dakota there is a marked decline in natural regeneration as normal precipitation is reduced from 22 inches to 14 inches from east to west across the state.

Managing natural regeneration usually means thinning competing woody vegetation re-growth in the understory to the desired spacings and controlling herbaceous weeds. Occasionally it involves removing some of the overstory to open the canopy and allow more sunlight to reach the younger plants.

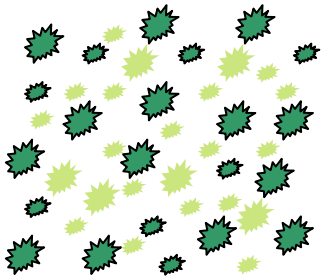
Herbaceous vegetation shall be controlled whenever it begins to adversely affect tree and shrub growth and vigor. Thinning of woody plants can begin once they attain a 3-4 foot height. Plant-to-plant spacings after the thinning operations are dependent upon the purpose of the windbreak.

Generally a residual plant-to-plant spacing of 12-18 feet for large trees, 8-14 feet for medium height trees, and 4-6 feet for the shrub species is appropriate. Mature plant size can be found in "Tree and Shrub Characteristics." These suggested spacings are a bit wider than those for a new windbreak planting, but since thinning operations are so labor intensive, the wider spacings will allow the effects of the thinning to last longer.

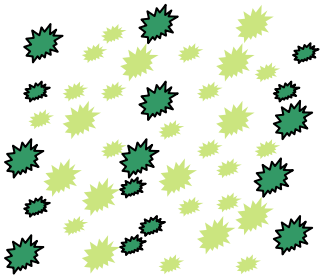
Management of natural regeneration can result in a windbreak that appears to have rows, or it can be managed to look totally natural (no noticeable rows.) See figure 2.



Figurer 2a: Naturally regenerated stand prior to thinning.



Figurer 2b: Naturally regenerated stand, thinned to look natural.



Figurer 2c: Naturally regenerated stand, thinned to rows.

Generally the easiest way to perform a thinning operation in a naturally regenerated windbreak is to walk through the windbreak and mark (with paint or flagging) the plants to be left. Select those plants with the best form for the species that are located approximately where needed to give the desired plant-to-plant spacings. Try to retain a diversity of species when marking for thinning. Remove the remaining plants and saplings.

Removal of unwanted saplings can be done with loppers, axes, chainsaws, powered brush trimmers or pole pruners, etc. In most cases the freshly killed stumps of deciduous species will resprout. To prevent re-sprouting, apply the appropriate herbicide at the correct time. Some herbicides may translocate through root grafts to nearby plants of the same species. Be sure to follow all label directions and precautions. Without chemical stump treatment, thinning operations may have to be performed 2-3 times on the same plant until the residual saplings have attained sufficient height to outgrow the competition.

Where appropriate, consider leaving a few of the larger snags for den trees and roost sites. If compatible with landowner objectives and local ordinances, pruned material could be stacked and left in brush piles for additional wildlife habitat.

Pruning

Pruning is the precise removal of selected branches from trees. For most tree species new tree limbs will not grow from the area pruned, unless pruning was performed incorrectly or the trees were under severe stress. Pruning techniques shall follow the guidance of Tree/Shrub Pruning – 660 or "Pruning Trees and Shrubs."

Pruning to alter windbreak densities will often need to be repeated at a later date to maintain the desired benefits. Remaining tree limbs will often grow (spread) to fill the space left by the pruning.

- Pruning to reduce windbreak density can be done in two ways.

  The first method involves removing all limbs from all trees to a certain height, usually 3-5 feet above the ground. This type of pruning is usually done on field windbreaks to address snow distribution. The result is a windbreak with the same density above the pruned area and essentially no density for the height of the pruning. After a field windbreak has been pruned in this manner, the downwind snowdrift will usually be wider, shallower, and farther away from the tree row. The down side to this method is that the protection to the crop during the growing season will be reduced, especially near the tree row. Wind velocities may be increased somewhat over open field velocities immediately adjacent to the pruned tree row, which may increase wind erosion risks. See figure 3 for the effects of this style of pruning on snow deposition.

The second method involves removing selected limbs throughout the canopy to reduce

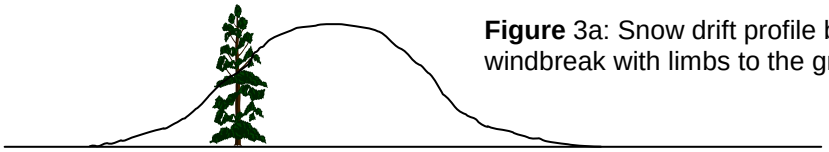


Figure 3a: Snow drift profile behind dense windbreak with limbs to the ground.

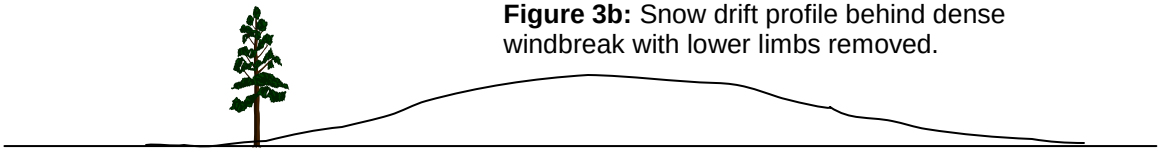


Figure 3b: Snow drift profile behind dense windbreak with lower limbs removed.

overall density of the windbreak to a desired level. This method will look more natural and would be very appropriate where windbreaks are protecting specialty crops that need the proper mix of airflow and protection. It is considerably more labor intensive and would have to be performed more often than the first method.

The zone of protection downwind from a windbreak pruned in this manner would be more uniform than for a windbreak pruned from the bottom up, though snow distribution patterns will be similar.

Best time for either type of pruning is when trees are dormant. (October to February)

Pruning to correct damage or to encourage proper tree form is probably best done whenever the need is noticed. Even though there may be a "best" time to prune, it is usually best to correct problems immediately. If problem-correcting pruning is delayed, the stress to the tree is greater, tree longevity is shortened, and the potential for the operation to be successful is decreased.

Early spring after snow melt is a good time to inspect windbreaks looking for damaged limbs, double leaders and other deformities caused by weather or animals. Using the proper pruning techniques listed at the web sites given above, prune off the damaged parts in a way that encourages rapid callus formation and proper growth forms. Some species, such as green ash, have a strong tendency to form double leaders. Double leaders decrease the longevity and function of the windbreak over time. Pruning to a single leader at the correct time (when limbs are less than one inch in diameter) will result in taller trees that are more wind hardy and will result in fewer limbs falling into adjacent fields. Windbreaks should be examined every year or after every major storm to determine pruning needs.

When scheduling pruning of pine and/or spruce windbreaks, contact local florists, crafters, and others to determine if there is a market for the pruned material. If a market exists for "greens" schedule pruning activities to coincide with market demands.

Root Pruning

Root pruning is a renovation method that severs competing tree roots within the top 18-30" of the soil. Reducing the spread of tree roots reduces the competition to nearby crops or newly planted trees. Root pruning should only be done to one side of a tree or shrub in any given year, to limit the stress to the existing plant.

- Root pruning to reduce crop stress -

  Will usually need to be repeated every 3-4 years to maintain the benefits.

  When performed to reduce crop stress, the root prune line shall be outside the crown drip line of the tree (usually 8-16 feet) to reduce the number and size of tree roots cut and to reduce damage to the tree foliage from the pruning machinery. See figure 3.

For some species of trees, it is best that the root prune line fall within the crop field so that normal cropland tillage or herbicide applications can control the potential re-sprouts from the root pruning.

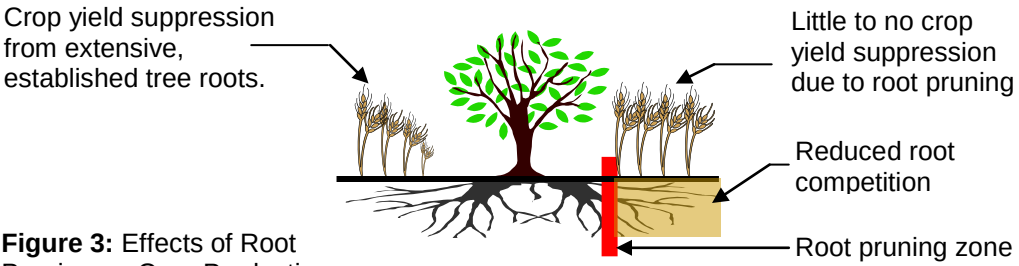


Figure 3: Effects of Root Pruning on Crop Production

- Root pruning to reduce stress to newly planted tree rows. See figure 4.

  Will only provide benefits for 2-3 years.

  The root prune line shall be outside the crown drip line of the tree (8 feet minimum) to reduce the number and size of tree roots cut and to reduce damage to the tree foliage from the pruning machinery.

  Will provide a minimum competition-free zone at least 8 feet wide at planting time.

  Will provide benefits only if adequate weed control is also performed.

  Can increase establishment success when underplanting trees.

  Depending upon species root pruned, root sprouts will need to be controlled.

  Is not as critical if the new tree row is at least 30 feet from the nearest established tree row.

  May be stressful to the remaining windbreak trees.

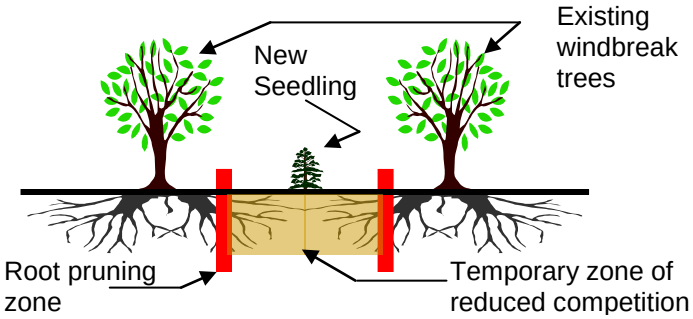


Figure 4: Root pruning to reduce stress on new trees

Row Removal and Replacement

At a minimum this renovation method removes the top growth of dead and dying trees. Traditionally it has often included the removal of stumps and roots and the leveling of the renovation site. Tops may be removed by an assortment of tools and machines such as chainsaws, hydraulic shears, hydraulic saws, PTO-driven saws, dozers, endloaders, etc. Root and stump removal and site leveling are often done with construction equipment or larger agricultural equipment.

In multirow windbreaks where removal and replacement will occur within the windbreak, one additional row will be removed beyond the number of rows to be replaced. Ex: remove 3, plant 2. This requirement is necessary to provide enough growing space for the replacement plantings. This requirement is not necessary in situations, without existing cottonwoods, where existing between-row spacings exceeded 25 feet.

Replacement plants may be planted in, or near the location of the old tree row, or they may be planted in a more distant location as long as the new windbreak(s) protect the same area or acreage.

If new trees or shrubs are to be established in the area of the old windbreak, re-sprouts will be controlled and the site will be fallowed at least one growing season before attempting to plant the new windbreak.

Perennial sod-forming grasses will be controlled for at least one growing season prior to planting the new trees or shrubs.

Tops of American elm and Siberian elm will be disposed of by burning, burying, chipping or debarking to reduce the risk of spreading Dutch elm disease. Elm wood disposal shall occur immediately if removal is during the growing season or before the next growing season if removed during the fall or winter. When this is not possible, disposal should occur within one year after removal.

Other species of woody material may be burned, buried, hauled away or left in piles as long as applicable local and state laws are followed and the disposal method meets landowner objectives. Consider burning, or burying other species if infected with diseases or infested with insects that may spread to nearby trees. Some, but not all of the laws that may apply to row removal and replacement include:

Open burning permit requirements, restrictions and liabilities.

Local ordinances regarding disposal of elm wood.

Potential impacts on cultural resources. NRCS policy lists the procedures to be followed.

Location of buried utilities. NRCS policy lists the procedures to be followed.

In multirow windbreaks where a stand of larger trees will remain after the row removal, consider leaving hollow trees as den sites and a few of the larger dead trees as raptor roost sites.

- Row removal including stumps and roots

  Site will be leveled after removals to allow for planting and maintenance with normally available equipment.

  Planting may be by any method that results in a healthy, vigorously growing tree or shrub. Refer to pages 8-11 of "Tree Care and Management."

  Use extreme caution when replanting sites that have been leveled after stump and root removal. Buried woody debris can be hooked by moving machinery and thrust at people on the tree planter. Ensure protective shields are in place or take other precautions to minimize risks to operators.

- Row removal taking only the tops and leaving the stumps and roots

  Stumps will be left short enough to not impede subsequent management operations.

  Live stumps will be treated with an approved herbicide immediately after cutting to prohibit resprouting. (If resprouting is desired, follow guidance under Coppicing.)

  Planting may be by any method that results in a healthy, vigorously growing tree or shrub. Due to the presence of stumps and roots, planting methods may be limited or must be modified. Often traditional tree planters will function well within a few feet of the stump row, especially when equipped with a coulter. When planting within the old stump rows, hydraulic augers work well to dig the hole, which allows for easy and proper hand planting. See figure 5. Refer to pages 8-11 of "Tree Care and Management." Though the risk of hooking roots that are buried in the soil may be less than on a leveled site, exercise caution and ensure protective shields are in place.

Maintenance operations may have to be modified on sites where new trees have been planted within the old tree row or immediately adjacent to the old tree row. Machine-applied fabric and in-row tillage are often not possible due to the remaining roots and stumps. Hand-placed and pinned fabric, mulching, warm-season grass seedings, herbicides, and careful tillage are alternative weed control methods that are appropriate- depending upon the site.

Continued control of resprouting may be needed for 1-2 years after the initial treatment. Effectiveness of initial treatment is dependent upon species, chemical, time of year, and growth stage of plant.

Figure 5a: Replacement trees hand-planted between dead stumps

Figure 5b: Replacement trees machine-planted close to dead stumps

Shearing

For reduced stress to the plant, reduced debris needing removal, and to reduce machine and labor requirements, shearing should be done as frequently as needed to refrain from cutting twigs and branches older than two years. If the condition of the windbreak has deteriorated to the point that larger limbs need to be removed, refer to Coppicing or Pruning.

Shearing is most often done on conifers managed for Christmas trees but can be effective on deciduous plants. Deciduous plants will often grow faster and require more frequent shearing. Shearing usually will increase windbreak density, no matter the owner's objective.

Shearing shall be done with tools that leave a clean, smooth cut. Damage to main stems and root systems will be negligible. Shearing will not be done with side boom rotary mowers, brush cutters, or flails.

When performed on young succulent branches, shearing can be performed with a wide assortment of tools, such as hedge trimmers, sickle-bar mowers, etc. These types of tools provide desirable, clean cuts, but may be damaged if forced to cut older limbs.

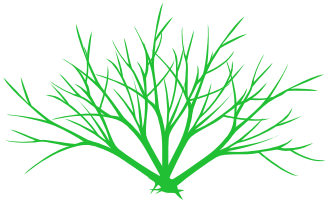


Figure 6a: Shrub with wide spread and tall height

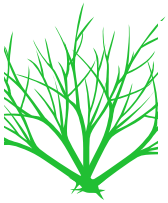


Figure 6b: Shrub sheared to reduce spread

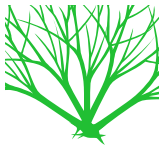


Figure 6c: Shrub sheared to reduce height and spread

- To increase windbreak density

  This application is useful to increase the effectiveness of a windbreak as a visual screen or noise barrier. Final shape and appearance are dependent upon landowner desires and specific plant characteristics.

- To reduce spread or extent of windbreak

  This application can constrain the plants and minimize the amount of land taken out of production. It may also control the tops of windbreaks to allow for effective operations of center-pivot irrigation systems or other uses. See figure 6.

- To shape conifers for Christmas trees or resale.

  Follow the recommendations found in "Christmas Trees, a Management Guide" - Nebraska Cooperative Extension EC 76-1741
  http://www.ianr.unl.edu/pubs/Forestry/ec1741.htm#shape or

  "Shearing Recommendations for Christmas Tree Producers"
  http://web1.msue.msu.edu/aoe/xmas/ncr310.PDF

  When managing a windbreak for Christmas tree production, ensure that the minimum number of trees, and/or tree rows are left to maintain the function of the windbreak. Refer to "Windbreak Shelterbelt Establishment" for the minimum number or rows and trees per row to fulfill a particular function.

Sod Release and Management is the control and management of herbaceous weeds, particularly sod-forming grasses, in order to reduce the stress on windbreak plants and prepare the site for other renovation methods.

- Releasing trees or shrubs from herbaceous competition

  For maximum effectiveness, sod-forming grasses will be controlled as early as possible in their growth stage, consistent with the control method chosen. Generally, the sods will be tilled or mowed or sprayed before the grasses get much taller than 3 inches.

  When using herbicides to control sods and weeds, follow the label directions as they relate to the stage of weed growth for proper application timing. All herbicides will be applied according to label regulations with particular care to minimize damage to trees and shrubs. Several applications may be needed for adequate control. Operations may have to be repeated yearly. Generally, herbicides are most effective in controlling sods when applied to green succulent leaves in late summer or early fall. Many of the effective herbicides work on contact or via translocation. Avoid contact of these products on young bark or green leaves of trees or shrubs. Be alert to potential long-term herbicide buildup.

  If tillage is used, it will not be deeper than 3 inches to minimize root damage. Tillage will not be performed within 1 foot of the trunk of the tree or shrub. Numerous applications (3-6 depending upon yearly moisture and weed species) will be needed each year. Each application runs the risk of mechanically damaging the trees and shrubs.

  If mowing is used it will be applied in such a way as to maximize the stress to the sod while minimizing stress- such as bark injury or soil compaction- to the woody plants. Mow before herbaceous vegetation reaches a 4-inch height and mow as short as possible without damaging the mower. Weather conditions often dictate frequency of mowing.

- Preparing the site for replanting

  The primary purpose of this renovation method is to reduce herbaceous competition on trees and shrubs.

  Guidelines for herbicides and tillage release of sod-bound trees will be followed with the following additional stipulation; Tillage and/or herbicides will be applied in such a way that the sod is completely killed for one growing season before new trees or shrubs are planted. Refer to pages 4-8 of "Tree Care and Management" for site preparation details.

  Mowing **is not** appropriate for this purpose.

Supplemental planting (intra-planting) is nothing more than establishing a new windbreak adjacent to an existing windbreak. Refer to the following tools for specific requirements of designing a supplemental planting.

County-specific windbreak suitability groups for each soil type are found in county specific Interpretive tables in FOTG – Section II – Soil Information.

Estimated 20-year tree heights and determining which tree species are appropriate for planting on which soils can be found in "Expected 20-Year Tree Heights" by Windbreak Suitability Groups, located in FOTG – Section I – Reference Subjects – Windbreaks and Woodland.

Planting stock, stock handling, site preparation, planting techniques, and maintenance details are found in "Tree Care and Management"

Design Requirements to meet a specific purpose are found in "Windbreak Shelterbelt Establishment"

"Tree and Shrub Characteristics"

Newly planted windbreak rows shall be no closer than 40 feet if the nearest adjacent row in the existing planting is a deciduous tree, spruce or suckering shrub.

Newly planted windbreak rows shall be no closer than 20 feet if the nearest adjacent row in the existing planting is a conifer (not spruce) or non-suckering shrub.

Thinning is a method that removes selected plants from a windbreak. Exercise caution when selecting trees to be thinned so that the function of the windbreak is not radically impaired.

Removal can be accomplished with chainsaws, tree spades, handsaws, brush cutters, tree shears, hydraulic saws or some other tool or machine. Rarely will the roots be removed, except in situations where tree spades are used to remove live trees for transplanting. Serious damage to the root systems of remaining trees or shrubs will likely occur if attempts are made to remove the roots of the thinned trees with tools other than a tree spade. (Root damage is still a possibility with a tree spade but the risk is smaller as long as the windbreak is 20 years old or less.)

Tree and shrub tops shall be removed in such a manner that residual stumps and the debris from the thinning operation do not impede subsequent management operations. Tops may be removed from the site, stacked or cut "low and short" and left where they fall. Manage the debris from the thinning in a way that is compatible with landowner objectives.

Debris from Siberian elm or American elm must be chipped, burned or buried to reduce risk of spreading Dutch elm disease. Elm wood disposal shall occur immediately if removal is during the growing season or before the next growing season if removed during the fall or winter. When this is not possible, disposal should occur within one year after removal.

Depending upon the species thinned, stump resprouting may have to be addressed. Repeat thinning operations or treatment with herbicides may be appropriate. Method chosen will depend upon the reason for the thinning. There may be a risk of selected herbicides being translocated from the treated stump to the adjacent tree or shrub via root grafts. Not all species readily develop root grafts. Root grafting does not occur between plants of different species.

- To alter windbreak density

  Ensure that the windbreak maintains enough density to meet the objectives of the landowner after any thinning operation. Depending upon thinning intensity, windbreak function may be reduced for several years after thinning. To reduce this effect do not thin all rows of a multirow windbreak at the same time, or establish new tree or shrub rows several years before thinning.

  Single-row windbreaks

Thinning consists of removing every other plant within the row to reduce density to the desired level. This type of thinning is most often utilized to reduce windbreak density and alter snow distribution patterns. See figure 7. Drift

Figure 7a: Dense windbreak before thinning, causing deep snowdrifts.

Figure 7b: Dense windbreak after thinning, spreading snow farther across the field.

configurations after thinning will be somewhat similar to figure 3b.

Stump re-sprouts are usually not desirable and shall be controlled. Extensive stump sprouting will often make snow distribution problems worse. If re-sprouts are desirable, refer to coppicing for details on management.

Multi-row windbreaks

Thinning consists of removing every other or every third plant within the selected row(s). It may also be done in such a matter that plant removals from several rows will result in the desired plant-to-plant spacings.

Stump re-sprouts may or may not be a problem. Control re-sprouts, if needed, by herbicides or repeated removals in a way that does not damage the remaining windbreak. If re-sprouts are desirable, refer to coppicing for details on management.

- To reduce competition to adjacent trees

  Thinning consists of removing selected trees or shrubs in a manner that leaves more growing space for each of the remaining trees or shrubs. Thinning may remove every other or every third plant within the selected row. It may also be done in such a matter that plant removals from several rows will result in the desired plant-to-plant spacings. Thinning is a key function in managing natural regeneration. A residual plant-to-plant spacing of 4-6 feet is appropriate for shrubs and 12-18 feet is appropriate for large trees.

  Thinning of conifers shall occur before adjacent tree canopies overlap by more than 2-3 feet throughout ¼ to ½ their height. Extended periods of overlapping limbs throughout much of the canopy will result in dieback of the limbs on conifers and a loss of windbreak function. Timely thinning will prevent such windbreaks from "pruning themselves up" and reduce the likelihood and/or severity of some fungal diseases, especially on spruce.

- To provide agroforestry products

  Depending upon the species and local markets, thinning efforts can be funded in part by the harvest and sale of agroforestry products such as Christmas trees and greens, vines, decorative twigs, or pine straw. Potential for agroforestry markets is dependent upon landowner objectives, presence of markets, and the products to be harvested.

Underplanting

Underplanting is the addition of trees or shrubs under the canopy of an existing windbreak. See figure 8. Often this type of renovation is appropriate for restoring function to a windbreak that has lost density in the lower portion of the canopy. In the absence of row removal and/or extensive pruning, species selected for underplanting shall be selected for a level of shade tolerance appropriate to the level of canopy in the existing windbreak. Refer to "Tree and Shrub Characteristics" to determine shade tolerances of individual species.

Figure 8a: Windbreak with reduced density in lower crown allowing wind and snow to blow through into areas needing protection.

Figure 8b: Windbreak renovated by establishing shade-tolerant trees or shrubs in understory.

Site preparation methods to control herbaceous weeds and sod shall be appropriate for the weed pressure. Sites with sods, deep-rooted legumes, or noxious weeds shall be fallowed for at least one season prior to planting in order to control vegetation and store moisture for the newer plants.

Where room permits, and based on the competitiveness of adjacent tree species, root pruning to provide a zone of reduced competition for several years will benefit the new planting. See root pruning for details.

Species selected for underplanting shall be shade-tolerant and suitable for planting on the soils at the planting site.

KEY TO DETERMINE APPROPRIATE RENOVATION METHOD *

Field Windbreak Key

1. The windbreak forms a complete barrier with no gaps; trees appear healthy and vigorous with few dead branches and no insect or disease problems. No noxious weeds or sod-forming grasses are present. The windbreak is meeting all of landowner objectives. No renovation is needed, continue annual maintenance program.

1. The windbreak appears unhealthy; trees may be overcrowded or protection is not adequate; individual trees are in poor condition with many dead branches. Noxious weeds or sod-forming grasses may be present. Over all, the windbreak fails to meet landowner objectives. Go to 2.

    2. Sod-forming grasses or noxious weeds are present. See Sod Release and Management.

    2. Sod-forming grasses or noxious weeds are not present. Go to 3.

        3. Individual trees in the windbreak appear healthy but there are large gaps (two or more adjacent trees are missing) in the windbreak. See Gap Planting.

        3. There are no large gaps in the windbreak. Go to 4.

            4. The density of the windbreak is low (less than 30 percent), especially in the lower one-third. The windbreak fails to provide sufficient wind erosion control or crop protection. See Underplanting or Supplemental Planting.

            4. The density of the windbreak is high (more than 50 percent) and there is adequate wind erosion control. However, deep snowdrifts form that restrict field access in the spring. See Thinning or Pruning.

            4. The density is about right to meet landowner objectives but there are problems not identified above. Go to 5.

                5. Individual trees have insects or diseases present. Contact a local tree care professional to determine the insect or disease present and the proper treatment. Treat only if necessary.

5. Windbreaks are in good condition and meet landowner's primary objectives but could be improved for wildlife. Consider adding a shrub row or leaving several rows of unharvested crop adjacent to the windbreak for wildlife. See Windbreaks and Wildlife http://www.ianr.unl.edu/pubs/Forestry/ec1771.htm or "Tree and Shrub Characteristics".

5. Windbreaks are in good condition but crop yields next to the windbreak are low. See Root Pruning.

5. Windbreaks are in good condition, but they are over 25 years old and it is time to plan for the future. See Supplemental Planting, Underplanting, or Coppicing.

Farmstead and Livestock Windbreak Key

1. The windbreak appears healthy and vigorous with few dead branches and no insect or disease problems. The trees are well spaced within rows and between rows.

2. There is a good mix of deciduous and coniferous tree and shrub species; trees are of several ages. No renovation is needed, continue annual maintenance program.

2. Windbreak is composed of a single species and all trees are approximated the same ages. See Supplemental Planting or Underplanting.

1. The windbreak appears unhealthy; individual trees are in poor condition; density may be too low or too high to meet landowner objectives.

3. Sod-forming grasses or noxious weeds are present. See Sod Release and Management

3. Sod-forming grasses or noxious weeds are not present. Go to 4.

4. Insects or diseases are present. Contact a local tree care professional to determine the insect or disease present and the proper treatment. Treat only if necessary.

4. Insects or diseases are not present. Go to 5.

5. Trees are overcrowded. See Thinning.

5. Trees are not overcrowded; density is low and wind protection is limited. See Coppicing, Underplanting, Natural Regeneration, Shearing, or Supplemental Planting.

*The Field Windbreak Key and the Farmstead and Livestock Windbreak Key were adapted from "Windbreak Renovation" University of Nebraska Cooperative Extension EC 98-1777-x; by Craig Stange, USDA Natural Resources Conservation Service; Jon Wilson and Jim Brandle, University of Nebraska; and Mike Kuhns, Utah State University