Planning and installation of windbreaks and shelterbelts shall adhere to the Natural Resources Conservation Service (NRCS) conservation practice standard “Windbreak/Shelterbelt Establishment,” (380), in the South Dakota Technical Guide (SDTG).

Windbreak and shelterbelt systems may be designed for a variety of purposes. Material in this document will provide information needed for a successful design that meets standards.

Supporting documents needed to complete a windbreak design include:

“Expected Tree and Shrub Heights at 20 years,” Section II, SDTG.
Woodland Technical Note 37 - “Tree and Shrub Characteristics for Riparian or Speciality Plantings.”
Woodland Technical Note 38 - “Tree and Shrub, Handling, Planting, and Care.”

It is important for the planner and the landowner to determine the primary purpose of the planting. Only through an onsite inspection of the area and understanding the needs of the landowner (the reason for the tree planting), can a successful plan be developed that will accomplish the intended function and purpose. Any tree planting practice is a long-term project. It is important to plan it right the first time. Design errors cost time and money, and may involve an overwhelming effort to make things right.

I. GENERAL DESIGN GUIDELINES - FOR ALL WINDBREAK TYPES

A. DESIGN HEIGHTS

Windbreak designs are based on the downwind protection provided by the tallest row in the windbreak at 20 years of age. The design of tree and shrub plantings must accomplish the intended purpose and function within a 20-year period. This distance is measured in multiples of windbreak height and is referred to as H. “H” equals the estimated height of trees or shrubs at 20 years.

1. Expected 20-year tree heights under good management are found in Section II of the SDTG; or they may be estimated based on performance of the individual species (or comparable species) in nearby areas on similar sites.

B. SPECIES ADAPTABILITY AND PLANTING STOCK QUALITY

1. To determine which trees and shrubs will grow satisfactorily on the soils present at the site, refer to “Expected Tree and Shrub Heights at 20 Years” in Section II of the SDTG. Windbreak tree species shall be selected that are compatible with the soils on which they will be planted. The document “Expected Tree and Shrub Heights at 20 Years” contains a listing of species commonly planted in South Dakota. Those species suited for each interpretive group show an expected height in 20 years. If there is no height range value, the species is not suited for planting on soils in that group. If there is an “x” in a group, there is no height data available, but the species
should be suitable for the group. Be aware of changes in soil properties within the planting site as it may require a species change within the row.

2. Planting stock requirements on page 2 in Woodland Technical Note No. 38 “Tree and Shrub, Handling, Planting, and Care” will be used to determine the appropriate quality of planting stock for establishing windbreaks and shelterbelts.

3. Refer to Woodland Technical Note No. 38, page 3, for guidance on proper storage, handling, and care requirements necessary to maintain viable planting stock.

C. SITE PREPARATION
1. To determine an appropriate and sufficient method of site preparation, refer to Woodland Technical Note No. 38, pages 3-6, for site preparation alternatives based on conditions encountered in the area of the planting.

D. PLANTING OPERATION
1. To determine an appropriate planting technique for particular stock and the proper time of year to plant trees and shrubs used in a windbreak/shelterbelt system, refer to Woodland Technical Note No. 38, pages 6-10.

E. ORIENTATION
When designing a windbreak, consider the effects of the surrounding topography and land management on the ability of the windbreak to perform its function. Consider the positive and potentially negative impacts the windbreak may have on the surrounding land uses. Items to consider include: areas of snow drifts, water runoff from melting snow, water erosion potential, stifling of air flows during the summer, visibility hazards, ice blockage of drains, etc.

The plantings should be oriented as close to perpendicular to the troublesome winds as possible. Since winds rarely blow from the same direction all the time, base the design on the predominant wind direction during the time of the year that the area needs protection. For snow control or snow harvest purposes and for winter livestock or farmstead protection in South Dakota, predominant winter winds come from the northwest.

Keep in mind that some damaging storms can come from another direction. Late season snowstorms from the southeast could plug a road or fragile crops could be blasted by hot dry winds from the southwest. Determine what needs protection and the direction of the damaging winds and locate the windbreak/shelterbelt accordingly.

Zones of protection will vary depending upon density and height of the windbreak. Generally, the denser the windbreak the greater the wind speed reduction, but the smaller the downwind zone of protection.

On sloping land, windbreaks should be located as near to the contour as possible to reduce erosion risks and water loss.

In western South Dakota or on droughty soils, consider locating windbreaks to allow the diverting of water from adjacent areas into the windbreak for supplemental moisture.

F. SETBACKS AND EASEMENT AREAS OF UTILITIES
1. Windbreaks shall be located no closer than 16 feet to any property line unless a signed agreement between both landowners exists that would permit a closer planting.
2. No trees or shrubs shall be planted within the easement area of overhead transmission lines or other utilities unless permission has been secured from the appropriate utility company.

3. The windward row of plantings on the north or west sides of roads will be a **minimum** of 160 feet from the shoulder of the road. For plantings on the south or east sides of roads, the row furthest south or east from the road will be a minimum of 100 feet from the shoulder, and the rows nearest the road will be at least 2 times their mature height from the edge of the road.

4. Windbreaks will be positioned to avoid causing visibility problems at road intersections, curves, and driveway entrances. Generally speaking, the crowns of trees or shrubs at maturity should not spread into the rights-of-ways of roads.

5. Windbreaks that are adjacent to, or cross, legal and private drainage ways should be setback at least 100 feet to prevent snow and ice buildup that will restrict spring drainage.

6. In all cases, if local units of government have established more restrictive setback distances, then the more restrictive regulations will apply.

II. DESIGN GUIDELINES FOR SPECIFIC WINDBREAK TYPES AND FUNCTIONS

A. FIELD WINDBREAKS FOR WIND EROSION CONTROL AND CROP PROTECTION

1. Windbreaks installed primarily to reduce soil erosion from wind are usually located to the north and west of the area needing protection.

2. Use 10 times the 20-year height of the tallest tree row, measured parallel to the problem wind to determine the protected area. This measurement, when combined with the results of the most current wind erosion calculations, will determine the appropriate windbreak spacing across a field to achieve desired soil loss objectives. To increase farmability between windbreaks, plan the spacing between windbreaks to those of even tool bar widths considering that an area up to two times the height (2H) may be protected on the windward side (upwind) of the windbreak.

3. Windbreaks needed primarily for wind protection of crops shall be located to intercept the troublesome winds at the critical stage of the crop needing protection. For some sensitive crops, any erosion, even if below the soil loss tolerance (T), may be damaging to the crop. Windbreak systems should be designed to address the maximum amount of soil erosion that the planned crop can withstand.

4. A windbreak density of 40 percent to 60 percent is required for wind erosion control. Windbreak densities can be controlled through the type of plants, within row spacing, and the number of rows used.

5. One to three rows of deciduous shrubs, trees, or conifers will provide the density needed for wind erosion control and crop protection windbreaks. Additional rows may be used to achieve landowner objectives, such as, enhancing wildlife habitat or to enhance aesthetics. In most situations, five rows will meet all of these objectives.

6. Increased windbreak density increases crop protection benefits but slightly reduces the overall area receiving benefits. Be alert to how increased density for crop protection may result in delayed spring fieldwork because of narrow, deep snowdrifts formed behind these denser barriers.
7. No more than two rows in any windbreak system shall be of the same species unless site conditions restrict the number of available species.

8. Usually more than one row of non-suckering shrubs or deciduous trees will be needed to provide adequate wind protection for specialty crops. Ensure that the planting has adequate density close to the ground.

Some crops and their annual soil loss tolerance to windblown soil are listed below:

- Tolerant ("T"): barley, oats, millet, rye, wheat
- Moderate tolerance (two tons): corn, soybeans, sunflowers
- Low tolerance (one ton): alfalfa, potatoes, orchard crops
- Very low tolerance (<one ton): vegetables, muskmelons, watermelons

Refer to Table 1 for within row and between row spacing to achieve desired density.

B. FIELD WINDBREAKS FOR SNOW HARVEST

1. Windbreaks installed primarily for snow control are usually located to the north and west of the area needing protection.

2. The planned density shall be from 25 to 50 percent when snow distribution is the primary purpose.

3. Maximum snow deposition will usually be located down wind in an area two to five times the height of the most windward dense row.

4. Because they form a dense winter time barrier, suckering shrubs, spruces, junipers, or cedars are not suitable for field windbreaks designed for snow spreading.

5. One row of non-suckering shrubs, deciduous trees, or pines is appropriate for snow spreading windbreaks. Multiple rows of pines or shrubs may become too dense to effectively spread snow.

6. When relying upon a single row, extra maintenance is required to ensure that no gaps develop in the windbreak.

7. Lower limbs may be pruned on pines or trees and shrubs thinned to increase snow distribution, reduce drift height, and subsequent delays in field operations near the windbreak.

8. Windbreaks designed for snow spreading may be spaced up to a maximum 20H apart.

9. Windbreaks designed to trap snow for supplemental water in stock ponds should be located in a position to dump the majority of the snow close to or in the stock pond or major tributaries. Avoid tree species such as cottonwood, willow etc., that are heavy water users. Windbreaks for this purpose should be as narrow and dense as possible (ex: twin-row conifer or twin-row shrub).

Refer to Table 1 for within row and between row spacing to achieve desired density.

C. FIELD WINDBREAKS FOR SNOW CONTROL (LIVING SNOW FENCE)

1. A 50 percent dense windbreak will store the most snow. Windbreak densities can be controlled through the type of plants, within row spacing, and the number of rows used.
2. Three or more rows of deciduous trees, shrubs, or conifers are required for snow control.

3. A denser windbreak does not store as much total snow, but the snowdrift will be deeper and closer to the windbreak.

4. No more than two rows in any windbreak system shall be of the same species unless site conditions restrict the number of available species.

5. The windward row will be 160 to 250 feet from the shoulder of the road or the area to protect.

6. Ends of windbreaks should extend 150 to 200 feet past the area needing protection to account for snow eddying around the end and to allow for shifts in wind direction.

7. Maximum snow deposition will usually occur within a zone located 2H to 5H from the most windward dense row.

When measuring from roadways, measurements begin at the edge of the road surface nearest to the proposed windbreak. See Figure 1. The most windward row of a snow trap can be used for setback measurement purposes. This setback distance also applies to the ends of windbreaks that are perpendicular to roads and areas needing protection.

Leeward rows of primary windbreaks, located to the north or west of a road, even with the minimum 160 foot setback to the windward row, should be no closer than 100 feet to the nearest traveled portion of a public road. See Figure 2.

Refer to Table 1 for within row and between row spacing to achieve desired density.

D. SHELTERBELTS FOR BUILDING SITE AND LIVESTOCK PROTECTION

Windbreaks planted primarily for wind protection and/or snow management are required on the north and west sides of the area needing protection. They are considered primary windbreaks and are installed to provide winter protection.

1. The windward row must be a minimum of 200 feet from the area needing protection, except where ownership or soil conditions restrict the planting.

2. All areas needing protection should be located within the 10H-15H zone on the leeward side of the windbreak.

3. No more than two rows in any windbreak system shall be of the same species unless site conditions restrict the number of available species.

4. Ends of windbreaks should extend at least 200 feet past the area needing protection to account for end effects and to allow for shifts in wind direction.

5. The minimum number of rows required for primary shelterbelts to provide at
least 65 percent winter time density and the space required to store drifted snow in the windbreak:

a) Six rows of trees and shrubs for Major Land Resource Areas (MLRA’s) 54, 58D, 60A, 61, 62, 63A, and 64.
b) Seven rows of trees and shrubs for MLRA’s 53B, 53C, 55B, 55C, 63B, 66, 102A, and 102B.
c) If the proper setback distances have been observed in the design, the number of rows in a livestock/building site windbreak may be reduced by one for each of the following that occurs:
   • Planting one of the first two windward rows to spruce, juniper, or redcedar.
   • An effective field windbreak is located less than 600 feet windward and parallel to the proposed windbreak.
   • A snow trap of one or more rows of shrubs or conifers is located 50 to 150 feet windward and parallel to the proposed windbreak. Snow traps located upwind of primary windbreaks can increase effectiveness of the rest of the windbreak system by reducing the amount of snow that is stored in the primary windbreak.

6. For complete snow storage under severe blizzard conditions, a total windbreak width of at least 120 feet will be necessary.

7. Trapping of snow outside the primary windbreak in western South Dakota areas should be planned with caution, since the removal of snow moisture from the root zone of the main windbreak may impact the life and effectiveness of the windbreak.

8. For snow control, windbreaks should not be placed farther from the area needing protection than 35 times the expected 20-year height of the tallest species to be planted or 600 feet, whichever is smaller.

9. If there is insufficient space or suitable soils, a narrower windbreak is permissible, though a minimum of one shrub row and two deciduous tree rows; or two coniferous rows shall be established.

Refer to Table 1 for in row and between row spacing to achieve desired densities.

Secondary windbreaks are located on the leeward sides, usually the south and east, of the area protected by the primary windbreak.

1. Secondary windbreaks should be located far enough away from the area needing protection to allow snow deposition where it won't be a problem and to provide year-round accessibility in and around the area protected.

2. The inside tree or shrub row in windbreaks on the south and east of areas needing
protection shall not be any closer than 100 feet, except where ownership or soil conditions restrict the planting. Where solar gain during the winter is important, windbreaks on the south side of a building site shall be no closer than two times the mature height of the tallest plant. Exercise caution in utilizing tall trees in secondary windbreaks that may restrict summer breezes.

3. Secondary windbreaks usually consist of shrubs or short trees to stop the rare snowstorm from the south or east while allowing summer breezes to penetrate the protected area.

4. Any design of one or more rows is acceptable for a secondary planting.

Windbreaks planted to the south or east of roadways shall be located no closer to the road than two times (2H) the mature heights of the trees and/or shrubs in order to reduce upwind snow deposition and shading problems. Refer to Woodland Technical Note No. 37 "Tree and Shrub Characteristics for Riparian or Speciality Plantings" for mature plant heights. When measuring from roadways, measurements begin at the portion of the road surface nearest the proposed planting. See Figure 4

E. SHELTERBELTS AS NOISE SCREENS

Noise barriers reduce noise by deflecting the noise away from the observer, or by absorbing some of the noise before it reaches the observer, or both. See Figure 5.

1. Noise barriers are most effective when they can be placed as close as possible to the noise source. Barriers should be placed within 50-80 feet of the nearest traffic lane. See Figure 6.

2. The amount of noise reduction attained is dependent upon the type of surface over which the noise passes as well as the width, setback distance and composition of the noise barrier. Vegetation, especially standing vegetation, reduces and attenuates noise better than bare or hard surfaces.

3. Where year-round noise reduction is desired, conifers should constitute the majority of the planting. Deciduous trees or shrubs can be used where noise reduction is needed only during the growing season.

When landforms or constructed barriers are incorporated into the design they should be as tall as the vehicles or objects making the noise and may be constructed of soil or other materials. If constructed of soil the landforms should be planted to tall grasses, shrubs or trees for maximum effectiveness.

Tree and or shrub barriers, when combined with landforms, either earthen or constructed, show greater benefits in noise reduction than do landforms alone or trees alone.
4. Barriers for reducing high-speed truck noise must be at least 75 feet wide if only trees or shrubs are used, or at least 50 feet wide if vegetation is combined with a landform.

5. Barriers for reducing moderate noise levels (cars) must be at least 40 feet wide if only trees or shrubs are used, or at least 20 feet wide if vegetation is combined with a landform.

6. Noise barriers must be twice as long as the distance from the observer to the noise source.

7. No matter how severe the noise, noise barriers shall not be positioned where the barriers will cause snow deposition or drifting on the road sufficient to create a safety hazard to the traveling public. For many of these situations a living snow fence system is often needed upwind from the observer thereby reducing the amount of snow that could cause a problem.

Information for designing noise barriers was obtained from an article by David I. Cook and David Van Haverbeke in the Journal of Soil and Water Conservation, November-December 1972, pages 259-261.

F. SHELTERBELTS AS VISUAL SCREENS

1. Rows of trees or shrubs shall be placed between the observer and the undesirable view needing screening. Visual screens shall be located as close to the observer as possible.

2. Plantings shall be at least one row of conifers or at least three rows of deciduous trees or shrubs or a combination of deciduous and coniferous plants. Increasing the number of rows in the planting will increase the effectiveness in blocking unsightly vistas.

3. Consider using species that are aesthetically pleasing to the observer or landowner for visual screens. Refer to Woodland Technical Note No. 37 for species specific information.

4. Where visual screens may cause snow problems on roads or building sites, the more restrictive setback distances for snow control must be followed.

G. SHELTERBELTS TO PROVIDE OR ENHANCE WILDLIFE HABITAT OR TRAVEL CORRIDORS

1. In multiple row plantings containing more than three rows, the leeward rows may be planted in groups or segments containing five or more plants of one species alternated with five or more plants of another species in a series to enhance wildlife values.

2. When the primary purpose of a planting is to improve conditions for wildlife, it is best to refer to the Wildlife Upland Habitat Management Standard, (645), for specific details appropriate for the wildlife specie(s) of interest. However, the designs of windbreaks for other purposes can be modified to make the practice more beneficial to wildlife while still addressing the original windbreak purposes.

3. Considerations for improving the wildlife value of windbreaks include, but are not limited to:
   a. Provide dense areas (thickets) of suckering shrubs or conifers, especially spruce and juniper for winter thermal protection.
b. Choose a variety of plants that will provide food throughout the growing season, especially during mid and late winter. Refer to Woodland Technical Note No. 37 for individual species value as a food source.

c. Using tall grasses, standing corn, trees or shrubs, establish a snow trap 50-100 feet upwind to prevent snow from covering the food sources and shelter areas.

d. Add additional rows that provide food or cover on the lee side of the planting.

e. Add a secondary windbreak to protect food and cover from storms from the south or east.

f. Connect isolated plantings together and provide travel corridors by extending the windbreak legs or by installing a hedgerow planting.

H. WINDBREAKS INSTALLED FOR BOUNDARY DELINEATION

1. When using trees or shrubs to delineate field boundaries, be aware of the impact the mature plant might have on machinery operation and adjacent fences, or how different spacing affects snow distribution and depth, timeliness of field operations, summer breezes, crop protection, or moisture harvest. Avoid creating a future nuisance for the landowner.

2. Boundary plantings can be made more valuable for wildlife by adding additional rows and/or using a variety of plants valuable to wildlife.

I. WINDBREAKS TO REDUCE CHEMICAL DRIFT

Windbreaks reduce chemical drift hazards in two ways - by reducing the wind velocities across the field where the chemicals are applied and by intercepting chemicals that have moved off site onto the leaves, twigs, and bark of the windbreak plants.

1. The minimum requirement for this purpose is one row of shrubs, deciduous trees, or conifers. Use the appropriate within row spacings found in Table 1. Where appropriate, use the tallest trees appropriate for the site. Tall trees can intercept more of the laterally moving air mass. Multiple rows of tall trees provide additional benefits since they provide more living matter that can intercept drift.

2. When installing a system of belts to reduce drift, space each belt at 10 times the expected 20-year tree height. Spacings between belts may be decreased downward to fit even multiples of toolbar widths. Encourage landowners to use methods and machinery that minimize drift thereby reducing the amount of chemical moving offsite that must be trapped by the windbreak.

3. The most difficult part of designing windbreaks for reducing chemical drift is determining what species of tree or shrub will be resistant to the chemical drift 20 years from now. Based on nearly 50 years of herbicide application in South Dakota, phenoxy-type herbicides have been the most damaging to trees. Conifers are most resistant to these types of herbicides, except during periods of rapid, succulent growth.
J. WINDBREAKS TO IMPROVE IRRIGATION EFFICIENCY

Windbreaks can improve irrigation efficiency by reducing evaporation at the sprinkler head, reducing evaporation from the plants and soil surface, and by reducing transpiration through the plant.

1. Plantings of tall trees just outside the arc of the sprinklers can provide some of the benefits listed above, as long as they intercept the troublesome winds.

2. Install a system of narrow shrub rows that are short enough to allow the sprinklers to pass overhead. These shrub rows can reduce transpiration from the growing crop and provide a microclimate that yields greater production. Benefits to the crop primarily accrue through stress reduction on the growing crop, protection during critical stages, and erosion reduction.

K. SHELTERBELTS TO INCREASE CARBON STORAGE

Carbon sequestration can be realized through several different mechanisms: cessation of soil tillage, accumulation of carbon in roots and upper tree material, and accumulation of a duff layer.

1. Generally speaking, maximum carbon sequestration can be expected through:
   a. Close row spacings that maximize plants per acre without unduly causing plant stress that would lead to early mortality. Use the minimum between row and within row spacings from Table 1. When different species require different spacings, use the larger of the minimum spacings.
   b. Establishing long lived trees
   c. Planting trees that will grow large with extensive and deep root systems.
   d. Harvest of woody material for lumber or alternative fuels.

2. For maximum carbon storage, minimize amount of tillage within the planting to that necessary for establishment.

3. For long-term carbon sequestration, establish and maintain adequate firebreaks to prevent catastrophic loss of the planting.

III. COMPOSITION AND SPACING GUIDELINES FOR ALL WINDBREAKS

For sustainability and long-term effectiveness, plan for a diversity of species within the planting, and where compatible with plant forms and owner objectives, within the row.

At a minimum, no more than two rows within any windbreak system shall be of the same species, unless site conditions limit the number of available species.

For multi-row plantings, consider at least one or more rows of conifers.

Often a single species will be planted in each row. Generally, this makes subsequent maintenance and renovation easier. However, single row, single species plantings are more prone to failure from drought, disease, and/or insects.

Alternating species of trees or shrubs in the row may be considered under certain circumstances or to reach specified objectives. If species are alternated within a row, they need to have similar growth habits and the projected heights at 20 years of age are within 10 percent of each other.
Mixing compatible species within the row, can reduce the severity of some insect and disease infestations and spread. Such mixing will usually complicate the planting and management of the windbreak.

In multiple row plantings, containing more than three rows, the leeward rows may be planted in groups or segments containing five or more plants of one species in a series to enhance wildlife or aesthetic values. This mixing of species within the row is not restricted by the rules for alternating plants above.

Appropriate selections of species and spacings can allow a planting to meet multiple purposes at the same time.

For most situations, a shrub or conifer will be used in the most windward row of a multiple row planting to provide additional snow (moisture) for the growing plants within the planting and to stop most of the snowdrift in an area that is out-of-the-way.

Species selection that allows for the production of nuts and fruits for human consumption, woody materials, such as grape vines, for floral arrangements, or other agroforestry products are appropriate for windbreaks, where production of these products does not hinder the primary purpose of the windbreak.

### SUGGESTED ROW ARRANGEMENT FOR DIFFERENT SIZE PRIMARY WINDBREAKS

<table>
<thead>
<tr>
<th>Width of belt (rows)</th>
<th>6</th>
<th>8</th>
<th>10</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shrub</td>
<td>1-2-6</td>
<td>1-2-7-8</td>
<td>1-2-7-8-9-10</td>
<td>1-2-7-8-9-10-11-12</td>
</tr>
<tr>
<td>Redcedar or Juniper</td>
<td>1-2-5-6</td>
<td>1-2-7-8</td>
<td>1-2-7-8-9-10</td>
<td>1-2-7-8-9-10-11-12</td>
</tr>
<tr>
<td>Midsize deciduous trees (10 to 25 ft.)</td>
<td>2-3-4-5-6</td>
<td>2-3-4-5-7-8</td>
<td>2-3-4-5-6-7-8-9-10</td>
<td>2-3-4-5-6-7-8-9-10-11-12</td>
</tr>
<tr>
<td>Pine or spruce</td>
<td>1-5-6</td>
<td>1-6-7-8</td>
<td>1-6-7-8-9-10</td>
<td>1-7-8-9-10-11-12</td>
</tr>
<tr>
<td>Tall deciduous trees ( &gt; 25 ft.)</td>
<td>3-4-5-6</td>
<td>3-4-5-6-7-8</td>
<td>3-4-5-6-7-8</td>
<td></td>
</tr>
</tbody>
</table>

Row 1 is the windward or outside row in relation to the area protected.

For a 5, 7, 9, or 11-row windbreak, eliminate row 3 of a 6, 8, 10, or 12-row windbreak in the above table.

### SPACING GUIDELINES

**In row spacing**

Refer to Table 1 for in-row spacing of the appropriate type of plant to meet a particular purpose.

**Between row spacing**

In order to provide adequate growing space, between-row spacings should be at least 1 1/2 times the in-row spacing for each type of plant, or wide enough to meet the minimum square footage per plant, except for twin-row high-density windbreaks. Use the wider determination when two adjacent rows each have different spacings, i.e., when a tree is adjacent to a shrub, use 1 1/2 times the tree spacing. See Table 1 for general in-row spacings.

Spacing between adjacent rows can vary or be uniform. If plantings are to be cultivated, plan the row spacing four feet wider than the width of the cultivation equipment. Maximum row spacing will depend on site conditions, species selected and planned barrier purpose but will not exceed 22 feet. Optimum average between row spacing is 12 to 16 feet.

Several species require specific row spacing recommendations due to rapid growth rates and form. Rows of conifers and deciduous trees should not be established within 20 feet of cottonwoods, hybrid poplars, and tree willows nor should they be alternated with these species...
within the row. Rows of conifers and deciduous trees should not be established within 20 feet of Siberian elm.

The closer spacing can increase disease potential and cause pines to self-prune lower limbs. Between-row spacings can be modified upward to fit machinery widths.

Using the wider spacing will usually provide better growing conditions for the tree but will increase the time before canopy closure, if closure happens at all. Canopy closure in the eastern part of the state can be fairly effective at controlling unwanted herbaceous vegetation. In the western part of the state, moisture stress and the presence of grass, limits the effectiveness of canopy closure as a weed control method.

The closer in-row spacing, as recommended in Table 1, will provide quicker closure and a more effective barrier to the wind.

**Isolation strip**

An isolation strip shall be included in the windbreak design. Maintain the isolation strip for the life of the planting. The minimum width of the isolation strip will be eight feet for unfenced plantings. For fenced plantings, the width of the isolation strip will be equal to the average between row spacing or to the width of the cultivation equipment plus four feet.
### Table 1: In-row Spacing (feet) by Plant Type for Specific Purposes

( Assumes vigorously growing row of species type listed. )

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Suckering shrubs</th>
<th>Non-suckering shrubs</th>
<th>Midsize deciduous trees 10 - 25 feet</th>
<th>Tall deciduous trees** &gt;25 feet</th>
<th>Spruce</th>
<th>Junipers and Cedars</th>
<th>Pines</th>
</tr>
</thead>
<tbody>
<tr>
<td>Snow Control/Stoppage, Noise Barriers, Carbon Storage 80 percent + Density</td>
<td>3 - 6</td>
<td>3 - 5</td>
<td>5 - 8</td>
<td>8 - 12</td>
<td>8 - 12</td>
<td>6 - 10</td>
<td>8 - 12</td>
</tr>
<tr>
<td>Snow Spreading 35 - 50 percent Density</td>
<td>Not Suitable</td>
<td>5 - 8</td>
<td>6 - 10</td>
<td>10 - 16</td>
<td>Not Suitable</td>
<td>Not Suitable</td>
<td>10 - 16</td>
</tr>
<tr>
<td>Erosion Control, Crop Protection 40 - 60 percent Density</td>
<td>4 - 8</td>
<td>4 - 6</td>
<td>6 - 10</td>
<td>8 - 12</td>
<td>8 - 12</td>
<td>6 - 10</td>
<td>10 - 14</td>
</tr>
<tr>
<td>Specialty Crop Protection, Visual Screens 60 - 80 percent Density</td>
<td>3 - 6</td>
<td>3 - 5</td>
<td>5 - 8</td>
<td>8 - 12</td>
<td>8 - 12</td>
<td>6 - 10</td>
<td>8 - 12</td>
</tr>
<tr>
<td>Building Site/Livestock Protection, Visual Screens 60 - 80 percent Density</td>
<td>3 - 6</td>
<td>3 - 5</td>
<td>5 - 8</td>
<td>8 - 12</td>
<td>8 - 12</td>
<td>6 - 10</td>
<td>8 - 12</td>
</tr>
<tr>
<td>Minimum square footage per plant*</td>
<td>15</td>
<td>15</td>
<td>80</td>
<td>144</td>
<td>144</td>
<td>144</td>
<td>192</td>
</tr>
</tbody>
</table>

* The minimum square footage per plant means that a design using a minimum in-row spacing will often require a wider between row spacing in order to ensure enough growing space for each plant. Adequate growing space per plant will maintain a healthy, vigorously growing plant, with a reduced chance of disease incidence, and a strong likelihood that lower limbs will be maintained throughout the life of the planting.

** Rows of conifers or deciduous trees should not be planted within 20 feet of cottonwoods, hybrid poplars or tree willows, nor should these plants be alternated within the row.

These in-row spacings are specific to the varied purposes of windbreaks only. Other forestry practices such as riparian forest buffers and tree/shrub establishment, etc., will likely have different spacing requirements.
IV. SPECIALITY DESIGNS

A. TWIN-ROW HIGH-DENSITY WINDBREAKS

Each pair of twin rows will be planted to the same species.

Twin-row high-density windbreaks installed as primary windbreaks for snow control/stoppage and livestock/building site protection shall consist of at least three pairs of twin-rows. The most windward row of the most windward pair must be at least 200 feet from the area needing protection. See Figure 7.

In-row spacing for each pair of a twin-row high-density windbreak will generally be the smallest value from Table 1 for the species type to be planted. Spacing between rows within each pair shall be the same as the in-row spacing. See Figure 7.

For secondary windbreaks, one or more sets of paired rows of a twin-row high-density planting is adequate.

The spacing between sets of paired rows in the windbreak will be 30 to 50 feet. See Figure 7.

B. WINDBREAK STUBS FOR SNOW CONTROL

To reduce end effects, where existing windbreaks are creating unwanted snowdrifts on roads or other areas needing protection, establish short windbreak stubs. These 300-400 feet stubs shall consist of 1-3 rows designed as a snow stoppage windbreak (see Table 1) and oriented perpendicular to the problem legs of the existing windbreak. See Figure 8.

For noncropland sites, the stubs may be planted immediately adjacent to the existing tree rows. With no access gaps, the stubs may be placed as close as 200 feet from the near edge of the area needing protection.

For cropland sites, leave a 50-80 foot machinery access gap between the existing trees and the new trees. When access gaps are a part of the design, the stub rows should be located 400 feet from the near edge of the area needing protection. Access gaps may be incorporated into designs on noncropland also, based on landowner desires, but the greater setback distance will apply. See Figure 8.
V. ESTABLISHMENT AND MAINTENANCE

A. WEED CONTROL OPTIONS DURING ESTABLISHMENT

The Maintenance After Planting section, pages 10-14, in Woodland Technical Note 38 will be used to determine an appropriate form of weed control.

B. REPLANTING

1. Any tree or shrub that fails within the first three years should be replaced with a similar plant. Replants shall maintain the intended function of the planting and be compatible with soils and climate. Growth rates of replants (within 3 years) are usually such that little, if any size difference is noted after 10 years.

2. After three years, a windbreak/shelterbelt shall have at least 85 percent of the trees planted in a healthy condition with no two adjacent plants missing.

C. DISEASE, INSECTS, WEATHER, AND ANIMALS

To determine ways to prevent or control damage due to disease, insects, weather, or animals, refer to Woodland Technical Note 38, page 16.

VI. REQUIRED DOCUMENTATION

A. LOCATION OF THE PLANTING

The location shall be marked on:

- the conservation plan map or aerial photo
- a scaled sketch on the SD-CPA-6 specification form.

B. COMPLETED SD-CPA-6 SPECIFICATION FORM

1. A copy of the location documentation and a completed specification form shall be provided to the landowner.

2. A copy of the location documentation and a completed specification form shall be retained in the landowner's case file, either electronically or as hard copy and kept at the NRCS field office.

VII. OPTIONAL DOCUMENTS FOR LANDOWNER USE

How Windbreaks Work http://www.ianr.unl.edu/pubs/Forestry/ec1763.htm
Windbreak Establishment http://www.ianr.unl.edu/pubs/Forestry/ec1764.htm
Windbreaks in Sustainable Ag http://www.ianr.unl.edu/pubs/Forestry/ec1772.htm
Windbreaks and Wildlife http://www.ianr.unl.edu/pubs/Forestry/ec1771.htm
Windbreaks for Rural Living http://www.ianr.unl.edu/pubs/Forestry/ec1767.htm
Windbreaks for Livestock Operations http://www.ianr.unl.edu/pubs/Forestry/ec1766.htm
Windbreaks for Snow Management http://www.ianr.unl.edu/pubs/Forestry/ec1770.htm
Windbreak Management http://www.ianr.unl.edu/pubs/Forestry/ec1768.htm
Field Windbreaks http://www.ianr.unl.edu/pubs/Forestry/ec1778.htm
Fruit Bearing Shrubs for Multi-Use Shelterbelts and Orchards http://www.agr.gc.ca/pfra/shbpub/fruitshr.htm