TECHNICAL NOTE

WOODLAND TECHNICAL NOTE NO. 42 July 25, 2016

WINDBREAK DESIGN GUIDE

It is important to determine the purpose of the tree planting. Only through an onsite inspection of the area, understanding the objectives of the landowner and identifying natural resource concerns, can a successful plan be developed that will accomplish the intended purpose. Any tree planting is a long-term project; it is important to plan it right the first time. This document outlines a variety of design options that have proven successful and will meet technical standards for various windbreak plantings in South Dakota (SD).

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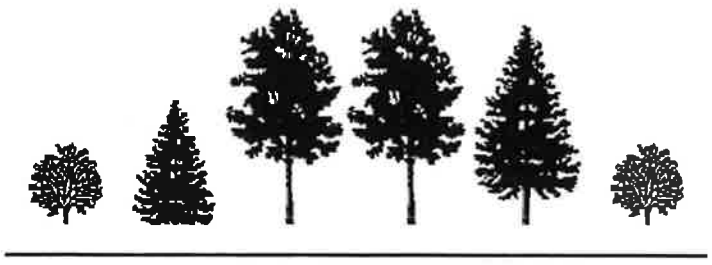


CONSERVATION TREE/SHRUB GROUPS

A Conservation Tree/Shrub Group (CT/SG) is a physiographic unit or area having similar climatic and soil characteristics that control the selection and height growth of trees and shrubs. All soil map units are placed in 1 of 10 main groups. Several of the groups are further divided into subgroups. The CT/SG's are used for selecting species best suited for different kinds of soil and for predicting height growth at 20 years (per CT/SG). **If there is no height value listed, the species is not recommended for planting on the soil in that group.** Soil map units should be verified in the field and landscape positions considered. Refer to Section II, Statewide Soil and Site Information, Windbreak Interpretations, of the SD Technical Guide (SDTG) for a description of each CT/SG and subgroup. Use the groups in "Expected Tree and Shrub Heights at 20 Years" to select trees and shrubs that are recommended for the soils on the proposed planting site and for determining expected heights in 20 years.

DESIGN GUIDELINES FOR ALL WINDBREAKS

A. SPECIES SELECTION

To determine which trees and shrubs are adapted to the site, see the document "Expected Tree and Shrub Heights at 20 Years" under Windbreak Interpretation in Section II of the SDTG. Windbreak species will be selected that are compatible with the soils on the site. Those species suited for each CT/SG show a value for expected height in 20 years. Be aware of changes in soil properties within the planting site as they may require a species change within the row.

Native trees and shrubs that achieve planning objectives will be utilized whenever possible. If nonnative plants are to be included in a windbreak, use only those that are noninvasive in the area. Be particularly cautious about including Russian-olive in the planting. Because it may invade and dispose native flora, do not plant it within or near riparian areas.

Even though it is a native plant, be judicious in the use of green ash. With the threat of the emerald ash borer, it is wise to not to become dependent on green ash as the only tall tree component of your windbreak.

Diversity of tree/shrub species is recommended in windbreak designs to minimize insect, disease, animal, and other potential pest problems. It is recommended that no more than two rows of a windbreak contain the same species unless soil conditions limit the number of choices.

Alternating species within the row may be considered under certain circumstances or to reach specified objectives. If species are alternated, they need to have a similar size, density, and growth habit at maturity.

B. 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. Items to consider include: areas of snow drifts, water runoff from melting snow drifts, water erosion potential, stifling of air flows during the summer, and visibility hazards, etc.

The plantings should be oriented as close to perpendicular to the troublesome winds as possible. Any wind direction may be troublesome, depending on the land use and season(s) of use. For snow control or snow harvest purposes and for winter livestock or farmstead protection in SD, predominant winter winds come from the north and northwest.

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

C. SETBACKS AND EASEMENT AREAS OF UTILITIES

Windbreaks shall not be located closer than 16 feet to any property line unless a signed agreement between both landowners exists that would permit a closer planting.

No trees or shrubs shall be planted within the easement area of overhead power transmission lines. Whenever below ground utilities are in close proximity to a windbreak

planting the utility company's one call system will be contacted prior to completing the design and again prior to planting (SD One Call). Species that will not interfere with local utility lines, and are approved in writing by the easement holder, may be considered for incorporation into the windbreak planting.

The windward row of plantings north or west of roads will be a minimum of 160 feet from the shoulder of the road. Leeward rows of windbreaks located on the north or west of a road, even with the minimum 160' setback to the windward row, should be no closer than 100 feet to the nearest traveled portion of a public road. This setback distance also applies to the ends of windbreaks that are perpendicular to roads. See Figure 1.

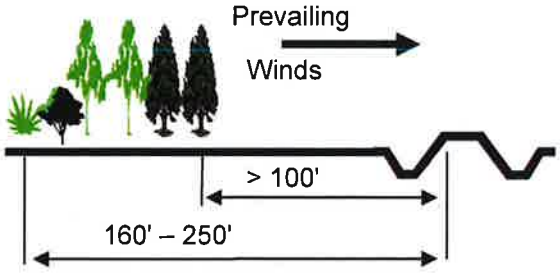


Figure 1

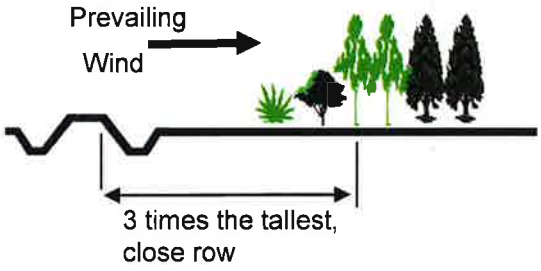


Figure 2

Windbreaks planted south or east of roadways shall be located no closer to the road than three times the 20-year height. The 20-year height shall be determined from Expected Tree and Shrub Heights at 20 Years" for the CT/SG. The closest tall row shall be used to determine the setback distance and in no case shall the row closest to the roadway be any closer than 100' from the traveled portion of the roadway unless county ordinance allows. See Figure 2.

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

D. 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. The "H" equals the estimated height of the tallest tree row in the windbreak at 20 years.

Expected 20-year tree heights under good management can be found in Section II of the SDTG under Statewide Soil and Site Information, Windbreak Interpretations; or they may be estimated based on performance of comparable species in nearby areas on similar sites.

E. DESIGN DENSITY

Windbreak densities can be controlled through the type of plants, within row spacing, and the number of rows used. Windbreaks installed for different purposes have different density requirements.

Zones of protection will vary depending upon density and height of the windbreak. Generally, a denser windbreak will have greater wind speed reduction immediately behind the windbreak but a smaller downwind zone of protection. The location and extent of snowdrifts are also dependent on the density of the windbreak. See the density table on Page 12.

As a windbreak's width approaches 10 times the height of the windbreak, the effect on wind flow changes and behaves more like wind passing over a forest or woodlot. Under these conditions the zone of protection downwind from the windbreak is greatly reduced.

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

DESIGN GUIDELINES FOR SPECIFIC WINDBREAK PURPOSES

A. FIELD WINDBREAKS FOR WIND EROSION CONTROL AND CROP PROTECTION

Windbreaks for wind erosion and crop protection should provide protection, in the critical season which the crop will be growing or tillage occurs. The predominant wind direction(s) per month can be found at: http://climate.sdstate.edu/windrose/windrose.shtm.

Use 10 times the 20-year height (H) 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. An area two times the height (2H) is protected on the windward side (upwind) of the windbreak. To increase farm ability between windbreaks, plan the spacing between windbreaks to those of even tool bar widths.

A windbreak density of 40 percent (%) to 60 % is required for wind erosion control. One to three rows of deciduous shrubs or trees, and/or one row of conifers will provide the density needed for wind erosion control and crop protection windbreaks. Additional rows may be added to achieve landowner objectives, such as enhancing wildlife habitat. A series of windbreaks may be used to protect a larger tract as part of an erosion control system. In most situations, five rows will meet all soil erosion and crop protection objectives.

Windbreaks needed primarily for wind protection of crops shall be located to intercept the troublesome winds at the critical growth stage of the crop needing protection. Select species that are taller than the crops being protected. For some sensitive crops, any wind erosion, even 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.

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 (three tons): barley, oats, rye, wheat
- Moderate tolerance (two tons): corn, grain sorghum, sunflowers
- Low tolerance (one ton): apples, cherries
- Very low tolerance (<one ton): alfalfa, vegetables, potatoes

B. FIELD WINDBREAKS FOR SNOW HARVEST

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

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

One row of non-suckering shrubs, deciduous trees, or pines is appropriate for snow spreading windbreaks. Multiple row plantings may become too dense to effectively spread snow. Be alert to how increasing density may result in deep snowdrifts formed behind these barriers; delaying spring fieldwork.

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

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.

Windbreaks designed for snow spreading will be oriented as close to perpendicular to the snow-bearing wind as possible. For optimal snow distribution the maximum interval between barriers should not exceed 20H (this is not mandatory).

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

A 50% dense windbreak will store the most snow. Three or more rows of deciduous trees, shrubs, or conifers are required for snow control.

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

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

Ends of windbreaks should extend 160 to 200 feet past the area needing protection to account for snow eddying around the end and to allow for shifts in wind direction.

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

D. SHELTERBELTS FOR BUILDING SITE AND LIVESTOCK PROTECTION

Windbreaks planted for wind protection and/or snow management are required on the north and/or west sides of the area needing protection. Conditions may also dictate that windbreaks be established if needed on the east side of the site. They are considered primary windbreaks and are installed to provide winter protection. The windward row must be a minimum of 200 feet from the area needing protection, except where ownership or soil conditions restrict the planting.

I. All areas needing protection should be located within the 10H - 15H (20 year height in CT/SG) zone on the leeward side of the windbreak.

II. For best performance, ends of windbreaks should extend at least 200 feet past the area needing protection for to account for end effects and to allow for shifts in wind direction (this is not mandatory).

III. The minimum number of rows required for primary shelterbelts to achieve optimum winter protection, and the space required to store drifted snow in the windbreak are:

a) Six (6) rows of trees and shrubs for Major Land Resource Areas (MLRA's) 54, 58D, 60A, 61, 62, 63A, 63B, 64, 65, and 66.

b) Seven (7) rows of trees and shrubs for MLRA's 53B, 53C, 55B, 55C, 102A, 102B, and 102C.

c) If the proper setback distances have been observed in the design, the number of rows in a primary windbreak may be reduced by one for <u>each</u> of the following that occurs:

- Planting the first windward row to Spruce, Juniper or Red Cedar.
- 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.

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

V. Trapping of snow outside the primary windbreak in western SD 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.

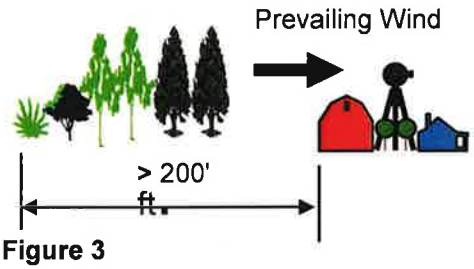


Figure 3

For windbreaks north and/or west of the area needing protection, the most windward row must be at least 200 feet from the area to be protected.

VI. 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.

VII. 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.

- Secondary windbreaks are located on the leeward sides, usually the south and east, of the area protected by the primary windbreak.
- Secondary windbreaks should be located far enough away from the area needing protection to allow snow deposition where it will not be a problem and to provide year-round accessibility in and around the area protected.

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 three times the mature height of the tallest plant.

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

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

Avoid total enclosure of a building site or feedlot with tall dense species. Cooling summer breezes are often desirable and such a design would stifle summer breezes and ventilation and could trap cold air in winter months.

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.

Noise barriers are most effective when they can be placed as close as possible to the noise source. See Figure 4.

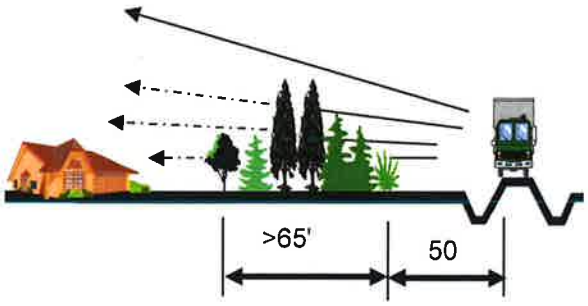


Figure 4. Vegetative Sound Barrier

Where year-round noise reduction is desired, conifers should constitute the majority of the planting. Deciduous trees or shrubs can be used as long as the planting achieves at least 65% density during the time of year when noise is a problem.

Barriers for reducing high-speed traffic noise must be at least 65 feet wide.

Barriers for reducing moderate speed traffic noise levels must be at least 20 feet wide.

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

No matter how severe the 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.

F. SHELTERBELTS AS VISUAL SCREENS

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.

Consider using species that are aesthetically pleasing to the observer or landowner for visual screens.

Be cognizant of differences between conifers and deciduous trees on screen effectiveness during leaf-off conditions.

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

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.

H. WINDBREAKS TO INTERCEPT AND REDUCE AIR BORNE PARTICULATE MATTER, CHEMICALS, AND ODORS

Windbreaks improve air quality in two ways - by reducing the wind velocities across a source area of particulates, chemicals or odor; and by intercepting particulates, chemicals or odors onto the leaves, twigs, and bark of the windbreak plants downwind of the source area.

I. Where appropriate, use the tallest trees appropriate for the site. Tall trees can intercept more of the laterally moving air mass.

II. Windbreak density upwind of a source area for chemicals or odors should be 50% or greater to reduce the air flow into the source area. Windbreak density downwind of the source area should be at least 65% dense to protect the affected downwind sites. Multiple rows of tall trees provide more living matter that can intercept drift.

III. When installing a system of belts to reduce drift, the distance between each belt should not exceed a maximum of 10 times the expected 20-year tree height. Encourage landowners to use methods and machinery that minimize drift thereby reducing the

amount of particulate matter, chemicals, or odors moving offsite that must be trapped by the windbreak.

IV. Orient windbreaks so that facilities, equipment, and management are not adversely affected as the planting matures. (back pressure on fans, access for feeding and loading, places to push snow, etc.).

I. 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.

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

ii. 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.

J. 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.

i. Maximum carbon sequestration can be expected through:

a) Close row spacing that maximize plants per acre without unduly causing plant stress that would lead to early mortality.

b) Maximize the width and length of the windbreak to fit the site.

c) Planting trees that will grow large, with extensive and deep root systems and are long lived.

d) Harvest of woody material for lumber or alternative fuels.

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

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

COMPOSITION AND SPACING GUIDELINES FOR ALL WINDBREAKS

For sustainability and long-term effectiveness, plan for a diversity of species within the planting. It is recommended that no more than two rows of a windbreak contain the same species unless soil conditions limit the number of choices.

Most often a single species will be planted in each row; but mixing compatible species within the row can reduce the spread of some insects and diseases. Alternating species within the row may be considered under certain circumstances or to reach specified objectives. If species are alternated within the row, they must have a similar mature size and growth habit. Do not alternate shrubs and trees or conifers and deciduous trees. Mature height of the species alternated must be within 10%.

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 the windbreak.

TABLE 1. SUGGESTED ROW ARRANGEMENT FOR DIFFERENT SIZE WINDBREAKS

Width of belt (number of rows)	6	8	10
Shrubs	1,2,6	1,2,7,8	1,2,7,8,9,10
Red Cedar or Juniper	1,2,5	1,7,8	1,7,8,9,10
Midsize deciduous trees (<25 ' tall)	2,3,4,5,6	2,3,4,7,8	2,3,4,5,6,7,8,9,10
Pine or Spruce	1,5,6	1,6,7,8	1,6,7,8,9,10
Tall deciduous trees (>25' tall)	3,4,5	3,4,5,6	3,4,5,6,7

Row 1 is the windward or outside row in relation to the area protected. For a 5, 7, or 9 row windbreak, eliminate row 3 of a 6, 8, or 10 row windbreak in the above table.

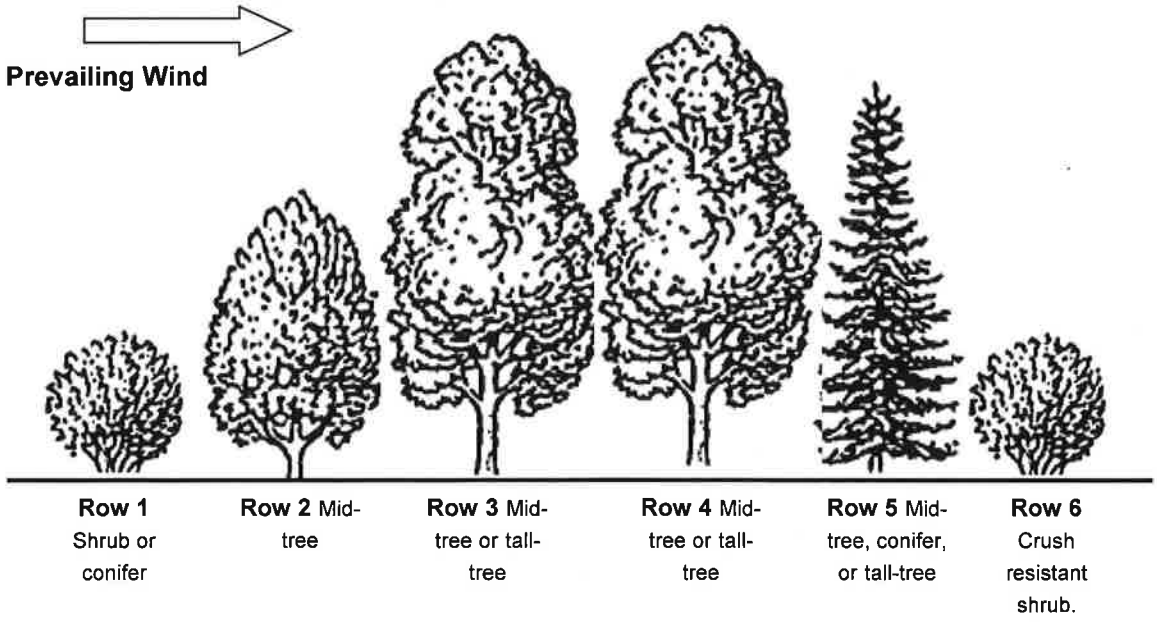
For windbreaks wider than 10 rows, the additional rows can be anything other than tall deciduous trees.

Because of snow breakage issues and possible loss of the second row, a mid-sized deciduous tree species that can withstand crushing is strongly recommended for row 2. Additionally, if an evergreen is planted in row 1, a shrub should not be planted in row 2.

If the windward row is planted to Juniper or Red Cedar, it is recommended that the in-row spacing be 10 feet apart to avoid breakage during heavy snow conditions.

A species should be shade tolerant if it is shorter than the species planted in either adjacent rows.

Figure 5 - Typical Suggested Windbreak Profile



The most effective windbreak planting has 5 or more rows of deciduous and evergreen trees and shrubs. The greater the height of the trees within the windbreak, the greater the downwind distance protected.

The drawing above depicts a suggested layout of a six row windbreak. Row 1 is the windward row. Arrange row with one row of shrub, or conifer on the windward side to provide low level density to stop most of the snow in the windbreak. Taller trees should be in the center to provide the greatest possible downwind zone of protection. The inside rows can be planned to provide food for wildlife and/or people;

woody decorative florals; or attractive flowering or leaf color displays. When selecting species for interior rows of a windbreak important considerations are species shade tolerance, ability to withstand competition, and snow load.

In multiple row plantings the species with the shortest 20-year height and slower growing species should be planted in outer rows so they are not overtopped by fast growing and taller species.

SPACING GUIDELINES

Table 2: Recommended Plant Spacing within the Row for new plantings

Plant Type	Windward (first) row or single row windbreaks	Interior or Leeward rows
Shrubs	3 – 6	4 - 6
Mid-sized deciduous trees <25' at maturity	6 – 10	8 - 12
Junipers and cedars	8-10	8-16
Tall deciduous trees >25' at maturity	8 – 12	10 - 16
Pine and larch	8 – 10	10 - 16
Spruce	8 – 12	12 - 18

Note: When determining whether a species is short, or tall, refer to the maximum height column in "Expected Tree and Shrub Heights at 20 Years by CT/SG."

Between row spacing

Spacing between adjacent rows can vary or be uniform. If plantings are to be sprayed, mowed, or cultivated to manage vegetation between rows, plan the row spacing at least four feet wider than the width of the equipment to be used. 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 14 to 16 feet (preferred but not mandatory).

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 22 feet of cottonwoods, hybrid poplars, silver maple, white poplar and/or tree willows. Rows of conifers and deciduous trees should not be established within 20 feet of Siberian elm.

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 and weeds, limits the effectiveness of canopy closure as a weed control method.

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 minimum width of the isolation strip will be equal to the average between row spacing or to the width of the maintenance equipment plus four feet.

Table 3. Density Requirements

Tree and Shrub Combinations to Achieve Desired Densities	**Density of Windbreaks** (see Agroforestry Note #36 from September 2007 http://nac.unl.edu/documents/agroforestrynotes/an36w03.pdf for pictures and more information)		
	25 – 40%	**40 – 60%**	**60 – 80%**
1 row deciduous tree	Snow distribution		
3 rows deciduous or 1 row conifer		Crop protection	
3 to 5 rows shrubs, conifers, or trees		Living snow fence	
3 to 5 rows deciduous trees or shrubs		Wind erosion control	
5 to 6 rows of shrubs, conifers, and trees			Winter protection of structures, livestock, and farmsteads
3 rows deciduous or 1 row conifer		Improved air quality-Windward side of odor source	
3 rows of conifers			Improved air quality-Leeward side of odor source
1 row conifer or 3 rows deciduous tree/shrub or combination			Visual screens
3 rows of conifers			Noise screens

Barriers with less than 20% density provide little useful wind protection. A windbreak with 50% density stores the most snow and provides the greatest downwind area of protection.

Windbreaks with only deciduous trees cannot achieve greater than 50% density in leaf-off condition.

The species used and their arrangement, the number of rows and the distance between rows, the distance between trees in the row and leaf retention (season) are the main factors controlling windbreak density. Increasing the number of rows or decreasing the distance between trees increases density. Conifers provide better year-round density, while tall deciduous trees are used to provide greater height, and; therefore, a greater zone of downwind protection.

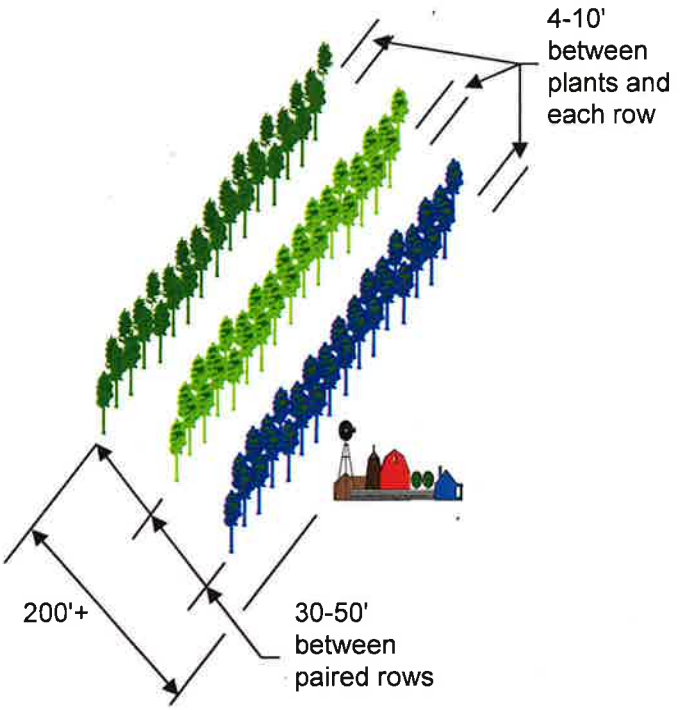


Figure 6. Twin-Row, High-density Windbreak

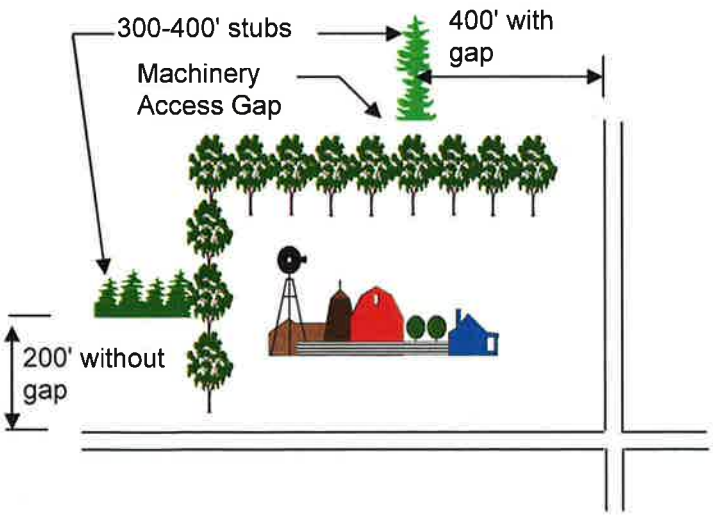


Figure 7. Windbreak Stubs for Snow Control

SPECIALTY 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.

Within-row spacing for each pair of a twin-row high-density windbreak will depend on the species type to be planted. Spacing between rows within each pair shall be the same as the within row spacing.

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.

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 foot stubs shall consist of 1-3 rows designed as a snow stoppage windbreak and oriented perpendicular to the problem legs of the existing windbreak.

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 7.

OPTIONAL DOCUMENTS FOR LANDOWNER USE

1. How Windbreaks Work http://nac.unl.edu/documents/morepublications/ec1763.pdf
2. Windbreak Establishment http://nac.unl.edu/documents/morepublications/ec1764.pdf
3. Windbreaks in Sustainable Ag http://nac.unl.edu/documents/morepublications/ec1772.pdf
4. Windbreaks and Wildlife http://nac.unl.edu/documents/morepublications/ec1771.pdf
5. Windbreaks for Rural Living http://nac.unl.edu/documents/morepublications/ec1767.pdf
6. Windbreaks for Livestock Operations http://nac.unl.edu/documents/morepublications/ec1766.pdf
7. Windbreaks for Snow Management http://nac.unl.edu/documents/morepublications/ec1770.pdf
8. Windbreak Management http://nac.unl.edu/documents/morepublications/ec1768.pdf
9. Windbreak Renovation http://nac.unl.edu/documents/morepublications/ec1777.pdf
10. Field Windbreaks http://nac.unl.edu/documents/morepublications/ec1778.pdf
11. Edible Woody Landscapes for People and Wildlife http://nac.unl.edu/documents/morepublications/sfp3_EdibleWoodyLandscapes.pdf