NebGuide

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# Windbreak Design

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This NebGuide provides general information for designing a tree and shrub windbreak. Landowners should work with a natural resource professional to develop site-specific tree planting plans.

What is the best design for a windbreak? The answer depends on the purpose of the windbreak, the benefits desired and the characteristics of the site where the windbreak will be located. The optimum windbreak will include enough trees to provide both wind and snow protection.

The typical multiple-row windbreak has several components: (1) dense conifer trees to reduce wind velocity; (2) tall broadleaf or conifer trees to extend the area of protection; (3) low shrubs to trip snow, provide wildlife habitat and/or provide aesthetic value. *Figure 1* illustrates a recommended multiple-row windbreak design.

Effectiveness of a windbreak is often expressed in terms of its density. Density is defined as the ratio of the solid area of the trees to the total area of the windbreak.

If the objective is protection from snow (e.g., a living snow fence), the windbreak should have a density of 70 - 80 percent. This can be achieved with multiple rows of dense conifer trees or closely spaced shrubs. If the objective is to spread snow across cropland using a field windbreak, the windbreak should have a density of 25 - 35 percent. One or two rows of mixed broadleaf or pine trees can provide this density. Most farmstead or livestock windbreaks should be designed with a density of 40 - 60 percent, which can be achieved by planting multiple rows of conifer and broadleaf trees (see *Figure 1*).

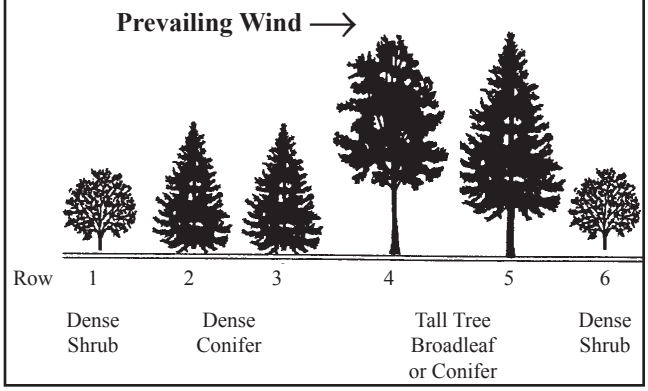


**Figure 1. Typical windbreak profile.**

## Windbreak Location

The most effective protection is obtained by orienting windbreaks perpendicular to the prevailing wind of concern. Windbreaks designed for winter protection are generally located north and west of farmsteads, livestock concentration areas, working facilities or other areas to be protected. Although often overlooked, protection from northeast storms should be considered when designing a windbreak.

*Figure 2* depicts two alternative windbreak designs. A windbreak with two legs protects a greater area than a single-leg windbreak. A common design error is not extending the windbreak beyond the area to be protected. This creates the problem of wind circling the end of the windbreak, increasing the windchill or snow deposition in the area being protected. In order to allow for snow deposition, the windward tree rows should be located approximately 150 - 250 feet upwind of the area to be protected. This will allow adequate space for snow deposition.

Field windbreaks designed to reduce soil erosion are generally single row windbreaks planted parallel to cropping patterns (north/south or east/west orientation). Windbreaks designed for growing season crop protection should be located on the south and east side of fields. The area protected by a windbreak is a function of the average height of the windbreak. Generally, a windbreak protects an area 10 - 15 times the average height ("H") of the trees. It may be better to use two single-row windbreaks spaced 15 times one height of the windbreak at maturity (15 "H"), than to use one double-row windbreak. These single-row windbreaks protect twice the cropped area, with the same amount of land in windbreaks. For more detailed information on how a windbreak works, please refer to the University of Nebraska Extension publication EC91-1763, *How Windbreaks Work.*

## Windbreak Composition

The number of tree rows in a windbreak depends on the objectives and available space. The following are guidelines for the number of tree rows for different types of windbreaks.

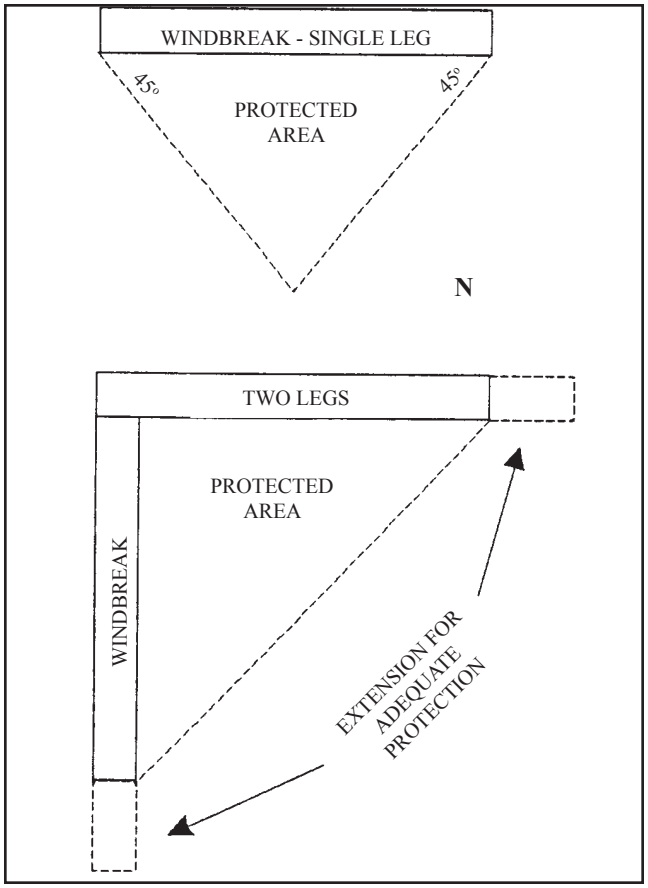


**Figure 2. Windbreak design and corresponding zones of protection.**

| Type | # Rows | # Rows of Dense Conifer |
|---|---|---|
| Farmstead | 4 - 10 | 2 - 4 |
| Livestock | 4 - 10 | 3 - 6 |
| Field windbreak | 1 - 2 | 0 - 1 |
| Living snowfence | 2 - 4 | 2 - 4 |

If the surrounding landscape is extremely unobstructed, more tree rows are needed in the windbreak to effectively influence wind speed and snow deposition.

A standard multiple-row windbreak should have windward rows of dense conifer trees or shrubs, interior rows of tall broadleaf trees and leeward rows of shrubs or conifers. A very important consideration in windbreak design is to maximize the diversity of species. This reduces the risk of insect, disease or environmental problems and provides excellent wildlife habitat.

## Spacing

A critically important windbreak design principle is that the individual tree and shrub plants interact and function as an integrated unit. Generally, the wider the initial tree spacing, the longer the effective life of the windbreak. Close spacing can be used to obtain windbreak protection and economic benefits sooner, but longevity of the windbreak will be reduced. Thinning (individual tree or whole row removal) can be used to extend the effective life of the windbreak. Very large spacings, where branches of individual trees and shrubs never intersect, may produce beautiful "specimen" trees, but such plantings will never function as a windbreak unit and will not effectively meet wind protection objectives.

Historically, most windbreaks in Nebraska were planted on very narrow spacings, causing their effectiveness to decline in about 40-50 years. As these trees matured, competition for light and moisture caused severe stress and eventual decline.

One common symptom of overly close spacing is the loss of interior foliage due to shading. This premature loss of foliage (needles) on conifer trees reduces density which reduces the effectiveness of the windbreak. Associated problems due to crowding include increased insect and disease problems, such as tree borers, canker disease or needle blights. Additionally, slow growing tree species, such as hackberry and honeylocust, can be stunted by fast growing tree species, such as Siberian elm.

*Table I* presents general guidelines for "within the row" and "between the row" spacing.

**Table I. General Spacing Guidelines for Windbreak**

| *Windbreak Position* | *Windbreak Component* | *Spacing (ft.) Between Trees in the Row* | *Spacing (ft.)* Between Tree Rows* |
|---|---|---|---|
| Windward Rows (Rows 1 or 2) | Dense Conifer | 6-12 | 12-20 |
| Leeward Rows (Rows 3+) | Dense Conifer | 8-12 | 14-20 |
| Leeward Rows (Rows 3+) Broadleaf /Conifer | Medium Ht. Trees | 10-18 | 14-20 |
| Leeward Rows (Rows 3+) | Tall Trees | 12-20 | 20-25 |
| Windward or Leeward Rows | Shrubs | 4-6 | 8-10 |

*A general guide would be to use a between-row spacing 4 feet wider than the largest piece of equipment to be used to maintain the windbreak or provide access.

## Species Selection

The species of trees or shrubs that should be planted depends on the soil type, precipitation zone, hardiness zone and personal preference. A County Soil Survey can provide detailed information on the suitability of various trees and shrubs for planting in specific soil types.

Available moisture during the growing season is critical for tree survival on the Plains. Supplemental irrigation or water conserving mulch can significantly increase tree seedling survival, as well as allow the planting of a wider variety of species in a windbreak.

*Table II* provides a general list of tree and shrub species that are adapted for planting in Nebraska. This list is not inclusive. Many species produce additional benefits, such as food for wildlife or commercially valuable specialty products.

## Windbreak Design Problems

A poorly designed windbreak may cause more problems than it solves. One of the most common design problems is locating the windbreak too close to the area to be protected.

**Table II. Tree and Shrub Selection Guide [1]**

| *Plant Type* | *Soil Type* | *Mature Height/ Width (in feet)[2]* | *Zone Within Nebraska* | *Specialty Products* | *Potential Problems* |
|---|---|---|---|---|---|
| **Conifer Trees[3]** | | | | | |
| Black Hills Spruce | Silty-Clay | 30-45/20 | West | cones | |
| Colorado Blue Spruce | Silty-Clay | 40-60/25-30 | Statewide | cones | |
| Concolor Fir | Silty-Clay | 40-50/25 | East | cones | |
| Eastern Redcedar | Silty-Clay; Sandy | 30-40/15-20 | East, Central | specialty wood | Cercospora Blight |
| Eastern White Pine | Silty-Clay | 40-60/20 | East | cones | Needs protection from wind |
| Jack Pine | Sandy | 35-40/15-20 | East | none | Pine Wilt |
| Norway Spruce | Silty-Clay | 45-60/25-30 | East | cones | Spider mites |
| Ponderosa Pine | Silty-Clay: Sandy | 40-60/20 | Statewide | cones | |
| Rocky Mt. Juniper | Silty-Clay; Sandy | 25-30/15-20 | West, Central | none | |
| **Broadleaf Trees** | | | | | |
| Amur Maple | Silty-Clay | 15-25/15 | East, Central | none | |
| Black Walnut | Silty-Clay | 40-60/30 | East | nuts, specialty wood | |
| Bur Oak | Silty-Clay | 40-55/30-40 | Statewide | wood | |
| Cottonwood | Silty-Clay | 65-85/40-50 | Statewide | none | |
| Crabapple | Silty-Clay | 15-20/10-15 | East, Central | none | |
| Green Ash | Silty-Clay | | East, Central | none | Stem borers |
| Hackberry | Silty-Clay: Sandy | 50-60/25-30 | East, Central | none | Sensitive to herbicides |
| Harbin Pear | Silty-Clay | 20-25/15 | East | none | |
| Hawthorne | Silty-Clay | 15-20/10-15 | Statewide | none | |
| Honeylocust | Silty-Clay: Sandy | 40-50/25-30 | Statewide | none | Invasive, thorns |
| Osage Orange | Silty-Clay | 40-50/30-40 | East | specialty wood | Invasive, thorns |
| Red Oak | Silty-Clay | 40-60/30-40 | East | wood | |
| Russian Olive | Silty-Clay: Sandy | 20-25/15-20 | Central, West | specialty wood | Invasive in riparian areas |
| Siberian Elm | Silty-Clay: Sandy | 50-60/30 | Statewide | none | Short-lived |
| Silver Maple | Silty-Clay | 50-65/40-50 | East, Central | wood | |
| **Shrubs** | | | | | |
| American Plum | Silty-Clay: Sandy | 10-12/10-15 | East | fruit | Forms thickets |
| Buffaloberry | Silty-Clay: Sandy | 10-12/6-8 | Statewide | fruit | |
| Caragana | Silty-Clay: Sandy | 6-10/4-6 | Statewide | none | |
| Chokeberry | Silty-Clay | 6-8/4-6 | East | fruit | |
| Chokecherry | Silty-Clay | 12-15/10-15 | East, Central | fruit | Forms thickets |
| Cotoneaster | Silty-Clay | 5-10/4-6 | Statewide | none | |
| Currant | Silty-Clay | 4-6/4 | East, Central | fruit, buds | |
| Dogwood | Silty-Clay | 6-10/6-8 | East, Central | decorative stems | |
| Elderberry | Silty-Clay | 4-8/6-8 | East, Central | fruit, flowers | Short-lived |
| False Indigo | Silty-Clay | 6-10/6-8 | East | none | |
| Hazelnut | Silty-Clay | 6-10/4-8 | East | nut | |
| Highbush Cranberry | Silty-Clay | 10-12/6-8 | East | fruit | |
| Honeysuckle | Silty-Clay | 6-10/4-6 | East | none | Aphids |
| Lilac | Silty-Clay | 6-10/6-10 | Statewide | flowers | Forms thickets |
| Nanking Cherry | Silty-Clay | 6-8/4-6 | East, Central | fruit | Short-lived |
| Sandcherry | Sandy | 3-6/3-4 | East, Central | fruit, seed | |
| Skunkbush Sumac | Silty-Clay: Sandy | 8-10/8 | East, Central | none | |

[1]Height/width figures from Nebraska NRCS Windbreak Suitability Technical Field Guide, Group 1 Table
[2]On better sites
[3]Because of the generally fatal pine wilt disease, Scotch Pine is no longer recommended for any long-term (greater than 8 years) planting in Eastern Nebraska.

This results in snow deposition where it is not wanted. For example, improperly located living snow fences may create hazards, such as reduced visibility, snow drifting on roads and shading, which prevents melting of ice on the roadway surface.

Another problem is the creation of a gap in the windbreak for access, which concentrates wind and accelerates it through the opening. For example, locating access lanes to fields through the middle of the windbreak can allow high velocity winds to enter these openings, along with high volumes of snow. It is better to locate field access lanes at the ends of the windbreak to avoid this problem. For maximum efficiency, the uninterrupted length of a windbreak should exceed the height of the windbreak by a ratio of at least 10:1. This ratio reduces the effect of end turbulence on the total protected area.

There is an old adage in windbreak design that goes, "if three rows of cedar are good, then eight to 10 rows are better." Large, multi-row, single-conifer-species windbreaks often lose their effectiveness in a short period of time (30-40 years) due to loss of density from shading or snow damage. *Figure 3* depicts this type of windbreak damage. The problem can be reduced by designing windbreaks with wider "between-the-row" and "within-the-row" tree spacings to allow sunlight penetration and snow deposition. Also, having a diversity of tree species in the windbreak will enhance the health and other benefits provided by the windbreak. Field windbreaks only need to be one to two rows wide to provide adequate wind protection. Adding additional rows to field windbreaks may be appropriate to produce other benefits, such as wildlife habitat or specialty woody crop production.

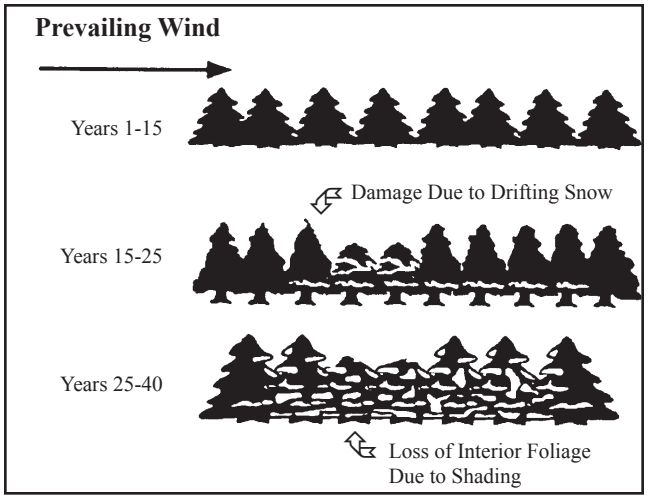


**Figure 3. Foliage loss in multi-row single species conifer windbreaks.**

Cool season, sod-forming grasses like smooth bromegrass should not be allowed in most windbreaks. Windbreaks function best when the design allows the trees to grow together and shade out competing grasses and weeds. However, vegetation between tree rows may be desirable in some cases for erosion control.

### Producing Specialty Woody Crops in Windbreaks

Multiple-row windbreaks can also be used to produce commercially valuable non-timber products such as tree- and shrub-based food crops (fruit and nuts), woody floral stems, specialty woods and medicinal plants. Such windbreaks are an example of "productive conservation," in which the windbreak not only protects the environment, but also provides important supplemental income through the production of specialty products. Fruit- and nut-producing woody plants that can be integrated into windbreaks include Nanking cherry, sandcherry, black, red or white currants, highbush cranberry, American plum, hybrid hazelnut, black walnut, northern pecan and Chinese chestnut. Superior cultivars that produce fruit or nuts with high-quality commercial characteristics are available for many of these species. Shrubs that produce copious numbers of woody decorative floral stems for use in the floral industry include curly willow, scarlet curls willow, pussy willow, a number of cultivars of red-stemmed dogwood and forsythia. Specialty woods can be obtained from osage orange (hedge), Russian olive, mulberry and most timber tree species. Even some medicinal plants can be produced in the shaded portions of the windbreak, given adequate moisture.

Government programs are often available to provide cost-share funds for windbreak establishment and maintenance and land rental payments for the land planted to the windbreak. However, some of these programs restrict or prevent any commercial harvest of timber or non-timber products from the windbreak during the program contract period. In this case, add one or more rows of trees or shrubs that produced specialty products to the windbreak, but outside the contracted area. Landowners need to work closely with their natural resource agency representative on their specific applications and income-producing objectives.

### Sources of Assistance

A successful windbreak is the result of proper planning, installation and maintenance. Anyone interested in planting a windbreak should contact their local Natural Resource Conservation Service (NRCS) office, Natural Resource District (NRD) office, county extension office or Nebraska Forest Service District Forester to obtain assistance in designing a windbreak. These natural resource professionals can provide specific information on soils, precipitation zone, tree and shrub species suitability, NRD tree planting programs and cost-share assistance. Several references are available that provide more detailed information on windbreak planning and establishment.

*How Windbreaks Work*, University of Nebraska–Lincoln Extension Publication, EC02-1763.

*Windbreak Establishment*, University of Nebraska–Lincoln Extension Publication, EC91-1764.

*Windbreak Renovation,* University of Nebraska–Lincoln Extension Publication, EC98-1777.

*Field Windbreaks,* University of Nebraska–Lincoln Extension Publication, EC00-1778.

*Windbreaks and Wildlife*, University of Nebraska–Lincoln Extension Publication, EC91-1771.

*Windbreaks in Sustainable Agricultural Systems*, University of Nebraska–Lincoln Extension Publication, EC91-1772.

*Windbreaks for Rural Living*, University of Nebraska–Lincoln Extension Publication, EC91-1767.

*Windbreaks for Snow Management*, University of Nebraska–Lincoln Extension Publication, EC96-1770.

*Windbreak Management*. University of Nebraska–Lincoln Extension Publication, EC96-1768.

*Windbreaks for Livestock Operations*, University of Nebraska–Lincoln Extension Publication, EC94-1776.

*Establishing Conservation Plantings of Nut Trees and Shrubs by Direct Seeding Methods.* University of Nebraska–Lincoln Extension Publication, G03-1512.

*Productive Conservation: Growing Specialty Forest Products in Agroforestry Plantings*. University of Nebraska–Lincoln Extension Publication, #AF0002.

*Trees and Shrubs for Nebraska Conservation Plantings,* University of Nebraska–Lincoln Extension Publication, EC88-1760.

*Field Office Technical Guide for Tree Planting.* Available at County Natural Resource Conservation Service Office.

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