USDA Forest Service
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Windbreaks #1

AGROFORESTRY NOTES

USDA Forest Service photo by Richard Straight

Windbreaks: An Agroforestry Practice

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Definition

Windbreaks or shelterbelts are single or multiple rows of trees or shrubs in linear configurations.

USDA Natural Resources Conservation Service photo by Gene Alexander

Windbreaks protect critical resources such as crops, soil, and livestock. Windbreaks also improve the *quality of life* on a farm, ranch, or around a community. They add beauty and a sense of permanence to homes and communities.

Windbreak Applications

Properly planned and planted, windbreaks protect:

Crops - Windbreaks protect wind-sensitive row, cereal, vegetable, orchard, and vine crops. While a windbreak requires some land to be removed from crop production, it typically results in a net increase in total crop yield (10 to 20%, depending on the crop).

Windbreaks enhance crop pollination, provide pesticide drift protection, as well as improve crop quality by reducing bruising and abrasion from soil particles. These benefits are especially important for vegetable and fruit crops. Windbreaks can also be designed to spread snow evenly across a field, increasing soil moisture in the spring, and improving irrigation efficiency.

Soils - Field windbreaks can reduce wind erosion and improve soil health. Strong winds can rob fields of organically rich topsoil, depriving plants of nutrients and soil of important components for developing soil structure. This loss of organic matter decreases soil's ability to store water and reduce its ability to support microorganisms.

Livestock - Livestock windbreaks can reduce animal stress and mortality from cold. They can also reduce winter feed consumption. Windbreaks can also be designed to minimize odors off-site and conceal unsightly views. A properly designed windbreak can protect livestock from cold winter winds and still allow summer winds to circulate in the feedlot or pasture area, reducing potential heat stress. Specialized livestock windbreaks called outdoor living barns are especially helpful during calving and lambing season (See AFN-2, WB-2 Outdoor Living Barns: A Specialized Windbreak).

Residences and Farmsteads - Protection of farm or ranch buildings reduces energy costs associated with heating and cooling. During the winter months, dense, multi-row windbreaks reduce the effects of cold winter winds and provide energy savings of 10 to 40%. Farmstead windbreaks reduce wind chill, making outside work safer and more comfortable. Properly located windbreaks reduce snowdrifts in work areas, save fuel, and add to the value of the farmstead.

Diversified Income Sources – Windbreaks can be used to generate additional income by incorporating trees and shrubs that yield non-timber forest production (NTFPs) like edible nuts and fruits, craft materials, and habitat for hosting honeybees. Windbreaks planted to grow income-producing crops can serve multiple functions.

Communities - Strategically placed community windbreaks can improve environments for both work and play. Cold winter and hot summer windspeeds can be reduced by more than 50%, making outdoor activities more comfortable. Windbreaks can also serve as visual screens between conflicting land uses, such as industrial sites and residential areas. The rural-community interface can be buffered with a windbreak designed to reduce impacts of dust and chemical drift from agricultural land.

Windbreaks controlling drifting snow improve accessibility around hospitals, fire stations, schools, and parking lots and can save lives. Many schools use their community windbreak as outdoor classrooms.

Roads and Highways - Trees and shrubs can be planted as living snow fences to keep roads clear of drifting snow and increase driving safety. Living snow fences are more cost effective than slat-fence snow barriers, have greater snow storage capacity, require less maintenance once established, have a longer life span, and can provide multiple benefits such as livestock and crop protection and soil erosion control.

Wildlife Habitat - Windbreaks used for wildlife habitat are usually much larger, with 5-10 rows of trees or shrubs being the preferred size. As with any activity, to improve wildlife habitat it is important to first identify which wildlife species are of interest and then determine which of the basic habitat needs are in short supply. If a windbreak can help meet this wildlife need, then a specific windbreak design can be developed.

Windbreaks can connect blocks of habitat, facilitating wildlife movement, and increase access to a food source. They can also provide winter protection or additional food sources. The composition of these windbreaks can be diverse with a single row containing more than one tree or shrub species.

Pollinators – More than 100 crop species in North America require visits from insect pollinators to be most productive. When farms are interspersed with pollinator habitat, native bees, feral honeybees, and other native pollinators can typically meet the needs of these diverse crops. However, in large farm fields pollinator habitat can be farther removed from the crops dependent on the pollinators. This is where trees and shrubs come in. A diverse planting of trees and shrubs can support pollinators within the area, increasing productivity of nearby crops especially if the windbreak species flower at different times. Also, insects pollinate more efficiently with lower wind speed.

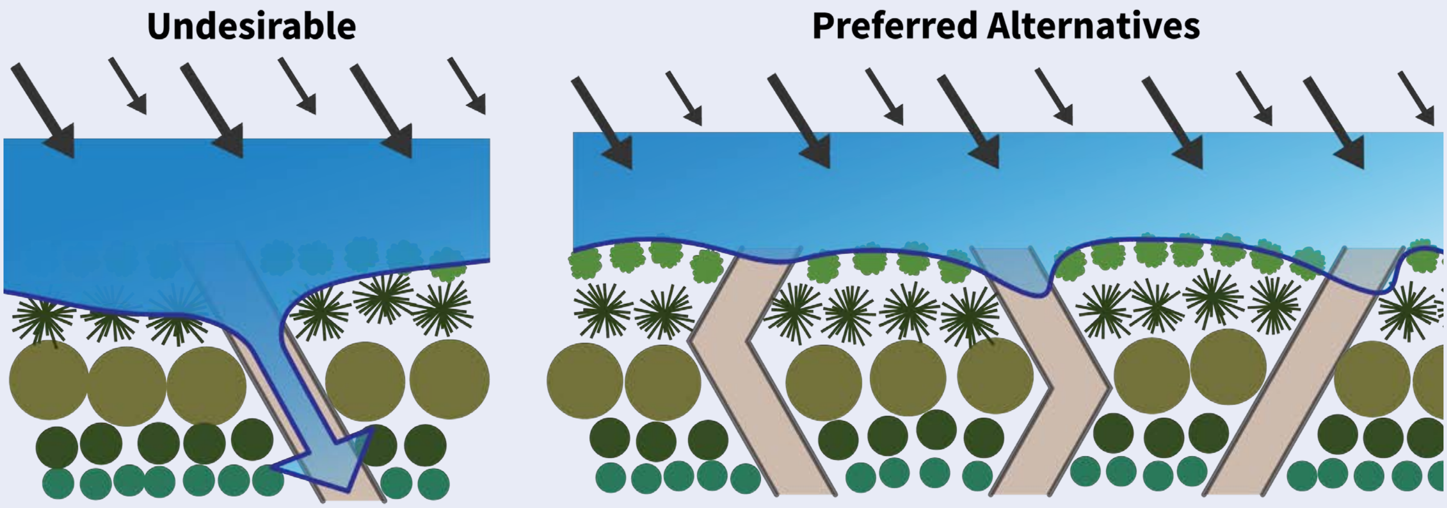
Design Considerations

Each windbreak design depends on the objectives of the landowner and local site conditions. Different applications require different designs. Windbreaks can be designed for multiple applications, but some functions are more compatible than others and all functions cannot be maximized at the same time. Consideration must be given to five key windbreak structural components: continuity, height, density, orientation, and length. By manipulating these components, an effective windbreak can be designed to meet the landowner's objectives.

Continuity of the windbreak is essential to achieve full effectiveness. Windbreaks should not have any large gaps. Gaps create a funnel effect that concentrates wind flow, increasing the wind speed in excess of that in the open field and often causing crop damage or soil erosion downwind of the gap. Replacing trees that die and locating access lanes around the ends of the windbreak can prevent gaps. If roads, lanes, or a large ditch must cross a windbreak, try to make the crossing at an angle to the prevailing wind direction. The goal is for the trees and shrubs to grow together to form a continuous barrier within ten years.

Diagram 1:

Avoid aligning access lanes through a windbreak parallel to the prevailing wind direction. A different alignment or changing the access lane direction will keep wind from blowing all the way through the gap in the windbreak.

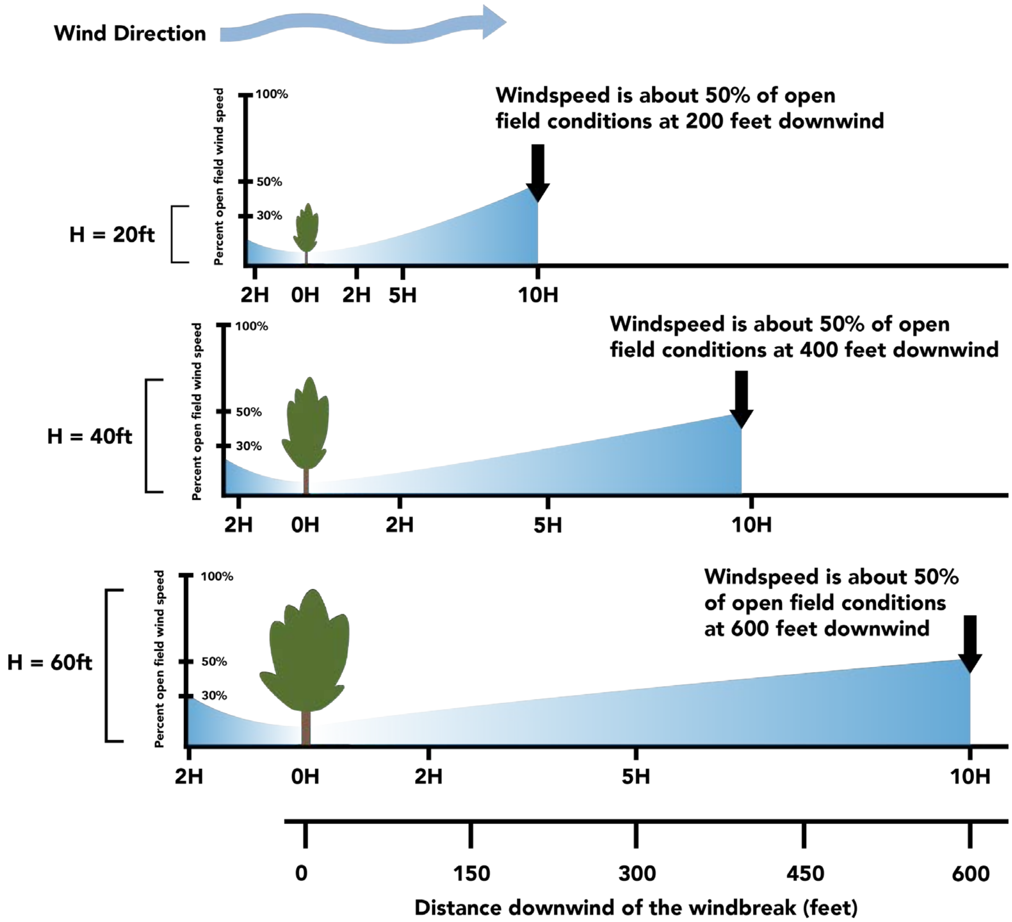


USDA Forest Service Graphic by SuJing May

Height of the windbreak, often referred to as H, is an important factor determining how far downwind the protected zone will extend. This value is based on the average height of the tallest row and will increase as the windbreak matures. The greatest wind speed reduction occurs in the area from two times (2H) to five times (5H) the height of the windbreak on the leeward, or downwind, side, with practical wind speed reduction up to 10H. Measurable windspeed reductions can occur as far away as 30 times the windbreak height.

Diagram 2:

As windbreak height increases, the distance down wind from the windbreak that is subject to wind speed reduction also increases. This also means that as a newly planted windbreak ages and the trees grow taller, the area downwind receiving protection will also increase.



USDA Forest Service Graphic by SuJing May, Josh Bundy

For example, for a windbreak where the tallest trees are 30 feet, the practical wind speed reductions will occur from 60 feet to 300 feet leeward of the windbreak. Contrast this with a 50-foot tall windbreak with a protected zone of 100 to 500 feet. On the upwind side of a windbreak, wind speed reductions are also measurable two to five times the windbreak height.

Density is the amount of leaves, branches and trunks in the windbreak. Wind blows over and around a windbreak and a portion also flows through the windbreak. Knowing or planning for the exact density of a windbreak is not critical. For practical purposes the targeted density for high density windbreaks is 60-80% dense; medium density windbreaks are 40-60% dense, and low density windbreaks are less than 40% dense. It is difficult to achieve windbreak densities over 80% with only vegetation. The more solid or dense a windbreak, the greater the wind speed reduction close to the windbreak, between 2 and 5 times the height.

This single row of blue spruce windbreak is about 60% dense. Courtesy photo by Dr. James Brandle

This single row of green ash without leaves is about 40% dense. USDA Forest Service photo

However, in high density windbreaks, the wind regains the speed it had in the open field closer to the windbreak than it does with a medium density windbreak. Recognize that windbreak density will change over time and from bottom to top. The density can be managed by the choice of species, evergreen versus deciduous, the spacing of the trees, and the number of rows in the windbreak. Identify the time of year when protection is desired and plan density accordingly. Different windbreak applications, such as wind erosion of soil, controlling snow drifting, or snow distribution, require different densities.

Diagram 3:

A dense windbreak will provide a greater reduction in wind speed closer to the windbreak than will a moderately dense windbreak.

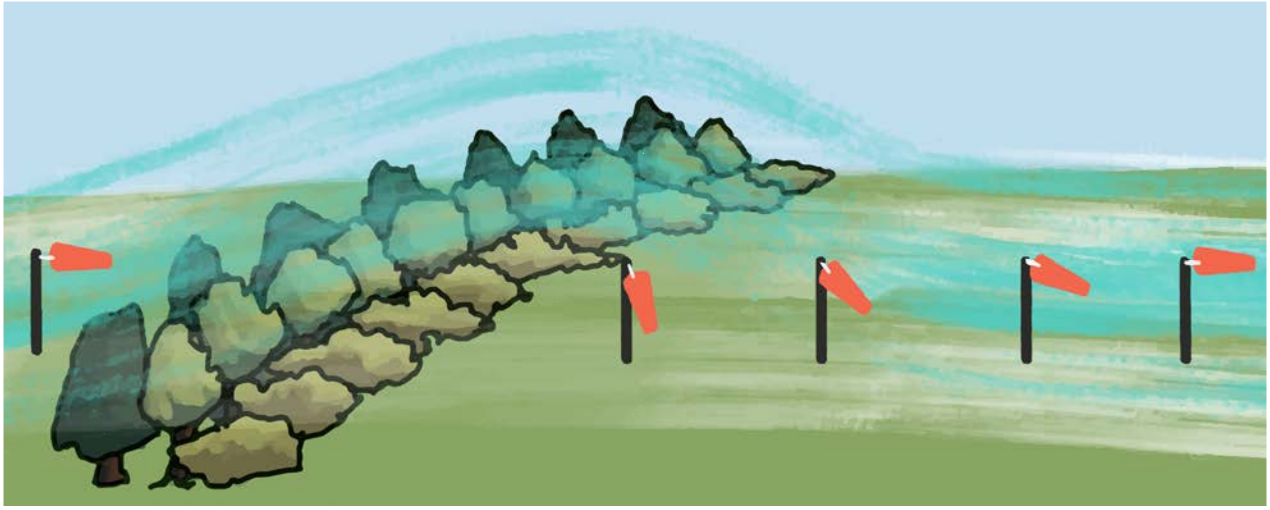
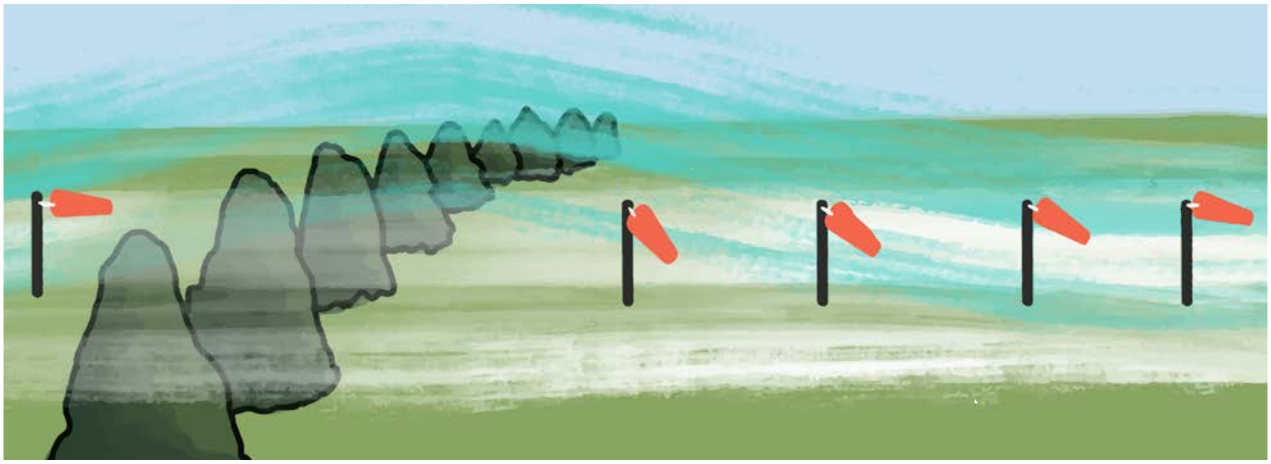


Diagram 4:

With a moderately dense windbreak the wind speed reduction will extend further downwind than with a very dense windbreak



USDA Forest Service Graphics by SuJing May, Josh Bundy

Orientation refers to the direction the windbreak faces. Windbreaks are most effective when oriented at right angles to the troublesome winds. To allow for changes in wind direction, windbreaks are often designed with rows extending in multiple directions such as an L, U, or E shape. When orienting the windbreak, avoid placement that may cause future management problems such as interference with utilities or road visibility.

Length of the windbreak determines the amount of total area receiving protection. For best protection, the uninterrupted length of a windbreak should exceed the height by at least 11:1. For example, if the height of the windbreak is 30 feet, the windbreak needs to be at least 330 feet long to minimize the impact of air turbulence around the ends of the windbreak.

Establishment

One of the most important decisions to improve windbreak establishment is the selection of trees and shrubs that are adapted to the soil and site. Poorly adapted species will require greater amounts of inputs, such as water, fertilizer, pest control, and time in order to become established and provide the desired benefits. Diversity of trees and shrubs within a windbreak is a must, especially with new insects and diseases being found each year. Varying the species within a row and limiting the amount of any single species in a windbreak will slow the possibility of an insect or disease wiping out the entire windbreak. However, complicated mixes of species within a row will slow the planting and must take into account the compatibility of the different growth rates, shade tolerance, and forms between the species.

Control of competing vegetation is a primary concern when considering site preparation, as well as ongoing management during the first three to five years of the windbreak. Common weed control methods include mulching, fabric mulch, tilling, herbicides, and mowing. Some people use cover crops between the tree rows, particularly when the entire site is tilled or trees are being planted into crop ground, to occupy the site and reduce annual weeds. Weed control reduces competition for sunlight, growing space for both above and below ground, and water, which will help reduce the need for irrigation in some regions. Reducing competition for all these resources through weed control will allow the trees and shrubs to occupy the site and outcompete the undesirable annual and perennial weeds.

Maintenance

Regular maintenance early in the life of a new windbreak is important and will occur up to five years or until canopy closure makes maintenance impossible. The primary maintenance activities are replacing dead seedlings, controlling competing vegetation, inspecting for insect and disease problems, irrigation (when necessary), and some corrective pruning.

When designing a windbreak, it is important to consider the equipment that will be used to maintain the windbreak. Adjust the width of the rows to fit any equipment that will be used to control competing vegetation. Enough space should be left at the end of the windbreak so that equipment can be turned around. If a fence will be installed adjacent to the windbreak, make sure enough space is allotted for installation of the fence. Finally, it is important to be aware of and follow all county and state regulations regarding setbacks from roads, road intersections and overhead and underground utilities.

Once the windbreak is established, management is not typically as intense. Seasonal inspection for common insect pests and diseases is a good practice for windbreaks of any age. Another long-term management consideration is whether to remove trees to reduce tree-to-tree competition and maintain a healthy windbreak.

Older or neglected windbreaks may require more significant management, often called windbreak renovation. Specific techniques can help address key challenge such as substantial amounts of competing vegetation, dead or dying trees, gaps in the windbreak, or other challenges. Windbreak renovation could include thinning trees, removing tree rows, adding additional trees or tree rows, or replanting the windbreak.

Conclusion

The information in this note is only an introduction to windbreak benefits and design. Each windbreak needs to be developed based on a detailed site analysis and a discussion with the landowner about his or her desired outcomes. For more detailed windbreak design criteria specific to your area, refer to the USDA Natural Resources Conservation Service/Field Office Technical Guide or Cooperative Extension Service bulletins in your county. More information is also available from the USDA National Agroforestry Center web site (www.fs.usda.gov/nac) and the references listed below.

Additional Information

USDA National Agroforestry Center Windbreak Webpage: https://www.fs.usda.gov/nac/practices/windbreaks.php

Agroforestry Note #2: Outdoor Living Barn: A Specialized Windbreak https://www.fs.usda.gov/nac/assets/documents/agroforestrynotes/an02w02.pdf

Agroforestry Note #35: Using Agroforestry Practices to Reduce Pesticide Risks to Pollinators & Other Agriculturally Beneficial Insects https://www.fs.usda.gov/nac/assets/documents/agroforestrynotes/an35g09.pdf

Agroforestry Note #36: Windbreak Density: Rules Of Thumb For Design https://www.fs.usda.gov/nac/assets/documents/agroforestrynotes/an36w03.pdf

Agroforestry Note #41: Windbreaks: A “fresh” tool to mitigate odors from livestock production facilities https://www.fs.usda.gov/nac/assets/documents/agroforestrynotes/an41w04.pdf

Agroforestry Note #42: Using agroforestry to buffer noise https://www.fs.usda.gov/nac/assets/documents/agroforestrynotes/an42w05.pdf

Field Windbreaks - University of Nebraska Cooperative Extension https://www.fs.usda.gov/nac/assets/documents/morepublications/ec1778.pdf

How Windbreaks Work - University of Nebraska Cooperative Extension https://www.fs.usda.gov/nac/assets/documents/morepublications/ec1763.pdf

Living Snow Fences – USDA NRCS and Idaho Resource Conservation and Development Association https://www.fs.usda.gov/nac/assets/documents/morepublications/livingsnowfences.pdf

Searchable Windbreak Bibliography, University of Nebraska School of Natural Resources https://snr.unl.edu/data/trees/research/windbreakbiblio.aspx

Trees Against the Wind, NRCS Technical Note #13 https://www.nrcs.usda.gov/Internet/FSE_PLANTMATERIALS/publications/wapmctn6337.pdf

USDA Natural Resources Conservation Service, CORE4 Conservation Practices, Chapter 3j - Windbreak/ Shelterbelt, August, 1999 https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs143_025540.pdf

Windbreak Design, Or How Windbreaks Work/webinar Nebraska Forest Service, Nebraska Windbreak Shortcourse https://youtu.be/lEhka5IkOwo?t=1985

Windbreak Economic Model https://www.fs.usda.gov/nac/resources/tools/windbreak-economic-model.shtml

Windbreak Establishment - University of Nebraska Cooperative Extension https://www.fs.usda.gov/nac/assets/documents/morepublications/ec1764.pdf

Windbreak Management – University of Nebraska Cooperative Extension https://www.fs.usda.gov/nac/assets/documents/morepublications/ec1768.pdf

Windbreak Purposes, webinar presentation, Nebraska Forest Service, Nebraska Windbreak Shortcourse https://youtu.be/lEhka5IkOwo?t=4555

Windbreak Renovation - University of Nebraska Cooperative Extension https://www.fs.usda.gov/nac/assets/documents/morepublications/ec1777.pdf

Windbreaks and Wildlife - University of Nebraska Cooperative Extension https://www.fs.usda.gov/nac/assets/documents/morepublications/ec1771.pdf

Windbreaks for Conservation – NRCS https://www.fs.usda.gov/nac/assets/documents/morepublications/windbreaksforconservation.pdf

Windbreaks for Fruit and Vegetable Crops - University of Nebraska Cooperative Extension https://www.fs.usda.gov/nac/assets/documents/morepublications/ec1779.pdf

Windbreaks for Livestock Operations - University of Nebraska Cooperative Extension https://www.fs.usda.gov/nac/assets/documents/morepublications/ec1766.pdf

Windbreaks for Rural Living - University of Nebraska Cooperative Extension https://www.fs.usda.gov/nac/assets/documents/morepublications/ec1767.pdf

Windbreaks for Rural Living - University of Nebraska Cooperative Extension https://www.fs.usda.gov/nac/assets/documents/morepublications/ec1767.pdf

Windbreaks in Sustainable Agricultural Systems - University of Nebraska Cooperative Extension https://www.fs.usda.gov/nac/assets/documents/morepublications/ec1772.pdf

Working Trees Information Sheet: Can windbreaks benefit your soil health management system? https://www.fs.usda.gov/nac/assets/documents/workingtrees/infosheets/WTInfoSheet-WBSoilHealth.pdf

Working Trees Information Sheet: Can windbreaks help with organic farming? https://www.fs.usda.gov/nac/assets/documents/workingtrees/infosheets/WindbreaksOrganicFarmingMarch2014.pdf

Working Trees Information Sheet: What is a windbreak? https://www.fs.usda.gov/nac/assets/documents/workingtrees/infosheets/wb_info_050712v8.pdf

Working Trees Information Sheet: Can windbreaks do more than slow the wind? https://www.fs.usda.gov/nac/assets/documents/workingtrees/infosheets/WTInfoSheet_WindbreaksDoMore.pdf

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