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Windbreaks: An Agroforestry Practice

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USDA National Agroforestry Center

AGROFORESTRY NOTES

AF Note — 25 March 2002

Windbreaks: An Agroforestry Practice

Purpose of Note

- Introduce the concept of windbreaks and their benefits
- Describe different applications of windbreaks
- Discuss basic design and planning considerations

Definition

Windbreaks are strips of trees and/or shrubs planted and maintained to alter windflow and microclimate, thereby protecting a specific area. They are often planted and managed as part of a crop and/or livestock operation. Windbreaks also improve the quality of life around farmsteads, rural residences, and communities.

Benefits

The main reason windbreaks are widely used is their ability to serve one purpose, while at the same time provide additional varied benefits. For example, a windbreak designed to protect a farmstead from severe winter weather also provides wildlife habitat, reduces dust and chemical drift, is aesthetically pleasing, and increases property value.

Windbreaks improve the *local environment.* Soil quality is maintained through prevention of wind erosion. Air and water quality are enhanced by filtering and trapping airborne pollutants like dust and drifting chemicals. And, reducing wind speed improves water use efficiency by lowering evaporation rates from plants and soils.

Windbreaks can increase *economic potential.* Windbreaks on a farm or in a community can reduce energy costs, improve crop yields, maintain livestock health and vigor, and produce specialty products (nuts, fruits, or decorative florals) or a wood product (firewood, posts, or lumber).

Windbreaks 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. The returns in comfort and protection far outweigh the costs.

Windbreaks provide *wildlife habitat.* If planned correctly, windbreaks provide food, shelter, and travel corridors that are necessary for many species of wildlife.

Windbreaks *store carbon.* While windbreaks protect farmsteads, livestock, roads, people, soils, and crops they also store carbon. Planting only 2.5 percent of the tillable land in the Great Plains to tree windbreaks could remove an estimated 80 million metric tons of carbon dioxide (CO_2) in only 20 years.

Windbreak Applications

Properly planned and planted, windbreaks *protect*:

Fields and 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 percent) and crop quality. Field windbreaks are especially beneficial in controlling wind erosion and increasing pollination and pesticide effectiveness. They can also be designed to spread snow evenly across a field, increasing spring soil moisture.

Livestock – Livestock windbreaks help reduce animal stress, mortality, feed consumption, visual impacts, and odors. 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*).

Rural Residences and Farmsteads – Protection of farm or ranch buildings reduces the 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 percent. 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.

Communities – Strategically placed community windbreaks can improve environments for both work and play. Cold winter and hot summer winds can be reduced by more than 50 percent, making outdoor activities more comfortable. Windbreaks can also serve as visual and noise 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 around hospitals, fire stations, schools, and parking lots can save lives. Many schools use their community windbreak as an outdoor classroom.

Roads and Highways – Trees and shrubs can be planted as *living snowfences* 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.

Design Considerations

Each windbreak design is unique depending on objectives of the landowner and local site conditions. Consideration must be given to five key windbreak structural components: height, continuity, density, orientation, and length. By manipulating these components, an effective windbreak can be designed to meet the landowner's objectives.

Height of the windbreak, often referred to as H, is an important factor determining how far downwind the protected zone will reach. This value increases as the windbreak matures. The greatest wind speed reduction occurs in the area from two times (2H) to ten times (10H) the height of the windbreak on the leeward, or downwind, side. Measurable reductions can also occur as far away as thirty times the height. For

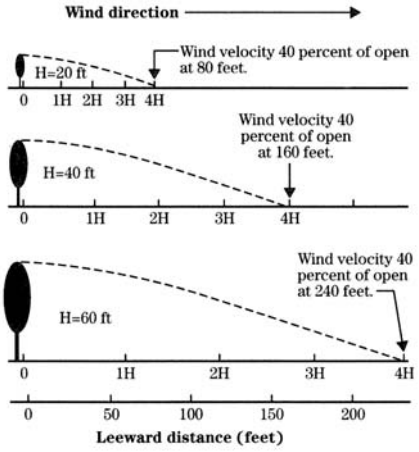
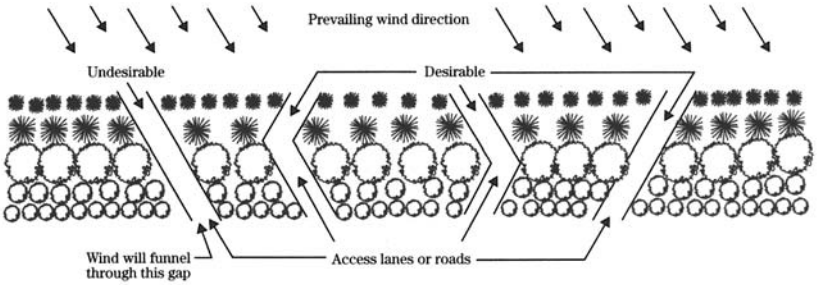


Figure 1 - Leeward distance of wind protection is proportional to height of the barrier.

example, for a windbreak where the tallest trees are 30 feet, the greatest 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 measurable for a distance of two to five times the height of the windbreak.



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 wind speed in excess of those in the open field often causing damage downwind from 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.

Density is the amount of leaves, branches and trunks in the windbreak. Wind blows over and around a windbreak but a portion also flows through the windbreak. The more solid or dense a windbreak, the greater the wind speed reduction. However, less dense planting allows for protection to a greater distance. The density can be managed by the choice of species, conifer versus deciduous, the spacing of the trees, and the number of rows in the windbreak.

Orientation is 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 planted 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 10:1. For example, if the height of the windbreak is 30 feet, the windbreak needs to be at least 300 feet long to minimize the impact of air turbulence around the end of the windbreak.

(A) Open wind speed 20 mph
Deciduous 25-35% density

H distance from windbreak	5H	10H	15H	20H	30H
Miles per hour	10	13	16	17	20
Percent of open wind speed	50%	65%	80%	85%	100%

(B) Open wind speed 20 mph
Conifer 40-60% density

H distance from windbreak	5H	10H	15H	20H	30H
Miles per hour	6	10	19	15	19
Percent of open wind speed	30%	50%	60%	75%	95%

(C) Open wind speed 20 mph
Multi row 60-80% density

H distance from windbreak	5H	10H	15H	20H	30H
Miles per hour	5	7	13	17	19
Percent of open wind speed	25%	35%	65%	85%	95%

(D) Open wind speed 20 mph
Solid fence 100% density

H distance from windbreak	5H	10H	15H	20H	30H
Miles per hour	5	14	18	19	20
Percent of open wind speed	25%	70%	90%	95%	100%

Figure 2 - Wind speed reduction to the lee of windbreaks with different densities.

The effectiveness of a windbreak for a given purpose is dependent upon blending these five components. Two key guidelines apply:

- Orient the windbreak(s) as close to perpendicular to the troublesome wind direction.
- Select tree and shrub species that are adapted to the soils and climate.

Windbreak Design Examples

The following are examples of how windbreak design elements will vary depending on the desired purpose(s) of the windbreak:

Windbreak for field protection (e.g. crops, soil)

- Windbreak density of 40 to 60 percent provides optimal downwind protection of crops or soil. This can be achieved with one to three rows of trees. A single row of conifers or a single row of deciduous trees in full leaf would be adequate.
- The windbreaks should be applied in a series across the field at an interval from 10H to 20H of mature height, depending on the level of protection desired. Windbreak intervals should account for the protection provided on both the windward and leeward sides of the windbreak. Windbreak intervals for wind erosion protection should be based on a wind erosion prediction tool that considers soil texture and wind speed. The windbreak should be at least as long as the field for maximum protection.

Windbreak for structural protection (e.g. farmstead, feedlot, roads, buildings)

- Windbreak density greater than 60 percent is usually desirable to maximize the wind reduction. This can be achieved with three or more rows of trees and shrubs. At least one row of conifers is needed if the goal is to provide protection with the fewest number of rows.
- When snow deposition is a concern, a windbreak setback of 100 to 200 feet from the site being protected is needed to allow adequate space for snowdrifts to accumulate.
- The windbreak should extend at least 100 feet past the site being protected to account for air turbulence around the end of the windbreak.

The information in this note is only an introduction to windbreak benefits and design. Each windbreak design 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.unl.edu/nac) and the references listed below.

Additional Information

Brandle, J.R. and Finch,S., "How Windbreaks Work." University of Nebraska Cooperative Extension EC 91-1763-B.

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Quam, V.C., Gardner, J., Brandle, J.R., and Boes, T.K., "Windbreaks in Sustainable Agricultural Systems." University of Nebraska Cooperative Extension EC 91-1772-X.

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