AGROFORESTRY IN MINNESOTA
FACTSHEET SERIES #3

Windbreaks

WHAT ARE WINDBREAKS?

Snow drifts caught by a willow living snow fence next to a soybean field in Waseca, MN.

Windbreaks are plantings of trees, shrubs, or a combination of the two installed to reduce windspeed in an agricultural area for multiple purposes. They are an agroforestry practice which involves the intentional integration of woody and crop species for greater and more diversified use of resources compared to monoculture cropping, and provides potential for economic outputs from both the woody and crop components. In the United States, windbreaks gained popularity during the extensive droughts and soil erosion of the Dust Bowl, when widespread initiatives were undertaken, such as those by the Civilian Conservation Corps, to plant windbreaks to reduce soil erosion on farmland.

BENEFITS OF WINDBREAKS

Today windbreaks are still planted to reduce soil erosion, but are also planted for the following benefits:

- **Reduce energy costs around farmsteads**: Planting windbreaks around rural homes and farmsteads can reduce energy costs from heating and cooling. On average, well-designed windbreaks have reduced energy costs for rural homes in the northern US and Canada by 10-20% (Brandle et al., 2004).
- **Provide odor mitigation around livestock operations**: Windbreaks can intercept and disperse odors before they accumulate and become a nuisance downwind of a livestock operation. Studies have shown that windbreaks can reduce downwind odor concentration by 6-33% (Brandle et al., 2009).

- **Reduce wind stress on crops and improve crop microclimate and yield**: Wind can physically damage plants through abrasion and leaf tearing, which can hinder plant growth. By reducing wind speed, windbreaks can reduce this damage to downwind crops. Reduced wind speed in the lee of a windbreak can also increase humidity as well as air and soil temperatures for crops. Studies have indicated that these favorable growing conditions were, on average, associated with a 6-44% increase in crop yield (Brandle et al., 2004).
- **Protect livestock from wind stress**: Like crops, microclimate conditions for livestock grazing can also be improved by windbreaks. Studies have shown that livestock tend to prefer grazing areas sheltered by windbreaks over open areas during cold and windy conditions (Brandle et al., 2009).
- **Manage snow around roads and farmsteads**: Blowing and drifting snow on roadways pose considerable costs to transportation industries and risks to motorists. Living snow fences - windbreaks planted next to roads to trap upwind blowing snow - are a cost-effective solution to reducing snow removal costs and preventing accidents (Gullickson et al., 1999). Well-designed living snow fences around farmsteads can reduce snow removal time and hassle, as well.
- **Manage snow on croplands**: Moisture from snow can be an important water resource for crop production in northern, semiarid areas. As much as one-third of the snowfall in these areas can be blown off open fields or lost to the atmosphere via sublimation (solid snow particles to water vapor). Windbreaks planted to trap snow on fields can add to soil moisture in the spring. Studies have shown this effect to increase crop yields by 15-20% (Brandle et al., 2004).
- **Provide ecosystem services, such as wildlife habitat, and recreational opportunities**: Ecosystem services are benefits humans receive from ecosystems, such as clean air and water. Ecosystem services provided by windbreaks include reducing wind erosion on farmland, which benefits soil fertility, structure, and moisture. Windbreaks also sequester carbon dioxide from the atmosphere into their woody biomass above and below the ground. This can play a role in reducing rising atmospheric carbon dioxide concentrations, as well as adding carbon - an important component of soil fertility and structure - to the soil via leaf and root litter from trees and shrubs. Wildlife is another benefit of windbreaks. Windbreaks can often provide structural habitat for birds and insects, some of which may be valuable for the control of crop pests. They can also attract game species such as pheasants and quail and improve hunting opportunities.
- **Provide timber, biomass, fruit, or floral products**: Windbreaks planted with valuable timber species can be harvested in the future and provide the farmer with additional income. Wood from the windbreaks can also be harvested for building material or firewood. Increasingly, fast-growing shrubs and trees, such as willows and poplars, are being considered for sources of biofuels from woody biomass. If these are incorporated into windbreak plantings, they could be harvested on short rotations and sold to a bioenergy facility. Lastly, windbreaks can provide economic outputs in the form of fruits and nuts or floral products (Streed and Walton, 2001).

DRAWBACKS OF WINDBREAKS

Windbreaks can offer many benefits to crops, livestock, and people, which begs the question, are there any drawbacks? Windbreaks will need to be maintained for weeds and moisture in the first years of establishment. Proper site preparation, which may include application of pre-emergent herbicides or mulch, can reduce the amount of time and effort spent on these issues. Windbreaks may also compete with crops in their direct vicinity for water, soil nutrients, and light. These effects can be reduced by selecting trees that grow deeper roots than crops or by root pruning the trees/shrubs. Although competition can reduce crop yield in the direct vicinity of windbreaks, studies have shown that, in some cases, this loss in yield can be overcompensated for by the increased yield due to improved microclimate conditions farther downwind of the windbreak (Brandle et al., 2009).

DESIGN ELEMENTS

How effective a windbreak is at its intended function will depend on how well it is designed. While the design of windbreaks will vary with landowner goals, there are three main design elements to consider for any windbreak goal: height, density, and length.

Rows of coniferous windbreaks on a pasture in southeastern MN.

Height: When wind encounters a windbreak, some of it goes through the windbreak while some of it travels up and over the windbreak. How far wind has to travel up and over the windbreak is one component in determining the zone of reduced wind speed downwind of the windbreak. This zone of reduced wind speed is typically defined as a length in reference to the windbreak's height, denoted by the letter *H*. As a rule of thumb, windbreaks typically reduce downwind wind speed for a length of 10*H* to 30*H*. For example, a windbreak with a height of 10 feet will reduce downwind wind speed for a distance of 100 to 300 feet. Windbreaks will also offer some distance of reduced upwind wind speed; this typically extends to a distance of 2*H* to 5*H* upwind.

Density: Windbreak density controls how much wind goes through a windbreak. One way to observe windbreak density is to face the windbreak perpendicularly and look through it; the harder it is to see through it, the denser it is. Different levels of windbreak density are used for different purposes. For example, when managing snow for crop moisture, windbreaks that are less dense will distribute snow over a greater downwind length than windbreaks with higher densities. Higher densities can be advantageous for living snow fences, where highway right-of-ways have a limited width and thus require short and deep snow drifts downwind of a fence. The desired density of a windbreak will influence the species used and their spacing in a windbreak. For example, spruce planted at a close spacing will provide a very dense windbreak, whereas poplar planted at a wide spacing will be less dense.

Length: In addition to passing through and over a windbreak, wind also travels around a windbreak. One design implication of this is that the length of the windbreak should be oriented perpendicular to the prevailing wind direction for maximum wind reduction. The more closely a windbreak is oriented to the prevailing wind direction, the more easily wind will flow around the windbreak and reduce the zone of protection. Additionally, since wind flows around the ends of a windbreak, the length of the windbreak should be at least ten times as long as its height (10*H*) to reduce this end effect. This end effect can be particularly pronounced for living snow fences. In general, living snow fences should have a length of at least 25*H*; snow fences with lengths less than 25*H* will have rounded drifts at their ends, extending in about 12*H*.

ADDITIONAL RESOURCES

Brandle JR, Hodges L, Tyndall J, Sudmeyer RA (2009) Windbreak Practices. In: Garett HE (ed) North American agroforestry: an integrated science and practice, 2nd ed. American Society of Agronomy, pp 75–104.

Brandle JR, Hodges L, Zhou XH (2004) Windbreaks in North American agricultural systems. Agroforestry Systems 61-62:65–78.

Gullickson D, Josiah SJ, Flynn P (1999) Catching the snow with living snow fences. University of Minnesota Extension Service, St. Paul, MN.

Johnson RJ, Beck MM, Brandle JR. Windbreaks and wildlife. University of Nebraska Extension EC 91-1771-B.

Streed E, Walton J (2001) Producing marketable products from living snow fences. University of Minnesota Extension Service, St. Paul, MN.

NEED FOR INFORMATION?

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