Living Windbreaks for Desert Dwellers

Robert Morris, Southern Area Horticulture Specialist
Alice M. Crites, Northeast Clark County Extension Educator

A windbreak is any interruption of the prevailing wind, whether the windbreak is a living one or a structural one. Reducing wind reduces damage to plants (Figure 1), improves overall plant quality and production, decreases plant water use, improves the outdoor living environment, decreases human and animal health problems due to blowing dust, reduces home energy use, attracts wildlife, provides visual screens for privacy or blocks undesirable views, and provides protection for domestic animals among many other things. However, living windbreaks require irrigation and maintenance. Costs and benefits of windbreaks, and the type and design of them, should be carefully weighed and considered before planting or constructing one.

How Windbreaks Work

As wind blows against a windbreak, air pressure builds up on the windward side (the side toward the wind), and large quantities of air move up, over the top or around the ends of the windbreak. The speed of wind passing through it is reduced. Interruption of wind provides a protected area on the leeward or downwind side of the windbreak. How much area is protected depends mainly on the windbreak’s average height, its porosity (the extent to which gaps let the wind through), the terrain on both sides of the windbreak, vegetative cover upwind, and the angle at which the wind meets the windbreak.

The density of a windbreak’s foliage affects the windbreak’s porosity. In wind tunnel experiments, winds were reduced 75% in a 30% porous windbreak compared to less than 40% in a 70% porous windbreak. Windbreak porosity has no significant effect on the size of the area sheltered. However, large openings in the windbreak can “channel” winds through the openings, increasing windspeed and reducing its efficiency.

Conifers such as pines, junipers and arborvitae typically are less porous and therefore more efficient at reducing windspeed than deciduous plants, providing year-round protection. Increasing plant density and the number of rows of plants in a windbreak also decreases porosity and makes the windbreak more efficient.

The size of the area protected by a windbreak is directly related to the windbreak’s height (H). The area protected by a windbreak on the leeward (downwind) side increases as the height of the windbreak increases. The protected area downwind can range from five times the height of the windbreak up to perhaps 30 times the height. So, for example, a 30-foot-high windbreak may provide protection to an area 150 to 900 feet downwind.

The impacted area of the windbreak can be divided into three zones (Figure 2): A) the zone of competition, B) the quiet zone, and C) the wake zone. The zone of competition is the area closest to the windbreak, on either side, where windbreak plants may compete for water, nutrients and light with any plants in their vicinity.
The area on the leeward side with the greatest reduction of wind speed is known as the quiet zone. The quiet zone may extend downwind to about 5-10 times the height of the windbreak.

At a distance of 5-10 times the height of the windbreak, wind modified by the windbreak begins mixing with air that was forced above and around the ends of the windbreak. As this mixing occurs, turbulence is created. This turbulence marks the beginning of the wake zone, where slowed wind picks up speed, moves out of the protected area, and returns to its pre-windbreak speed. The wake zone may extend a distance of 10-30 times the height of the windbreak.

Immediately on the leeward side of the windbreak, a small microclimate is created; temperature and humidity are elevated, providing some protection from freezing temperatures which may benefit early-season horticultural crops. At a downwind distance of about 15 times the height of the windbreak, these microclimate changes disappear; air temperature and humidity return to their windward side condition with benefits mentioned earlier disappearing.

It is important to accurately determine the direction of the prevailing wind so that the windbreak can be planted at right angles to that wind. The angle at which the prevailing wind intercepts the windbreak, and the length of the windbreak in relation to its height, affects a windbreak’s efficiency. As long as a windbreak’s length is more than 20 times its height, wind angles less than 30 degrees from perpendicular produce only small reductions in the protected area downwind. At angles more than 30 degrees from perpendicular, the size of the protected area declines rapidly.

Designing and Managing Windbreaks

Decisions to be made in the design of a windbreak include where it should be located, what height is needed for the protected area, the types of plants to use and their spacing. Costs need to be considered, which include irrigation water, fertilizers, and regular maintenance such as pruning and weed, insect and disease control. Benefits versus costs should be compared carefully before deciding to plant a living windbreak.

Location. In regions where the wind primarily comes from a single direction, the orientation and location is fairly simple and a “single-line” windbreak will work. Elsewhere, decisions concerning orientation may be more difficult and an L-shape or U-shape windbreak may be more effective. For example, in some locations prevailing winds can shift during the seasons. Time of year when protection is needed may dictate the location and shape of the windbreak. For the protection of wind-sensitive crops planted in large fields, multiple windbreaks spaced across the field may be needed.
Rough terrain on the windward side of a windbreak will reduce a windbreak’s efficiency. Windbreaks are more efficient when terrain on the upwind side is flat and free from obstructions. Rocky outcroppings, buildings, trees or hills on the windward side increases the turbulence of the approaching wind, decreasing the windbreak’s efficiency.

**Porosity and uniformity.** The porosity, or degree of openness of a windbreak, determines the reduction in wind speed in the protected area. Porosity will be determined by the type of plants used, planting distances between plants and between individual rows in the windbreak, and how the windbreak is watered, fertilized and maintained. Large gaps in the windbreak due to passageways, plant damage or openness under plant canopies will reduce the effectiveness of the windbreak and cause “channeling” of the wind.

**Height.** Height of the windbreak determines the size of the protected area. The height or size of a living windbreak also determines its potential water use. Unnecessarily tall windbreaks increase irrigation and maintenance costs without providing desirable benefits. It is important that a living windbreak reaches its desirable height as soon as possible through the use of fast-growing species and judicious fertilization and pruning practices. Siting a windbreak on an elevation rise will give increased height sooner to a living windbreak and may allow the use of smaller plants.

**Length.** A windbreak with a length less than 20 times its average height has little value, since wind moves around the ends of the windbreak and reduces the size of the protected area. The longer the windbreak, the more protection provided when winds blow at angles other than perpendicular. On the other hand, the longer the windbreak, the more plants that are needed. More plants means increased irrigation and maintenance costs. Windbreak length should be determined carefully.

**Width.** A living windbreak’s width (depth) contributes to its overall porosity. Windbreak width is increased primarily by adding more rows of plants. Most typically, windbreaks use multiple rows of plants to achieve a lower porosity and lower downwind speeds. Multiple rows of plants increase costs in irrigation and maintenance. Crowding of plants in a windbreak causes increased pest susceptibility and eventual plant dieback.

### Plant Spacing for Windbreaks

<table>
<thead>
<tr>
<th>Type of Plant</th>
<th>Spacing</th>
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<tbody>
<tr>
<td>Shrubs</td>
<td>4’ to 6’</td>
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<tr>
<td>Conifers like Pines</td>
<td>8’ to 14’</td>
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<tr>
<td>Deciduous Trees</td>
<td>10’ to 16’</td>
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**Selection of plants.** Selection, number and arrangement of plants should be made to maximize the efficiency of the windbreak, provide the desired size of protected area and minimize costs. Of primary concern in the desert is the cost associated with irrigation. In a very general sense, probably the most critical factors that will determine water costs of a windbreak are the height and width (number of rows) of the windbreak and whether the plants used are deep or shallow rooted. Species of plants used are probably less critical in determining water use when compared to these other factors. So-called “drought tolerant” plants are frequently NOT low water use when used for the purposes of a windbreak. They will, however, play a role in recovery from drought when other trees may not.

When selecting plants, remember that:

- Shorter trees generally use less water.
- Coniferous evergreens generally are less porous than deciduous plants.
- Deciduous plants will not provide year-round protection.
- So-called “drought tolerant” plants may not achieve any water savings if substituted for non-drought tolerant plants unless watering schedule is adjusted.
• Deep-rooted plants can be irrigated less often, once established, saving pumping costs.
• Multiple rows, and a variety of heights and shapes, will “plug” voids in a windbreak.
• A wide variety of plants creates a windbreak more resistant to disease and insect epidemics.
• Fast-growing plants can be short-lived plants and subject to more damage causing windbreak failure and higher costs.
• For suggestions on plants for windbreaks, contact local sources such as Cooperative Extension, the Natural Resources Conservation Service or the State Division of Forestry.

Managing Windbreaks

**Irrigating the Windbreak.** There is a direct relationship between the amount of water applied, up to a plant’s maximum, and the overall density and vigor of plants in a windbreak. Once the plants, their numbers and physical layout are selected, the amount of water required for their healthy upkeep is predetermined. As the size and density of the windbreak increases, its demand for water will also increase. Little can be done to change this amount without affecting the quality of the windbreak. Therefore, initial plant selection and windbreak design are critical factors in determining a windbreak’s future demand for water.

Conservation of water can occur through irrigation tradeoffs (water saved in one location to be used in another location). Plants growing in the protected area of a windbreak will use less water due to decreased wind speeds. Plants protected by the windbreak can be irrigated with a more efficient irrigation system such as drip irrigation. High-water-use plants in the protected area can be replaced with plants that can be irrigated more efficiently. In Amargosa, Nevada, alfalfa hay production was switched to more water-efficient wine grape production, protected by a windbreak, and an efficient drip irrigation system was installed. The resultant savings of water was more than enough to irrigate the windbreak and still save water overall.

Drip irrigation is the most efficient method of applying irrigation water to individual plants. However, as the size of plants increases, the number of emitters needed goes up tremendously along with maintenance costs. It is generally recommended that plants with mature heights over 20 feet be irrigated by basin, furrow or bordered flood irrigation.

Irrigation of a windbreak should be deep and infrequent, with applications of water penetrating 18 to 24 inches deep. Frequency of irrigation should be changed at least seasonally and follow the general ET (evapotranspiration) curve for your area.

**Maintaining the windbreak.** A major objective in windbreak management should be to ensure that plant growth is vigorous and protected from major plant pests and maintains a suitable density for wind protection. Mulches will play an important role in conserving water and keeping weeds at a minimum. Pruning during winter months should be focused on maintaining plant integrity and the desired porosity for managing windspeed inside the protected area. Fertilizers, also applied during the late winter, will help maintain plant vigor and canopy density.

**References**

*Windbreaks for Rural Living*, Univ. of Neb. Extension Publication EC91-1767.

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