TECHNICAL NOTES

U.S. DEPARTMENT OF AGRICULTURE NATURAL RESOURCES CONSERVATION SERVICE
PLANT MATERIALS - 13 SPOKANE, WASHINGTON
FEBRUARY, 2005

WINDBREAK, SHELTERBELT, and LANDSCAPING TECHNOLOGY

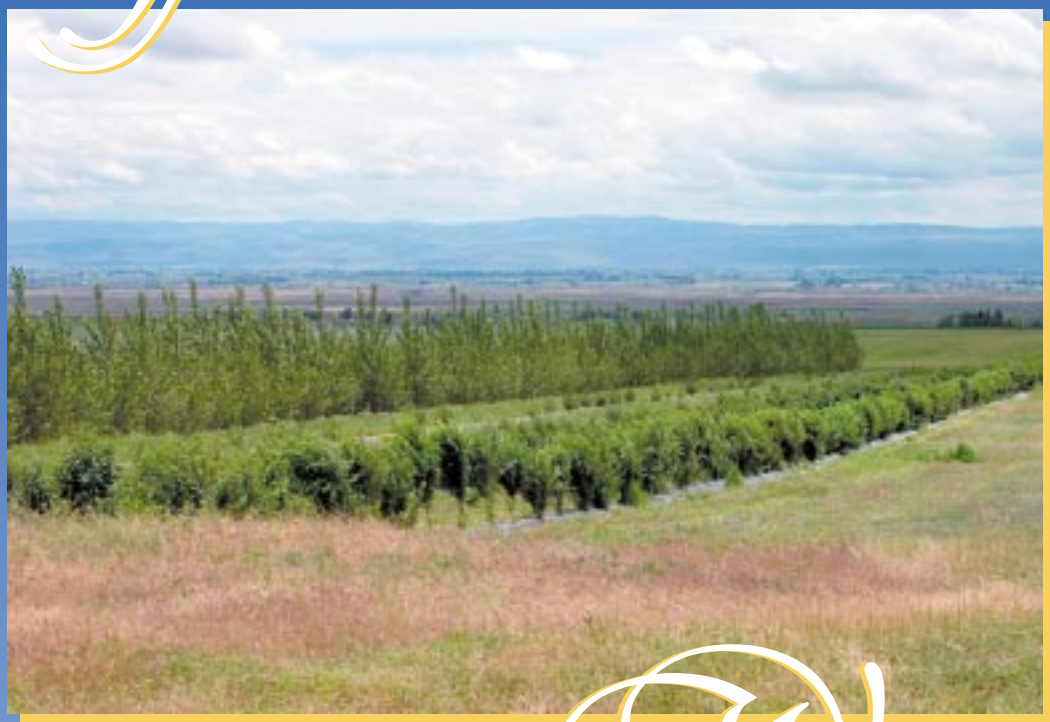
This Technical Note #13 is subdivided into the following Sections:

Section 13.1 – "Trees Against the Wind", a Pacific Northwest Extension Publication.

http://www.wsu.edu/pmc_nrcs/Docs/PNW005.pdf.

PNW0005

Trees against the Wind



A Pacific Northwest Extension Publication

Washington State University • University of Idaho • Oregon State University

Cover photo: A newly established windbreak located in southern Idaho that utilizes fabric mulch and drip irrigation.

Designed by

Gerald Steffen, MFA,
CAHE Information

Trees against the Wind

PNW005

Material in this publication is for agriculturists in Idaho, Oregon, and Washington to use in planning, establishing, and caring for windbreaks, shelterbelts, and living snow fences. Though much of the information will apply in other areas, the authors suggest asking advice from a forester or conservationist before following species and spacing recommendations.

The authors graciously acknowledge the contributions made to this bulletin by professionals working in the public domain.

Extensively revised by

Donald P. Hanley, PhD, CF,
WSU Extension Forester

Gary Kuhn, MS,
USDA-NRCS Agroforester

Contents

The forest acts powerfully in checking the force of the winds because the elastic swaying of the twigs and branches is a very effective hindrance to the movement of air.

~Gifford Pinchot, 1905

What Is a Windbreak?

A windbreak is a planting, usually of both trees and shrubs, designed and established to reduce undesirable effects of strong winds.

When the pioneers settled the treeless areas of the Northwest, they needed trees to provide shade and to give protection from the wind. Most farm and ranch plantings used fast-growing trees such as Lombardy poplar, eastern cottonwood, and black locust. Windbreak design was simple. The common practice was to plant one to six rows of a single species on a rather close spacing. The success of a planting depended on the owner's judgment regarding species, spacing, location, and the amount and kind of care needed (Figure 1).

Northwest farmers and ranchers are still planting windbreaks. The difference is they now can follow recommendations giving them high assurance of satisfactory windbreak performance. Much information has been gained through research on how design, location, and proper tree species affect windbreak efficiency. This bulletin is a guide for your use in planning, planting, and caring for a windbreak. Its recommendations are based on extensive windbreak research and experience in several states.

Windbreak Benefits

Your need for a windbreak can be measured in terms of the benefits you would derive (Figure 2). The major benefits of windbreaks are

- Improved farmstead environment. Homes protected from cold winds use less energy for heating (Figure 3).
- Improved crop yields.
- Reduced soil erosion.

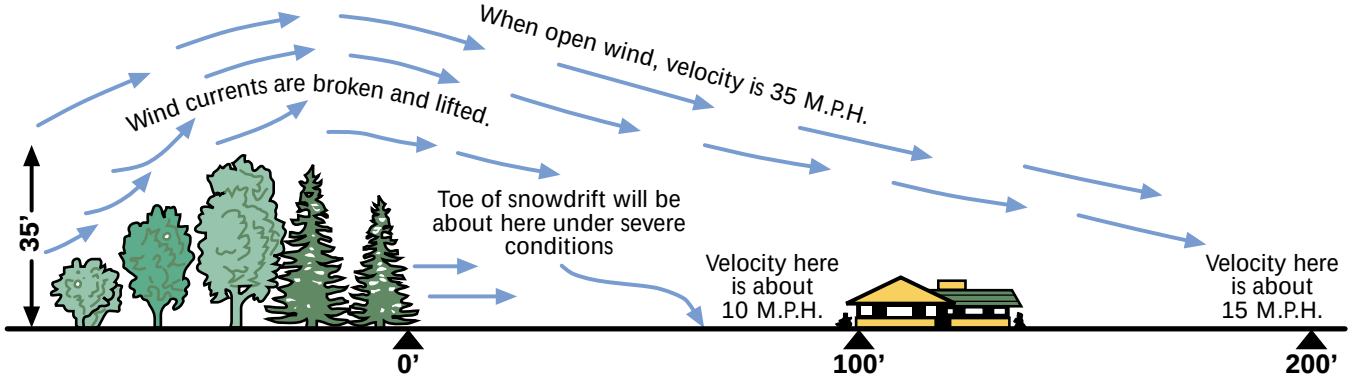


Figure 1. *A dense windbreak that is properly designed and correctly located will reduce winds and control snow drifting. Note that a "traditional design" windbreak is illustrated here.*

Summary of Benefits

Windbreaks protect crops, soil, livestock, and humans while also improving air and water quality, enhancing fish and wildlife habitat, broadening biodiversity, and beautifying the landscape.

Conservation buffers allow farmers, ranchers, and homeowners to express their commitment to conservation.

Figure 2. *Windbreak benefits are numerous.*

- Better livestock performance. Animals gain more weight when protected.
- Vegetative windbreaks attract game and songbirds.
- Windbreaks provide a buffer against loud noises.
- Windbreaks help mitigate strong odors from feedlots and other localized sources.
- Vegetative windbreaks add to a beautiful countryside.

Probably the single most important benefit of a farmstead windbreak is the reduction of energy required to heat a home. Energy savings are further increased by the proper placement of foundation plantings around the home.

Recent studies show that windbreaks can reduce winter fuel consumption by 10% to 30%. For example, one study in Nebraska compared the fuel requirements of identical houses, in which a constant inside temperature of 70°F was maintained. The house protected by a windbreak used 23% less fuel. Energy usage was compared for two identical, electrically heated homes in South Dakota. A farmstead windbreak sheltered one home; nothing sheltered the other. Inside temperatures were maintained at 70°F. The sheltered home used 34% less electricity (Figure 4).

In addition to reducing the force of the wind, windbreaks also can reduce the wind-chill effect on people outside the house. Studies of three-row windbreaks, where trees were 25 feet tall, showed reduced wind velocities and wind-chill index (Figure 5).

Improved Crop Yields

A survey in South Dakota examined how windbreaks influence crop yields. On 677 fields of corn, oats, and barley, yield increased 8 to 9 bushels per acre due to windbreak protection. Alfalfa averaged $^{3}/_{4}$ ton per acre more on 123 protected fields. Corn silage from 13 protected fields showed more than a 3-ton-per-acre increased

Environmental Purposes of Windbreaks

- ☐ **Structure protection**
- ☐ **Screening**
- ☐ **Noise abatement**
- ☐ **Dust reduction**
- ☐ **Beauty**
- ☐ **Wildlife habitat**

Figure 3. *Windbreaks provide many benefits around homes and other outbuildings.*

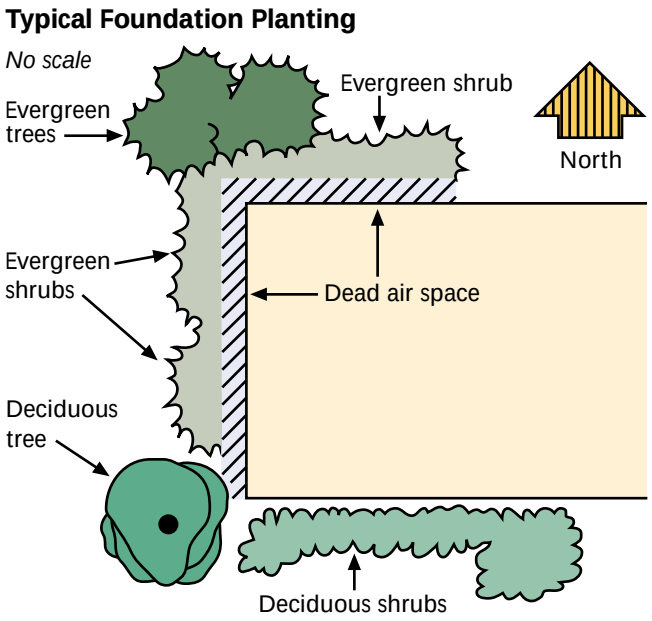


Figure 4. *Foundation planting around a home to supplement a windbreak gives further energy savings.*

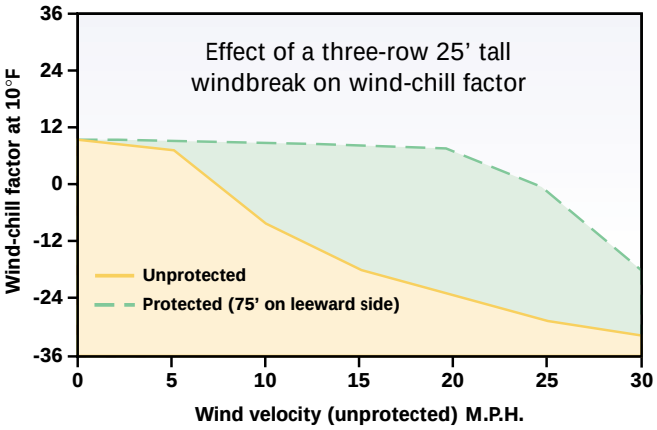


Figure 5. *A three-row windbreak significantly reduces wind velocity on the leeward side of the break.*

yield, and four fields of potatoes gained nearly 48 cwt per acre due to protection by windbreaks. A Nebraska experiment showed 34 acres protected by windbreaks produced the same amount of canning tomatoes and beans as 40 acres of similar land without windbreak protection. A study in southern Idaho reported yields of several field crops increased by 1% to 7% in fields that had windbreak protection. In other areas, where cereal grains are the prime crop, windbreak influences on crop yields are less conclusive (Figure 6).

In a South Dakota survey, nearly all farmers said their field windbreaks more than pay for the ground they occupy. Many commented favorably about the effects their windbreaks had on soil blowing, crop damage, and drifting snow.

Orchards

Orchards need shelter against high winds, especially during pollination and preharvest when the fruit is ripening. Fruit often is blown off the trees or bruised and scarred in unprotected orchards. Behind a good windbreak, you can spray, dust, and prune fruit trees with greater control. The WSU Wenatchee Tree Fruit Research and Extension Center reported bees are more numerous in orchards having windbreak protection. Honeybees and other pollinating insects are more effective when sheltered against winds. Windbreaks reduce irrigation evaporation, and trapped snow adds more soil moisture in the spring. An orchard owner in Idaho observed that

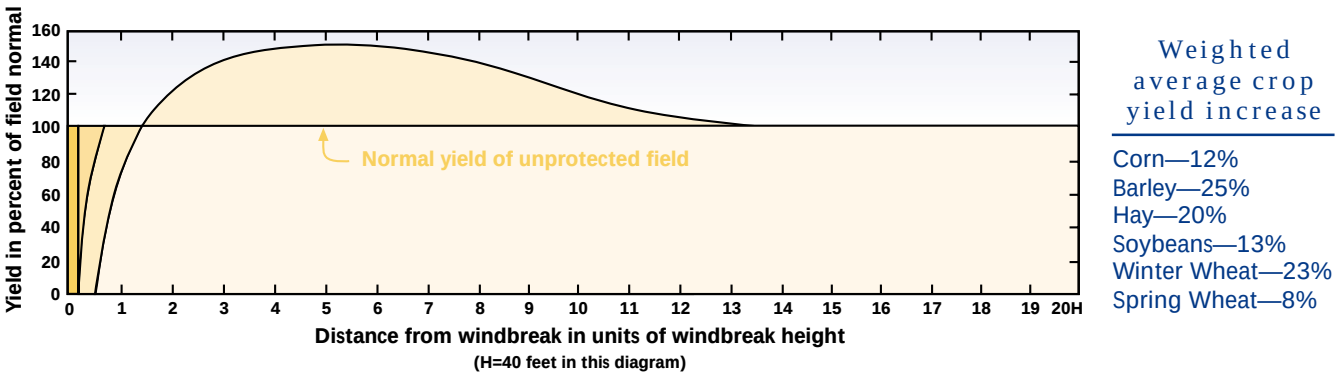


Figure 6. *Field windbreak benefits.*

his fruit crop from an orchard with windbreak protection was consistently better than crops from neighboring orchards without protection (Figure 7).

Figure 7. *Field windbreaks protecting orchards.*

Wind Erosion Reduction

Soil erosion caused by high winds is called wind erosion. Land managers or owners can control wind erosion in several ways: through the use of good plant cover; tillage practices that leave the soil ridged or cloddy; or windbreaks that reduce the wind velocity. Areas where erosion hazards are high call for a combination of measures (Figure 8).

The wind can easily move fine soil particles, both organic and mineral. Often the soil particles blowing from a field contain 10 to 20 times as much humus and plant nutrients as the heavier particles that stay on the field.

Soil particles do not ordinarily blow until wind velocity reaches about 13 miles per hour at a height of 1 foot above the ground. This is known as "threshold velocity." Above the threshold velocity, the capacity of winds to carry soil is proportional to the square of the wind speed. Therefore, small reductions in wind speed cause great reductions in the rate of soil loss.

Conditions conducive to wind erosion on cropland include:

- Loose, dry, and finely granulated soil
- Smooth soil surface with sparse or no vegetative cover,
- Large crop areas, and
- Sufficient wind velocity to move soil.

Better Livestock Performance

Feedlot and livestock windbreaks primarily protect livestock from wind and windborne soil and snow. Windbreak protection can significantly reduce stress on animals and their feed requirements. This protection results in better animal health, lower death loss, and lower feed costs (Figure 9).

In cold weather, cattle must increase food intake for energy to keep body temperatures within a specific comfort range. For example, a study in Indiana found energy requirements for cows in good condition increased 13% for each 10-degree drop in wind-chill temperature below 30°F. Cows in poor condition needed 30% more energy for each 10-degree drop.

Canadian researchers have reported cattle on winter range require a 50% increase in feed energy for normal activities and an additional 20% to overcome the direct effects of exposure to cold temperatures and wind. They concluded adequate wind protection could reduce the direct effects of cold by more than half. The Canadian studies also indicated feeder cattle,

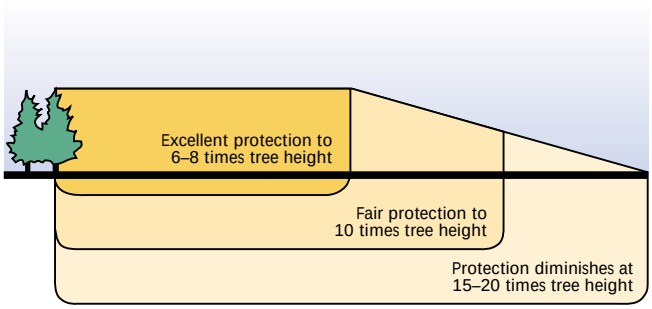


Figure 8. *Windbreaks proved excellent protection as far out as six to eight times tree height and fair protection up to 10 times tree height.*

when provided with wind shelter and kept dry, are not affected significantly by cold weather.

Iowa studies with calves and yearlings concluded feed requirements were 7% greater in open lots than in lots with shelter.

Many livestock owners also have attested that shade provided by windbreaks and other tree plantings helps animals during very hot summer days. While this windbreak value has never been quantified in pounds of livestock gain, the shade value of trees is, nonetheless, widely recognized.

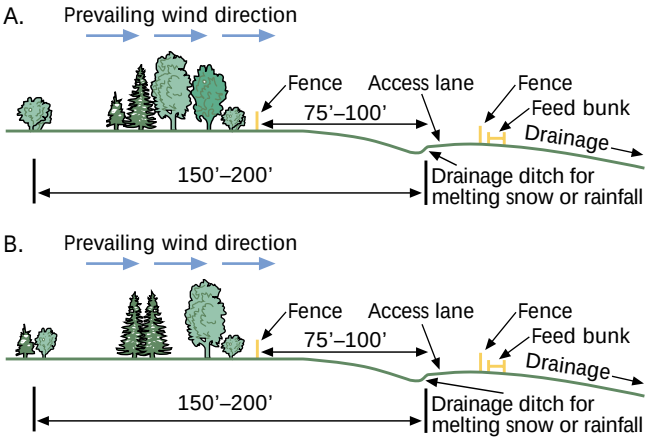


Figure 9. *Locate windbreaks that protect livestock so the snow deposition falls outside the feeding area.*

Odor Mitigation by Windbreaks[1]

New university research in the Midwest and Great Plains regions is experimenting with use of windbreaks as odor control mechanisms. This exciting windbreak application warrants continued study and experimentation here in the Pacific Northwest. While the majority of this research focuses on hog production in Iowa and Nebraska, the application appears useful to mitigate odor at dairy, beef, and poultry enterprises.

Animal waste is becoming a major problem in the U.S., where more than 1.4 billion tons of manure are produced annually. Most of the manure is concentrated, as production facilities and feedlots have become larger. Odor from these facilities is causing significant social problems, especially as non-farm-based residents encroach on traditionally agricultural land (Figure 10).

Windbreaks have the potential to be an effective and inexpensive odor control device. The odors produced from animal waste originate near the ground and often stay close to the ground due to temperature inversions, especially in the winter months. Windbreaks can act as interceptors of this ground-based odor plume (Figure 11). According to the university researchers, windbreaks can ameliorate livestock odors in four primary ways:

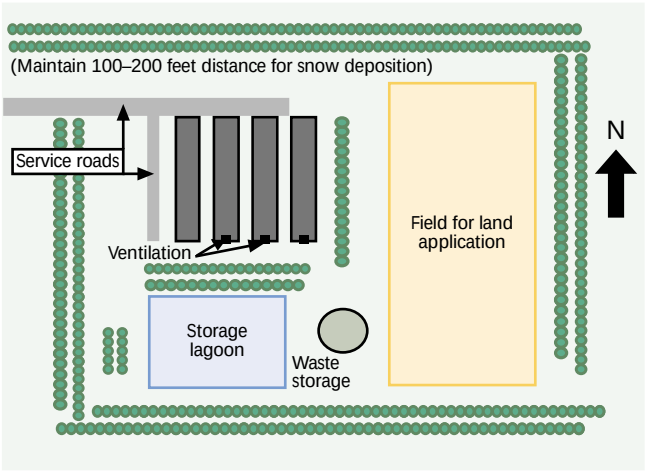


Figure 10. *Hypothetical windbreak system design for a typical swine production facility. Courtesy Iowa State University.*

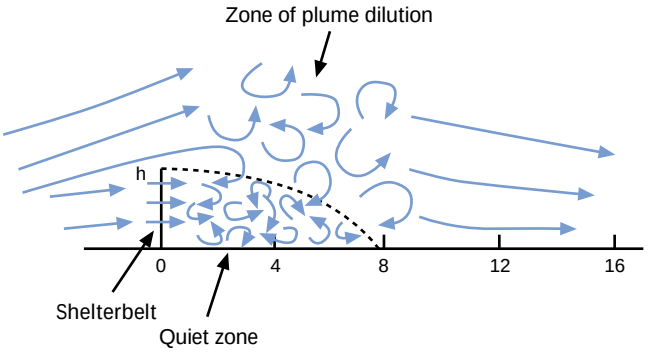


Figure 11. *Schematic representation of turbulence and zone of potential odor dilution. Courtesy Iowa State University.*

[1] This section is adapted from: *Air Quality and Shelterbelts: Odor Mitigation and Livestock Production, A Literature Review*. USDA National Agroforestry Center Sponsored Research Project. John Tyndall and Joe Colletti, Forestry Department, Iowa State University.

- Diluting gas odor concentrations into the lower atmosphere
- Encouraging dust and other aerosol deposition by reducing wind speeds
- Physically intercepting dust and other aerosols
- Acting as a sink for the chemical constituents of odor

Odor is composed of gaseous volatile compounds and particulate matter. Particulate matter is a component of odor plumes and closely related to odor from cattle, swine, and poultry (housing) facilities and from outdoor lots for swine, cattle, and sheep. Animal dust and other particulates easily absorb and carry the majority of the odorous compounds. Dust can carry many times more molecules of some odorous compounds than the same volume of air, thus concentrating odors.

Windbreaks, especially those composed of evergreen tree species, serve as physical interceptors of dust and other aerosols. As air moves across vegetative surfaces, needles and leaves capture and remove some of the dust, gas, and microbial burden normally carried by the wind. This removal occurs mostly by way of a dry windborne route, in raindrops, or in rain splash droplets. The total surface area of leafy plants is very large, often exceeding the surface area of the soil containing those plants by as much as 20-fold. The amount of leaf surface area positively favors the interception of dust and other aerosols.

Little is known about the ability of trees and other plants to ameliorate odor by intake or absorption of odorous chemicals or about the managerial use of vegetation for this purpose. Compelling indirect evidence suggests this is possible. In the last few decades, tremendous interest has grown in the ability of plants to remove pollutants from the air. Several reviews address the capability of plants to act as a sink for air contaminants.

Windbreaks also can mitigate odor from land applications of liquid and solid manure (Figure 12). Multiple windbreaks, used on both sides of the field and oriented perpendicular to prevailing winds, can offer diverse effects when application is primarily from liquid sources. A windbreak on the windward side of the field can capture off-field particulates that would otherwise pass over the field surface and pick up volatile organic compounds being emitted. This design encourages particulate deposition. A windbreak on the far side should create air turbulence and enhance odor dilution as well as intercept and encourage deposition of some particulates. Shelterbelt density should be increased above

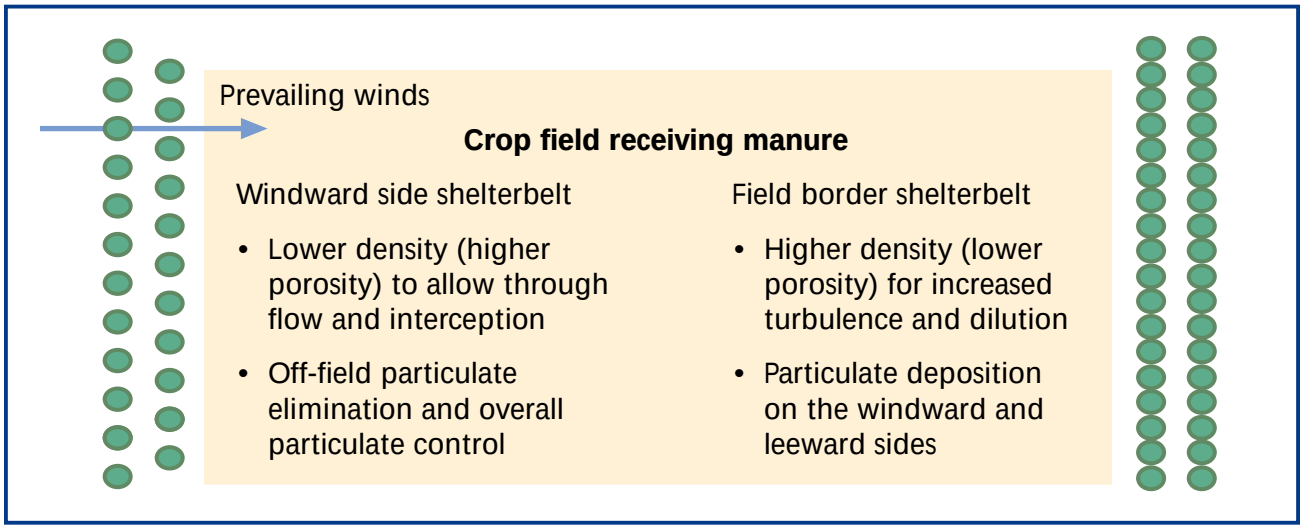


Figure 12. *Possible windbreak benefits in mitigating odor from field application of manure. Courtesy Iowa State University.*

60% for maximum turbulence. To maximize turbulence, wind speed must be at its prevailing rate. When using a two-belt system, make sure the field is wide enough to allow wind speed to regain prevailing velocity as it approaches the turbulence-creating windbreak. Since windbreak height is also an important variable for odor dilution, use taller tree species. Where field applications of solid manure are involved, windbreak designs may need to maximize particulate interception and deposition. To maximize this particulate interception, allow some wind to pass through the windbreak to encourage plant-particulate interactions. The use of lower density belts (~50% density) should facilitate this interaction.

Wildlife Enhancement—Especially Birds

From observations, wildlife biologists conclude windbreaks make very desirable nesting, brooding, and loafing areas for many game and songbirds. Some windbreak species provide significant

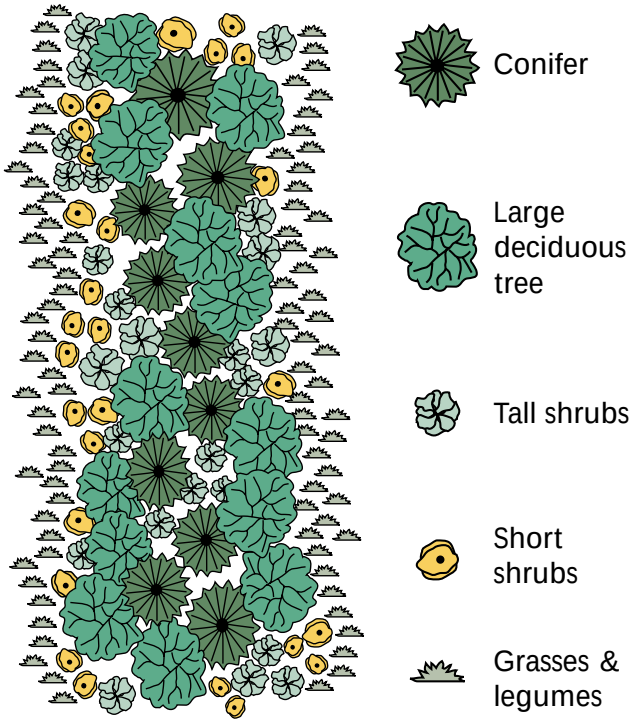


Figure 13. *Windbreaks designed primarily for wildlife can have more plant diversity for a natural look.*

Table 1. *Windbreak Species Use by Wildlife for either Food or Cover*[†]

	Green ash	Russian olive	Siberian elm	Blue spruce	Chokecherry	Honeysuckle	Caragana	Buffalo-berry	American plum
Pheasant		X	X	X	X	X		X	
Gray partridge		X			X				
Sharp-tailed grouse		X	X		X	X		X	X
California quail				X	X	X	X		
Ruffed grouse		X		X	X	X	X	X	
Wild turkey	X	X	X	X	X	X		X	
Mule deer	X		X		X		X	X	
White-tailed deer	X	X	X	X		X		X	X
Mourning dove			X	X	X	X			
Cottontail rabbit	X	X	X	X		X		X	X
Squirrels	X	X	X						
Migratory songbirds	X	X	X	X	X	X	X	X	X

[†]Slight modification of table by Erling Podell, USDA-NRCS, Bismark ND.

amounts of food for birds and other wildlife (Figure 13). Dense windbreaks also protect birds from predators. During critical winter periods, windbreaks mean survival for large numbers of birds that would otherwise perish from the cold (Table 1).

Sound Barriers

Windbreaks act as favorable deterrents to loud, low frequency sounds. Plant leaves, branches, and twigs all absorb sounds of different frequencies. The vibration of the tree parts absorbs the sounds. Heavier branches and trunks deflect sounds. Evergreens are preferred because of their year-round protection.

More Beautiful Countryside

Well-kept windbreaks and other tree plantings undeniably enhance the aesthetic value of individual farms and the countryside. Aesthetically improving a farmstead by adding a good windbreak increases its economic value (Figure 14). When the buyer of a farm was told $1,000 was added to the sale price because of the windbreak, he replied, "I wouldn't want the place without the trees."

Structural Wind Barriers

It may not be possible to establish a living windbreak in every instance where wind protection is needed. A fence of boards, steel slats, or baled straw will provide some windbreak benefits (Figure 15). The main advantages of structural barriers are requiring little space and providing protection immediately upon construction. However, trees are the only barriers tall enough to protect a large area. Protection from a structural barrier is provided on the leeward side in a zone 3 to 10 times the barrier's height. Thus, an 8-foot barrier would give its best protection in a zone lying between 24 feet and 80 feet on its leeward side. Such a barrier normally will reduce open wind velocities by 40% to 60%.

A structural barrier should not present a solid face against the wind, since a solid face causes severe wind turbulence, resulting in a reversal of wind direction near the ground. Construct structural barriers of slats or narrow boards with about 50% density in the upper two-thirds of its height and 25% density in the lower third. These density values also provide more uniform snow deposition behind the barrier.

Structural barriers are not very effective in minimizing dust, and they have practically no wildlife value.

Figure 14. *Windbreaks and other vegetation near homesteads add protection, value, and a distinct atmosphere to rural living.*

Figure 15. *Where soils are too shallow, structured barriers are used to trap snow.*

Why Are Not More Windbreaks Successful?

You might logically ask: If windbreaks yield all these benefits, why are not more windbreaks successfully established (Figure 16)? In the past, only about half the plantings made ever survived in a manner to give good performance. Inadequate care caused most failures. Weeds, lack of water, poor planting practices, uncontrolled livestock, careless handling of farm equipment when planting, and spraying weeds in nearby crops are the main causes of windbreak failure. Other failures arise from poor planning, unforeseen circumstances, or an attitude that trees will take care of themselves once they are planted. Trees seldom perform satisfactorily without care.

Today, the use of the new fabric mulch has greatly enhanced the success of windbreak plantings in terms of both initial survival and tree and shrub growth (Figure 17). Living snow fences planted in southeastern Idaho show excellent survival and growth. These Idaho living snow fences utilize drip irrigation systems. A few dryland field plantings in eastern Washington, where natural precipitation is as low as 10 inches, also show excellent growth and vigor.

Figure 16. *Windbreaks are not common in many inland northwest locations.*

How Many Years Are Needed to Grow a Windbreak?

Many people think trees grow slowly. Some farmers say slow growth is their major objection to planting trees. In truth, irrigated windbreaks grown at elevations below 5,000 feet provide noticeable protection within 3 to 4 years and usually give effective protection within 7 or 8 years. Dryland windbreaks ordinarily will give effective protection in 7 to 12 years, depend-

Figure 17. *New windbreak with fabric mulch and drip irrigation has an excellent chance to provide protection in 3 to 5 years.*

ing on the soil and amount of precipitation. Providing supplemental moisture for dryland windbreaks not only improves tree survival but also increases growth rates and shortens the establishment period. Fabric mulches, established at the time of planting, reduce these values significantly—possibly by a third.

Generally in the arid areas of the region, evergreens have less height growth than deciduous trees and shrubs during the first 10 years. After that, the difference between growth rates becomes minimal. The average time needed for a windbreak to provide effective protection is short when compared with the life span of the windbreak. Well cared for trees and shrubs often exceed 60 years before restoration is needed.

What Does a Successful Windbreak Require?

Success in growing trees depends mostly on factors you can control. Windbreaks can be grown successfully in almost all areas of the Pacific Northwest where the climate and soil are suitable for producing agricultural crops. Great advances in tree and shrub stock and the techniques used to establish them have made success a certainty.

For windbreaks to survive and make satisfactory growth where climate and soil are suitable, young trees need:

- A sound design, using the correct planting stock.
- Careful handling of trees and shrubs prior to planting and post planting care.
- Adequate moisture, by rainfall or with high efficiency drip irrigation.
- Protection from weeds for at least 3 to 5 years after planting.
- Protection from livestock and other grazing animals.
- Periodic inspection for insect, rodent, and disease damage.

Since your windbreak will be a long-term investment, planning it well in advance of the planting date is good business. Only a well-planned windbreak that receives good care can provide maximum protection and satisfaction (Figure 18). Carefully consider the following:

- Locate the windbreak where it will be most effective.
- Design the planting to fit the available space.
- Allow ample room for good tree and shrub growth.
- Select tree and shrub species adapted to the growing conditions in your locality and that will best provide the benefits you want.

Environmental Benefits of Windbreaks

- ☐ **Wind erosion protection**
- ☐ **Plant protection**
- ☐ **Snow management**
- ☐ **Irrigation efficiency**
- ☐ **Livestock protection**
- ☐ **Water quality**

Figure 18. *Windbreaks provide many environmental benefits.*

- Order needed trees and shrubs from a reliable nursery well ahead of planting time.
- Prepare the planting site at the correct time so it is ready to receive the planting stock.
- Provide fencing, if necessary, to protect the new planting from livestock, rodents, and rabbits.
- Arrange in advance for planting help and equipment so you will be ready to plant at the correct time.
- Ensure refrigerated storage of your trees in case the weather does not permit you to plant.
- Design your irrigation system. Set the planting date after water is available or plan a way to give your young trees some supplemental water if your planting is dry.

All these points deserve consideration. The rest of this section gives details on planning and design as they pertain to different types of windbreaks: farmstead or feedlot, field, sound barriers, and snow fences.

Planning Your Windbreak

> ***The best time to plant a windbreak was 20 years ago—the next best time to begin is today!***
>
> ***~Anonymous***

Planning a windbreak is by far the most important step. This phase determines the location, size (number of rows), tree spacing, and tree species to be used. A windbreak placed in the wrong place or configuration can create greater problems than those it was intended to solve. Also, during the planning phase, consider the method and timing to plant and to maintain the windbreak. Plan for irrigating and weeding to assure these jobs will be done at the right times.

Climate

Most settled areas below 5,000 feet elevation in the Pacific Northwest have a favorable climate for growing trees as long as appropriate irrigation supplements natural precipitation. As elevation increases above 5,000 feet, the shortened growing season and increased severity of winter make establishment of trees more difficult. Choices of adaptable species become more limited, and the trees make less annual growth than they do at lower elevations. Severe damage sometimes results as deep snow pack settles on young trees. Frozen ground also leads to winter desiccation.

Soil

Some tree species are naturally adapted to acid soils, while others can easily endure a saline soil condition. Some species grow naturally in boggy or swampy situations; others do best on dry sites. A deep, well-drained loam having neutral pH and average fertility is almost ideal for growing a variety of trees. Many sites are far from ideal and present problems severe enough to prevent successful establishment of trees. These sites can include permanently wet areas, sites experiencing a high water table during the growing season, salty or alkaline soil, droughty and infertile soil such as deep sands and gravels, shallow soil over hardpan or bedrock, and extremely heavy clay soil.

Sometimes you can remedy a problem soil situation by use of corrective practices such as drainage, addition of organic matter, fertilization, or chiseling. A less expensive alternative is to select a tree and shrub species mix that will grow in your soil type.

Climate and soil characteristics vary greatly among different areas in the Pacific Northwest. These variations create many problems for tree planting. They cause the optimum time for planting to vary widely from area to area and influence the amount of care needed by tree plantings. Climate and soil variations make the choice of species difficult for some areas.

Protection

Fencing the windbreak planting is usually necessary to protect it from damage by livestock and other grazing or browsing animals. Other protective measures using pesticides may have to be taken against rodents, rabbits, and insects. Disease and fire suppression and prevention is usually accomplished by pruning and weed control. The best defense against these damaging agents is usually the selection of the best, most adapted species. When planning the windbreak, be sure the needed measure for protection can be taken. Otherwise, all efforts to establish a successful planting may be lost. Contact Cooperative Extension or Natural Resources Conservation Service personnel for fencing specifications or other protective measures.

Farmstead and Feedlot Windbreaks

Locate your windbreak as nearly as possible at a right angle to the prevailing winds. The windbreak at a right angle to the wind is more effective than one at an oblique angle to wind currents. Place the windbreak about 100 feet from the house or feedlot. This distance to the tallest tree species row will provide good protection; yet, it avoids the sultry air conditions that normally occur near the leeward side of a dense windbreak on hot days. Maximum wind reduction occurs from 2 to 5 times the height of the tallest row (Figure 19). This reduction is often represented by the formula: 2–5H, where H is the height of the tallest tree or shrub row. If you have considerable snow in your locality, locate the windward row of the windbreak about 150 feet from buildings, driveways, or areas that need to stay free of drifts. Should the arrangement of your farmstead make this impractical, consider a snow trap planting. A snow trap is a single or double row of dense shrubs paralleling the main windbreak 60 to 100 feet away on the windward side. This snow trap arrangement will cause most of the snowdrifts to accumulate between the shrubs and the main windbreak and not in the farmstead. To provide the best protection, the windbreak should have a density greater than 60%. This density level can be achieved using three to five rows of different tree and shrub species.

Extend your windbreak at each end 50 to 100 feet beyond the boundaries of the house or feedlot. This will prevent winds from whipping around the windbreak into the area needing protection. If you have to cross roads, driveways, or large ditches with your windbreak, try to make the crossings at oblique angles to prevent direct wind tunnels through the planting. Windbreaks need not be straight but should be designed to fit the contour of the land to minimize water erosion problems. Curved windbreaks also are easier to cultivate with equipment than those having right-angle corners.

Field Windbreaks

Field windbreaks or shelterbelts are designed to protect orchards, field crops, and bare soil from the effects of strong winds. Since field windbreaks are permanent farm improvements, plan them carefully. Consider field boundaries, irrigation systems, power lines, and roads because they are important in determining the location of your windbreaks.

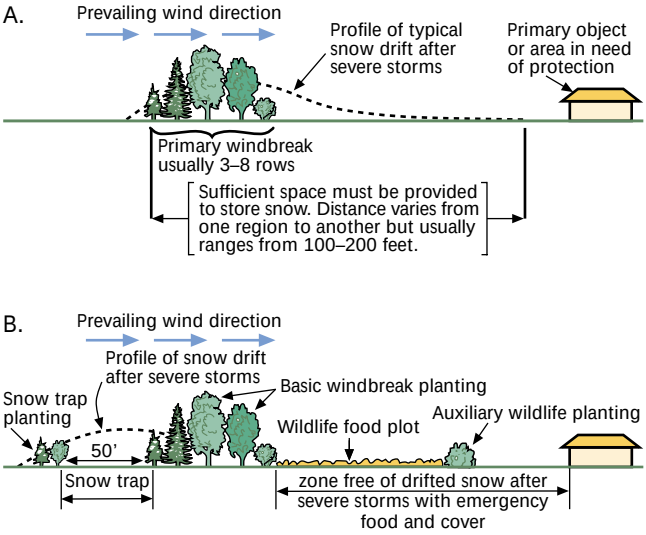


Figure 19. *Locate windbreaks so the snow accumulation zone does not impact driveways and other structures.*

In this region, fields subject to severe wind erosion may require multiple-row plantings along the field border, supplemented by parallel single-row plantings at intervals of 500 feet or less. The usual velocity of erosive winds in your locality and the nature of your soil will determine the best intervals to use between the supplemental plantings. If the usual maximum wind velocity in your locality exceeds 30 miles per hour and you have light soils, place the supplemental windbreaks 350 feet apart. Under less severe conditions, tall trees in single-row plantings spaced 600 to 1,320 feet apart will give adequate protection. The root competition zone is minimal when compared with the production gains across the field (Figure 20).

Center-Pivot Irrigation Designs

Center-pivot irrigation systems have brought great changes to the field windbreaks of this region. Many field windbreaks planted on section and half-mile lines have been modified or eliminated to fit this new irrigation technology. Straight-line windbreaks are just not compatible with the arc of the pivot systems. Existing windbreaks are valuable resources; preserve them whenever possible (Figure 21).

Where the windbreak must be modified, remove the trees completely rather than "top" them. "Topping" of most hardwoods is a short-lived alternative more expensive than removal in the long run because of the numerous sprouts produced. Establishment of low-growing (under 9 feet) shrubs such as mugho pine, honeysuckle, or cotoneaster will provide some protection in these gaps. The pivot can irrigate existing windbreaks in the corners if you use "corner-catchers."

The 16 corners of a four-field pivot system occupy about 20% of the total area or 130 acres. Use these corners to establish new field windbreaks that give partial protection to the crop area. Plant trees established in these areas parallel to the circumference of the crop area to make cultivation easier. Use normal between-row and between-tree spacing. The corners are also ideally suited for establishing woodlots for fence posts or firewood. Firewood values of windbreak species are given under Individual Species Characteristics at the end of this bulletin. If these corners were planted for firewood, the estimated yield for irrigated black locust would be 10 cords per acre after 10 years.[2]

Figure 20. *The root competition zone is minimal and is negligible when compared with the gains associated across the field.*

Figure 21. *Multi-row windbreak providing protection and wildlife habitat at the corner of a pivot irrigated field.*

[2] Estimate based on initial planting of 680 trees per acre (8x8 feet), which are thinned as necessary. After 10 years, approximately 480 trees per acre remain, having an average diameter of 4.5 inches (Miller, F. G. 1928. Black locust and how to grow it. University of Idaho School of Forestry Bull. No. 2).

Sound Barriers

Windbreaks and other tree plantings reduce noise from high-speed traffic or other surface-located sound sources. To make a windbreak an efficient sound barrier, follow these recommendations:

- Locate the planting as close to the noise source as possible.
- If traffic on a highway is the source, the planting should parallel the road.
- Plant tall, dense species for the main body of the planting.
- Use a dense shrub in the row next to the noise source.
- Include at least one evergreen row for year-round abatement.
- Use as many rows as the available space will allow, using the recommended spacing.
- Make the planting twice as long as the distance from the noise source to the receiver.

Living Snow Fence

Single-row plantings of trees and shrubs paralleling your driveways and roads will catch snow on the fields. An experiment in Kansas showed a well-designed windbreak caught 3.5 times as much snow as the best arrangement of structural snow fences the researchers were able to make. A snow fence planting should never be closer to the road than 100 feet (Figure 22).

In areas of eastern Washington, Oregon, and Idaho, deep snowdrifts accumulate on steep leeward slopes. They cause serious soil erosion when they melt, and they may delay spring farming operations. Living snow fences will collect these drifts on gentler slopes on the windward sides of the ridge crests. Hilltop snow fences should parallel the ridgelines. Place them about 100 feet back from the ridge crests on the windward sides of the ridge crests (Figure 23).

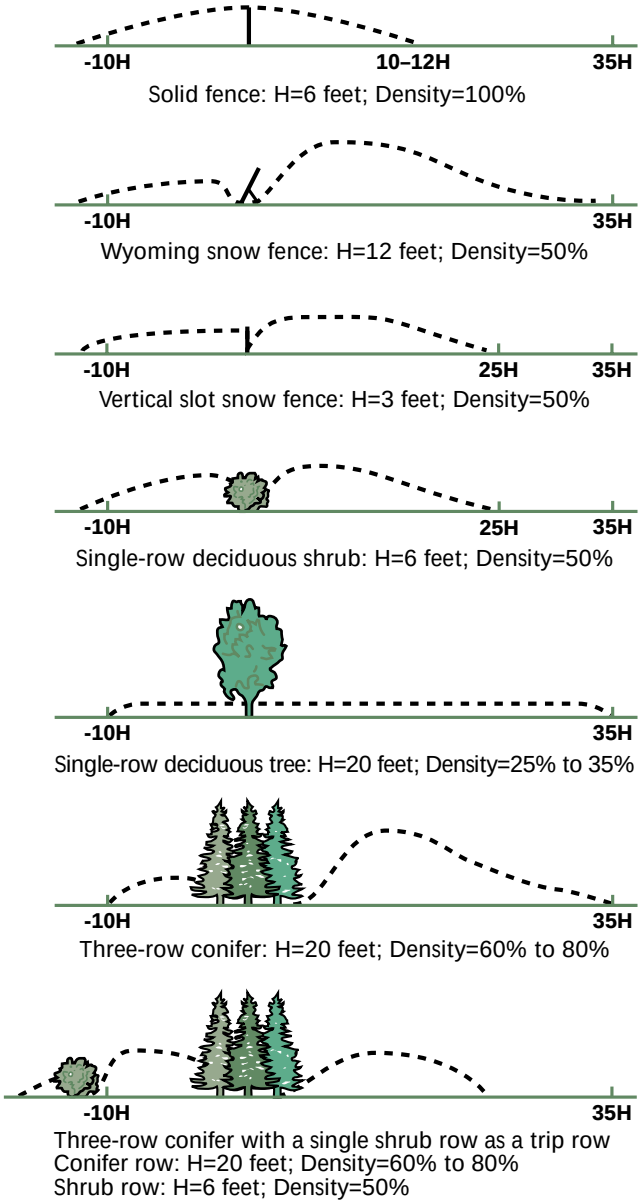


Figure 22. *When designing a living snow fence, the height and density determine the storage capacity.*

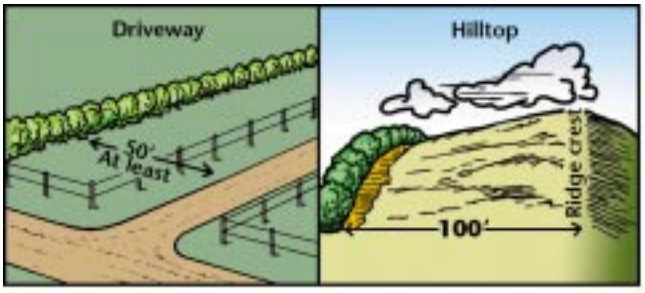


Figure 23*. Living snow fences should be located back from driveways and roads. Place hilltop fences 100 feet on the windward side of ridge crests.*

Snow fence plantings may be planned as part of your field windbreak system. This kind of planting has been used effectively to control drifting soil on cropland. It prevents snow collection in irrigation ditches, along fence lines, and in roadways. The choice of species for snow fence plantings can greatly enhance their values for wildlife. Snow fences and field windbreaks serve as travel lanes for upland game birds (Figure 24).

How Many Rows to Plant?

"Traditional Windbreak Design"

Shrubs

A windbreak must be dense near the ground. For this purpose, always choose a dense, bushy deciduous or evergreen shrub for the windward row of a multiple-row planting. Shrubs make ideal single-row or double-row low windbreaks around yards and gardens. Shrubs often are chosen for living snow fences and supplemental plantings in field windbreak patterns. Land managers often recommend using shrub rows for protection while establishing evergreens in a windbreak (Figure 25).

Deciduous Trees

Deciduous trees generally grow faster than evergreens, thus providing earlier protection. They are commonly used for the middle rows in windbreak designs. Managers generally prefer deciduous trees and shrubs where severe soil freezing is common, as evergreens in these localized environments are prone to winter desiccation. Avoid using Russian olive, as it will volunteer from seed if planted along ditch banks, in low pastures, or in wet wastelands. Siberian elm is generally not recommended because it grows so rapidly that the wood is brash, making it subject to breakage from high winds. It also bears heavy seed crops, and the seedlings sometime create a nuisance.

Evergreens

Many call evergreen trees the foundation for windbreaks because they give year-round protection. Include them in all windbreaks wherever possible. The traditional practice in establishing windbreaks is to plant evergreens in one or two leeward rows. In areas of deep soils and moderate climates, evergreens may be used for the entire windbreak, or when fabric mulch is used (Figure 26).

Figure 24. *Double twin-row living snow fence installed along I-84 in southern Idaho.*

Figure 25. *Skunkbush sumac is a desired shrub species in both irrigated and non-irrigated windbreaks.*

Plan your windbreak to fit the space you have available, keeping in mind protection normally increases with the number of rows planted if the trees have room to grow.

A five-row planting makes a very desirable farmstead windbreak (Figure 27). The best performance usually is obtained by using a different kind of tree or shrub in each row. As an example, an irrigated planting of Siberian pea shrub, green ash, hybrid poplar, ponderosa pine, and blue spruce develops fast, has good height, offers high year-long density, provides excellent bird habitat, and presents a pleasing appearance the year around. In a dryland planting, you could choose honey locust instead of hybrid poplar and Austrian pine or Rocky Mountain juniper in place of blue spruce. A windbreak of mixed species also gives some protection against insects or diseases damaging the entire planting (Table 2).

If limited space prevents planting a five-row windbreak, then use fewer rows rather than crowd the trees. Results will be better with three rows that have room to develop than with five seriously overcrowded rows. Crowding trees in a windbreak causes a loss of vigor due to severe competition as the trees try to increase in size. Tree growth slows down at an early age and may

Figure 26. *Twin-row Rocky Mountain juniper used as a living snow fence.*

Figure 27. *The Traditional Design utilizes five rows of trees and shrubs.*

Table 2. *Recommended Minimum Spacing between Trees and Shrubs.*

	Irrigated or dryland receiving 16 inches or more annual precipitation		Dryland plantings receiving 16 inches or less annual precipitation	
	Multiple-row windbreaks (feet)	Single-row windbreaks (feet)	Multiple-row windbreaks (feet)	Single-row windbreaks (feet)
Dense shrub	4	3	4	3
Medium-size deciduous	10	6	10	8
Tall deciduous	12	8	12	10
Medium evergreen	10	6	10	8
Tall evergreen	12	8	12	10

Note: *The minimum spacing between rows for irrigated or dryland plantings receiving 16 inches or more annual precipitation is 16 feet. The minimum spacing between rows for dryland plantings receiving less than 16 inches annual precipitation is 20 feet.*

reach a point of almost no growth. The planting becomes more susceptible to injury and loss from insects, disease, drought, and cold. Lower limbs die out early from too much shade in an overcrowded planting, thus making the windbreak much less effective because of lower density next to the ground.

In dry areas, supplemental irrigation can reduce the number of rows used in a windbreak or make the standard number of rows more effective. For example, two or three rows of trees given supplemental irrigation easily equal five rows depending only on natural precipitation. A well-developed single row can be more satisfactory than three rows with inadequate irrigation. Use the guide in Table 3 if you must plant fewer than five rows in your windbreak.

Tree and Shrub Spacing Is Important

Adequate growing space tends to keep your trees thrifty. It gives assurance that your windbreak will have a better appearance and a longer, useful life. The recommended spacing will certainly look quite large when planting seedling-size trees (Figure 28). Keep in mind that trees will grow rapidly and fill the available space in just a few years. Use spacing between rows and between trees within rows that will:

- Leave adequate room for use of your tillage equipment.
- Provide your trees with ample room for good growth.
- Avoid wind-whipping damage to trees in adjacent rows.
- Prevent early dieback of the lower limbs.

Spacing for windbreak trees varies by the type of trees and shrubs used (Tables 2 and 4). Too wide spacing results in a significant time lag before wind reductions occur. Too narrow spacing provides early protection but can cause overcrowding, which later limits effectiveness due to self-pruning. The spacing recommended in Table 2 will give your trees room to develop good crowns before strong competition sets in. These

Table 3. *Traditional Design Planting Guide for Windbreaks.*

If you have room for a windbreak with only	**These are combinations you may use.** Each combination starts with the windward side of the planting. Assuming equal success in establishment, the order of combinations from left to right is from highest to lowest in year-round protection afforded by the planting.			
	Highest protection ◄——► **Lowest protection**			
Four rows	Dense shrub Medium evergreen Tall evergreen Medium evergreen	Dense shrub Medium deciduous Tall evergreen Medium evergreen	Dense shrub Medium deciduous Tall deciduous Medium evergreen	Dense shrub Medium deciduous Tall deciduous Medium deciduous
Three rows	Dense shrub Tall evergreen Medium evergreen	Dense shrub Tall deciduous Medium evergreen	Dense shrub Medium deciduous Tall deciduous	Dense shrub Medium deciduous Medium evergreen
Two rows*	Medium evergreen Tall evergreen	Dense shrub Tall evergreen	Dense shrub Tall deciduous	Dense shrub Medium deciduous
One row	Tall evergreen	Medium evergreen	Tall deciduous	Medium deciduous

Notes: *Highest protection is recommended for farmstead and livestock protection areas.*

*It is best to use the new twin-row design if you have only space for one or two rows.

spacings are also within the optimum range for highest windbreak efficiency. Wider spacing can be used; however, more time is needed before full protection from the planting occurs.

When you have decided on the spacing you will use, figure the number of trees you will need for the planting. Order a few more trees than you actually need so you will have replacements. Most trees that die fail during the first growing season.

Figure 28. *Clean cultivation improves survival and growth in all windbreaks.*

Twin-Row, High Density Windbreak Design—A New Alternative

This design is excellent for living snow fences, supplemental or renovation plantings, and for windbreak applications where space is limited.

The USDA-Natural Resources Conservation Service has proposed a new twin-row, high-density windbreak design. This design is used extensively in the Great Plains region and is well suited for windbreak applications in the Pacific Northwest. Trees or shrubs are planted every 4 to 8 feet within the row with two rows planted 6 to 8 feet apart. If using shrubs, plant them 4 to 5 feet apart; if using medium evergreen trees, plant them 6 feet apart; if using tall evergreen trees, plant them 8 feet apart (Figure 29).

Twin-rows should be 25 to 50 feet apart. Use the same tree or shrub species within a twin-row.

Some advantages of the new design are

- The 100-foot open area between windbreak and home can be reduced.
- The distance between twin-rows (25 to 50 feet) is wide enough to be cultivated. A vegetable garden, strawberry patch, or other specialty crops are usually suitable in this area.
- The twin-rows provide rapid wind protection and reduce the duration for weed control between the two closely spaced rows.
- Drip irrigation can easily be installed between the two closely spaced twin-rows.
- Windbreak renovation using twin-rows provides continuous protection in a small area (Figure 30).

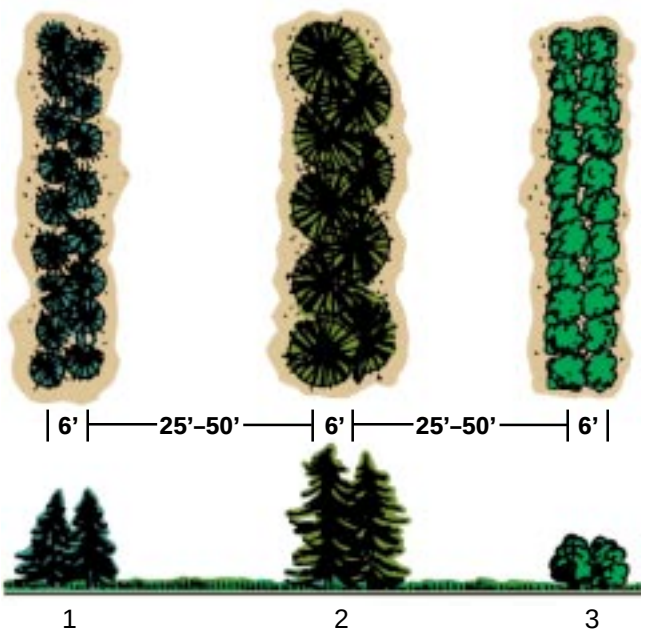


Figure 29. *In the twin-row design, trees and shrubs are planted 4-8 feet apart within the row with two rows planted 6-8 feet apart. Use the same tree or shrub species within the row.*

Figure 30. *Clean cultivated Eastern redcedar is used in this windbreak renovation. Rocky Mountain juniper is the preferred species in the Pacific Northwest.*

Windbreak Density

A key component in the design of any windbreak is the ultimate density attained. Density or wind porosity is the percentage of structural elements used to stop the wind. As density increases, protection immediately adjacent to the break generally increases at the expense of less protection farther from the barrier. Density is also an important factor in snow movement, such as with a living snow fence. It is generally best to follow the tree planting recommendations in this bulletin to ensure the density will be at least 40% to 60% for field windbreaks and 60% to 80% for farmstead and livestock protection. Living snow fences provide the best protection when the density is in the 60% to 80% range (Figure 31).

Selecting Species to Plant

Planting

Plant trees and shrubs in a well-prepared, firm, moist, and weed-free seedbed. Keep trees moist and cool from the time they arrive from the nursery until they are planted. In the actual planting, set the roots into the ground in as natural a position as possible. Do not bend or plant them in a "j" fashion. Plant at the same depth the trees grew in the nursery. Firmly pack moist soil around the roots. If you have questions about the planting process, the Extension bulletin "Plant Your Trees Right" (PNW Bull. No. 33) is available from any county extension office in the Pacific Northwest.

The selection of tree and shrub species must satisfy three basic requirements: 1) they must grow,

Open wind speed 20 M.P.H.
Deciduous 25%–35% density

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

Open wind speed 20 M.P.H.
Conifer 40%–60% density

H distance from windbreak	5H	10H	15H	20H	30H
Miles per hour	6	10	12	15	19
% of open wind speed	30%	50%	60%	75%	95%

Open wind speed 20 M.P.H.
Multi-row 60%–80% density

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

Open wind speed 20 M.P.H.
Solid fence 100% density

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

Figure 31. *Windbreak density influences the leeward wind protection zone.*

2) they must block the wind and, 3) they must be aesthetically pleasing to the owner. For these reasons and because of the variations in local environments of Idaho, Washington, and Oregon, we include only a brief list of recommended species in this publication. Read the species descriptions and ask advice on your choice of species before making final selections. Local soil and water tables may limit the usefulness of a species (Table 4).

Traditional Windbreak Design—Suggested Species—in Priority Order

Dense shrub	Medium-size deciduous	Tall deciduous	Tall evergreen	Medium-size evergreen
• Siberian pea shrub (*Caragana*) • Skunkbush sumac • Common lilac • Honeysuckle[1] • Wild rose • Red osier dogwood • Nanking cherry • Serviceberry[2]	• Choke cherry • American plum • Crabapple[3] • Hackberry • Artic blue willow[2,4] • Sandbar willow • Silver buffalo-berry • Bur oak	• Green ash • Honey locust[4] • Golden willow[2] • Hybrid poplar[2,5] • Russian olive[6]	• Colorado blue spruce • Austrian pine • Norway spruce • Ponderosa pine • Scotch pine • Douglas-fir[7] • Incense cedar[8]	• Rocky Mountain juniper • Northern whitecedar • Eastern redcedar

Notes:

[1] Suggested varieties *Amur*, or *Freedom*.
[2] Not recommended on soils with pH greater than 7.5 because of iron deficiency.
[3] Suggested varieties *flowering, manchurian, siberian*.
[4] Use on leeward side only.
[5] Suggested varieties *siouxland, robusta, ID hybrid, carolina*.
[6] Avoid use in riparian areas and along irrigation ditches.
[7] Supplementary irrigation generally required for best growth.
[8] Willamette Valley and Interior Valley regions of SW Oregon only.

New Twin-Row Windbreak Design—Suggested Species—in Priority Order

Dense shrub	Medium-size evergreen	Tall evergreen
• Siberian pea shrub (*Caragana*) • Skunkbush sumac • Common lilac • Honeysuckle	• Rocky Mountain juniper • Austrian pine • Northern whitecedar • Eastern redcedar	• Austrian pine • Blue spruce • Scotch pine • Ponderosa pine

Table 4. *Windbreak Species and Mature Characteristics Under Arid Conditions.*

Species	Mature height (feet)	Effective life span	Crown width (feet)	Minimum precipitation (inches)	Saline soil tolerance	Winter damage resistance
Shrubs						
Siberian pea shrub (*Caragana*)	10	80	10	10	excellent	excellent
Skunkbush sumac	10	20 +	8	10	excellent	excellent
Common lilac	10	20 +	10	15	good	excellent
Amur honeysuckle	8	20	7	12	fair	excellent
Common privet	10	20	8	15	good	good
Nanking cherry	6	15	4	15	fair	fair
Peking cotoneaster	5	20	4	12	fair	fair
Mugho pine	8	50	8	20	fair	fair
Deciduous trees						
Russian olive	30	30	20	12	excellent	excellent
Golden willow	35	60	30	15	good	excellent
Black willow	40	60	35	20	excellent	excellent
Black locust	50	50	40	15	fair	fair
Honey locust	40	60	20	12	good	fair
Hybrid poplar	50	30	30	15	good	excellent
Green ash	60	50	40	15	good	good
Lombardy poplar	70	30	15	20	good	fair
Evergreens						
Rocky Mountain juniper	20	60	15	12	excellent	excellent
Northern white cedar	35	50	20	20	poor	fair
Incense cedar	60	50	20	12	fair	fair
Austrian pine	40	60	30	20	fair	good
Scotch pine	40	40	20	15	fair	good
Blue spruce	40	80	25	20	good	excellent
Norway spruce	60	60	25	15	fair	good
Ponderosa pine	60	80	30	12	fair	good
Douglas-fir[1]	60	60	25	18	good	good
Lodgepole pine[2]	40	60	20	12	good	excellent

Mature height = expected mature tree height in feet when grown under medium or fair growing conditions.
Crown width = expected mature crown width in feet when grown under medium or fair growing conditions.
Minimum precipitation = the least amount of annual precipitation in inches expected to result in satisfactory survival and growth.

[1] Douglas-fir and lodgepole pine are recommended for wetter sites, if irrigation is not available.

[2] Lodgepole pine is often used near the coast where the soil is very sandy. In this situation it is commonly called shore pine.

Special Windbreak Designs

Dryland Plantings

If you have less than 20 inches of annual precipitation and you cannot provide supplemental irrigation, the best shrub species to use are Siberian pea shrub, (*Caragana*), and skunkbush sumac. Excellent tree species include Rocky Mountain juniper, black locust, and Austrian pine. Do not plant black willow, golden willow, hybrid poplar, or Lombardy poplar in low rainfall areas without supplementary irrigation.

High Elevations and "Frost-Pockets"

All species listed at the end of this bulletin do well up to 5,000 feet, with the exception of black locust in localities subject to hard frosts in early fall. Local topographic features can create widely different growing conditions in areas having the same elevation. The most reliable species for high elevation plantings are Siberian pea shrub, common lilac, golden willow, hybrid poplar, ponderosa pine, blue spruce, and Rocky Mountain juniper.

Low depressions or "frost-pockets" where the topography traps cold air can cause minimum temperatures as much as 10°F below those of adjacent lands. These sites can have growing seasons substantially shorter than those on adjacent lands of the same elevation. We recommend high elevation species in these localized areas.

Windbreaks for Wildlife[3]

A Place to Nest

Shelterbelts provide nesting habitat for a wide variety of birds and other wildlife species. At least 57 kinds of birds are known to use windbreaks in the United States during the breeding season. Mourning doves nest and call in windbreak trees but forage nearby for the seeds they eat. Birds such as the black-billed cuckoo ("rain bird"), house wren, gray catbird, and northern oriole conduct nearly all their activities within the windbreak. American robins, kingbirds, brown thrashers, and American goldfinches sing and nest in windbreaks but forage both in and out of them. Other species, including squirrels and cottontail rabbits, nest in windbreaks, and white-tailed deer with fawns use windbreaks for cover (Table 5).

Food and Foraging Sites

Windbreaks provide food for wildlife. When wildlife forages in adjacent areas, windbreaks provide protective cover. Foods potentially available in windbreaks include fruits, nuts, acorns, seeds, foliage, and insects or other invertebrates. Availability of these foods varies seasonally and depends largely on what is planted or growing in the windbreak. Trees and shrubs produce fruits, and some hold them into winter, a time when food is often critical for survival but generally less available. Wild turkeys, pheasants, quail, squirrels, deer, and songbirds use acorns, nuts, and other seeds from trees such as elm, maple, and ash. Seeds also may be available from grasses or herbaceous plants growing in the windbreak or from wildlife food plots planted within or adjacent to the woody vegetation. Foliage such as leaves or other plant parts may provide food for browsing animals such as deer. Insects and other invertebrates are important foods for many birds, particularly during nesting periods, and for various small field mice and shrews. Windbreaks provide foraging sites that would otherwise be unavailable. Chickadees glean along branches, peeking in and under crevices in the bark for insects to eat. Windbreak species such as hackberry, hawthorn, black cherry, autumn olive, honeysuckle, and others serve as nectar sources and habitat for butterflies, honeybees, and hummingbirds.

Food availability near shelterbelts is also important for many species. In fact, pheasants gener-

[3] Adapted from Designing Tree Plantings for Wildlife—Prairie Farm Rehabilitation Administration, Shelterbelt Centre, Indian Head, Saskatchewan, Canada.

Table 5. *Examples of windbreak plants that benefit wildlife and their primary wildlife values.*

Table indicates which seasons of the year activity occurs: mostly during summer and fall (S), fall and winter (W), or include browse (B). Bold letter indicates primary emphasis. (From USDA-NRCS sources).

			Songbirds		**Gamebirds**		**Fur & game mammals**	
Plants[1,2]	**Overall wildlife value**	**Nesting**	**Food**	**Cover**	**Food**	**Cover**	**Food**	**Cover**
Conifers (Excellent winter cover, food, and nesting sites)								
Rocky Mtn. juniper	Excellent	+	**W**	S**W**	W	S**W**	B	S**W**
Northern whitecedar	Good–Excel	+		S**W**		S**W**	B	S**W**
Spruce	Good	++		S**W**		S**W**		S**W**
Pine	Good–Excel	+	S	S**W**	S	S**W**	B	S**W**
Douglas-fir	Fair	+		S**W**		S**W**		S**W**
Lodgepole pine	Fair	+		S**W**		S**W**		S**W**
Deciduous trees (Nesting and foraging sites, food, canopy and habitat structure)								
Cottonwood/poplar	Fair	+		S		S	B	S
Flowering crabapples	Excellent	++	**W**	**S**	**W**	S	WB	S
Hawthorn	Good	++	W	**S**	W	S	B	S
Honeylocust	Fair	+	S	S				
Serviceberry	Good	+	S	S	S	S	B	S
Tall shrubs (Nesting sites, food, cover near ground)								
Skunkbush sumac	Excellent	+	W	SW	W	SW	B	SW
Amur maple	Excellent	+	S	S	S	S	B	S
Common privet	Good	+	S	SW	S	S		S
Honeysuckles	Excellent	++	W	**S**W	W	SW	WB	SW
Viburnums	Excellent	+	W	SW	W	SW	WB	SW
Shrub dogwoods	Excellent	+	S	SW	S	SW	B	S
Buffalo-berry	Good		W	SW	W	SW		SW
Staghorn & smooth sumacs	Good		W	S	W	S	B	S
Short shrubs (Nesting sites, food, cover near ground)								
Common chokecherry	Excellent	++	**S**	SW	**S**	SW	SB	SW
Chickasaw plum	Excellent	+	S	SW	S	SW	S	SW
Sargent crabapple	Excellent	+	W	S	W	S	WB	S
Cotoneaster	Good		S	S	S	S	S	S
Snowberry	Good–Excel		W	SW	W	SW	B	SW

[1] Bold letters or ++ indicate an especially good wildlife feature.

[2] Several plants in this list have a variety of species or cultivars, and some may have features that differ from those indicated. Also, there may be good plant selections for your area that are not included.

ally do not use windbreaks, especially in winter, unless a food source lies nearby. Adjacent croplands, such as cornfields, which have waste grains and interspersed weed seeds, make a good food source for ring-necked pheasants, northern bobwhites, mourning doves, and others. Avoid autumn plowing of such croplands where possible and consider using cropping systems such as no-tillage that leave ground cover. Old field habitats or water sources near windbreaks can provide habitat requirements for some species.

Shelter from Predation—Escape Cover

Windbreaks provide escape cover and refuge for many wildlife species. Pheasants often stay near windbreak cover while feeding in adjacent areas, where, during midday loafing periods, they find refuge from people and overhead predators. In general, wider shelterbelts having a good vegetation layer near the ground offer better escape cover than do narrower and open belts. When planning wildlife escape cover, consider the surrounding land use. Where no trees or perches presently exist, introducing tall deciduous windbreak trees may attract avian predators. In most situations, hawks and owls are welcome because they eat pest rodents and inspire joy and awe in many who watch them. However, where enhancing pheasants, quail, or partridge is the primary wildlife goal, choosing shrubs, or moderately-sized trees may be the better alternative.

Shelter from Weather

Shelter from the wind is a critical aspect of wildlife survival in winter. An animal maintains warmth by avoiding exposure to the wind, ideally in a warm sunny spot, and by fluffing feathers or fur coats. Food is vital because it is the basic source of all body heat. An animal must balance the need of finding food against the increased exposure to wind when foraging. Locating shrubs on leeward rows allows animals to receive sun within the shrub row and to remain hidden from predators. Evergreen rows windward of the shrub rows provide protection from cold winter winds.

Windbreak Species and Mature Characteristics

Species are categorized in Table 3 as:

Shrubs—The species commonly used for the first rows in windbreaks and for low, dense, single row plantings for yard protection and snowdrift control.

Deciduous trees—The species used for the remaining rows of windbreaks where evergreens do not grow well and for single-row plantings where height is needed.

Evergreens—The species that ordinarily provide a selection for at least one row in each windbreak. In areas where they do well, evergreens may be used for the entire windbreak and for the new twin-row plantings.

Use Table 3 as a guide. Consult with professionals in your local area for species expertise that may override the general recommendations in this table.

Nursery Stock

Nearly all windbreaks and other farm tree plantings start with seedling-size plants. The principal reason is to keep the root-to-shoot ratio in balance. The root-to-shoot ratio is the natural proportion of the top to the roots. Large stock or even potted or balled and burlap stock has had its root-to-shoot ratio altered drastically. The altered root-to-shoot ratio is commonly deficient in roots for the aboveground leaf area. Drought damage is common with trees and shrubs in this condition. Small-size plants normally survive better than large-size plants when transplanted because of the more equal shoot-to-root ratio. In other words, a smaller tree loses less moisture than a large tree, in proportion to its ability to supply moisture through its root system.

Small-size conservation stock also is less expensive than the larger landscape stock used for horticultural purposes. When using small plants,

your nursery, transportation expenses, and planting costs are only a small fraction of what they would be for large plants. For these reasons, you will save by buying nursery stock on a per 100 or per 1,000 basis.

Common seedling types (called stock type) are bare root and plug. Bare root trees are grown in a seedbed, usually outside. They are lifted and sold in bundles—with bare roots. Evergreen seedling trees grown in a greenhouse are called "plug" stock, because they are normally grown in plastic foam blocks filled with potting soil. The tree is pulled from the block and transplanted with potting soil still attached to the roots. Plug seedlings are more expensive than bare-root trees but often result in a higher survival rate. Plug sizes vary. Generally, a 10- to 20-cubic-inch plug for evergreens is recommended for windbreak plantings.

Individually potted trees are not suited for windbreak use because of their restricted root systems. These trees are best used for horticultural purposes.

You can obtain planting stock from state or federal nurseries, commercial nurseries or by starting your own cuttings. Ask for a list of commercial nurseries from your county Extension agent or USDA-NRCS district conservationist. Some Soil Conservation Districts specialize in supplying stock for farm plantings. They often have species not available from the state nurseries.

Nonrooted Cuttings

The following trees and shrubs can be grown from cuttings: golden willow, black willow, poplars, common lilac, and common privet (Figure 32). If you decide to use your own cuttings from established trees, follow these suggestions:

- Make cuttings in late winter before new growth starts. Cut last year's new growth.
- Make cuttings long enough to contain five to six buds. Leave one bud near the top of the cutting.
- Store cuttings where it is cool and moist. Refrigeration is ideal.
- Plant in spring after the danger of frost is past.
- Plant the cutting so that only 1–2 buds are above the soil surface.
- Pack the soil firmly around cuttings.
- Use cuttings only on irrigated land or on sites with a good natural supply of moisture throughout the growing season. Soil must be kept moist for cuttings to root. Soil surface mulches are advantageous on coarse-textured soils. Rooting hormones are not required for success in growing cuttings of the species mentioned earlier.

Figure 32. *If your cuttings come from one parent tree, they will usually result in very uniform windbreak rows as illustrated here.*

Site Preparation

Site preparation is the foundation of tree planting. Without it, all your tree planting efforts may be for naught.

Prepare a clean, firm seedbed for your tree planting because good ground preparation conserves soil moisture. Some cropland and pasture sites have compacted underlying soil layers which are impenetrable to tree roots. Check for these hard pans. If they are within 18 inches of the surface, plan to rip the tree planting rows to at least a 24-inch depth. This will aid in long-term windbreak survival and growth. Shallow disking or harrowing just before planting is adequate on cultivated land without weed problems. For areas with perennial grasses or weeds, use summer fallow, then disk or harrow before planting time. After disking or harrowing, roll the ground to be sure the soil is firm (Figure 33).

Care of Trees before Planting

Do not allow tree roots to dry out or expose them to warm temperatures from the time the trees arrive until they are planted. Exposure of root systems to drying conditions—sun or wind—is the cause of many planting failures. If planting is possible within a week after you receive your trees from the nursery, you may leave them in the original package for transporting to the planting area (Figure 34).

Store the package in a cool place. Refrigerated storage is ideal, but covering packaged seedlings with snow or space blankets in a shaded location will keep them in good shape for several days. Ideal temperatures are 34°F to 38°F with 95% humidity.

If you must delay planting and refrigerated storage is not available, unpack and "heel" in trees. Follow these steps:

- Dig V-shaped trench in a moist, shady place.
- Break bundles and spread out evenly, three to four trees thick.

Figure 33. *Excellent site preparation is necessary for successful windbreak establishment.*

- Fill in loose soil and water well.
- Complete filling in soil and firm with hands.

We strongly suggest the use of a tree-planting machine. Its use will result in better survival and better initial growth.

Planting the Tree

You may use several methods and tools to plant trees. Machine planters usually are the best alternative on flat, well-prepared soil if you have many trees to plant. However, hand planting using a spade or shovel is still a popular method. Whatever method you use, follow these instructions closely:

Figure 34. *When planting seedlings, keep roots covered with wet material such as peat moss. Do not submerge the roots in water.*

Hand Planting Techniques

- Make the hole deep enough for all roots.
- Cut long roots back to 10 or 12 inches.
- Remove one tree at a time from bucket only after hole is ready for the tree.
- Keep foreign matter (leaves, sticks, rocks, and dry soil) out of hole.
- Place all tree roots in a downward position.
- Place tree in center of hole.
- Hold treetop upright while working soil around roots.
- Firm soil around roots by hand while filling hole, leaving no air spaces. Make sure to use moist soil.
- Bring soil level to root collar (look for color change on stem) above the first roots. Too deep is better than too shallow.
- Firm soil all around tree by hand to give good compaction.

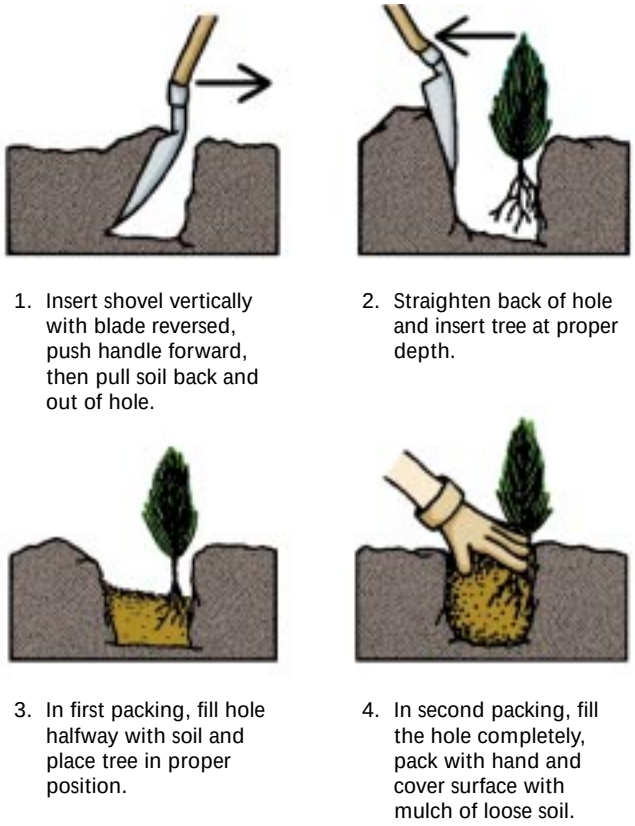
Trees planted in an unsatisfactory manner have little chance to survive. Take an extra moment with each tree, and do a good job. (Figures 35 and 36)

We strongly suggest the use of a weed barrier or "fabric mulch." Its use will result in better survival and initial growth.

Weed Barrier Fabric Mulch for Tree and Shrub Plantings[4]

Weed barrier fabric mulch is a polypropylene geotextile product having the texture of burlap. The barrier eliminates vegetative competition with newly planted trees and shrubs by acting as mulch. It conserves soil moisture by reducing evaporation. Water can penetrate weed barrier fabric, but sunlight cannot, so vegetation will not grow through it. The fabric barrier provides this protection for at least 5 years. In the arid west, we have observed good control for up to 10 years (Figure 37).

Weed barrier fabric comes in long rolls 6 feet wide and 300 to 500 feet long. It is also available in 3- foot and 6- foot squares. The roll product is probably more convenient when using a mulch-laying machine. The 6-foot-wide rolls are mechanically installed over the top of seedling immediately after planting. An "L" shaped slit is cut at each tree location no larger than is necessary to pull seedlings through. Though limiting the size of cut is important, make it large enough to prevent the fabric from rubbing against the seedling. It is crucial to pull the seedlings through immediately on warm days, as the heat generated by the fabric can damage or kill tender seedlings.



1. Insert shovel vertically with blade reversed, push handle forward, then pull soil back and out of hole.
2. Straighten back of hole and insert tree at proper depth.
3. In first packing, fill hole halfway with soil and place tree in proper position.
4. In second packing, fill the hole completely, pack with hand and cover surface with mulch of loose soil.

Figure 35. *Planting with a shovel is usually a two-person operation following these steps.*

[4] Adapted from Weed Barrier Fabric Mulch for Tree & Shrub Plantings, Kansas State & Extension Forestry, Kansas State University.

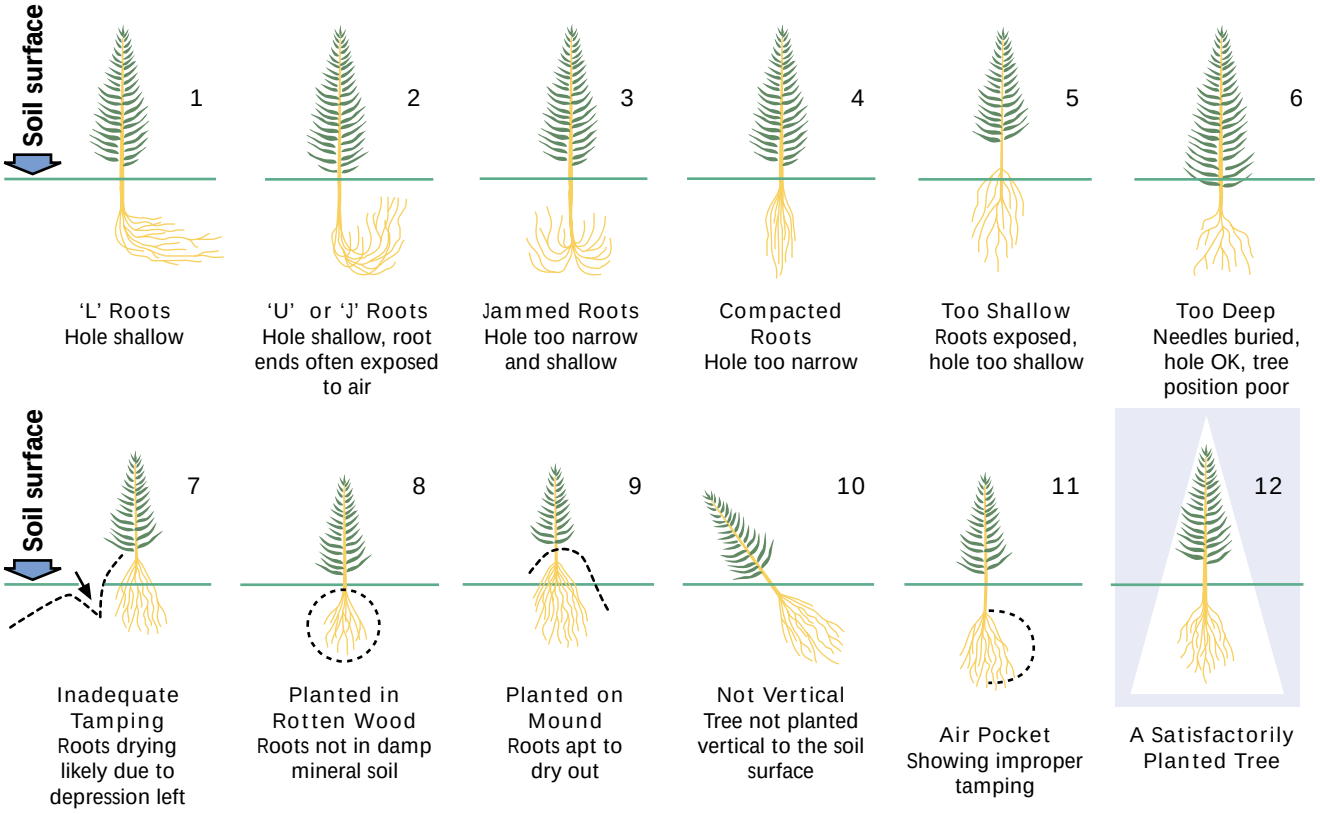


Figure 36. *Plant trees and shrubs in a satisfactory manner. These drawings show various ways trees should NOT be planted.The ideal is drawing 12.*

Update:

The Plains states, where land managers have had several years experience with fabric mulch, are reporting that the mulch under shade is not deteriorating after 5 years and has caused some problems with trunk girdling. In older plantings where the trunk is tight against the mulch, enlarging the slit is recommended. In new plantings, cutting the initial slit in an "L"-shape instead of straight, can alleviate this concern. In the future, look for fabric mulch products guaranteed to break down after 5 to 7 years, even under shade conditions.

We still strongly suggest that you use fabric mulch in all new windbreak plantings.

Figure 37. *Weed barrier fabric mulch is a polypropylene geotextile product. We recommend its use in all windbreak applications.*

Application of Weed Barrier by Machine

The basic function of the machine is to lay the fabric and bury the fabric edges. The fabric usually is laid over small windbreak plants *just after they have been planted*. The small plants are bent over under the weight of the fabric. The operator (rider) marks them using a can of spray paint. A person *immediately* follows the machine, cutting a small slit and pulling the small plants up through the fabric (Figures 38, 39, 40).

At the end of a roll, dig a trench one shovel wide by one shovel deep just in front of the press wheels. Place the last foot of one roll and the first foot of the next roll in the trench and cover with dirt. This will hold the new roll tight until the press wheels and closer disks anchor the next few feet of material.

Prepare the site to make the ground surface as firm and smooth as possible to keep the laid fabric close to the soil surface. Close soil contact controls weeds and prevents the material from whipping in the wind. We recommend putting as little soil as possible on top of the weed barrier. Weed seeds can sprout and grow down through the material. Wire staples are available to hold down the center of the fabric.

Variations are possible on this operational pattern. If the plants are large and stiff, the operator may have to slit the fabric as it is tightened to prevent breakage. The fabric also can be laid prior to planting, with or without pre-dug holes. If the plants are tall or stiff, operators may need to set the tool bar and fabric roll high, then slit the fabric and pull the plants through as the tractor moves very slowly. However, if you move too slowly, you may not get adequate soil covering the fabric edges.

Fabric mulch laying machines are becoming more common in the Pacific Northwest. Check availability for short-term lease by contacting your local conservation district or USDA Service Center. The personnel at the USDA-NRCS Plant Materials Center in Aberdeen, Idaho, have developed plans for the manufacture of a weed bar-

Figure 38. *Installing fabric mulch in a field windbreak.*

Figure 39. *Marking the location of each newly planted seedling under the fabric mulch.*

Figure 40. *Cutting fabric mulch to free newly planted seedling.*

rier machine. These plans are available by contacting the center at 1691 A South 2700 West, PO Box 296, Aberdeen, ID 83210-0296. Ask for Technical Note 25, *Function and Operation of a Machine to Lay Weed Barrier Material*, by Simonson and Cornforth.

Post Planting Care

> ***"Ninety percent of a successful windbreak is conscientious maintenance,"***
>
> ***Loren St. John, Team Leader, Plant Material Center, USDA-NRCS, Aberdeen, ID***

Although you plan and plant a windbreak to get effective wind protection, some factors will prevent you from achieving your goals unless you can give your trees good care. This section describes commonly needed practices.

Irrigation

A good supply of moisture close to the soil surface is essential for successful establishment of new tree plantings. In our arid regions, drip irrigation is the best system to use, especially when combined with fabric mulch. Windbreaks have been established on deep loam soils using the fabric mulch but without supplemental watering in Adams County, Washington, which receives less than 10 inches of annual precipitation. Water windbreaks often enough to keep the trees in active growth all summer. Watering frequency depends on soil type, local temperature, and wind conditions. As a rule, water your trees once each week during hot weather in their first growing season. During the second and third seasons, water about once every 10 days.

When you irrigate your trees, leave the water on long enough to get deep-water penetration throughout the root zone. Shallow watering encourages shallow rooting. Stop watering in the fall 3 weeks before the usual date of first frost, which will help your trees harden off to cold weather. If you have water available in the fall, irrigate the evergreens once more after you have had two hard frosts. This fall watering helps the trees withstand drying winter conditions.

Weed Control

The first 2 to 3 years after planting are critical times for young trees. Survival relates directly to available soil moisture. Weed control is essential. If you do not control weeds, the chances of tree survival are slim. Usually a combination of cultivation and herbicide treatments results in the best weed control.

Heavy weed cover robs newly planted trees of soil moisture and nutrients. Young trees grown over with weeds or grass may be kept alive by frequent watering, but the tree growth will usually be disappointing. Since weed control is so essential to the success of any farm tree planting, a plan for appropriate and timely application of the cultivation, herbicides, or mulch is vital. After the trees are well established, you can seed grasses in irrigated plantings and substitute mowing for cultivation. In most dryland plantings, the use of fabric mulch is a necessity. This new technology makes it possible to establish and grow trees and shrubs on the most difficult sites (Figure 41).

Figure 41. *Rocky Mountain juniper provides excellent growth under dryland conditions in eastern Washington when fabric mulch is used.*

Cultivation

Cultivate your windbreak often to control weeds. Cultivate when the weeds are small, less than 2 inches in height. Shallow cultivation (2 to 4 inches) is best since deep cultivation near the trees destroys many feeder roots and wastes soil moisture. Avoid hilling up the soil around young trees. Covering branches will injure or kill them.

Duck-foot cultivators and spring tooth harrows are good cultivating tools. Disk harrows are not as good but can be used if carefully regulated. While trees are small, over-the-row cultivating may be feasible with side delivery rakes. Putting 16-inch flexible tines in a section harrow can make a good over-the-row cultivator. A dump type rake fitted with smaller wheels does a satisfactory job.

Hand hoeing may be necessary if you do not have equipment to get at weeds within the tree rows. Special tools are available like the grape hoe and shelterbelt cultivator that swing out from the side of a tractor to remove the weeds from within the tree rows. Attaching suitable tines to an old mower bar can make a usable in-row cultivator.

Cultivate irrigated windbreaks for at least 3 years. After the trees are well established, you may seed a cover of low grass to help keep down the weeds. The best practice for dryland windbreaks is to keep your planting clean cultivated as long as possible.

Herbicide Usage

Herbicides are effective chemical tools for controlling unwanted weeds. Some are safe to use in established plantings, while others should only be used as "directed sprays" on the weeds. Always follow label directions. If herbicides are not applied according to label directions, damage to your trees or soil may result. *Many different herbicides are available; check with your Extension county agricultural educator for proper recommendations*. Recommended herbicides vary depending on the tree species in the windbreak and the target weed species. The species you wish to protect (site) must appear on the product label, the pest species to control should also be listed.

Fertilizers

Trees usually make good growth without any fertilizer on agricultural soils. However, most established trees respond favorably to nitrogen or other limiting elements after growing for two seasons or more. In general, do not fertilize young trees at the time of planting unless the planting site is extremely low in fertility. The root systems of young trees are susceptible to damage by fertilization.

Windbreak owners have no single indicator to tell them if trees need fertilizer. Some suspected low fertility conditions or symptoms also could be caused by disease, poor root system, inappropriately applied herbicides, or other problems. These symptoms include leaves of smaller than usual size, presence of light green or off-color foliage, dead twigs on the ends of branches, very short elongation of branches during the growing season, and general lack of thriftiness or vigor. If any of these symptoms are present, the tree may benefit from fertilization. Similarly, if the tree has been physically injured or has sustained severe defoliation by insects, disease, or hail, fertilization may be helpful during the recovery period.

While windbreak trees require nitrogen, phosphorus, and potassium in the largest amounts, all windbreak trees and shrubs require several other nutrients. These include calcium, magnesium, sulfur, chlorine, iron, manganese, copper, boron, zinc, and molybdenum. Three numbers on all fertilizer packages represent nitrogen, potassium, and phosphorus concentrations in a formulation. For example, 20-10-10 indicates that the formulation contains 20% N, 10% P and 10% K. Most soils contain adequate amounts of these elements, except for iron, which is frequently deficient. To confirm fertility needs, complete a soil test for the site.

Iron Chlorosis

Specific foliage discoloration may signal some nutrient deficiencies. Prolonged nutrient deficiency will result in poor vigor, making the tree vulnerable to disease and insect attacks, often resulting in the tree's death.

The most commonly occurring discoloration of leaves is the development of a yellow or light yellow-green color. If this discoloration occurs in the areas between the leaf veins, it usually leaves the leaf veins and leaf tissue near the veins a darker green color. This condition, called "chlorosis," is associated with a lack of available iron. The chlorosis may occur only on part of the tree, such as a single branch, or may affect the entire tree. Apply iron-rich fertilizers if this symptom is present. Chelated iron formulations are usually the best. The practicality of this recommendation depends on whether the symptom appears on just a segment of the windbreak or an on entire row. One alternative is to know the soil situation during the planning stage and avoid selecting trees or shrubs most susceptible to chlorosis.

Timing Fertilizer Applications

For greatest value to the tree, apply fertilizer in the spring as soon as the soil is frost-free or apply on top of a late season snow layer. Fertilizer applied in early spring is available for the tree to use as soon as growth resumes. Since root growth will begin before leaf development, apply fertilizers as early as possible.

Do not fertilize trees in mid-summer because irrigation is not usually sufficient to avoid foliage "burning." Also avoid late summer applications because they may produce new growth tissue that will not harden off sufficiently before fall freezes, resulting in winter injury.

Fertilizer Quantities

In dryland plantings receiving less than 16 inches of annual precipitation, you can easily do serious damage to evergreens with nitrogen. Use no more than 40 pounds nitrogen per acre. In irrigated plantings, you can apply 80 pounds nitrogen per acre to established trees. For area determinations, include only the area under trees and shrubs, not the area between the rows. Be sure to keep the amount of fertilizer you apply in line with the amount recommended. For example, if the recommendation is 40 pounds nitrogen per acre, this corresponds to 200 pounds per acre of a 20-10-0 fertilizer.

Protection

Livestock, poultry, mice, gophers, rabbits, deer, porcupines, insects, diseases, and herbicide drift can be real enemies of farm tree plantings. You can control the threat from livestock and poultry by fencing them out. You will be wise to fence before you plant. If you plant trees next to meadow, hay land, sagebrush areas, or road rights-of-way, you may have to combat mice, gophers, or rabbits (Figures 42 and 43).

Figure 42. *Livestock can damage this excellent windbreak in short order by rubbing, trampling, and compacting the soil.*

Figure 43. *Windbreak damage caused by livestock grazing.*

Clean cultivation helps keep out mice and gophers but does not provide complete assurance against damage from them. Mice and gophers move into clean plantings under snow cover. You may choose screen wire or hardware cloth cylinders to protect small trees, as fencing can prevent damage from rabbits and rodents. Sometimes live trapping or poisons are the only options.

Examine your windbreak periodically in late fall, winter, and early spring for signs of insect or disease damage. If you discover a pest problem in your tree planting and do not know how to control it, ask the Extension agricultural agent in your county for recommendations.

What appears to be disease damage in farm tree plantings frequently results from the improper use of herbicides. A cause of such damage is repeated occurrences of herbicide drift in fields or along roads. Both deciduous trees and evergreens are affected, but some species are much more susceptible than others. As a group, evergreens in the dormant stage (after bud set) are more resistant to herbicide damage than are deciduous trees in full leaf. However, pines are very susceptible to herbicide drift during active growth in the early spring. New growth on evergreens may wilt, with browning of the needle tips developing later. Twisted, malformed leaders or tree deaths often result.

In deciduous trees, the most serious herbicide damage usually occurs in spring or early summer while the new leaves are still tender. Common symptoms are crinkling or curling of the leaves, fading of the green color between the leaf veins, and stunted leaf and twig development. In severe cases, all new growth on trees may be stunted or deformed and killed.

Soil-active herbicides are not recommended for most windbreak plantings, as the chemicals can be quite damaging to trees with shallow root systems, especially blue and Norway spruces. Herbicide symptoms on these species include a random pattern of purplish colored needles in the tree crown, followed by defoliation.

If your windbreak has herbicide symptoms, minimize tree stress by frequent irrigation, by fertilizing the following spring, and by controlling aphid and scale insects. In most cases, the trees will survive from a single herbicide application. Death is most always attributed to repeated herbicide contact.

Renovation of Old Plantings

Trees in many old windbreaks and other farm tree plantings show sparse crowns, dying branches, and other signs of low vigor (Figure 44). Over-

Figure 44. *Renovation of old windbreak using eastern redcedar in the Great Plains region. Rocky Mountain juniper is the preferred species in the Pacific Northwest for a similar application.*

crowding often causes these conditions. Old plantings commonly were made with spacing too close to give the trees room to grow. The trees probably did well during their early years, but long before reaching maturity, they were crowding each other severely. Growth rate slowed down, vigor decreased, and the trees became more susceptible to disease, insects, drought, and herbicides. Often the older windbreak has grown less effective due to the decrease in density, especially near the ground.

In an old planting, thinning or cutting out the weaker trees helps strengthen the remaining ones. Remove every other tree within the row or, if some rows are overtopped or almost entirely dead, remove them completely. Fertilizers aid in rejuvenating old plantings, particularly black locust and Siberian pea shrub.

Enlargement plantings are a form of windbreak renovation. If the main windbreak is not too weak, simply add new rows to it on either the windward or leeward sides, space permitting. Use evergreen trees or dense shrubs to increase the density near the ground for improved wind reductions and snow catchments (Figure 45).

Figure 45. *Twin rows of eastern redcedar are often used to renovate older windbreaks in the Great Plains region. Rocky Mountain juniper is the preferred species in the Pacific Northwest for a similar application.*

Rejuvenation options are often site specific. Seek help from your local Extension agent or USDA-NRCS specialist for rejuvenation alternatives (Figure 46).

Figure 46. *Renovated windbreak protecting this clean cultivated field.*

A Final Word

In the past, windbreaks were thought to be conservation practices that would provide benefits way off in the future. This notion is no longer true as new establishment technologies, coupled with better tree and shrub species, result in effective barriers in just a few years, even on the harshest sites in the arid regions of the Pacific Northwest (Figure 47).

Figure 47. *This windbreak is providing benefits just a few years after establishment.*

Sources of Additional Information

You may obtain additional information, advice, or planning assistance from any of the following:

- Washington State University, University of Idaho, and Oregon State University Extension Services: located in virtually every county of the three states.
- District Conservationist, or a forestry or agroforestry specialist with the USDA.
- Natural Resources Conservation Service, located at the USDA Service Center.
- The local soil and water conservation district.

Sources of Planting Stock

State or Federal Nurseries

Each of the three Pacific Northwest states has a publicly owned nursery established to provide tree and shrub planting stock to rural landowners at reasonable costs. Tree and shrub species commonly used for windbreak plantings can be purchased from these nurseries:

- Idaho
  University of Idaho
  Forest Research Nursery
  PO Box 441137
  Moscow, Idaho 83844-1137
  (208) 885-3888

- Washington
  Department of Natural Resources
  Webster Forest Nursery
  9805 Blomberg St SW
  PO Box 47017
  Olympia, WA 98504-7017
  (360) 753-5305—Toll Free: (877) 890-2626

- Oregon
  Oregon Department of Forestry
  D. L. Phipps Nursery
  2424 Wells Rd.
  Elkton, Oregon 97436
  (541) 584-2214

Contact each nursery for ordering and price information. Planting stock purchased from these public nurseries has a few restrictions:

- Trees may not be planted inside the limits of incorporated towns or cities.
- Trees may not be used for ornamental purposes.
- Trees may not be resold with roots attached.
- Trees may not be planted outside the state in which they were ordered.

Commercial Nurseries

Many commercial nurseries produce seedling-size trees for farm and forest plantings. They frequently have species or varieties of trees and shrubs not available from the public nurseries. There is no restriction on the use of planting stock purchased from a commercial nursery. Purchase trees only from nurseries that provide quantity prices, as individual potted trees would be very expensive. Ask your Extension county agent or USDA-NRCS district conservationist for a list of commercial nurseries that produce seedling trees for farm plantings.

Soil Conservation Districts

A third source of tree stock is Conservation Districts. Conservation Districts often purchase trees from commercial nurseries in large quantities. The districts then resell the trees to individuals as a service. Contact your local district or USDA-NRCS office for details.

Individual Species Characteristics: Shrubs

Siberian pea shrub (*Caragana arborescens*)

A dense, attractive, many stemmed shrub. Grows rapidly. Has long life, adapts to a wide range of soils and elevations. Generally insect and disease free. Sprouts from root collar only. Good for dryland or irrigated plantings. Reaches full size on irrigated land in 5 to 7 years, on dryland in 10 to 12 years. Can be trimmed to make an excellent protective hedge. Forms a superior windbreak shrub adaptable to the whole region. It is weakened by repeated 2,4-D exposures.

Skunkbush sumac (*Rhus trilobata*)

A dense, attractive, many stemmed shrub. Grows well on very droughty sites. Adapts to a wide range of soil and salinities. It has the ability to grow in dryland conditions having as little as 10 inches of annual precipitation. Growth rates are much better under drip irrigation. The deep green summer foliage changes to bronzy red in fall, and clusters of red fruit develop in late summer. Fruit provides excellent fall and winter food as soft mast for birds. Produces light yellow flowers.

Common lilac (*Syringa vulgaris*)

Very dense. This long-lived shrub has a low to medium growth rate. It adapts to a wide range of soils and elevation. Sprouts heavily, mainly at the root crown, but spreads slowly. Makes excellent hedge or shrub row in windbreak. Has high aesthetic value. Occasionally becomes infested with scale insects, extremely sensitive to 2,4-D. Has high resistance to drought and cold.

Amur or freedom honeysuckle (*Lonicera* spp.)

Attractive, globe shaped, many stemmed shrub. Bears numerous pink or white flowers. Red fruit holds on until fall. Provides good wildlife food and cover. Improved varieties not commonly subject to insect or disease problems. Does well on most soils.

Common privet (*Ligustrum vulgare*)

An extremely dense, attractive shrub producing medium to rapid growth. Needs well-drained soil. A nearly ideal plant for low, single-row windbreaks, as well as the shrub row in multiple-row plantings.

Nanking cherry (*Prunus tomentosa*)

An attractive, upright shrub with a fast growth rate. Produces abundant, edible fruit that makes good jelly. Fruit is retained throughout winter and makes good wildlife food. Some hybrid varieties grow to 10 feet tall. Has fair to good windbreak qualities. Few insect or disease problems. Do not plant near cherry orchards because it is an alternate host to Western X cherry disease. Does not do well in the coldest areas.

Peking cotoneaster (*Cotoneaster acutifolia*)

Similar to Nanking cherry. Will grow on severe sites. Moderate growth rate. Withstands drought well. Produces abundant fruit retained throughout the winter. An excellent species for adding wildlife value to a windbreak. Few insect or disease problems.

Mugho pine (*Pinus mugo*)

An attractive, compact evergreen shrub with moderate growth rate. Does best on fertile, well-drained soils. Performs best as a windbreak shrub at elevations below 4,500 feet as winter burning is a problem above this elevation.

Individual Species Characteristics: Deciduous Trees

Golden willow (*Salix alba* var. *vitellina*)

A medium-size tree having good growth form for windbreak use. Bright yellow to orange colored young branches make it attractive in winter. Grows rapidly; adapts to a wide range of soil and moisture conditions. Sprouts only

from roots and does not spread from runners. Subject to severe damage from scale insects and aphids. Use for dryland plantings only if supplemental moisture is available. Excellent in the Palouse. Poor for firewood.

Black willow (*Salix nigra*)

Grows very rapidly under irrigation. Forms broad, moderately dense globe-shaped crown. Usually produces several stems from near ground level. Serves well as a middle row in windbreaks. Not very suitable for single row plantings because of its low, wide spreading branches. Has performed well in localities having salty soils and high water tables, where establishment of other species was difficult. Subject to damage by scale insects. Poor for firewood.

Black locust (*Robinia pseudoacacia*)

Has rapid growth rate. Forms moderately dense crown. Tolerates very hot climates. Adapts to a wide range of soil conditions but does not withstand water logging. Locust borer is a serious insect problem in young trees. Not recommended for ditch bank or fencerow plantings because injured roots produce thickets of sprouts. Requires little maintenance once it is established. A widely used tree providing good shade, aesthetic and wildlife values. The locust borer makes it impractical for new plantings. Excellent for firewood.

Honey locust (*Gleditsia triacanthos* var. *inermis*)

Medium to tall tree. Fairly drought resistant. Withstands alkaline soils well. Attractive zigzag twigs, fine textured leaflets. Two- to four-inch thorns. Fruit is a large 12-inch (maximum) pod. Winter injury on harsh sites. Good for firewood.

Hybrid poplar (*Populus x* spp.)

Grows rapidly. Has dense crown and good form. Does best under irrigation but performs well in dryland plantings receiving 25 inches or more annual precipitation. Provides quick protection. Suckers develop from injured roots. Do not plant near field drains or along irrigation ditches. Susceptible to poplar and willow borer. Much clonal variation; purchase stock from a source field tested in your area. (*Note: There are many hybrid poplars. Be sure to get the correct variety for your area.*) Poor for firewood.

Green ash (*Fraxinus pennsylvanica* var. *lanceolata*)

A deep-rooted, long-lived tree having a dense, symmetrical, and attractive crown. Growth may be slow at first but becomes moderate to rapid after tree is established. It will be overtopped by more rapidly growing trees, such as black locust and Siberian elm, if planted too close to them. Sprouting is negligible. An excellent tree for ditch bank and fence row plantings. It is more winter hardy and salt tolerant than black locust. It is damaged by herbicide sprays but is more resistant than Siberian elm. Subject to damage by scale insects and aphids. Excellent for firewood.

Lombardy poplar (*Populus nigra* var. *italica*)

Overplanted throughout the Pacific Northwest, where it is not generally recommended. Grows very rapidly, reaching 40 feet in 12 years under favorable conditions. Has very narrow, though fairly dense, crown. Makes good middle row where fast growth and extra windbreak height are desired. Subject to some canker diseases and heart rot, especially if trees have been damaged by topping, fire, or other causes. Windfirm unless diseased. Susceptible to poplar and willow borer. Short lived. Poor for firewood.

Russian olive (*Elaeagnus angustifolia*)

Do not use this tree along ditch banks, in wet pastures, or along streams. A small tree with dense, attractive crown. A superior tree for windbreak, wildlife, and aesthetic values and for drought resistance. Makes a dense hedge when clipped. Its spiny-tipped twigs make a dense planting an almost impenetrable barrier. Considered one of the best deciduous species for dryland plantings in the region. Grows rapidly, especially on good soil with ample moisture. Adapted to a wide range of soils. Sprouting is negligible, but it spreads by seed where soil moisture is adequate. More resistant to spray damage than other deciduous species but not as resistant as dormant evergreens.

Individual Species Characteristics: Evergreens

Rocky Mountain juniper (*Juniperus scopulorum*)

Excellent success when planted using the new fabric mulch. Achieves medium to rapid growth. Forms very dense, symmetrical crown. Adapted to wide soil variations. Tolerates high water table. A superior small windbreak tree for this region. Bare-rooted planting stock is difficult to establish on dry land but does well once established. Subject to damage by spider mites; sometimes a host to cedar apple rust.

Eastern redcedar or Virginia juniper (*Juniperus virginiana*)

Has moderate to fast growth rate. Similar in appearance to Rocky Mountain juniper and generally as adaptable. It is easily established except on very dry sites and at high elevations. Well liked for single row screens. Subject to attack by cedar apple rust. Do not plant near apple orchards.

Northern white cedar (*Thuja occidentalis*)

Commonly called Arborvitae. Moderate growth rate. Forms very dense, attractive crown. Holds lower branches well. Makes a dense single-row windbreak or leeward row in a multiple row planting. Survives well under irrigation where soils are not highly saline. No known insect problems; is susceptible to *Phytophthora cinnamomi*. Has not been widely used, but existing plantings indicate it is a good tree for many localities. Well-liked in Oregon for single-row screens and windbreaks.

Austrian pine (*Pinus nigra*)

Has medium growth rate. Develops very dense symmetrical crown for a pine. Holds lower branches well. An excellent tree under irrigation but sometimes fails in low rainfall dryland plantings after 10 to 12 years. If planted without supplemental watering in localities receiving less than 20-inch annual precipitation, it needs a deep, fertile soil with good moisture holding capacity. Considered an excellent species for the Columbia Basin. Ponderosa pine is preferred in Wasco, Gilliam, Sherman, and Morrow counties, Oregon. Usually remains free of insect and disease problems. Susceptible to iron chlorosis. Moderate for firewood.

Incense cedar (*Calocedrus decurrens*)

Recommended for western Oregon in the Willamette and interior valley regions only, but not to be planted within a mile of commercial pear orchards, as it is the alternate host for Northwest pear rust. Medium to good growth on better soils. Develops a nice symmetrical crown that holds lower branches well. It can grow in many soil types including rhyolite, sandstone, and serpentine. Tolerates dry summer conditions. Free of major insect and disease problems when tree vigor is maintained.

Scotch pine (*Pinus sylvestris*)

Has rapid growth rate. Crown density is usually medium. Lower branches shade out and die if they do not get full sunlight. Adapts to a wide variety of soil conditions. Withstands permanently moist soil conditions better than ponderosa pine. Susceptible to a variety of needle diseases in wet climates. Sequoia pitch moth can be a serious problem in western Oregon if lower branches are pruned in the growing season. A widely used tree for windbreaks. Many strains of Scotch pine are available. Some have poor form. Spanish burgo variety does well in Idaho. Moderate for firewood.

Blue spruce (*Picea pungens* var. *glauca*)

Growth rate is unusually slow for first 5 years after planting but has medium growth rate after that. Crown is very dense with attractive pyramidal form. Traps and holds snow well. Makes an excellent windbreak species in most of the region. Color varies from green to blue. Sometimes it is difficult to establish. Subject to damage by spider mites, scale insects, and spruce gall adelgid.

Norway spruce (*Picea abies*)

Grows rapidly. Develops a very dense crown that extends to the ground unless the base of the crown is in heavy shade. Moisture and

soil fertility requirements are higher than for the pines. Does fairly well in dryland plantings if soil is deep and fertile. Subject to spider mite and spruce bud scale damage. Sometimes becomes stunted in growth due to zinc deficiency. Spruces are poor choices for firewood.

Ponderosa pine (*Pinus ponderosa*)

Has moderate growth rate. Crown is symmetrical and fairly dense. Needs full sunlight for best development. Lower branches shade out and die under close spacing. Adapts well to a variety of soil conditions but must have good drainage. Withstands hot, dry sites well. Can be damaged or killed by too much irrigation. Generally free of insect and disease problems. Many consider this the most reliable evergreen for windbreaks. Highly preferred in Oregon and in much of the Columbia Basin. Moderate for firewood.

Douglas-fir (*Pseudotsuga menziesii*)

Generally not a good windbreak tree in the arid areas of the PNW. Has medium growth rate. Crown is dense and symmetrical. Needs a well-drained soil. More difficult to establish under irrigation than Scotch pine or Norway spruce. Sometimes difficult to establish on grassland soils. Growth is generally slow without supplemental watering in areas receiving less than 18 inches annual precipitation. Good for firewood.

Lodgepole pine (*Pinus contorta*)

Generally not a good windbreak tree in the arid areas of the PNW, but commonly found along the coast in very sandy soils. Also known as shore pine. Has slow growth rate. Crown is dense on poor sandy soils and thin on better sites. Tolerates salty atmosphere and periodic flooding as well as any conifer. Fair to poor for firewood.

Suggested Reading

Atchison, Robert L., and Leah B. Riche, 1996. Weed Barrier Fabric Mulch for Tree and Shrub Plantings. Kansas State University Cooperative Extension Service, MF-2216.

Boehner, Patricia, and James Brandle. Windbreak Establishment. University of Nebraska Cooperative Extension, EC 91-1764-B.

Brandle, James, Tom Wardle, and Gerald Bratton. 1992. Working Trees for Carbon: Windbreaks in the US. USDA-National Agroforestry Center. Available from www.unl.edu/nac.

Brandle, James, and H. Doak Nickerson. Windbreaks for Snow Management. University of Nebraska Cooperative Extension, EC 96-1770-X.

Brandle, James, and Laurie Hodges. Field Windbreaks. University of Nebraska Cooperative Extension, EC 00-1778-X.

Brandle, James, and Sherman Finch. How Windbreaks Work. Nebraska Cooperative Extension, EC 91-1763-B.

Garrett, H.E., W.J.Rietveld, and R.F. Fisher, Eds. 2000. North American Agroforestry: An Integrated Science and Practice. American Society of Agronomy. 402p.

Josiah, Scott J. 2000. Discovering Profits in Unlikely Places: Agroforestry Opportunities for Added Income. University of Minnesota Extension Service, BU-7407-S.

Kuhn, Gary, James Robinson, Bruce Wight, and Lyn Townsend. 1996. USDA-NRCS, Agroforestry Tech. Note 1.

Quam, Vernon, LaDon Johnson, Bruce Wight, and James Brandle. Windbreaks for Livestock Operations. University of Nebraska Cooperative Extension, EC 94-1766-X.

Quam, Vernon, James Brandle, and Teresa Boes. Windbreaks in Sustainable Agricultural Systems. University of Nebraska Cooperative Extension, EC 91-1772-X.

Stange, Craig, and James Brandle. Windbreak Management. University of Nebraska Cooperative Extension, EC 96-1768-X.

Stange, Craig, Jon Wilson, James Brandle, and Mike Kuhns. Windbreak Renovation. University of Nebraska Cooperative Extension, EC 98-1777-X.

Tyndall, John, and Joseph P. Colletti. 2001. Air Quality and Shelterbelts: Odor Mitigation and Livestock Production, A Literature Review. USDA National Agroforestry Center Sponsored Research Project, Forestry Department, Iowa State University.

Wight, Bruce, Teresa Boes, and James Brandle. Windbreaks for Rural Living. University of Nebraska Cooperative Extension, EC 91-1767-X.

_____, Windbreaks for Conservation. 1969. USDA-Natural Resources Conservation Service, Agricultural Information Bulletin No. 339, 25 p.

_____, 2001. NAC Free Informational/Educational Agroforestry Materials—NAC Publication List. Summer 2001. Available from www.unl.edu/nac

_____, 1999. Living Snow Fences. USDA-NRCS, Idaho State Office, Boise, ID.

Order information:

Washington State University Cooperative Extension
Web http://pubs.wsu.edu Fax 1-509-335-3006 Toll-free phone 1-800-723-1763
bulletin@coopext.cahe.wsu.edu

Oregon State University Extension Service
Web http://eesc.orst.edu Fax 541-737-0817 Phone 541-737-2513
puborders@orst.edu

University of Idaho Extension
Web http://info.ag.uidaho.edu Fax 208-885-4648 Phone 208-885-7982
Kristinj@uidaho.edu

Pacific Northwest extension publications are produced cooperatively by the three Pacific Northwest Land-Grant universities: Washington State University, Oregon State University, and the University of Idaho. Similar crops, climate, and topography create a natural geographic unit that crosses state lines. Since 1949, the PNW program has published more than 550 titles, preventing duplication of effort, broadening the availability of faculty specialists, and substantially reducing costs for the participating states.

Published and distributed in furtherance of the Acts of Congress of May 8 and June 30, 1914, by Washington State University Cooperative Extension, Oregon State University Extension Service, University of Idaho Cooperative Extension System, and the U.S. Department of Agriculture cooperating. Cooperative Extension programs, activities, materials, and policies comply with federal and state laws and regulations on nondiscrimination regarding race, sex, religion, age, color, creed, national or ethnic origin; physical, mental, or sensory disability; marital status, sexual orientation, and status as a Vietnam-era or disabled veteran. Washington State University Cooperative Extension, The Oregon State University Extension Service, and University of Idaho Extension are Equal Opportunity Employers. Evidence of noncompliance may be reported through your local Cooperative Extension office. Trade names have been used to simplify information; no endorsement is intended. Published January 1953. Revised February 2003. $8.00. PNW0005