WINDBREAKS FOR MONTANA

a landowner's guide

Cooperative Extension Service
Montana State University, Bozeman

Bulletin 366
July 1986

CREDITS

Some of the figures and tables in this publication are reprinted or adapted by permission from other sources:

Figures 1, 2, 7, 8, 10-12, 14, 15 and 19-21, and Table 2 are adapted from *Trees Against the Wind*, D. Hanley, 1984, Pacific Northwest Extension Bulletin PNW-5.

Figure 3 is adapted from *Plants, People and Environmental Quality*, G. Robinette, 1972, USDI National Park Service, Washington, D.C.

Table 1 is adapted from "Utilization of Windbreaks by Wildlife," by Erling B. Podoll, 1979. In *Windbreak Management*, Great Plains Agricultural Council Publication No. 92, Norfolk, Nebraska.

Figures 4 and 16 were supplied by the Soil Conservation Service and the Conservation District, Big Sandy, Montana.

Figure 9 was provided by Dr. David Hintz, Soil Conservation Service, Lincoln, Nebraska.

Figures 22-24 are reprinted from *Regenerating Oregon's Forests*, B. Cleary (ed.), 1978, Oregon State University, Corvallis.

The cover photos taken in Toole County, Montana, were provided by Dean Hellinger and Toole County Extension Agent Kevin Laughlin.

ACKNOWLEDGEMENTS

Portions of this publication were adapted from *Trees Against the Wind*, by Dr. Donald Hanley, Pacific Northwest Extension Bulletin PNW-5.

Text for some sections of this publication was provided by Mr. Ronald F. Batchelor, Soil Conservation Service, Bozeman, Montana, and by Mr. Steven Bodmer and Mr. Willis Heron, Department of State Lands, Division of Forestry, Missoula, Montana.

Reviews were offered by landowners and by personnel from Montana agencies, including the Soil Conservation Service, Conservation Districts, Department of State Lands, and Cooperative Extension Service.

The authors appreciate the opportunity to use these materials and acknowledge the contributions of the aforementioned people.

Issued in furtherance of cooperative extension work in agriculture and home economics, acts of May 8 and June 30, 1914 in cooperation with the U.S. Department of Agriculture, Carl J. Hoffman, Director, Cooperative Extension Service, Montana State University, Bozeman, Montana 59717.

1657—UM Printing Services

WINDBREAKS FOR MONTANA

a landowner's guide

by Steven B. Laursen and Harold E. Hunter[1]

This publication is for homeowners, farmers and ranchers in Montana. It is a guide to planning, planting, maintenance and renovation of conservation plantings, including windbreaks, sound barriers and living snow fences. The recommendations on tree and shrub species and row spacings reflect Montana conditions and should not be used elsewhere without advice from a forester or conservation technician.

[1]Forestry and Natural Resource Specialist, Montana Cooperative Extension Service, Montana State University, Bozeman, and State Staff Forester, Soil Conservation Service, Bozeman, respectively.

CONTENTS

Credits and Acknowledgements ..... Inside front cover

Introduction 1

Windbreak Benefits 1
- Farmstead Windbreaks 1
- Feedlot Windbreaks 2
- Field Windbreaks 2
- Living Snow Fences 4

How Long Before a Windbreak Becomes Effective? 4

Steps Toward a Successful Windbreak 4

Windbreak Layout 5
- Farmstead/Feedlot Windbreaks 5
  - *Design and Location* 5
  - *Arrangement of Rows* 7
  - *Spacing Within and Between Rows* 8
- Field Windbreaks 10
  - *Design and Location* 10
  - *Arrangement of Rows* 10
  - *Spacing Within Rows* 10
  - *A Special Case—Center-Pivot Irrigation Designs* 12
- Sound Barriers 13
- Living Snow Fence 13

Species Selection—What to Plant 14
- Special Considerations 14
  - *Climate* 14
  - *Soils* 14
- Species Characteristics 15
- Ordering 15
- Windbreaks as Habitat for Wildlife 15
- Fruit Plantings 16

Site Preparation 16

Storage and Handling of Seedlings 16

Planting Seedlings 17
- Hand Planting 19
- Machine Planting 21
- Planting and Care of Evergreens 21
- Containerized vs. Bareroot Stock 21

Ongoing Maintenance and Protection 22
Irrigation 22
Weed Management 23
Cultivation 23
Chemical Treatment 23
Fertilization 24
Timing Fertilizer Applications 24
Fertilizer Rate 24
Protection From Damaging Agents 24

Renovation of Older Windbreaks 25

References 26

Appendix 1—Sources of Plant Materials, Assistance and Information 27
State Nursery 27
Commercial Nurseries 27
Information Sources 27

Appendix 2—Recommended Windbreak Species and Characteristics 29
Individual Species Characteristics and Management Tips 32
Shrubs 32
Deciduous Trees 33
Evergreens 34

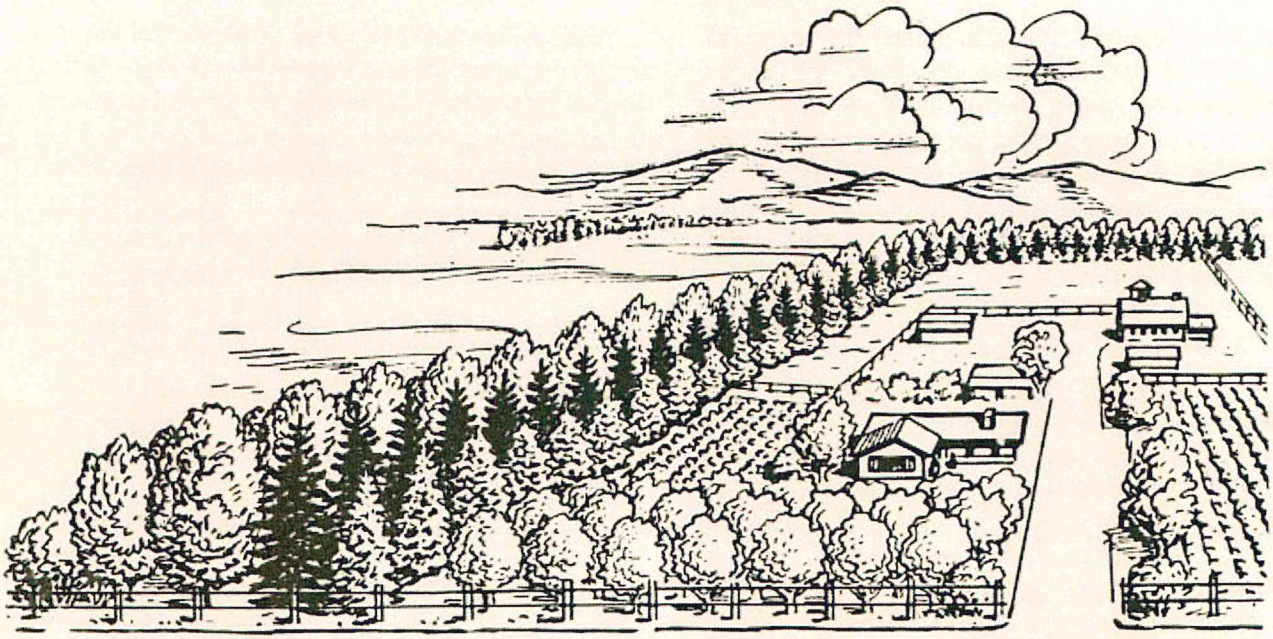


Fig. 1. A well-planned windbreak makes any farmstead a more desirable place to live.

INTRODUCTION

A windbreak is a planting of trees and shrubs that is designed to reduce undesirable effects of strong winds, control drifting snow, provide wildlife habitat and beautify the landscape (Figure 1).

Montana farmers and ranchers have planted windbreaks since the first settlers arrived on the treeless plains. They needed trees to provide shade and protection from the wind for homesites, livestock and crops. Success of early plantings depended upon the owner's judgment regarding plant selection, spacing, location and amount of care needed.

Farm and ranch managers are still planting and maintaining windbreaks today. However, chances of achieving satisfactory windbreak survival and performance have increased dramatically over the years. The reason is that owners now benefit from recommendations based on research that shows how design, location and proper species can affect windbreak efficiency.

This bulletin is a guide for landowners in planning, planting and maintaining windbreaks. Its recommendations are based on windbreak research and experience gained by practitioners, landowners and scientists in Montana and several other states. Unless otherwise noted, recommendations reflect dryland (nonirrigated) conditions.

WINDBREAK BENEFITS

Protection from the wind is perhaps the most important reason man plants trees and shrubs—protection not only for himself, but also for livestock, wildlife and the soil he cultivates to provide his food.

Your need for a windbreak can be measured in terms of the benefits you would derive. There are significant benefits of windbreaks in Montana on the farmstead, around feedlots, in fields and adjacent to roadways.

FARMSTEAD WINDBREAKS

Farmstead windbreaks make the farmstead area a more comfortable place to live and work, reduce energy costs, increase garden and fruit tree yields, enhance wildlife populations, buffer noises and raise property values.

Probably the single most important benefit of a farmstead windbreak is reduction of energy required to heat a home. Recent studies show that windbreaks can reduce winter fuel consumption by 10 to 35 percent. One study in Nebraska compared fuel requirements of identical test houses that maintained a constant inside temperature of 70°F. The house protected by a windbreak used 23 percent less fuel. Two identical electrically heated homes in South Dakota were compared

for energy usage. One was sheltered by a farmstead windbreak and the other was not. Inside temperatures were maintained at 70°F. The sheltered home used 34 percent less electricity.

In addition to reducing the force of wind, windbreaks also can reduce wind chill impact on people outside the house. Studies of three-row windbreaks, where trees were 25 feet tall, showed that wind velocities and wind chill index were effectively reduced (Figure 2).

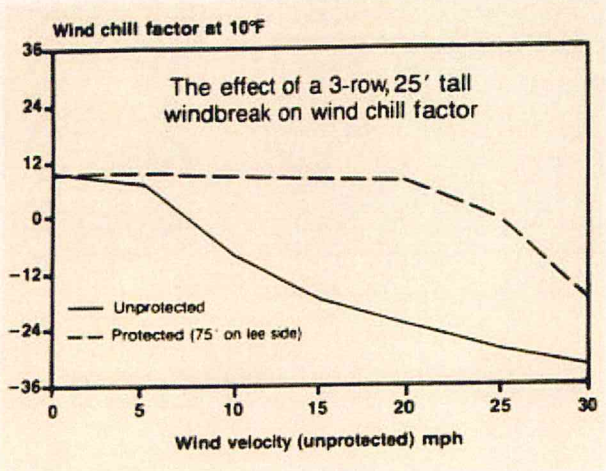


Fig. 2. A three-row windbreak significantly reduces wind velocity on the lee (downwind) side of the barrier.

Fruit trees need shelter against high winds, especially during pollination and when fruit is ripening. Fruit is often blown off trees in unprotected orchards or is bruised and scarred. Behind a good windbreak you can spray, dust and prune fruit trees with greater control. Honeybees and other pollinating insects are more numerous and more effective when sheltered against winds. Irrigation evaporation is reduced and trapped snow adds more soil moisture in the spring.

Wildlife biologists conclude that windbreaks make very desirable nesting, brooding and loafing areas for game birds and songbirds. Many trees and shrubs provide significant amounts of food for birds and other wildlife, and dense windbreaks protect birds against predators. During critical winter periods, windbreaks may mean survival for birds that would otherwise perish from the cold.

Windbreaks act as favorable deterrents to loud, low-frequency sounds. Plant leaves, branches and twigs all absorb sounds of different frequencies. Heavier branches and trunks deflect sounds. Evergreens offer year-round noise protection.

Well-kept windbreaks and other tree plantings enhance the aesthetic value of individual farms and the countryside. Aesthetic improvement of a farmstead with a good windbreak also can increase property value by thousands of dollars.

FEEDLOT WINDBREAKS

Feedlot and livestock windbreaks are used to protect livestock from wind and wind-borne soil and snow. Windbreaks significantly reduce storm-caused mortality, enable cattle to maintain better weight with less feed, reduce calf losses and make feeding operations easier.

In cold weather, cattle must increase food intake to obtain the energy needed to maintain body temperatures. Results from the Montana Agricultural Experiment Station's Northern Agricultural Research Center at Havre show that cattle in a herd protected by windbreaks each gained 35 pounds more during a mild winter and lost 10.5 pounds less during a severe winter than an unprotected herd.

Canadian studies show that when feeder cattle are provided with wind shelter and are kept dry, they are not affected significantly by cold weather.

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

FIELD WINDBREAKS

Field windbreaks reduce soil erosion losses, increase stored soil moisture for crop growth, retard the spread of weeds between fields, and enhance wildlife populations.

Field windbreaks contribute to the protection of cropland from wind erosion by reducing wind velocities significantly for at least a distance of 20 times the height of the trees or shrubs.

Fine soil particles, both organic and mineral, are easily moved by wind. Often the soil particles that blow from a field contain 10 to 20 times as much humus and plant nutrients as the heavier particles that remain on the field.

Soil particles do not ordinarily blow until wind velocity is about 13 miles per hour at a height of

1 foot above the ground. This is known as "threshold velocity." Above the threshold velocity, capacity of winds to carry soil is proportional to the square of wind speed. Therefore, small reductions in wind speed cause great reductions in the rate of soil loss.

Soil from a long, unprotected field, where winds can get a good sweep, is more likely to blow than soil from a small field.

Windbreak reduction of wind velocity not only controls soil erosion, it also helps reduce flattening of crops, keeps newly planted seed from blowing out, prevents young stands from being cut off by blowing soil and restricts the movement of weed seeds between fields.

Windbreak design will influence the amount and distribution of snow retained on cropland (Figure 3). Storing the snow on the field can increase the amount of soil moisture available for crop growth and may increase the frequency with which a field may be cropped. However, storing too much snow near the field windbreak can contribute to the development of saline seep.

Many studies on the Great Plains have shown that a reduction in wind velocity and an increase in stored soil moisture, brought about by windbreaks, can actually increase crop yields. A survey

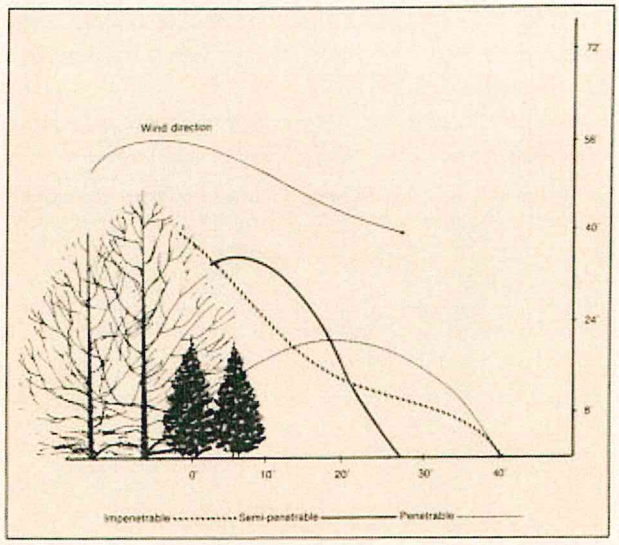


Fig. 3. The general pattern of snow storage in relation to windbreak penetrability.

was made in South Dakota to find out how windbreaks influence a variety of yields of crops. On 677 fields of corn, oats and barley, yield increased 8 to 9 bushels per acre due to windbreak protection. Alfalfa averaged ¾-ton per acre more on 123 protected fields, and four potato fields yielded an additional 48 cwt per acre when protected by windbreaks. A study in southern Idaho

Table 1. Windbreak trees and shrubs used by various wildlife species for staple and emergency food.

	Trees					Shrubs			
Wildlife Species	Green ash (*F. pennsylvanica L.*)	Russian olive (*E. angustifolia*)	Siberian elm (*U. pumila*)	Ponderosa pine (*P. ponderosa*)	Colorado blue spruce (*P. pungens G.*)	Common chokecherry (*P. virginiana*)	Tatarian honeysuckle (*L. tatarica*)	Silver buffaloberry (*S. argentea*)	American plum (*P. americana*)
Pheasant		e		e	e	e	e		e
Gray partridge		e			e				
Sharp-tailed grouse		s	e	s		s	e	s	s
Prairie chicken						s			s
Sage grouse									
Ruffed grouse						s		e	s
Wild turkey	e	e		s		s			s
Mule deer	e			s	e	s		s	s
White-tailed deer	e	e	e	s	e	s		s	s
Antelope									
Mourning dove				s	e				
Cottontail rabbit	e	e	s	e	e	s		s	s
Songbirds (seed-eating)	s	s	e	s	s	s	s	e	e

s = staple food.

e = emergency food (used by few songbirds or by indicated species under stress).

showed that yields of several field crops were increased by 1 to 7 percent in fields that had windbreak protection.

For production of small grains in an alternate crop-fallow system, significant increases in crop production are arguable. In Montana, estimates show that increases in grain yields have generally offset the loss of land occupied by the windbreak.

Windbreaks in fields, like those around the farmstead, create desirable habitat for wildlife. They provide food, cover and brooding areas that augment and conserve populations of a variety of species (Table 1).

Before establishing field windbreaks, one should be aware that their presence makes the application of herbicides more difficult. Frequent aerial application of herbicides, to date, has not been possible without adversely affecting windbreak performance.

LIVING SNOW FENCES

Since their introduction in Nebraska in 1975, living snow fences consisting of trees and shrubs are being used more and more as a cost-effective method of controlling snow along driveways, roads and highways. They improve highway safety and reduce snow removal costs.

Living snow fence windbreaks are replacing traditional slatted snow fences for several reasons. They improve snow control due to greater snow-storage capacity and less failure once established. An experiment in Kansas showed that a well-designed living snow fence caught 3.5 times as much snow as the best arrangement of structural snow fences researchers were able to make.

Living snow fences have a longer life span (up to 25 years better longevity) than mechanical barriers. They provide better wildlife habitat, livestock protection and aesthetic benefits. Furthermore, a living snow fence is considerably more cost-effective than a traditional slatted snow fence. Nebraska has realized annual savings per mile of $1,383.

HOW LONG BEFORE A WINDBREAK BECOMES EFFECTIVE?

The average time needed for a windbreak to provide effective protection is short when compared to the span of years that the average farmer spends on the farm.

Dryland windbreaks ordinarily will give effective protection in 3 to 10 years, depending upon the soil and amount of precipitation. Providing supplemental moisture for dryland windbreaks not only improves tree and shrub survival but also increases growth rates and shortens the establishment period (Figure 4).

Generally, evergreens produce less height growth than deciduous trees during the first 10 years. After that, the difference between growth rates becomes minimal.

STEPS TOWARD A SUCCESSFUL WINDBREAK

Windbreaks can be grown successfully in most areas of Montana where climate and soils are suitable for producing agricultural crops. Some locally severe conditions make establishing trees difficult, but success in establishment and growth depends predominantly upon factors within control of the landowner.

A successful windbreak program requires a sound management plan that addresses a series of activities to take place throughout the life of the windbreak. Careful planning will help ensure that the planting accomplishes your objectives. During planning, the following activities should be considered:

- Layout: design, arrangement of rows and spacing.
- Species selection and purchase of seedlings.
- Site preparation.
- Storage and handling of seedlings.
- Planting.
- Weed management.
- Irrigation.

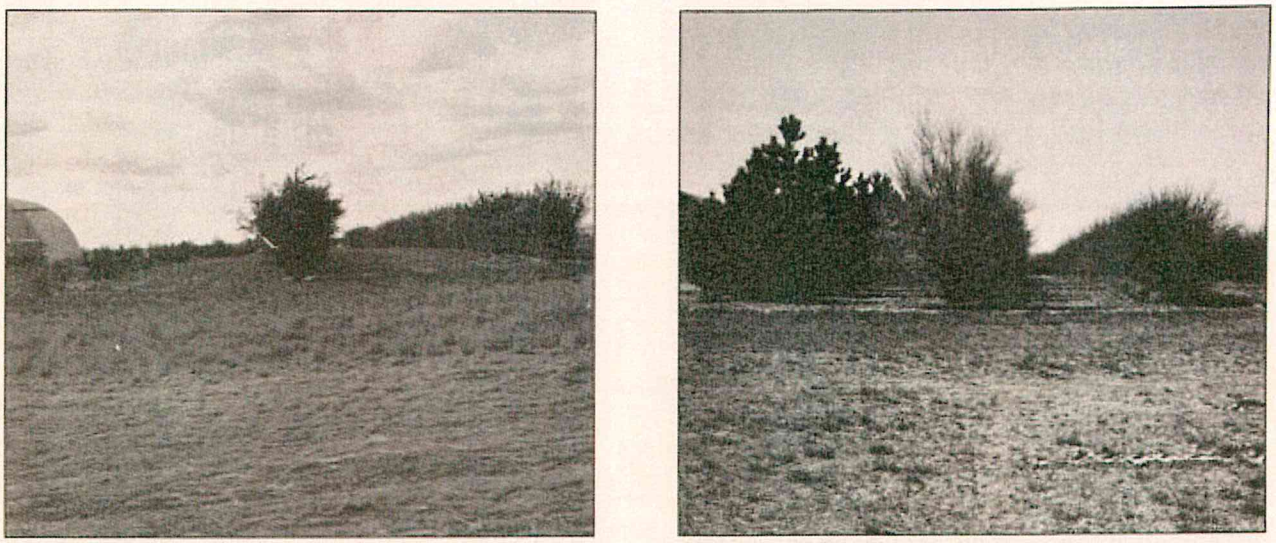


Fig. 4. A dryland (13" annual precipitation) windbreak near Big Sandy, Montana, photographed at age 3 (left) and age 10 (right). Windbreaks properly established can begin providing noticeable protection in as few as 3 years. The growth rate of deciduous trees is much faster in the first several years, after which the difference is minimal. Species from left to right are ponderosa pine, Siberian elm and Siberian peashrub.

- Protection from damaging agents.
- Renovation of older plantings.

Proper and complete planning will help with each of these activities. Planning assistance is available from your local Soil Conservation Service district conservationist, county extension agent or Montana Department of State Lands service forester.

WINDBREAK LAYOUT

Layout may be the most important step in windbreak planning. This phase involves the determination of location, size and spacing to be used. An improperly placed windbreak can create problems greater than those it was designed to alleviate.

The remainder of this section of the landowner's guide presents details on the design of different types of windbreaks used in Montana: farmstead/feedlot, field, sound barrier, and living snow fence.

FARMSTEAD/FEEDLOT WINDBREAKS

Design and Location

Windbreaks should be located on the windward side of the area to be protected and as perpendicular as possible to commonly prevailing winds. Prevailing wind directions vary throughout Montana. Figure 5 shows wind rosette diagrams for seven different locations in the state.

For the most effective protection, windbreaks should be placed on at least two sides of the farmstead or feedlot. Extend the planting at least 50 feet beyond the protected area to control wind and drifting snow that sweeps around the ends (Figure 6).

Where space permits, windbreaks should be located so there will be at least 200 feet between buildings or feedlots to be protected and the most windward row of the windbreak. This will reserve adequate room for storing snow (Figure 7). On the windward side of the windbreak there should be 50 feet between the windbreak and the highway

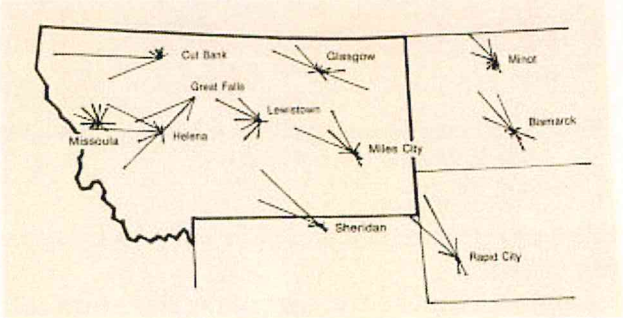


Fig. 5. Wind direction rosettes for locations in Montana and adjacent states. Lines indicate wind direction toward the dot. Line length indicates relative frequency.

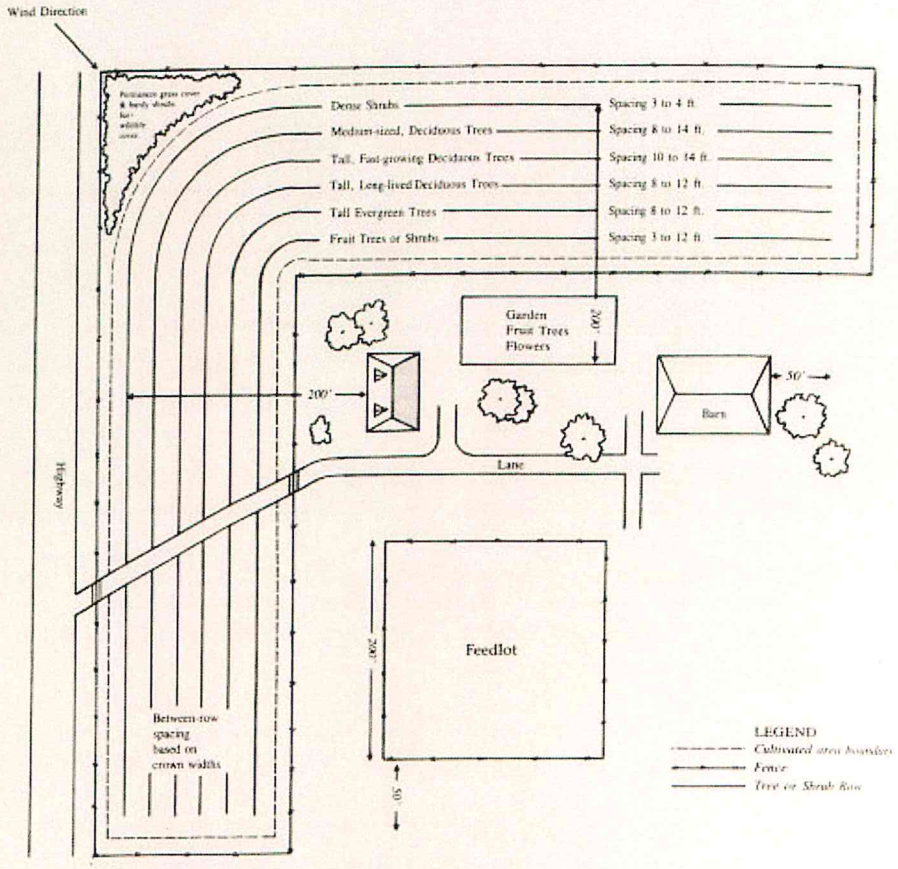


Fig. 6. An example of the proper way to lay out a farmstead windbreak to maximize protection for gardens, orchards and buildings.

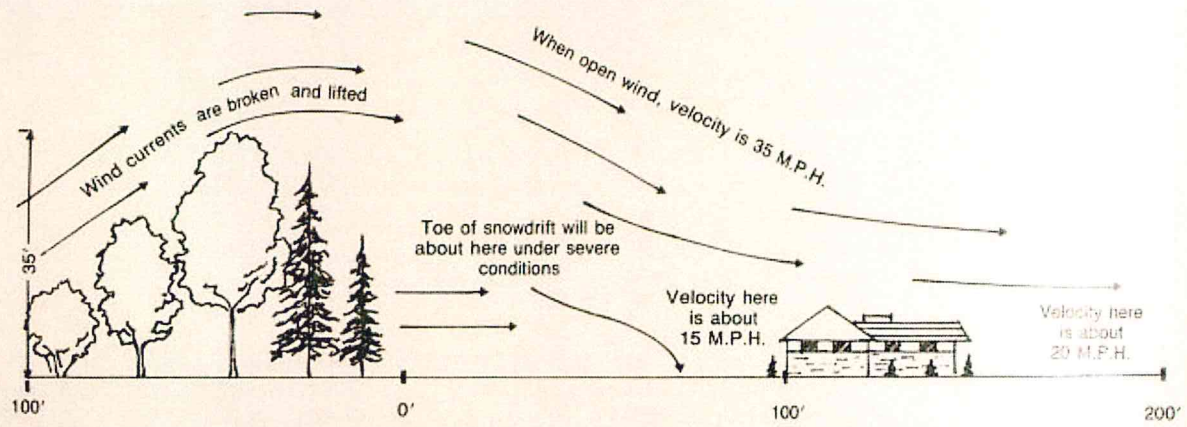


Fig. 7. A dense windbreak that is properly designed and correctly located will effectively reduce wind velocity and control snow drifting.

or other features that would be affected by drifting snow.

In localities that receive considerable snowfall, a snow-trap planting may help prevent drifts within the farmstead. 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. Where space permits, it can be added later if the original windbreak design does not keep snow out of the farm yard.

Windbreaks should not be interrupted by openings. An opening will act as a funnel and bring in snow rather than keep it away. If it is necessary to cross a windbreak with roads, driveways or

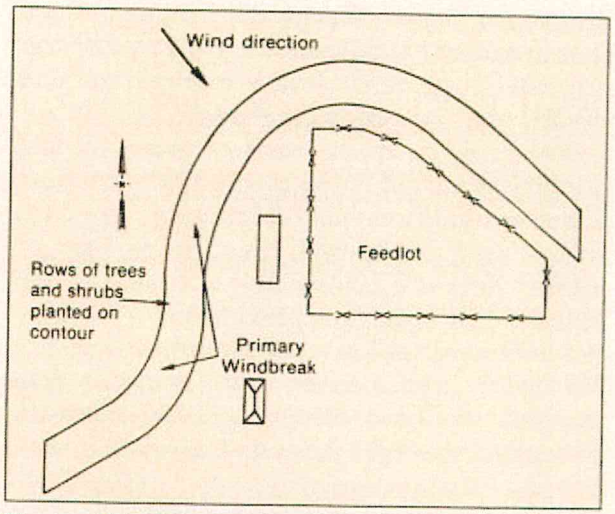


Fig. 8. Windbreaks should be designed to fit the contour of the land to minimize water erosion problems.

large ditches, crossings should be made at an oblique angle to prevent direct wind tunnels through the planting.

Windbreaks need not be straight, but should be laid out across slope or designed to fit the contour of the land to minimize water erosion problems (Figure 8). Slopes greater than 15 percent are generally considered unsuitable for windbreak plantings. Windbreaks can be planted on steeper slopes, but special precautions need to be taken to control water erosion. Diversions may be necessary to divert runoff water to safe outlets, and windbreak establishment and maintenance will be more difficult.

A cultivated strip at least 12 feet wide should be left on all sides of the planting to provide additional moisture and to serve as a fire guard. L-shaped windbreaks should be designed with wide, rounded corners to facilitate cultivation.

Windbreaks used for feedlot protection should be at least 200 feet long to prevent overconcentration of livestock. Feedlot windbreaks must be protected from the livestock they are designed to shelter. The windbreak itself should always be enclosed by fencing to prevent trampling and browsing damage by feedlot animals (Figure 9).

Arrangement of Rows

Windbreaks should be planned to fit the space available.

A five-row planting makes a very desirable farmstead windbreak (Figure 10). Three rows are generally considered to be the minimum necessary to have a satisfactory farmstead or feedlot windbreak. Best performance usually is obtained by us-

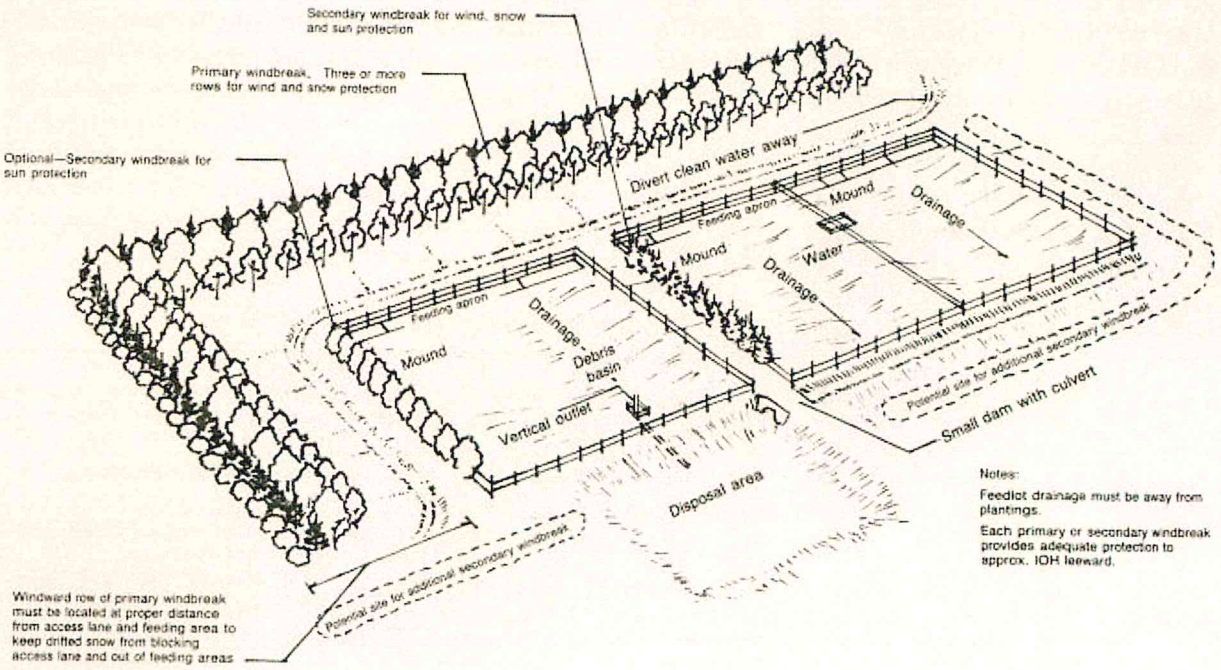


Fig. 9. A windbreak of trees and shrubs protects cattle and farm buildings. Most of the snow is trapped within the trees, and plantings next to the barn catch snow during severe storms, keeping it from eddying into the barn. Windbreaks should be fenced to prevent damage by livestock.

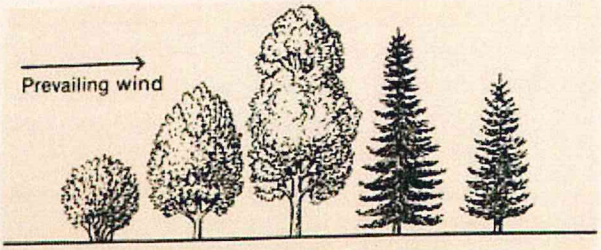


Fig. 10. The most effective windbreak planting has five rows of deciduous and evergreen trees. The greater the height of the trees within the windbreak, the greater the downwind distance protected.

ing a different kind of tree or shrub in each row. A windbreak of mixed species gives protection against insects or diseases damaging the entire planting.

In a typical windbreak arrangement, a row of shrubs is planted in the windward row. Shrubs are used because they are easy to establish, provide low-level density and, by catching snow, create an environment behind them suitable for larger trees. Downwind from the shrub row is planted an intermediate-height tree, such as Russian olive, or a tall tree to provide intermediate and high levels of density.

The third row is usually planted to a tall, fast-growing tree such as Siberian elm. Additional interior rows can be planted to long-lived hardwoods or to evergreens, which provide year-round density. Evergreen trees (conifers) can be planted in any tree row, but there is less problem with snow breakage when planted toward the interior (leeward side) of the windbreak. At least one row of evergreens is desirable. Evergreens help provide year-round density, are very attractive and are among the longest-lived and most insect- and disease-free species. The area behind (leeward of) the windbreak is a good place for ornamentals, gardens, fruit-bearing trees and shrubs, and food plots for wildlife.

Slow-growing species such as green ash and evergreens should not be planted between rows of fast-growing trees like Siberian elm, tree-form willow and cottonwood. Evergreens may be planted next to a tall tree row if at least 20 feet between-row spacing is provided.

If limited space prevents planting a five-row windbreak, using fewer rows is better than crowding the trees. Results will be better with three rows that have room to develop than with five rows that are seriously overcrowded. Table 2 provides a guide for planting fewer than five rows in a windbreak.

Different species should not be alternated within a row. Generally, intermixed species are not compatible, as one species may suppress the growth of another. If species must be mixed, they should be planted in segments. For example, if two tree species are to be used within a row, half of the row should be planted to species A and the other half to species B.

Spacing Within and Between Rows

Adequate growing space keeps trees thrifty. It assures that the windbreak will have a better appearance and a longer, useful life. Recommended spacings will look quite large when planting seedlings, but trees will grow rapidly and fill the available space in just a few years. Spacing should reflect the type of planting, species, width of cultivating equipment, planting site and geographic location. Spacings between rows and between trees within rows should:

Table 2. Guide for planting design and plant selection for windbreaks with fewer than five rows.

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-around 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

- Leave adequate room for use of your tillage equipment (at least 2 feet on either side of the implement).
- Provide trees with ample room for good growth.
- Avoid wind-whipping damage to trees in adjacent rows.
- Prevent early dieback of the lower limbs.

Between-row spacing on dryland and irrigated sites may vary from 16 to 30 feet, depending on moisture availability, size of equipment and species in adjoining rows. Between-row distances on irrigated sites will be somewhat narrower. In both situations, between-row spacings should be wide enough to accommodate cultivation equipment throughout the life of the windbreak.

One good method is to determine between-row and within-row spacings based on the 20-year (mature) crown widths of the various species. Between-row spacing should equal the sum of radial crown projections of species in adjoining rows plus whatever additional width is needed to ensure adequate cultivation. Spacing within the row should be 3 to 4 feet for most shrubs and approximately 80 percent of mature crown width for tree species. Table 1 in Appendix 2 provides crown width information for windbreak species planted on nonirrigated sites. Mature tree crowns will be larger on irrigated and subirrigated sites, but spacing adjustments are not necessary.

Closer spacings than those recommended have been used by some farmers to get more rows in their windbreaks, to save ground for another use or to get earlier protection. Close spacing of trees in a windbreak may result in earlier protection, but the windbreak will not be satisfactory over time (Figure 11). Without adequate between-row space to allow for long-term cultivation, and without adequate within-row space, the period of time that windbreaks are effective is reduced. Crowding causes a loss of vigor due to severe competition among the trees as they try to increase in size. Growth slows down, causing stagnation at an early age. The planting becomes more susceptible to injury by 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. Wider spacings can be used with no disadvantage, except more time is needed before the planting provides full protection.

When the number of rows and spacings have been planned, the next step is to figure the number of trees to be ordered. It is always wise to order a few more trees than actually needed so replacement plants will be available. Most trees that die will fail during the first growing season.

A new twin-row, high-density windbreak design has been proposed in South Dakota by the Soil Conservation Service and South Dakota State

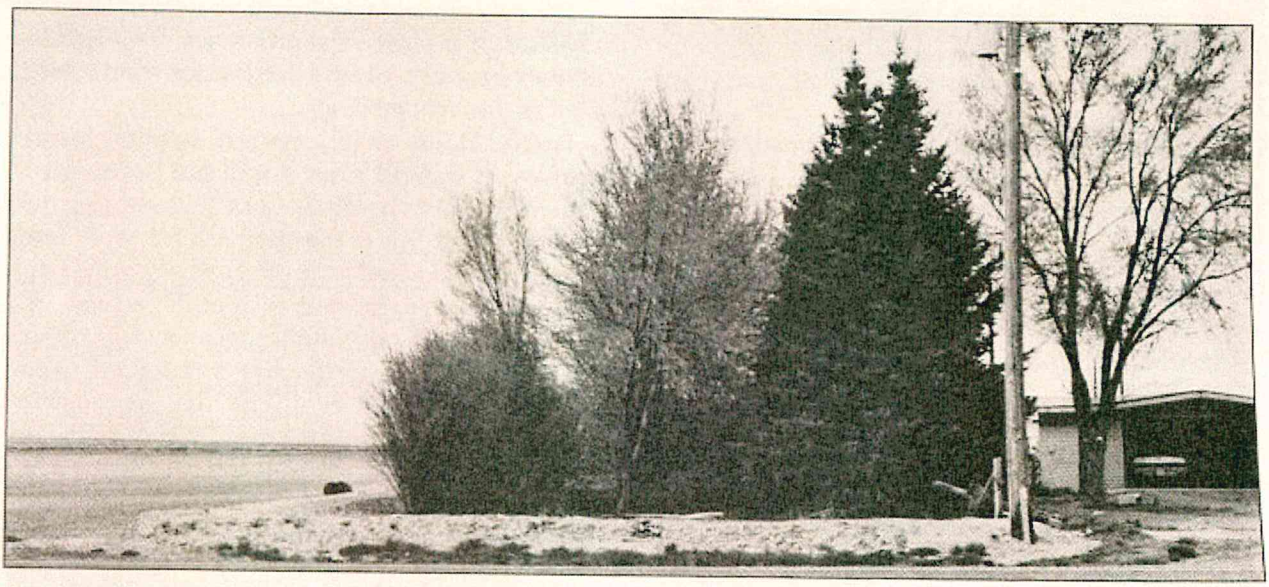


Fig. 11. Close spacing of windbreak rows will provide earlier protection but in time will result in overcrowded, ineffective windbreaks. This windbreak also is planted too close to the building it is intended to protect.

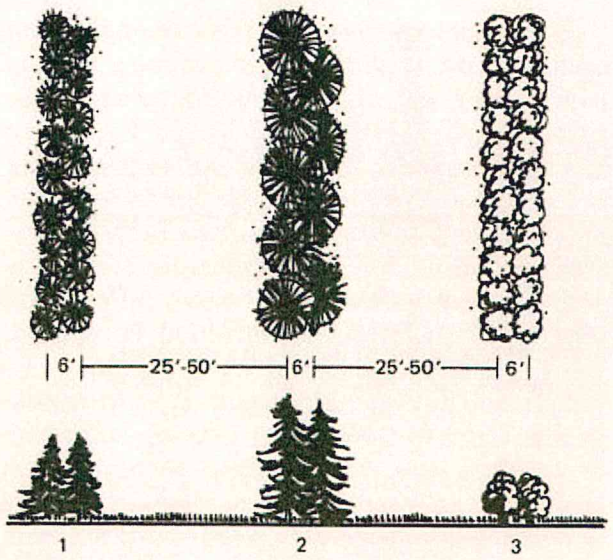


Fig. 12. A new twin-row windbreak design uses 6-foot spacing between two rows and 25 to 50 feet between each set of rows. Row 1 could be medium-height evergreen trees, Row 2 tall deciduous or evergreen trees and Row 3 shrubs or medium-height broadleaf deciduous trees.

University (Figure 12). Alleged advantages of the new design are that the 200-foot distance between the windward row of the windbreak and the home can be reduced, and distance between twin-row sets is wide enough to be cultivated.

One potential disadvantage of this design is that narrow between-row spacing of the pairs makes weed control more difficult during the establishment period. This design has not been extensively field tested in Montana.

FIELD WINDBREAKS

Design and Location

Field windbreaks are designed to protect field crops and bare soil from the effects of strong winds. Since field windbreaks are permanent farm improvements, they must be carefully planned. Field boundaries, irrigation systems, power lines and roads should be considered because they are important in determining the location of your windbreaks.

Windbreaks should be oriented at right angles to prevailing winds. On sloping land, layout should be across the slope or on the contour, when practical, to reduce water erosion from snowmelt. Diversions may be needed to direct run-off water to safe outlets.

Location of windbreaks relative to roads and other features should be considered. (See the section on location of farmstead windbreaks.)

Another significant consideration in the application of field windbreaks is the control of snow distribution across the field. In some areas of the state, evidence indicates that field windbreaks are contributing to saline-seep problems. In such cases, snow accumulates in a narrow, deep drift near the windbreak. More moisture is stored in the snowdrift than can be used by grain crops, and the excess becomes ground water that can contribute to the saline-seep problem. Consequently, field windbreaks should be designed to distribute snow uniformly across the field, or cropping practices should be modified to utilize the "excess" moisture. Continuous cropping of the snow drift zone with small grains or planting deep-rooted, water-hungry crops such as alfalfa are practices that can reduce excess moisture. Tall tree species can be planted in field windbreaks to distribute snow more uniformly across the field. Pruning lower tree branches up to a height of about 4 feet allows snow to be distributed more uniformly across the field while providing adequate wind erosion protection. To avoid excessive accumulation of snow around the windbreak, spacing between rows of dense shrubs should not exceed 10 to 15 times their mature height.

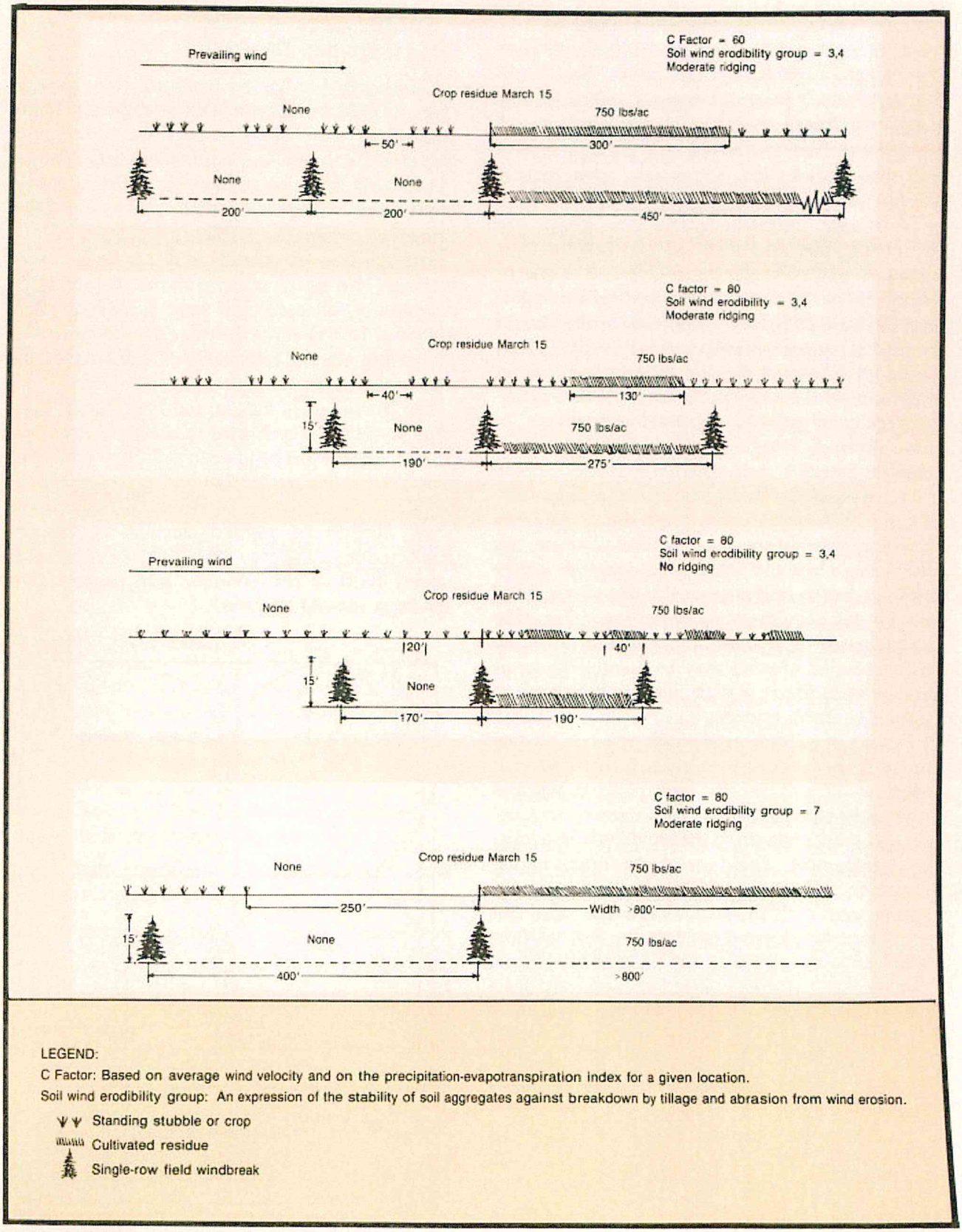
Arrangement of Rows

The typical field windbreak system in Montana consists of a series of single rows. Research has shown single rows are effective for wind erosion control on cropland.

Trees alone may prevent wind erosion. However, in most cases it will not be feasible to depend solely on windbreaks because they will occupy too much of the site. A landowner must decide on a desired level of wind erosion control and consider several factors in each decision. Factors out of the landowner's control include climate (wind frequency and velocity), wind direction and soil properties. Factors within his control include soil ridging, crop residue, spacing between windbreak rows and windbreak height (Figure 13)

Spacing Within Rows

In single-row windbreaks, shrubs should be placed a uniform distance apart within the row. Spacing between trees will be variable, depending upon species and the desired snow distribution



LEGEND:

C Factor: Based on average wind velocity and on the precipitation-evapotranspiration index for a given location.

Soil wind erodibility group: An expression of the stability of soil aggregates against breakdown by tillage and abrasion from wind erosion.

Standing stubble or crop

Cultivated residue

Single-row field windbreak

Fig. 13. Examples of the effect of windbreaks and cultural and environmental factors on spacing required between small grain crop strips to meet an allowable annual soil loss rate of 5 tons per acre per year.

pattern. Spacing within the row should be 3 to 4 feet for most shrubs and approximately 80 percent of mature crown width for tree species. Table 1 in Appendix 2 provides crown-width information for windbreak species planted on nonirrigated sites. Mature tree crowns will be larger on irrigated and subirrigated sites, but spacing adjustments are not necessary.

To provide uniform density throughout the windbreak, tree and shrub species can be alternated. At tree spacings up to 10 feet, it is best to alternate one shrub with each tree. At tree spacings in excess of 10 feet, additional shrubs should be used at regular intervals (never less than 3 feet) to provide low-level density. A cultivated strip on each side of the single-row shelterbelt will encourage good growth and development.

In dryland, single-row windbreaks where uniform density is desired, a hardy shrub, usually Siberian peashrub (caragana), is commonly alternated with Russian olive, green ash or Siberian elm. Any suitable species may be used alone, but alternating a tree and shrub species provides more uniform density and ensures that one species may survive and provide some protection if the other is eliminated by disease. On irrigated land any recommended species may be planted alone or alternated in the row with Siberian peashrub or a suitable shrub species.

Density of a single-row windbreak can be controlled by choice of species and spacing in the row. Medium- to low-density trees planted without alternating shrubs results in low density and will deposit snow away from the windbreak in a long, low-profile drift. This type of windbreak is preferred on soils that tend to remain wet in the spring, even with the sacrifice of some wind erosion control. It also minimizes the risk of field windbreaks contributing to saline seep. Dense, single tree or shrub species, or trees planted alternately with shrubs, result in a dense windbreak and tend to deposit snow in a short, high drift close to the trees. This provides effective wind protection and additional moisture to the trees (Figure 3).

For information and assistance to locate and plan your field windbreak see your local Soil Conservation Service district conservationist, county extension agent or Montana Department of State Lands service forester.

A Special Case—Center Pivot Irrigation Designs

Center-pivot irrigation systems have greatly changed field windbreaks in some regions of Montana. Field windbreaks planted on section and half-mile lines can be modified or eliminated to fit this new irrigation technology. Existing windbreaks are valuable resources and should be preserved whenever possible.

Straight-line windbreaks may not be compatible with the arc of pivot systems. Figure 14 illustrates a full section of land with four pivot systems. This illustration suggests alternatives to preserving existing straight windbreaks in the field and at the homestead.

The 16 corners of the four fields in Figure 14 occupy about 20 percent of the total area or 130 acres. These corners can be used to establish new field windbreaks (Figure 15) that will give partial protection to the crop area. Trees established in these areas should be planted parallel to the circumference of the crop area to make cultivation easier. Normal between-row and between-tree spacings should be used.

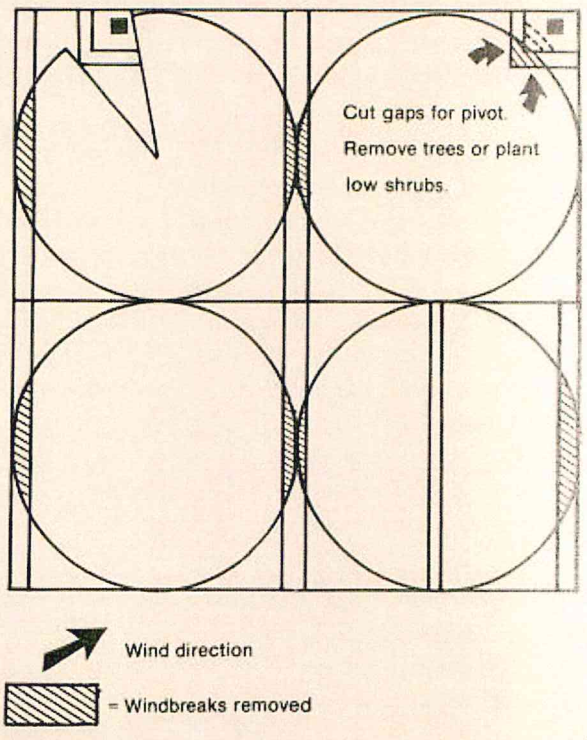


Fig. 14. Methods of preserving windbreaks when they interfere with pivotal irrigation systems at the half-mile and section lines of a farmstead or field.

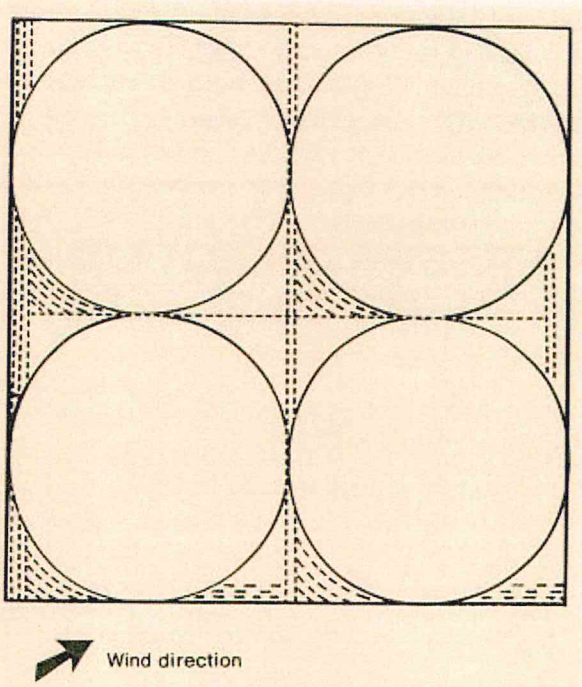


Fig. 15. Recommended location for field windbreaks on one section with center-pivot irrigation.

SOUND BARRIERS

Windbreaks and other tree plantings reduce noise from high-speed traffic or other surface-located sound sources. Woody plantings properly located can reduce noise levels by as much as 65 percent.

To make a windbreak an efficient sound barrier, follow these recommendations:

- Locate the planting as close to the noise source as possible.
- If traffic 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 noise abatement.
- Plant as many rows as available space will allow, using recommended spacings.
- Make the planting twice as long as the distance from the noise source to the point of protection.
- Avoid planting right up to road intersections or other areas needing a clear line-of-sight for safety reasons.

LIVING SNOW FENCE

Plantings of trees and shrubs can be used as living snow fences to prevent snowdrifts from blocking driveways and roads.

Living snow fences, like more traditional windbreaks, require planning, site preparation, careful planting and ongoing maintenance and protection (Figure 16).

A minimum of three rows is recommended for effective wind control and added snow storage, but single- or double-row plantings may be appropriate in some cases. The distance between the windward row of the snow fence and the edge of road right-of-way should be 200 feet (Figure 17). Planting at road corners and intersections should be avoided to prevent reduced visibility and subsequent traffic problems.

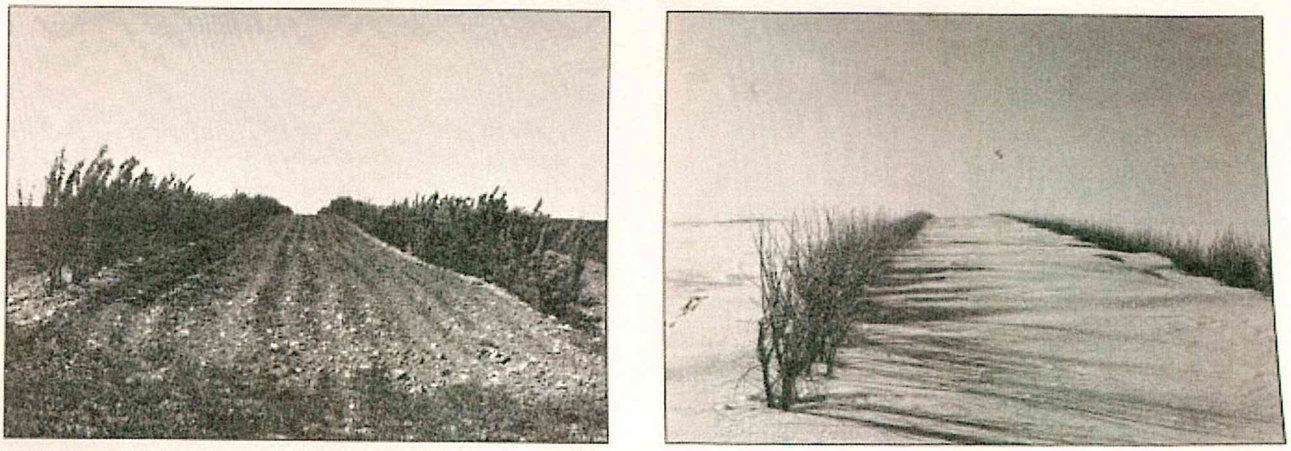


Fig. 16. Living snow fence with two rows of Siberian peashrub near Big Sandy, Montana. Cultivation for weed control in the summer (left) results in healthy plants and full protection in the winter (right).

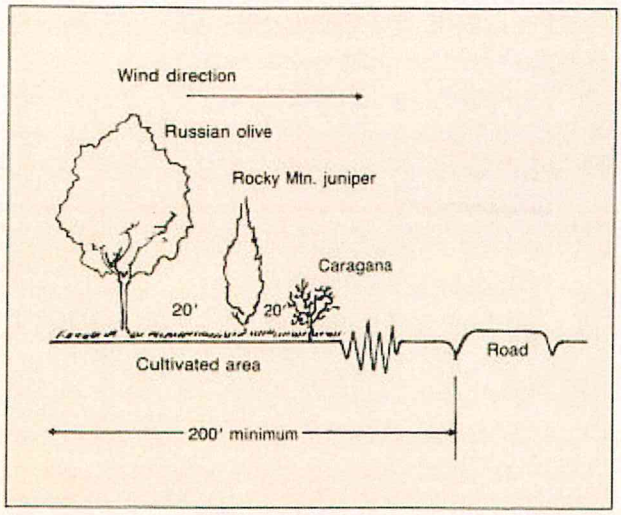


Fig. 17. The windward row of living snow fence plantings should be at least 200 feet from the outer edge of the road right-of-way.

Species selection will vary depending on site and available space. Commonly used tree and shrub species include Siberian peashrub, Russian olive, Rocky Mountain juniper, ponderosa pine and Colorado blue spruce. Choice of species for snow fence plantings can greatly enhance their values for wildlife.

In areas where deep snow drifts accumulate on steep lee slopes, hilltop snow fences should be planted parallel to ridge lines about 100 feet back from the ridge crests on the windward slopes (Figure 18).

Snow fence plantings may be planned as part of a field windbreak system. In some areas this kind of planting has been used effectively to control drifting snow on cropland and prevent its collecting in irrigation ditches, along fence lines and in roadways.

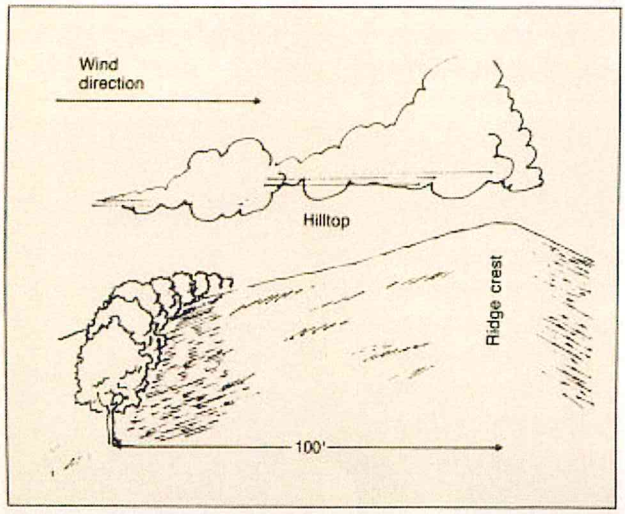


Fig. 18. A living snow fence designed to control snow drifting over a hilltop should be planted 100 feet to the windward side of the ridge crest.

SPECIES SELECTION—WHAT TO PLANT

Selected tree or shrub species must satisfy basic requirements. They must:

- be the right size at maturity,
- be adapted to local soil and weather conditions,
- block wind, and
- be aesthetically pleasing to the owner.

SPECIAL CONSIDERATIONS

The success of plantings is just as dependent on selection of adapted materials as on site preparation, proper care and planting techniques, and management. Climatic and soil characteristics vary greatly among areas in Montana. These variations create many problems and influence the amount of care needed by tree plantings. Some plant materials perform well over a wide range of site and climatic conditions, while others have restricted areas of adaptation. Plant materials that originate from an area of known adaptation for a species, from local areas, or cultivars that have proven adaptable should be used. There are no infallible rules since the range of adaptation varies for different species.

Climate

Short growing seasons and increased severity of winter make establishment of some trees difficult. Severe damage sometimes results as deep snow pack settles on young trees. Frozen ground combined with minimal snowpack and either high solar radiation levels or chinook winds also lead to winter dessication.

Soils

Some tree species are naturally adapted to acid soils and others can endure a saline soil. Some species grow naturally in boggy or swampy con-

ditions and others do best on dry sites. However, a deep, well-drained loam with neutral pH and average fertility is nearest to being ideal for growing a variety of trees. Situations far different from the ideal present problems that may be severe enough to prevent successful establishment of trees. The main examples are permanently wet areas, high water table during the growing season, salty, alkaline or alkali soil, droughty and infertile soil such as deep sands and gravels, shallow soil over hardpan or bedrock, and extremely heavy clay soil.

A problem soil situation may be remedied through use of corrective practices such as drainage, addition of organic matter, fertilization or chiseling; but the cost, time and effort involved are often excessive. A less expensive alternative is to select tree and shrub species that will grow in the local soil type.

More detailed information on species adaptation can be obtained from your county extension agent or Soil Conservation Service district conservationist.

SPECIES CHARACTERISTICS

Some tree and shrub species are characterized by rapid, early growth. Many of these species achieve considerable height but become senescent and lose vigor at a relatively early age. Other species develop more slowly and are longer-lived. They generally are more tolerant of shading and grow satisfactorily even when overtopped by neighboring plants. These important characteristics should be considered in the planning of windbreak design and in the selection of species for each row.

Table 1 in Appendix 2 lists tree and shrub species commonly used for conservation plantings in Montana. Information provided for each species includes common and scientific names; tolerance to drought, shade and alkali conditions; average height and crown width; growth rate; suitability ratings for wildlife plantings; and adaptation zones.

ORDERING

Some of the species described in Appendix 2 are grown by the Department of State Lands Nursery in Missoula. Trees from this nursery are available for conservation plantings on agricultural lands in Montana and *must not be used for landscape purposes.*

Trees from the Missoula nursery can be ordered through the local county extension agent or Soil Conservation Service district conservationist. It is important to read all species descriptions and remember that local soil, water table and climatic conditions may limit the usefulness of certain species. Agents, conservationists, and state service foresters can help in the selection of species and varieties that will grow best under local conditions.

WINDBREAKS AS HABITAT FOR WILDLIFE

Windbreaks on farmsteads and in fields significantly enhance the quality and amount of wildlife habitat throughout Montana.

Tree and shrub plantings provide food (Table 1), shelter, and travel lanes for a variety of wildlife species. Mixed plantings of trees and fruit-bearing shrubs supply shelter and food such as fruit, foliage, buds and twigs. Woody plantings provide nesting habitat for many songbirds.

Large, established, multiple-row windbreaks are generally more valuable to wildlife than narrow, young ones. Windbreaks do not achieve their maximum benefit to wildlife until trees and shrubs are nearly mature. Multiple-layered shrub and tree plantings are of greater value to wildlife than single-row plantings of one species. A windbreak that is bare underneath is not nearly as attractive to wildlife as one with a well-developed grass and forb understory. A well-developed shrub row adjacent to a herbaceous understory tends to increase songbird diversity.

The ideal planting would have a stairstep effect with dense shrubs planted on the outside to prevent snow from piling in the center of the belt where wildlife seek protection. In the center would be deciduous trees and evergreens where birds and mammals could retreat during periods of severe winter weather.

Food plots of corn, wheat, sorghum or sunflower immediately adjacent to tree and shrub plantings significantly improve their value to a variety of wildlife species.

FRUIT PLANTINGS

Several trees and shrubs not only make satisfactory windbreak species but also produce fruits that can be used by man for food. They are Nanking cherry, western sandcherry, American plum, common chokecherry, Siberian crabapple and "Midwest" Manchurian crabapple. There are other shrubs that may not be competitive enough to use in the main windbreak but can be planted on the inside of a dryland windbreak and do well. Among them are Haralson, Stevens, Hart River and Regent apples, Whitney and Dolgo crabapples, Waneta plum, Sacajawea cherry plum, Pioneer pear, Welcome and Pixwell gooseberries and Red Lake currants.

SITE PREPARATION

It is important to prepare a cultivated, weed-free site for planting. Seedling survival is directly related to available soil moisture. Weed control is essential to the success of a windbreak planting as weeds rob newly planted seedlings of soil moisture and nutrients. Planning must address the cultivation and chemical treatment necessary to eliminate weeds before planting, and to keep weeds out for several years thereafter.

Shallow disking or harrowing just before planting is adequate on cultivated land that has no weed problem. Areas with perennial grasses or weeds should be summer fallowed. If a tree planter is to be used, the area should be plowed deep enough to ensure that the planter will work properly. Then the site should be disked or harrowed before planting to provide a smooth and uniform planting site.

When a windbreak is to be planted on a site that is in sod, it is best to summer fallow for two years prior to planting to control weeds, store soil moisture and ensure good tree-planter operation. With chemical treatment, over-the-row cultivation or hand hoeing to control weeds, the time interval can be reduced if there is adequate stored soil moisture. In any case, there should be 3 inches of available water within a 3-foot soil depth before planting, unless supplemental water is to be applied.

If the planting is to be made on a grain- or row-crop site, summer fallow by July 1 of the year prior to planting. This is not necessary if the soil, to a 3-foot depth, will be at field moisture capacity and there is more than 3 inches of available water or supplemental water is to be applied. This will give the planting a good start. A summer fallow strip at least 8 feet wide should be maintained on the inside and outside of the windbreak. A one-way disk plow or subsurface tiller is preferred where there is danger of wind erosion.

If the site is steep, rocky or cannot be plowed or cultivated with machinery, sod should be scalped in 3-foot circles and the seedlings planted in the center of the scalped areas.

Any of these methods of site preparation may require follow-up herbicide treatment to prevent grass and weed regrowth. The section on weed management (page 23) and Montana Cooperative Extension Service Circular No. 312, "Weed Management for Montana Windbreaks," provide detailed information on integrated weed management, including herbicide selection and application techniques for Montana windbreaks.

STORAGE AND HANDLING OF SEEDLINGS

Between delivery and planting, seedling roots are exposed and vulnerable to environmental stress. Seedlings are particularly sensitive to temperature and moisture extremes during this time. Exposure of roots to warm, dry or windy conditions will significantly decrease seedling survival. The critical length of exposure varies by seedling condition and the severity of the surrounding environment.

When seedlings arrive, landowners should be prepared to plant them immediately, if possible. In situations where seedlings will not be planted immediately, there are two methods that can be used to keep them safely. The first is to put them in a cool place and moisten the roots. Ideal storage conditions can be found in refrigerated units with temperatures between 33 and 35°F and relative humidity of at least 95 percent. Seedling respiration and subsequent damage increase rapidly when temperatures exceed 40°F. If refrigerated storage is not available, covering packaged seedlings with snow or space blankets in a root cellar, cool garage or other shaded location will keep them in good shape for several days. Conserva-

tion districts in North Dakota have handled the storage problem by freezing ice on the floor of a building during winter and covering it with straw. The trees are placed in the building in the spring, and the melting ice maintains a cool environment.

If planting *must* be delayed a week or more, and refrigerated storage is not available, trees should be unpacked and "heeled-in" (Figure 19). Follow these steps:

1) Dig a V-shaped trench in a moist, shady location.
2) Break bundles and spread out evenly, three to four trees wide. Whole bundles can be heeled-in without breaking bundles as long as they are covered with soil and watered.
3) Cover the roots with soil and pack firmly to avoid air pockets.
4) Water well and shade with any wind-fast material.

If the soil is dry, it should be watered thoroughly to keep roots moist.

Mold on trees can sometimes be a problem when storage conditions have been less than adequate. Cold storage usually prevents severe mold problems, but once molds have started in tree bundles, they should be opened to enhance air circulation, and then placed in a heel-in bed or planted immediately. Moderate amounts of white mold on the surface can be washed off of trees, but once black molds have penetrated the tissue, trees probably will not recover. Close attention should be given to storage temperature and possible mold development.

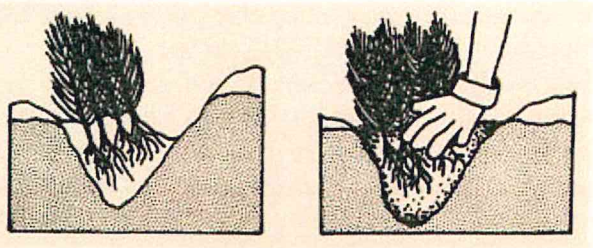


Fig. 19. One method of long-term tree storage is the "heeling-in" technique. Roots must be packed tightly in soil and kept moist, and the heel-in trench must be shaded and protected from the wind.

PLANTING SEEDLINGS

Planting needs to be performed as though everything in the success of the windbreak project were dependent upon it. Seedling quality and viability deteriorate rapidly during the period of handling and planting. A seedling out of the ground or improperly planted is just like a fish out of water. The idea is to keep the rate of deterioration at a minimum. A few seconds of sun exposure can kill root tissue of evergreens (Table 3). Many hardwoods are much more forgiving and often can come through a half-day's exposure with no noticeable effect.

Several methods and tools can be used to plant trees and shrubs for windbreaks, but studies have shown that careful handling and planting results in increased survival and growth, regardless of the tool or method employed.

When it is time to plant, the following things should be kept in mind: care of the seedlings, root placement, planting depth and soil compaction.

Seedlings require constant protection and care during planting. Ideal weather conditions for tree

Table 3. Percent mortality of bareroot Scotch pine seedlings due to exposure of roots before planting.

Weather	Hour	Air temperature (°F)	Minutes of exposure						
			0	2	5	10	20	40	80
			—Percent mortality—						
Cloudy	9-11 am	48.2	12	50	62	64	69	73	88
Cloudy	12-2 pm	50.0	12	49	64	66	69	83	93
Cloudy	3-5 pm	53.6	23	54	65	75	83	94	99
Rainy	9-11 am	60.8	8	40	42	46	56	63	66
Hot, clear	11 am-1 pm	73.4	55	80	88	90	94	100	100

planting are the most miserable conditions for the planting crew: cold and wet. The worst conditions for planting are hot, sunny and windy. When working with conifers, planting should be stopped when the temperature reaches 65°F and the wind speed exceeds 20 miles per hour. The most sensitive species should be planted as early in the day as possible.

Seedlings should be removed from the carton or heel-in trench and immediately placed in a planting pouch or bucket partially filled with moist soil (Figure 20). One alternative is to wrap seedlings in moist burlap and place them in a bucket. This method allows individual seedlings to be removed more easily during planting. The seedling container must be covered tightly except during brief periods that it takes to lift and plant. When machine planting, one should always use wet burlap or moss to protect roots, and expose as few seedlings at a time as possible.

Proper planting technique and root placement are as important as timing. The sooner and better a seedling's root system establishes contact with soil moisture and nutrients, the greater the probability of survival and growth. Root tissues do not thrive in air pockets. Air space left in planting holes will result in root tissue dessication and probably seedling mortality. When hand planting, the root system should be placed on the straight edge of the hole and the dirt packed in with your foot. The idea is to get all of the air pockets out and have all of the roots in contact with soil. To test the planting job, the tree should be grasped with the thumb and one finger and pulled up firmly—the tree should not move. When machine planting, it also may be necessary to follow the planter and compact the soil around each seedling. This will depend on the effectiveness of the planter and soil conditions at the time of planting.

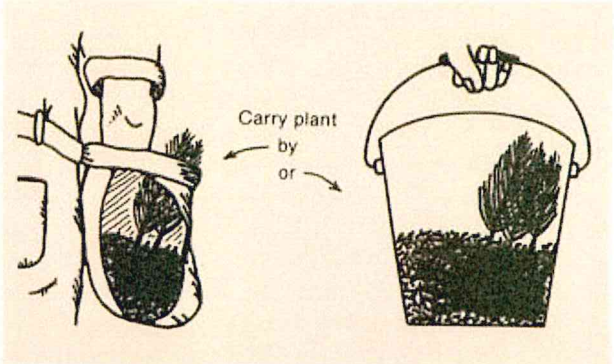


Fig. 20. During planting operations, roots should be completely covered with wet soil or peat moss, but should not be submerged in water.

Seedlings should be planted with roots fully extended downward, avoiding J-rooted plantings. It may be better to trim long roots than to have them distorted at the bottom of a shallow hole, but care should be taken to maintain "natural" root condition. For example, when considering cutting a 12-inch root system back to 10 inches for ease of planting, one also should consider the consequences. Root pruning may limit a plant's capacity to function. The deeper the roots reach into the ground, the longer the seedling will have moisture available as the soil moisture is depleted during the year. On a dryland planting site it may be necessary to haul 5 gallons of water to each plant later in the season to compensate for 2 inches of rooting depth removed at planting.

Planting depth recommendations vary with the type of stock. Bareroot stock should be planted with the root collar at or just slightly below groundline. Containerized stock should be planted about ½-inch below groundline so that dirt covers the soil mix on the root ball. If the root ball is exposed, it can act as a wick and dry the plant out.

Soil compaction during planting often leads to seedling mortality. In heavy clay soil a dibble or auger that is just big enough for a container could create a compacted cavity that roots cannot penetrate. A good job of site preparation that loosens the soil before planting usually will prevent compaction problems.

Planting quality should be stressed for all planting situations. Ease or speed of planting should never be the only factor or even the most important factor in selecting a method or tool. Trees planted in an unsatisfactory manner have little chance for survival. An extra moment spent with each tree will greatly increase the chances for survival and enhance good long-term growth (Figure 21).

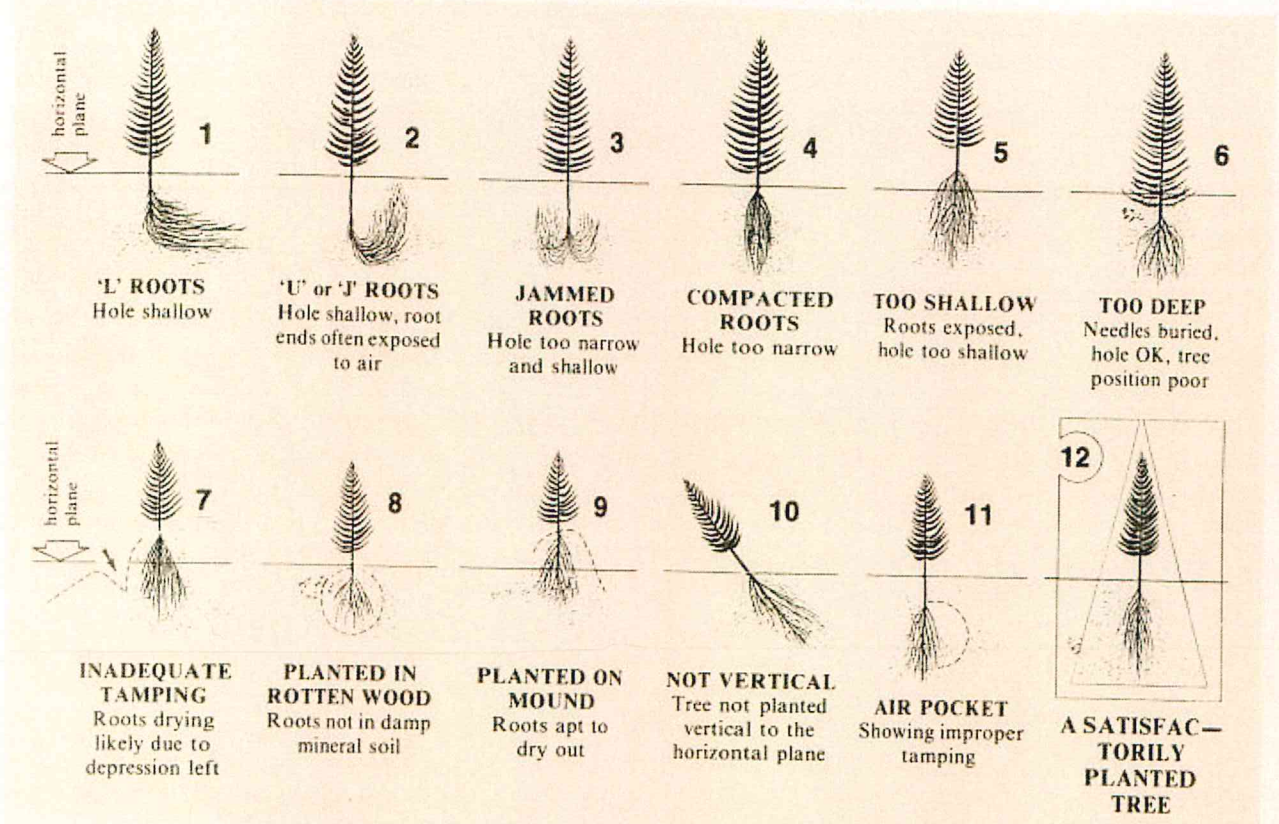


Fig. 21. **Drawings 1 through 11 illustrate various ways that trees should *not* be planted. The ideal planting is shown in drawing 12.**

HAND PLANTING

Hand planting with a planting tool is an effective but relatively slow method. There are a wide variety of tools available for hand planting. Dibbles are tools that force a container-size hole in the ground without removing any soil. Mattocks, hoedads, tree-planting bars (Figure 22) and tree-planting hoes (Figure 23) were developed for various soil types for planting conifer stock in a reforestation situation. Most of these tools have a 3-inch wide blade, which will not make a wide enough slot for most of the hardwood stock used in Montana windbreaks. Planting bars should not be used in clayey soils as they may cause soil compaction.

Tree-planting spades (Figure 24) and shovels have a straight blade, 5 or 6 inches wide and 12 to 16 inches deep. Most hardware stores sell tile spades or posthole shovels that have a similar straight, narrow and deep blade. A standard shovel is probably the tool most commonly used for hand planting in Montana.

Tree-planting augers with a chainsaw engine make a 4- or 6-inch hole. They are expensive and not needed on well-prepared sites. However, they provide a feasible solution in situations where deep planting is a problem. Tractor-mounted posthole augers work very well and are quicker and easier to use than some other techniques.

No matter what hand-planting tool is used, these instructions should be followed to achieve a successful planting:

- Make the hole deep enough for all roots.
- Remove one tree at a time from bucket, only after hole is ready for the tree.
- Keep foreign matter (leaves, sticks, rocks, dry soil, etc.) out of hole.
- Place all tree roots in a downward position.

After planting the seedling and filling the hole, the planting site should be watered thoroughly to help ensure survival.

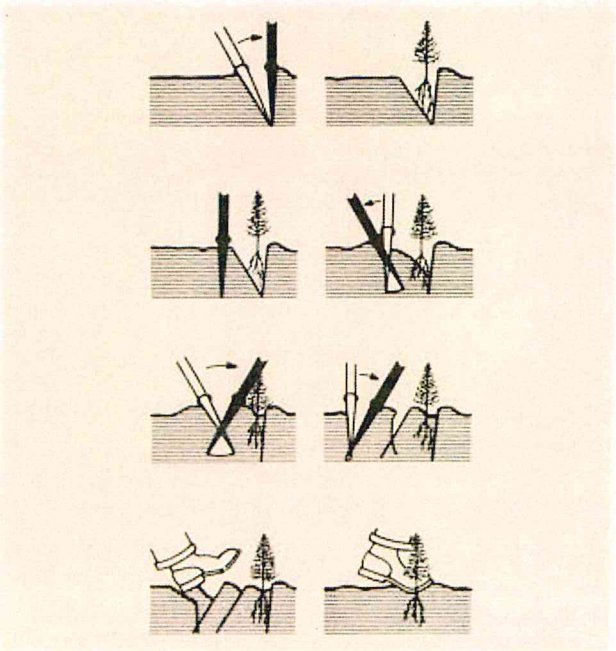


Fig. 22. The correct procedure for planting bareroot stock with a planting bar: 1) Insert bar at angle shown and push forward to upright position. 2) Remove bar and place seedling at the proper depth. 3) Insert bar vertically about 2 inches toward the planter from the seedling. 4) Pull bar handle toward planter to firm soil at bottom of roots. 5) Push bar handle forward to firm soil at top of roots. 6) Insert bar vertically about 2 inches from last hole. 7) Push forward, then pull backward to fill hole. 8) Fill in last hole by stamping with heel. 9) Firm soil around seedling. When firming soil, be careful not to scuff the seedling.

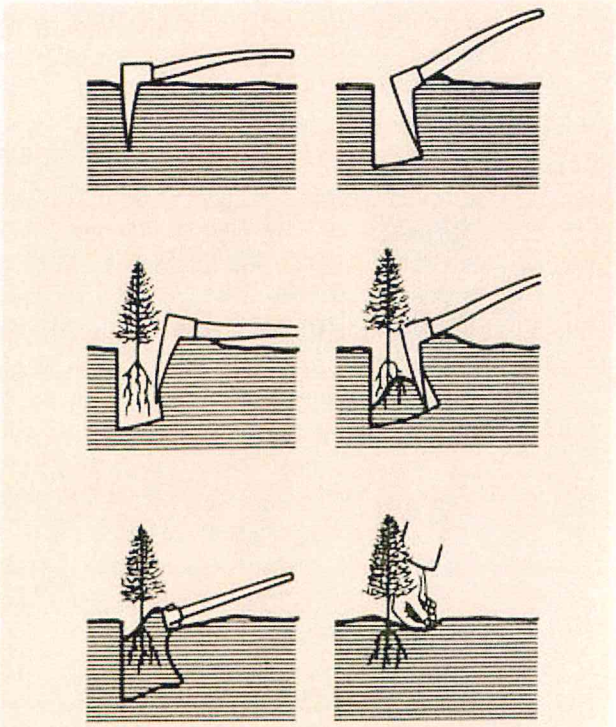


Fig. 23. The correct procedure for planting bareroot stock with a planting hoe: 1) Swing hoe to get full vertical penetration; hoe blade must be vertical, not slanted. 2) Lift handle and pull to widen hole. 3) Place seedling in hole at proper depth while using hoe to hold back soil. 4) Pack soil at bottom of hole. 5) Pack soil at top of hole. 6) Firm soil around seedling. When firming soil, be careful not to scuff the seedling.

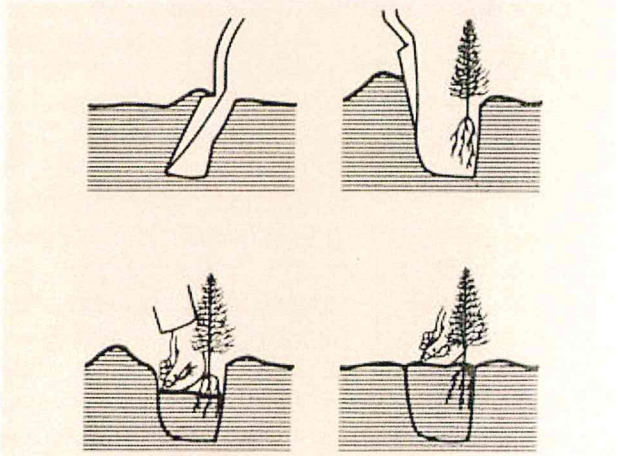


Fig. 24. The correct procedure for planting bareroot stock with a shovel or tilting spade: 1) Insert shovel into soil vertically, with the blade reversed. Push handle forward. Pull soil back and out of hole. 2) Straighten back of hole. Insert tree at proper depth. 3) Pack soil at bottom of hole. 4) Pack soil at top of hole and firm soil around seedling. When firming soil, be careful not to scuff the seedling.

MACHINE PLANTING

When there are large numbers of trees to be planted on flat, well-prepared soils, machine planters are usually the best alternative. Tree planters will plant as many as 1,000 trees per hour. Many conservation districts and 4-H councils have tree planters that can be contracted or rented at a reasonable cost.

Tree-planting machines are usually manufactured in small machine shops and are available with a variety of features. The basic component is the pointed shearer, which opens the planting furrow. The shearer should be able to operate at a depth of at least 12 inches, and there should be packing wheels on the back. Single-seated or double-seated models are available. The double-seated models have a real advantage when planting a closely spaced row of shrubs. It may be impossible for some tractors to move slowly enough for a single planter to do a good job when close spacing is required.

Maintenance and adjustment are necessary to make a planter work properly. The point on the shearer needs replacement at times just to stay in the ground, and the depth and angle must be adjusted each time a different tractor is used. The packing wheels may need adjustment for different planting conditions.

Soil should not be extremely wet or dry during machine planting. Clean summer fallow and fall-plowed planting sites both will provide favorable conditions for mechanical planting. The following steps should be taken in machine planting operations:

1) Untangle and prune (if necessary) long roots during the transfer from the shipping package or heel-in bed to the container used on the machine planter. Prune roots only to the length necessary to ensure placement of the seedlings at the proper depth.
2) Insert seedling 1 inch deeper than it was in the nursery row and well forward in the trench made by the planter.
3) Hold the seedling back at slight angle until soil closes around root. Movement of the machine or planting operation will tilt the seedling slightly forward, hence leaving the seedling planted straight.
4) Release seedling and the packing wheels will do the rest.
5) It is a good practice to walk each tree row, following behind the planter, to straighten trees or to cover any trees where roots are exposed.
6) After planting, to ensure good soil-root contact, drive the tractor down the row with a drive wheel near the seedling row. This will help ensure that the planting furrow is closed.

PLANTING AND CARE OF EVERGREENS

Starting evergreens is a problem in many farming areas. Evergreens as a group do not become established as easily as deciduous species on prairie or desert soils. The reason is that most evergreens are naturally adapted to soil and climatic conditions that are far different from prairie or desert.

Broad shingles or boards driven into the ground on the windward sides of small evergreens give helpful protection. Shingles also minimize late winter dessication caused by exposure to high winds and direct sunlight. Shelters should be located so that shade is provided from just past midday through most of the afternoon. Rubber tires should not be used as sun shields as they raise surface temperatures to a lethal level.

Mulches including straw and tree bark are often recommended for moisture conservation and to prevent freezing and thawing of the soil around evergreens. *However,* they create a suitable habitat for rodents that may cause serious damage to tree stems and roots.

CONTAINERIZED VS. BAREROOT STOCK

Containerized seedlings often have higher survival rates than bareroot seedlings given the same handling. This is particularly true for evergreens. The styrofoam container protects the seedling roots from any drying during handling, shipping and planting. The roots of bareroot seedlings are repeatedly exposed to dry air, from the time of lifting at the nursery through planting.

When planting bareroot stock, it is often difficult to plant a seedling without bending the roots into a "J' or "L' shape. This type of planting reduces seedling survival and long-term growth rate.

Many conservation plantings in Montana are done in an unnatural (off-site) environment. Because of this, only the hardiest seedlings will survive. Containerized seedlings are planted with a soil mass attached to the roots. This helps a seedling survive until it becomes acclimated to its new environment.

This is not to say that bareroot seedlings are not excellent planting stock. However, given the typical planting site in Montana and the usual planting and handling methods, containerized seedlings will be planted in better condition and, thus, will survive better than bareroot seedlings (Table 4).

The State Forest Tree Nursery produces two types of containerized seedlings: a 30-cubic-inch styroblock seedling, which should be used on agricultural land in eastern and western Montana, and a 4-cubic-inch Ray Leach seedling to be used only on forest land types in western Montana. The 4-cubic-inch seedlings are usually grown by special request only.

Table 4. First- and second-year survival of bareroot and containerized transplants of ponderosa pine under different irrigation treatments. Seedlings were transplanted in May 1979 at the Bridger Plant Materials Center, Bridger, Montana.

Treatment	Percent survival 1979	1980
Containerized—irrigated weekly	77.5	57.5
Containerized—no irrigation	75.0	65.0
Bareroot—irrigated weekly	22.5	17.5
Bareroot—no irrigation	2.5	0

ONGOING MAINTENANCE AND PROTECTION

After a windbreak has been carefully planned and planted, there are factors that will prevent achievement of goals unless trees and shrubs are given continual attention and care.

A fair percentage of windbreak plantings in Montana fail to survive or do not meet landowner needs. Some failures are caused by lack of planning, improper storage and handling of seedlings and poor planting techniques. However, most failures result from inadequate care. Weeds, lack of water, uncontrolled livestock, careless handling of farm equipment and herbicide drift all contribute to the demise of good intentions. Sometimes, lack of care is due to unforeseen circumstances, but more often it results from the attitude that trees can take care of themselves. Trees seldom perform satisfactorily without care, especially in severe climates and soil conditions, both commonplace in Montana.

The remaining sections of this landowner's guide address the problems commonly encountered after planting, and suggest management strategies and techniques necessary for their prevention and control.

IRRIGATION

Montana has areas that warrant supplemental irrigation of windbreak plantings to ensure satisfactory survival. Typically, these areas have soils with low available-moisture-holding capacity, less than 10 inches of average annual rainfall, or a combination of these characteristics. However, in other areas of the state where tree survival is not a significant problem, irrigation may be desirable to increase growth rates or broaden the choice of windbreak species.

Irrigated windbreaks should be watered often enough to keep trees in active growth most of the summer. Watering frequency will depend on soil type, local temperature and wind conditions. As a general rule, during their first growing season trees should be watered once each week during hot weather. During the second and third season, watering should be done about once every 10 days.

The objective in irrigation of windbreak trees is to get deep water penetration throughout the root zone. Shallow watering encourages shallow rooting. Watering should be ceased by mid-August to help trees harden-off to cold weather. If water is available in the fall, evergreens should be watered thoroughly once after the second hard frost. This later watering helps trees withstand drying winter conditions.

Tree and shrub species have different moisture requirements than agricultural crops. Trees and shrubs should be irrigated relative to their moisture requirements as affected by local site characteristics, season and current weather conditions.

Throughout much of the plains area in Montana, water from shallow wells is of poor quality. Water from questionable sources should be tested to ensure that it is of high enough quality to be used for irrigating trees and shrubs.

Consult the county extension agent or Soil Conservation Service district conservationist to determine whether moisture is limiting and to what extent irrigation is necessary in your area.

WEED MANAGEMENT

Weeds can be a serious problem in windbreak establishment and maintenance, both in the lanes between windbreak rows and between plants within individual rows. Therefore, weed management strategy, including selection and timing of control treatments, should vary based on the length of time following windbreak planting and the area in the windbreak where control is to be applied. A combination of cultivation and herbicide treatments usually results in the most effective weed control.

Control of competing vegetation both within and between tree and shrub rows is essential during the first three to five years after planting. If weeds are not controlled during this period, the chances of tree and shrub survival are slim. After the three- to five-year establishment period, weed control in the lanes between plant rows should be continued indefinitely.

Cultivation

Within Rows. Over-the-row cultivation controls weeds within rows, between individual plants. It can be accomplished with a variety of mechanical equipment. Weeder-type implements, like the harrow weeder with 16-inch teeth, a modified dump rake lowered by substituting mower wheels, the side-delivery rake, the spring-tooth harrow with 11-inch control shoes to regulate depth, and the flexible-tooth field weeder, work well for this purpose.

The first over-the-row cultivation should be delayed until tree and shrub seedlings have been in the ground about 10 days. Cultivate slowly—4 to 6 miles per hour. Reduce this to 2 to 4 miles per hour with the side-delivery rake.

If mechanical equipment for over-the-row cultivation is unavailable, hand-hoeing or specialized mechanical equipment can be used for within-row weed control. Special tools, like the grape hoe and shelterbelt cultivator, swing out from the side of a tractor to remove weeds between plants. A usable in-row cultivator can be made by attaching suitable tines to an old mower bar.

During the three- to five-year establishment period, cultivation can be used every 10 days or as soon as weeds appear. Weeds should not be allowed to get more than 2 inches tall. Some sites may require 10 cultivations during the first growing season. After the establishment period, trees and shrubs usually will grow well without extensive within-row cultivation for weed control. However, seeding-in a low growing, adapted grass species will reduce the likelihood of weed establishment in the within-row space.

All within-row cultivation should be stopped by mid-August. Trees begin entering dormancy in mid-August and must be allowed to "harden-off" to be protected from winter damage. Root pruning, caused by late season cultivation, stimulates tree growth and retards the dormancy process.

Between Rows. Between-row cultivation in the lanes between individual tree and shrub rows should be applied at the same times as within-row cultivation during the three to five years after trees and shrubs are planted. Following this establishment period, cultivation should be applied two to three times a year, and continued indefinitely, to prevent establishment of weeds and grasses between rows.

Chemical Treatment

Herbicides are effective chemical tools for controlling unwanted weeds. Some are safe to use in established plantings while others should be used as "directed sprays" on the weeds only. Many different herbicides are available. Recommended herbicides will vary depending on tree species in the windbreak and target weed species.

Nearly all chemicals used for weed control also can kill or injure shrubs and trees. Therefore, the following precautions and measures must be observed:

- Follow label directions exactly!
- Do not spray herbicides on leaves or green bark of trees and shrubs.
- Do not use more chemical on a given area than directions call for.
- Avoid putting chemical into the root zone of the soil, especially in light, sandy soil. Roots

of established trees may extend as far as four times the radius of the lower tree crown.

- Use soil-active herbicides that are stable or low in solubility, so they will not leach into the root zone. When others are used, confine them to the weed foliage.

Weed Management for Montana Windbreaks, Montana Cooperative Extension Service Circular No. 312, provides detailed information on weed management strategies and herbicide selection and application techniques for Montana.

FERTILIZATION

Trees planted on agricultural soils usually will grow well without fertilizer treatment. However, most trees respond favorably to applications of nitrogen or other limiting elements after the windbreak has been established for two or more years. In general, young trees should not be fertilized at the time of planting. The root systems of young trees are susceptible to damage by fertilizer. If the planting site is known to be extremely low in fertility, it should be fertilized in the fall preceding planting.

Windbreak owners have no single indicator to tell them if trees need fertilizer. Some specific conditions or symptoms can also be caused by disease, poor root system, inappropriately applied herbicides or other problems. These symptoms include unusually small leaves, 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, hail, etc., fertilization may be helpful during the recovery period.

While nitrogen, phosphorus and potassium are required in the largest amounts, several other nutrients are required by all windbreak trees and shrubs. These include calcium, magnesium, sulfur, chlorine, iron, manganese, copper, boron, zinc and molybdenum. Most soils in Montana contain adequate amounts of these elements. The exception is iron, which is frequently deficient, especially in highly calcareous soils.

A soil test should be performed during the windbreak planning phase to determine nutrient deficiencies and soil properties peculiar to your area. This information will help you make decisions about what fertilizer treatments will be necessary and when they should be applied.

Timing Fertilizer Applications

Fertilizer should be applied in the spring as soon as soil is frost-free. Fertilizer applied in early spring is available for the tree as soon as growth resumes. Since root growth will begin before leaf development, fertilizers should be applied as early as possible.

Fertilization after mid-June is not recommended. Irrigation usually is not sufficient to avoid foliar "burning" and late summer applications of fertilizer may produce new growth tissue that will not "harden-off" sufficiently before freezing, resulting in winter injury.

Fertilizer Rate

In dryland plantings with less than 16 inches of annual precipitation, nitrogen fertilizer can easily do serious damage to evergreens. No more than 40 pounds of nitrogen per acre should be applied. In irrigated plantings, 80 pounds of nitrogen per acre can be applied to established trees. It is important to keep the amount of fertilizer applied in line with the amount recommended. For example, a recommendation of 40 pounds nitrogen per acre corresponds to 200 pounds per acre of 20-10-0 fertilizer. A county extension agent or Soil Conservation Service district conservationist will have fertilizer recommendations for your locality.

PROTECTION FROM DAMAGING AGENTS

Livestock, poultry, mice, gophers, rabbits, porcupines, insects, diseases and herbicides can be real enemies of farm tree plantings. The threat from livestock and poultry can be controlled by fencing. Trees planted next to meadows, hayland, sagebrush areas or road rights-of-way may need to be protected from mice, gophers and rabbits.

Clean cultivation helps keep mice and gophers out of plantings, but it does not ensure complete protection from damage. Mice and gophers will move into clean plantings under snow cover. Screen wire or hardware cloth cylinders may be used to protect small trees and fencing will often prevent damage from rabbits and larger rodents. Plastic tubes and netting are also available to repel

rabbits and deer. Also several Thiram-based repellents are reportedly effective and can be sprayed on the plants. Sometimes trapping or poisons will be required.

Windbreaks should be examined periodically in late fall, winter and early spring for signs of insect or disease damage. If pest problems that are not familiar are discovered, the county extension agent can help with identifications and give control recommendations.

The best way to protect trees and shrubs from pathogens is to maintain an environment that assures healthy and vigorous plant growth. Plants under stress are highly vulnerable to attack by opportunistic insects and diseases. A healthy plant usually can protect itself from attack. Use a pest management strategy based on reducing a plant's vulnerability to attack by potentially damaging agents. This preventative approach is far more economically and ecologically efficient than treating crisis situations and attempting to recoup losses.

What appears to be disease damage in farm tree plantings frequently results from the improper use of herbicides. Usually such damage is caused by repeated occurrences of drift in fields or along roads. Both deciduous and evergreen trees can be affected, but some species are much more susceptible than others. As a group, evergreens in the dormant stage (after buds are 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. Symptoms include wilting of early growth, followed by browning of needle tips in the summer and fall. Twisted, malformed leaders or tree death often result.

For 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 leaves, fading of the green color between leaf veins and stunted leaf and twig development. In severe cases, all new growth may be stunted or deformed and killed.

Soil-active herbicides are quite damaging to trees with shallow root systems. Colorado blue spruce is very vulnerable. Symptoms of herbicide injury on these species include a random pattern of purplish-colored needles in the tree crown, followed by defoliation. Be sure plant species names are listed on the herbicide label before use. When in doubt, use cultivation to control weeds.

If a windbreak has herbicide damage symptoms, tree stress can be minimized by frequent irrigation, fertilizing the following spring and controlling aphid and scale insects. In most cases, trees will survive from a single incident of herbicide poisoning. Death is most always attributed to repeated herbicide contact.

RENOVATION OF OLDER WINDBREAKS

Renovation is a means to improve the condition of established windbreaks and thereby maintain or improve their effectiveness.

Basic to windbreak renovation is a consideration of space. Adequate space for trees and shrubs to grow and adequate space to allow perennial cultivation (unless irrigated) are necessary for satisfactory windbreak development under dry Montana conditions. Trees in older windbreaks and other farm tree plantings are often characterized by sparse crowns, dying branches, slow twig and shoot growth and other signs of low vigor. Plantings were commonly made with spacings too close to give the trees room to grow. The trees did well during their early years, but long before they reached maturity they were crowding each other severely. Growth rate slowed, vigor decreased and the trees became more vulnerable to damage caused by disease, insects, drought and herbicides. Also, as trees grew larger, there came a time when between-row cultivation was no longer possible and grasses and other plants occupied the between-row spaces. This resulted in additional reduction in windbreak vigor.

In many cases, thinning or cutting out weaker trees will help strengthen the remaining ones. Before removing any trees or shrubs, it is important to consider the longevity and desirability of each species, current conditions of the various plants, and each plant's ability to respond to improved growing conditions. If a row is overcrowded but the trees are still reasonably healthy, one option is to remove every other tree within the row. Removal of entire rows may be necessary to make room for the operation of cultivation equipment so that competing grasses and other plants can be kept out of the windbreak. Remove rows that are in extremely poor condition or rows that

are made up of relatively short-lived species. If a row is overtopped or most trees are dead, the entire row can be removed. Fertilizers also can be used to rejuvenate some tree and shrub species.

Each windbreak deserves special consideration and examination before a decision is made as to treatment needed. The county extension agent or Soil Conservation Service district conservationist can suggest renovation alternatives and techniques.

REFERENCES

Evans, G. E. and J. L. Murphy. 1976. A Woody Ornamental Plant Inventory of Selected Montana Communities to Evaluate Length of Freeze-Free Season as an Indicator of Plant Hardiness. Montana Agri. Exp. Sta. Res. Rep. 96. 65p.

Ferber, A. E. 1969. Windbreaks for Conservation. USDA Soil Cons. Serv. Agri. Info. Bull. No. 339. 30p.

Hanley, D. 1984. Trees Against the Wind. Pacific Northwest Coop. Ext. Serv. Bull. No. PNW-5. 28p.

Helwig, L., N. Baer and S. Dronen. 1983. A New Plan for Shelterbelts/Windbreaks: TW-HD (Twin Row-High Density). South Dakota Coop. Ext. Serv. FS 813. 4p.

Hunter, H. E. 1979. Windbreak Species Performance Data by Soils. USDA Soil Cons. Serv. Tech. Note Woodl. No. 12. 82p.

Lacey, J. R. and C. A. Lacey. 1985. Controlling Pasture and Range Weeds in Montana. Montana Coop. Ext. Serv. Bull. No. 362. 34p.

Living Snow Fences Can Save You Money. Montana Dept. of State Lands, Division of Forestry.

Loucks, W. L. 1983. Windbreak Bibliography. Great Plains Agri. Council Publ. 113. 111p.

McCarver, O. W. 1985. How to Diagnose Common Physiological Tree Problems. Montana Coop. Ext. Serv. Circ. No. 1136. 3p.

Nelson, J. R., S. B. Laursen and C. A. Lacey. In prep. Weed Management for Montana Windbreaks. Montana Coop. Ext. Serv. Circ. No. 312.

Prevention and Control of Wildlife Damage. 1983. R. M. Timm, ed. Nebraska Coop. Ext. Serv., Univ. of Nebraska, Lincoln.

Riffle, J. W. and Peterson, G. W. 1986. Diseases of Trees in the Great Plains. USDA Forest Serv. Gen. Tech. Rep. RM-129. 149p.

Robinette, G. O. 1972. Plants, People and Environmental Quality. USDI Natl. Park Service, Washington, D.C. 140p.

Stein, J. D. and P. C. Kennedy. 1972. Key to Shelterbelt Insects in the Northern Great Plains. USDA Forest Serv. Res. Paper RM-85. 153p.

State Forest Tree Nursery Sales Policy. 1985. Montana Dept. of State Lands, Forestry Division, Missoula, Mont. 2p.

Windbreak Management. 1979. Great Plains Agri. Council Publ. No. 92. PFRA Tree Nursery, Indian Head, Saskatchewan, Canada. 132p.

Windbreaks and Shelterbelts. 1974. Montana Coop. Ext. Serv. Bull. No. 318. 21p.

APPENDIX 1
Sources of Plant Materials, Assistance and Information

STATE NURSERY

Montana has a publicly owned nursery, established to provide tree and shrub planting stock to rural landowners at reasonable costs for windbreak and wildlife plantings. Trees also are available for use in reforestation. Contact:

Montana State Forest Nursery
Department of State Lands
Division of Forestry
2823 Spurgin Road
Missoula, MT 59801

Contact your county extension agent, Soil Conservation Service district conservationist, or Department of State Lands service forester for ordering and price information. Planting stock purchased from the State Lands Nursery:

- May not be used for ornamental purposes.
- May not be resold with roots attached.
- May not be planted outside Montana.

COMMERCIAL NURSERIES

Many commercial nurseries in Montana also produce seedling-size trees for farm and forest plantings. They frequently have species or varieties of trees and shrubs that are not available from the public nursery. There is no restriction on the use of planting stock purchased from a commercial nursery. Trees purchased at quantity prices are much less expensive than individually potted trees.

A county extension agent or Soil Conservation Service district conservationist can supply a list of commercial nurseries that produce seedling trees for farm plantings. Trees and shrubs purchased from commercial nurseries should come from local seed sources or be adapted to Montana growing conditions.

INFORMATION SOURCES

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

- County extension agent, the local representative of the Cooperative Extension Service, Montana State University, usually located in the county courthouse.
- District conservationist of the USDA Soil Conservation Service, affiliated with the local Soil Conservation District.
- Service forester of the Montana Department of State Lands, located in 12 unit offices throughout Montana.

Assistance personnel will use standard forms to help you plan for windbreak planting and renovation activities. Tear-out copies of these forms are provided at the end of this appendix. Included are two copies each of a "Tree Planting Plan and Record" and a "Species Performance Form." The Species Performance Form is a windbreak planning aid. It makes it easy to sketch what a windbreak will look like at maturity (20 years). This form also aids in the evaluation of an existing windbreak by helping to determine whether renovation is necessary and, if so, the best approach to take.

The first copy of each form is a completed example for a typical windbreak situation in Montana. The second copy is a blank for landowner use. It is helpful to fill out these forms as much as possible prior to visiting an assistance office.

APPENDIX 2
Recommended Windbreak Species and Characteristics

The following table, figure and descriptive text give common and scientific names, growth characteristics, adaptation zones and tolerance ratings of shrub and tree species commonly used for windbreaks in Montana.

Height and crown width values are for trees and shrubs at 20 years of age (Table 1).

Growth rate is expressed in three classes: slow, moderate and rapid. Plant species within each shrub or tree group are rated relative to other plants in that group.

Plant adaptation zone is a new classification system developed by the Soil Conservation Service for use in Montana. The state is divided into 10 zones (Figure 1). Each zone delineates an area where environmental conditions are generally uniform throughout. Within a particular zone, moisture and temperature regimes are relatively consistent with respect to changes in elevation and aspect. The zone numbers are only used to designate areas and imply no order of limitation or severity. This site classification system integrates length of growing season, minimum winter temperature and chinook frequency.

Table 1 indicates whether a plant species will perform satisfactorily or marginally in each plant adaptation zone. Species are recommended for planting only in listed zones.

Table 1 implies that a species is adapted to the conditions for a particular zone and will grow there if it receives adequate moisture. If the table indicates that a species is adapted to your zone, but the minimum annual precipitation column (under tolerance ratings) indicates otherwise, you may be able to sustain a successful planting if you have a high water table or exceptional soil moisture-holding capacity, or if you supply supplemental moisture through irrigation.

Tolerances to drought, shading and alkali soil are rated as excellent, good, fair or poor. Each species is rated relative to all other tree and shrub species (Table 1).

Most species in the table have good or excellent cold tolerance and can withstand the extreme cold temperatures encountered in windbreak areas across Montana. However, there are significant differences in species' ability to withstand sudden changes in temperature associated with chinook weather conditions.

Plants with good or excellent tolerance to drought can be planted successfully in cultivated dryland windbreaks without supplemental moisture. Species with fair drought tolerance are apt to need favorable moisture situations (irrigation, water table, overflow sites) in order to develop satisfactorily.

Russian olive and silver buffaloberry are the two most salt-tolerant plants listed. If they will not survive in alkali areas, it is unlikely that other species will. Few plants will grow where white salts coat the soil surface.

Species are listed in three main categories:

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

Deciduous Trees—Species used for remaining rows of windbreaks where evergreens do not grow well, and for single-row plantings where height is needed.

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

Table 1. Common names, growth characteristics, plant adaptation zones, tolerance levels and wildlife habitat ratings for tree and shrub species planted in cultivated, dryland (nonirrigated) windbreaks in Montana.

Common name	20-year height (feet)	20-year crown width: Actual (feet)	20-year crown width: 80% of actual (feet)	Growth rate[a]	Plant adaptation zones[b]: S	Plant adaptation zones[b]: M	Tolerance ratings[c]: Drought tolerance-min. precip. (inches)	Tolerance ratings[c]: Saline-alkali soils tolerance	Tolerance ratings[c]: Shade tolerance	Wildlife ratings[d]: Birds: Nesting	Wildlife ratings[d]: Birds: Food	Wildlife ratings[d]: Mammals: Cover	Wildlife ratings[d]: Mammals: Browse	State Lands Nursery[e]
Shrubs														
Silver buffaloberry	10	7		M	All		E-8	E	I-S	E	E	E	E	BR
Nanking cherry	7	8		M	1,2,4-10		G-10	F	I	E	E	F	E	BR
Common chokecherry	10	9		M	All,?		G-10	F	S	E	E	E	F	BR
Peking cotoneaster	7	4		M	1,2,4-10		F-12	F	S	E	F	F	P	
Golden currant	6	5		M	All		G-11	F	S	G	G	F	G	BR
Red-ozier dogwood	7	6		R	?		F-18	P	S	E	F	E	G	
Tatarian honeysuckle	10	10		M	2,4-10		E-10	F	S	E	P	F	P	BR
Common lilac	6	7		M	All		E-9	F	I-S	E	P	E	P	BR
Siberian peashrub	12	12		R	All		E-8	G	T	E	F	F	P	BR
American plum	10	9		M	1,2,4-10	3	G-10	F	I	E	G	F	E	
Western sandcherry	4	6		M	1,2,4-10		G-10	F	I	G	E	F	F	BR
Skunkbush sumac	8	5		S	All		E-8	F	I-S	E	F	E	G	
Purple-ozier willow	8	6		R	All		F-20	F	I	E	P	F	E	BR
Deciduous Trees														
Green ash	18	11	9	M	All		E-10	F	T	G	F	F	G	BR
Plains cottonwood	45	25	20	R	1,2,4-10	3	F-14	F	I	F	P	P	F	BR
Robusta cottonwood	45	25	20	R	All		F-14	F	I	F	P	P	F	BR
Manchurian crabapple	15	14	11	M	?		G-12	F	-	F	G	F	F	BR
Siberian crabapple	15	14	11	M	1,2,4-10	3	G-12	F	-	F	G	F	F	BR
Siberian elm	25	19	15	R	All		G-12	G	S	F	F	P	P	BR
Common hackberry	13	10	8	M	1,2,10,?	4-9,?	G-13	F	S	E	F	E	P	
Honeylocust	15	11	9	M	?		G-12	F	-	F	F	P	P	
Russian olive	17	15	12	R	1,2,4-10	3	E-8	E	T	E	E	F	P	BR
White poplar	25	19	15	R	All		G-12	F	I	F	P	P	F	
Golden willow	25	13	10	R	All		G-12	F	I	F	F	F	F	
White willow	25	13	10	R	All		G-12	F	I	P	P	P	P	BR
Evergreens														
Douglas-fir (east)	15	10	8	M	3-10		G-12	P	S	G	F	P	P	BR,C30
Douglas-fir (west)	15	10	8	M	1,2		F-15	P	S	G	F	P	P	C4
Rocky Mountain juniper	12	9	7	M	All		E-8	F	S	G	G	G	E	C30
Limber pine	-	9	7	S-M	1,2,6,8,10,?		G-10	P	I	G	F	F	P	BR,C30
Ponderosa pine (east)	17	12	9	M	3-10		G-10	F	I-S	G	F	F	P	BR,C30
Ponderosa pine (west)	17	12	9	M	1,2		G-12	F	I	G	F	F	P	BR,C4
Scotch pine	17	12	10	M-R	All		G-10	P	I	P	G	P	P	BR
Eastern redcedar	10	9	7	M	?		G-10	F	I	G	G	G	E	
Colorado blue spruce	15	10	8	M	All		G-10	P	T	E	F	P	P	C30
White spruce	15	10	8	M	All		G-12	P	S-T	E	F	P	P	

[a] Growth rate: R = rapid, M = moderate, S = slow.

[b] Species performs satisfactorily (S) or marginally (M) in plant adaptation zones indicated (1-10). Species are not recommended for planting in unlisted zones. Recommendations apply only to valleys and foothills within the foothill and mountain areas of the state. See Appendix 2, Figure 1.
? = listed species have not been extensively used or tested in Montana. Limited testing and experience suggest these species will perform as noted.

[c] Relative tolerance ratings: E = excellent, G = good, F = fair, P = poor.
Drought tolerance = relative ability to tolerate droughty conditions; minimum precipitation = least amount of annual precipitation that can be expected to result in satisfactory survival and growth in windbreaks with cultivation, planted in well-drained soils with good moisture-holding capacity and gently sloping terrain.
Saline-alkali tolerance = relative ability to tolerate saline-alkali soil conditions.
Shade tolerance: S = semi-tolerant of shade; I = intolerant of shade; T = tolerant of shade.

[d] Wildlife habitat suitability ratings: E = excellent, G = good, F = fair, P = poor.

[e] BR = bareroot stock, C4 = 4-cubic-inch containers, C30 = 30-cubic-inch plugs.

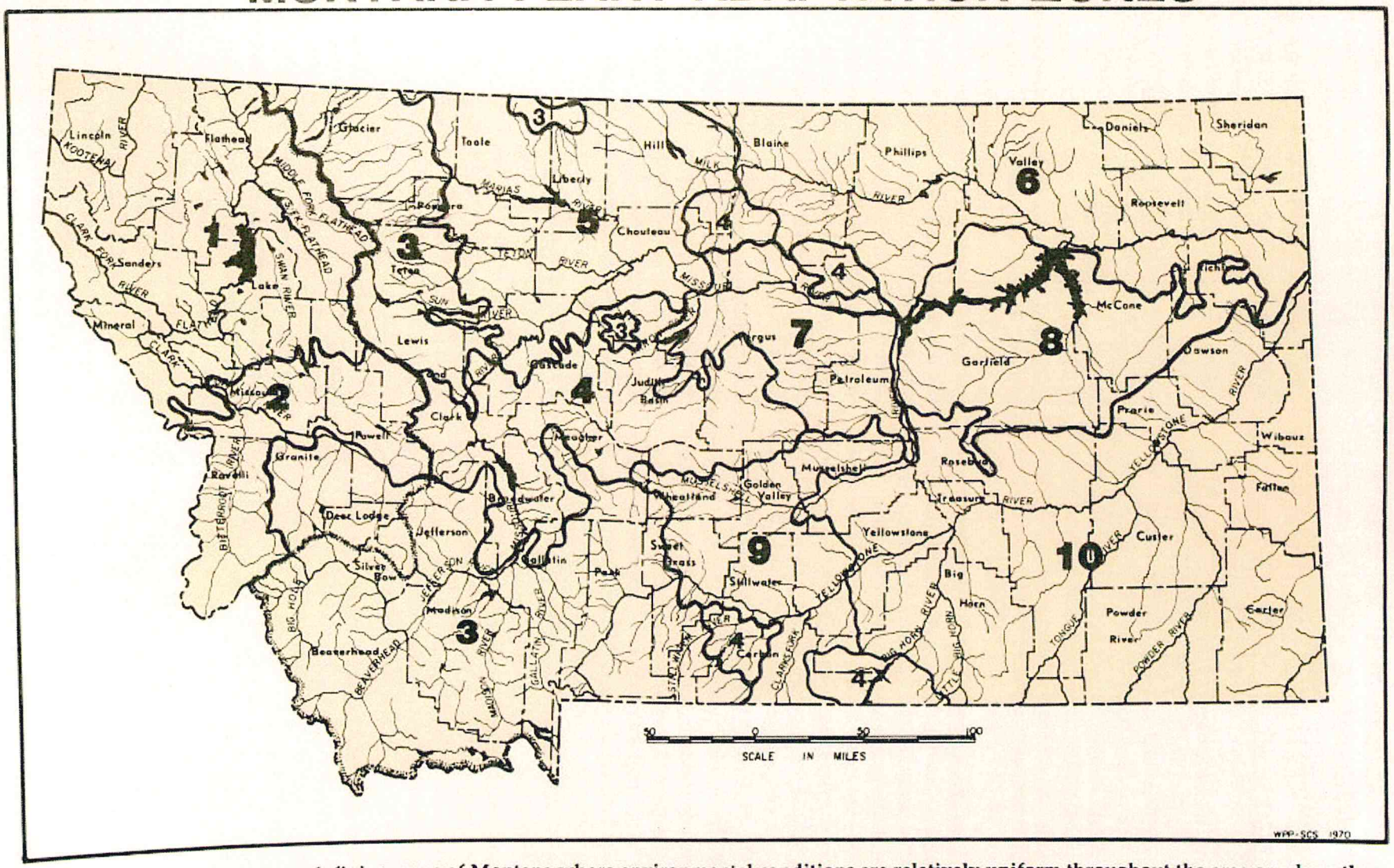


Fig. 1. Plant adaptation zones defining areas of Montana where environmental conditions are relatively uniform throughout the area or where there are relatively consistent environmental relationships with changes in aspect and elevation.

INDIVIDUAL SPECIES CHARACTERISTICS AND MANAGEMENT TIPS

—*Shrubs*

Silver buffaloberry (*Shepherdia argentea*). Thorny, thicket-forming, medium to tall, native shrub. Leaves are opposite-simple. Male and female flowers are borne on separate plants. Inconspicuous female flowers appear in May and develop into yellow to red fruits. Subject to heart rot, which can cause serious problems. Normal cultivation prevents encroachment into adjacent cropland.

Nanking cherry (*Prunus tomentosa*). Short-lived (5-7 years), upright, attractive shrub with alternate-simple leaves. Pink flowers blooming in April or May give rise to abundant, edible, red fruits. Few insect or disease problems. Should not be planted adjacent to cherry orchards as it is an alternate host for Western X cherry disease. Productive life can be extended by topping to a height of 1 foot as plant condition deteriorates. Best planted as an inside row.

Common chokecherry (*Prunus virginiana*). Tall, dense, long-lived, native shrub. Leaves are alternate and simple. White flowers appear in May. Black or dark reddish fruits. Virus X and black knot diseases may cause serious injury or mortality. Recommended for planting in outer rows or in single-row windbreaks.

Peking cotoneaster (*Cotoneaster acutifolia*). Long-lived, upright shrub. Withstands drought well. Produces abundant fruit that is retained throughout the winter. Provides excellent nesting habitat for birds. Few insect or disease problems.

Golden currant (*Ribes aureum*). Dense, native shrub. Yellow flowers bloom in late May followed by edible, yellow-black fruit. No serious insect or disease problems.

Red-ozier dogwood (*Cornus stolonifera*). Many-stemmed, medium-tall, attractive, native shrub. Leaves are alternate with prominent veins. Small white flowers in clusters turn into white fruits in late summer. Normally found on wet sites. No serious insect or disease problems. Good browse material for deer and elk.

Tatarian honeysuckle (*Lonicera tatarica*). Attractive, global-shaped, many-stemmed shrub. Leaves are opposite and simple. Pink or yellow flowers bloom in May. Red fruits may persist until fall. Few insect or disease problems.

Common lilac (*Syringa vulgaris*). An attractive, long-lived, very dense shrub with wide soil and elevational adaptability. Leaves are opposite-simple. Fragrant purple or white flowers bloom in May. Excellent hedge or shrub row with high aesthetic value. Occasionally infested by scale insects, borers and leaf blight. Extremely sensitive to 2,4-D. Sprouting may create cultivation problems.

Siberian peashrub (*Caragana arborescens*). An attractive, dense, long-lived shrub that is adapted to a wide range of soil and moisture conditions. Leaves are alternate and compound. Small yellow flowers appear in May or June. Generally insect- and disease-free but may be defoliated by blisterbeetles and grasshoppers. Excellent outside shrub-row species that reaches full size on irrigated land in 5 to 7 years and in 10-12 years on drylands. It is weakened by repeated exposure to 2,4D.

American plum (*Prunus americana*). Moderately dense, long-lived, many-stemmed shrub. Leaves are alternate-simple. White flowers bloom mid-May, followed by a cherry-like or plum-shaped fruit in late summer. Crown rust, fungus and borers cause problems but are not considered serious. Fruit highly prized for jellies and preserves. Excellent cover for small game animals. Suckering habit of growth may cause problems without cultivation.

Western sandcherry (*Prunus besseyi*). Dense, relatively short-lived (5-10 years) shrub species. Leaves are alternate. White flowers bloom mid-May followed by purplish-black, edible fruit. Fruit is abundant and valuable for jams and jellies. No serious insect or disease problems. Best planted as an inside row; fruit production is best under irrigation. (Frequently sold by nurseries as "bush cherry.") Productive life can be extended by topping to a height of 1 foot as plant condition deteriorates.

Skunkbush sumac (*Rhus trilobata*). Medium height, long-lived, dense, spreading shrub with three-lobed leaves that turn red in the fall. Colorful red fruits appear in the fall. Excellent wildlife cover and nesting habitat. Highly resistant to insects and disease. Subject to severe damage by snow-breakage.

Purple-ozier willow (*Salix purpurea*). Long-lived, dense, introduced shrub. Leaves are alternate-simple and linear. Bark and leaf veins are purplish in appearance and become gray in older plants. Inconspicuous flowers are borne on separate male and female plants. Considered disease-free. Excellent as a stream bank stabilizer.

—Deciduous Trees

Green ash (*Fraxinus pennsylvanica*). Deep-rooted, dense, long-lived, native tree. Leaves are opposite, pinnately compound with 5 to 9 leaflets. Excellent middle-row tree and can also be used for single-row plantings. Easily overtopped by faster-growing trees. Easily transplantable but should not be planted next to fast-growing species unless a sufficient row spacing is allowed. Fairly susceptible to herbicide damage. Green ash borer, scales and carpenter worms can be serious problems. Elm leaf beetle larvae and adults may defoliate in summer months but usually will not permanently damage trees. Excellent firewood.

Plains cottonwood and robusta cottonwood (*Populus deltoides, Populus robusta*). Very large, single-stemmed, relatively short-lived (under dryland conditions). Both are moisture-loving species. Plant in central rows of windbreaks or as single-row plantings. Not recommended for planting near foundations, septic systems, drain systems or open ditches. Canker diseases are a common problem on both species. Robusta cottonwood is a cottonless hybrid male tree. Plains cottonwood is a native species with male and female flowers borne on separate trees. May or may not be cottonless depending upon nursery selection practices.

Midwest Manchurian crabapple (*Malus baccata* var. *Mandsurica*). Introduced species similar in size and shape to Siberian crabapple, but highly resistant to fire blight and other foliar diseases. Attractive pink flowers are followed by small fruits that provide excellent food for wildlife most of the year. Tests indicate that this variety is well-adapted to northern climates.

Siberian crabapple (*Malus baccata*). Small, introduced species. Attractive white or pink flowers are followed by apple-like fruit in the late summer that is commonly used for jellies. Subject to fireblight and various scale and fruit-damaging insects.

Siberian elm (*Ulmus pumila*). Short-lived, medium to tall, introduced tree with a dense crown. Leaves are alternate-simple. The fruit is a rounded, laterally-winged samara. Adapted to a wide range of conditions. Sprouting common under irrigation. Susceptible to stem canker, wetwood, canker worms, scale insects and aphids. Highly susceptible to herbicide (2,4-D) and winter injury. This tree should be centrally located in the windbreak or may be planted as a single row. Resistant to Dutch elm disease. Good firewood.

Common hackberry (*Celtis occidentalis*). Small tree with dense, spreading crown. Prominent, distinctive, elongated ridges appear in the bark of larger stems and the main trunk. Reddish-brown fruits appear mostly in upper crown.

Honeylocust (*Gleditsia triacanthos* var. *inermis*). Medium to tall tree with attractive zigzag twigs. Winter injury common on harsh sites. Good firewood.

Russian olive (*Elaeagnus angustifolia*). A rapid-growing, long-lived, medium-size, introduced tree with a dense, oval crown. Best noted for its attractive leaves and fruit. Simple leaves are covered with a white, powdery bloom. One of the best tree species for dryland plantings in Montana. Wide range of soil adaptation. Relatively disease-free. May spread by seed on wet sites. Thorns may create a problem.

White poplar (*Populus alba*). Medium to tall, rapid-growing, introduced tree species commonly found in older plantings in Montana. Conspicuously hairy buds and leaf undersides have attractive silver coloration. Leaf shape and coloration similar to silver maple. Bud scales usually resinous and pungent. Male and female flowers borne on separate trees.

Golden willow (*Salix alba* var. *vitellina*). Medium to tall, short-lived, introduced tree. Leaves are alternate, simple and finely serrate. Golden-colored twigs are attractive in winter. Wide soil and moisture adaptability. Subject to severe damage from scale insects and aphids. Should be planted in central rows or as a single-row planting. Shallow-rooted tree that may buckle curbs and sidewalks, and plug drain lines.

White willow (*Salix alba*). Similar to golden willow except for pale-colored, heavily ridged bark.

—Evergreens

Douglas-fir (*Pseudotsuga menziesii* var. *glauca*). Medium-tall, dense, pyramid-shaped, long-lived, native conifer. One-inch needles are single, flat, slightly grooved above and marked below with two light bands. Requires a well-drained soil. Reportedly difficult to establish in plains windbreaks. No serious disease or insect problems except spruce budworm. Should be placed between the middle and inner rows. Both east- and westside seed sources available from Montana State Nursery. Excellent firewood.

Rocky Mountain juniper (*Juniperus scopulorum*). Long-lived, slow-growing, dense, symmetrical, small, native tree. Leaves are scale-like, pointed and bluish green. Cones borne on female plants require two years to mature. Acts as an alternate host for cedar apple rust, which damages both the juniper and apple trees, hawthorn, mountain ash and shrubby cinquefoil. Tolerates a high water table and wide range of soil conditions.

Limber pine (*Pinus flexilis*). Medium-tall conifer. Needles 1 to 3 inches long are borne in fascicles of five. Has not been widely planted in Montana windbreaks but is being tested for use in cool-dry climates in southwestern Montana.

Ponderosa pine (*Pinus ponderosa*). Medium-tall, moderately dense, symmetrical, long-lived, native tree. Needles 4 to 7 inches long are borne in fascicles of two or three. Needs full sunlight for best development. Easily damaged by overwatering. Generally free of disease and insect problems except for pine needle scale and tip moth. Montana state tree. Both east- and westside seed sources available from Montana State Nursery.

Scotch pine (*Pinus sylvestris*). Medium-tall, open-crowned, introduced species. Most hardy varieties turn yellow in winter. Stout, twisted or spiraled needles are borne in fascicles of two. No serious disease or insect problems except occasional infestation by tip moths and pine needle scale. Moderately good firewood.

Eastern redcedar or Virginia juniper (*Juniperus virginiana*). Similar in appearance to Rocky Mountain juniper but may be less adaptable. Well-liked for single-row screens. Subject to attack by cedar-apple rust. Should not be planted near apple orchards.

Colorado blue spruce (*Picea pungens* var. *glauca*). Medium-tall, attractive, long-lived, dense-crowned conifer. Best known for very stiff, sharp-pointed needles, green or blue in color. Spider mites, scale insects and spruce gall aphids may be slight problems. Difficult to establish in alkali soils. Does very well on nonirrigated upland soils.

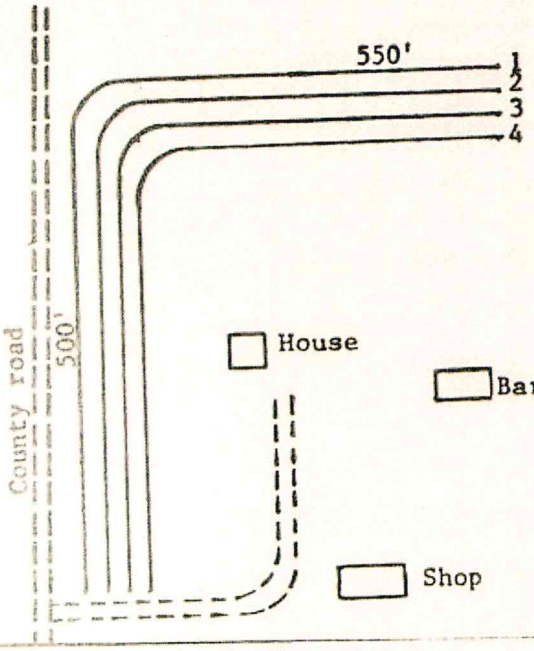
White spruce (*Picea glauca*). Medium-tall, dense, long-lived conifer. Performance and site adaptation similar to Colorado blue spruce. Spider mites, scale insects and aphids may cause some problems.

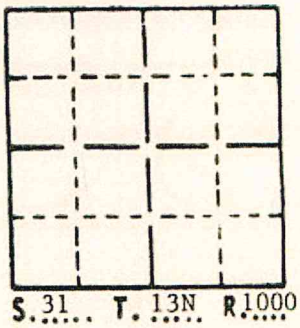
TREE PLANTING
PLANTING PLAN AND RECORD

Cooperator LBJ Ranch
Address P.O. Box 3, Heavenly, MT
SWCD Heavenly
County Heavenly
Planned Land Preparation Summerfallow

Date of Plan 5-'84
Type of Planting Farmstead Shelterbelt
Date of Planting (Proposed) 4-'86
Soil Type 33B-Degrand loam

Sketch of planting layout; or attach separate sheet.
Approx. scale 1/2"==100'





As Planned 2.2 ac						As Planted					
Row No.	Species	Row Length	In Row Space	No. of Trees	Betw'n Row Space	Species	Row Length	In Row Space	No. of Trees	Betw'n Row Space	Notes on Survival & Remarks
					15'						
1	Lilac	1050'	4'	262							
					25'						
2	Sib Crab	1000'	9'	111							
					25'						
3	Grn Ash	950'	12'	80							
					25'						
4	C Bl Spr	900'	12'	75							
					15'						

(Clip Out)

TREE PLANTING
PLANTING PLAN AND RECORD

Cooperator _____ Date of Plan _____

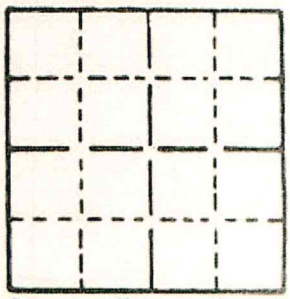
Address _____ Type of Planting _____

SWCD _____ Date of Planting (Proposed) _____

County _____ Soil Type _____

Planned Land Preparation _____

Sketch of planting layout; or attach separate sheet.
Approx. scale _____



As Planned						As Planted					
Row No.	Species	Row Length	In Row Space	No. of Trees	Betw'n Row Space	Species	Row Length	In Row Space	No. of Trees	Betw'n Row Space	Notes on Survival & Remarks

(Clip Out)

SAMPLE NO. 071-6 | BLOCK C. CROSS SECTION DIAGRAM – SPECIES PERFORMANCE | DATE 9/27/66

ROW NO.	1	2	3	4	5	6	7	8	9	10	11	12
SPECIES	CAR.	S.ELM	G. ASH	S. ELM	G. ASH	P. PINE						
SPACING WITHIN ROW	3	10	10	10	9	9						
AGE	16	16	16	16	16	16						
AVE. HEIGHT	10	21	17	24	16	18						
AVE. DIAM.		5.0	3.5	4.5	3.0	6.5						
CONDITION	GOOD	GOOD	FAIR	FAIR	GOOD	EXC.						
CROWN SPREAD	6 7	12 14	6 7	13 15	7 9	7 8						
HEIGHT TO LIVE CROWN	0 0	1 2	3 2	3 3	1 2	2 3						
ALIVE	10	10	10	10	10	10						
MISSING	0	0	0	0	0	0						
DEAD	0	0	0	0	0	0						

BLOCK D. COMMENTS BY SPECIES

COMMENTS BY ROWS AND SPECIES

Trees have had good care during life
Sprayed for insects several times

5, L-19, 373-2(2)

(Clip Out)

SAMPLE NO. _____ **BLOCK C. CROSS SECTION DIAGRAM – SPECIES PERFORMANCE** DATE _____

ROW #1 IS ON: N, NW, W, SW (circle one)													INDICATE VERTICAL SCALE
SPACE BETWEEN ROWS →													

ROW NO.	1	2	3	4	5	6	7	8	9	10	11	12
SPECIES												
SPACING WITHIN ROW												
AGE												
AVE. HEIGHT												
AVE. DIAM.												
CONDITION												
CROWN SPREAD												
HEIGHT TO LIVE CROWN												
ALIVE												
MISSING												
DEAD												

BLOCK D. COMMENTS BY SPECIES

COMMENTS BY ROWS AND SPECIES		

5,L-19,373-2(2)

(Clip Out)