III

Planning and Design Considerations

A. Row-type plantings

1. General criteria

A well-designed and well-maintained row planting is useful and beautiful. Plantings made without thought to basic design principles, soils and species selection often function and grow poorly. Poorly designed plantings may not protect target areas; they may deposit drifted snow on buildings, lanes, roads, feeding and other areas causing damage, expensive removal operations, blocked access roads or soil wetness problems. They can also be difficult to maintain.

Row plantings are frequently designated as primary or secondary. Primary plantings are located on the sides where the greatest need for protection exists. For example, if troublesome winds come from the north and west, the plantings on these sides are primary windbreaks. Any plantings on the south and east sides would be secondary.

a. Location

A preliminary review of any planting site is a must before steps are taken to design a functional barrier. During the review, a sketch should be drawn of the area. All objects or areas needing protection; existing plants, groves or clumps of trees and shrubs; soil problems; utilities; prevailing or troublesome wind direction; property lines; and roads or access lanes should be noted. Figure 28 illustrates the type of information that is desirable in the sketch.

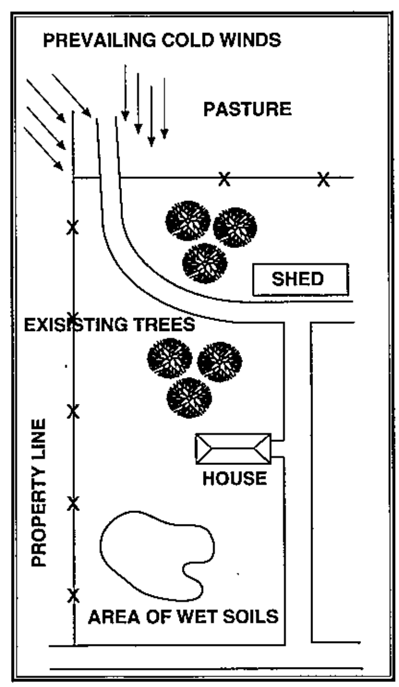
Several general guidelines which must be taken into account when planning a row-type planting. The most important are:

- Position the planting as nearly perpendicular as possible to troublesome winds, snow or noise.
- For wind protection, position the row containing the tallest growing tree species about 2-5 H from the primary area or object in need of protection. Where the object to be protected is located uphill from the windbreak, the row may need to be located closer to provide adequate wind protection. All areas in need of wind protection should be located within 10 H of the tallest tree row. Since H will change until the tallest tree row reaches maturity or becomes effective, it is suggested that the estimated height of the tallest tree species at 20 years of age (H) be used for planning purposes.

When the primary area in need of protection is located more than 10 H leeward of a primary windbreak, supplemental windbreaks of one to three rows should be established at 8 to 10 H intervals leeward of the primary windbreak.

- The number of legs in a row planting will depend upon its purpose. Plantings with one leg can be effective for controlling troublesome winds,

Figure 28
A sketch of a site's physical features is an important aid in the windbreak design process.



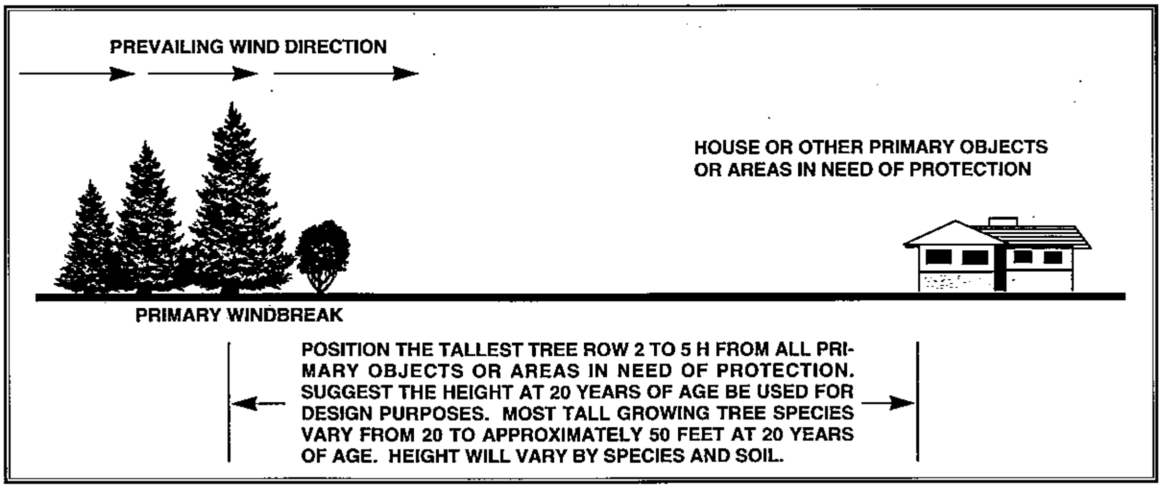


Figure 29
Cross section of a row-type planting designed for wind protection.

drifting snow and loud noises. They can also serve as a visual screen; however, wind, snow and noise may come from several directions requiring more than one leg to the barrier. Figures 30 and 31 illustrate the effect that a one- and two-leg windbreak will have on the area of protection.

Figure 30 illustrates area protected by a primary windbreak planted on one side. The area to be protected is vulnerable to winds from the other three directions. Figure 31 illustrates the area protected by primary windbreaks planted on two sides. It also illustrates why the standard (L) shaped windbreak is necessary for protection of most farmsteads and feedlots.

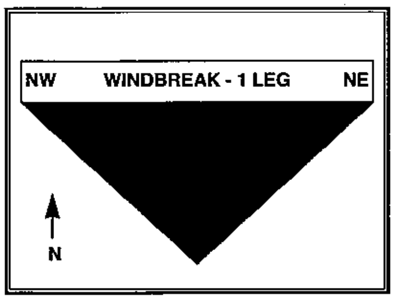


Figure 30
Area protected by one primary windbreak.

- Access lanes or roads which cut through a row planting designed for wind protection should be oriented at an angle to prevailing or troublesome wind (see Figure 32). Access lanes or roads which are parallel to the prevailing wind direction will cause the winds to funnel through gaps. Lanes or roads located at an angle to prevailing or troublesome winds will not allow wind to funnel into areas in need of protection.

In areas subject to blowing snow, access lanes or roads which must be used during winter months should not cut through a windbreak. Lanes and roads located in such a manner are prone to deep snowdrifts. It is recommended that access roads be located at the ends of windbreaks in areas beyond where snowdrifts form. The lanes or roads should be a minimum of 100 to 500 feet from the ends of the windbreaks to minimize snow drift problems (see Figure 33).

- Soil types on the planting site are an important factor. If there is more than one soil type, there may be a need to plant different tree and shrub species on each or to plant around areas where problem soils exist.

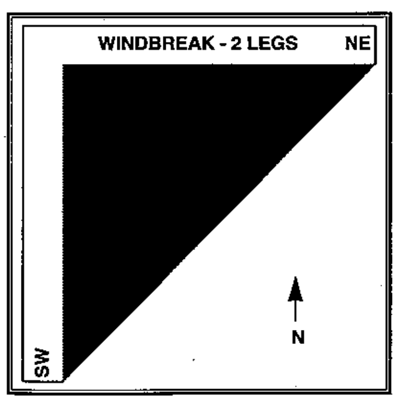


Figure 31
Area protected by two-leg primary windbreak.

- Know the location of property lines, subsurface drain fields and septic fields. Property lines can severely restrict the location of plantings. In some cases where severe snow drifting can be a problem and sufficient space is not available to properly locate a planting, it might be advisable not to plant all or a portion of a windbreak. Subsurface drain lines or septic fields should be relocated or avoided. Species such as the willows and poplars (includes cottonwoods) should not be planted within 100 feet of such lines or fields unless sealed conduit is used.
- Any existing clumps of trees or shrubs, and, in some cases, large individual trees, should be outside the boundaries of new plantings. New plantings should not be located within 50 feet of any existing trees if space is available. If space is limited, existing trees should be incorporated into the design of the new planting where practical.

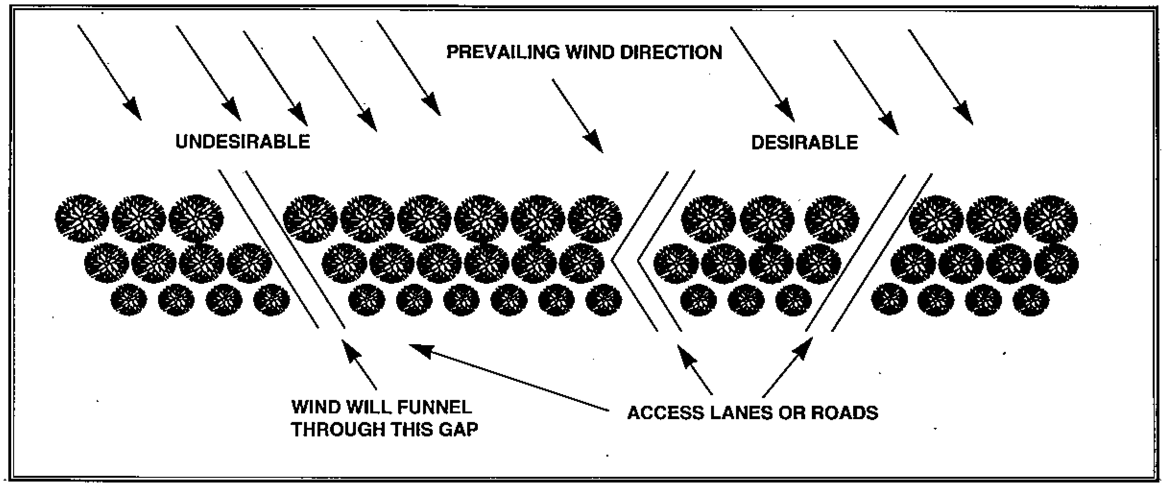


Figure 32
Access lanes should be at an angle to prevailing or troublesome winds.

b. Number of rows

The minimum number of rows recommended will vary from one row in areas where wind protection is the only concern to 3-5 rows where high winds, noise and snowdrift problems are common or where wildlife is important. Instead of being concerned about the density of the species being planted, there has been a tendency to be concerned about the number of rows needed. Research and experience have shown that dense windbreaks (those that exceed 65 percent density) are needed to provide adequate protection from wind, drifting snow and wind erosion. Therefore, the density of the species planted should be more important than the number of rows. Exercise care in selecting species so that density in the lower half of the windbreak is maintained.

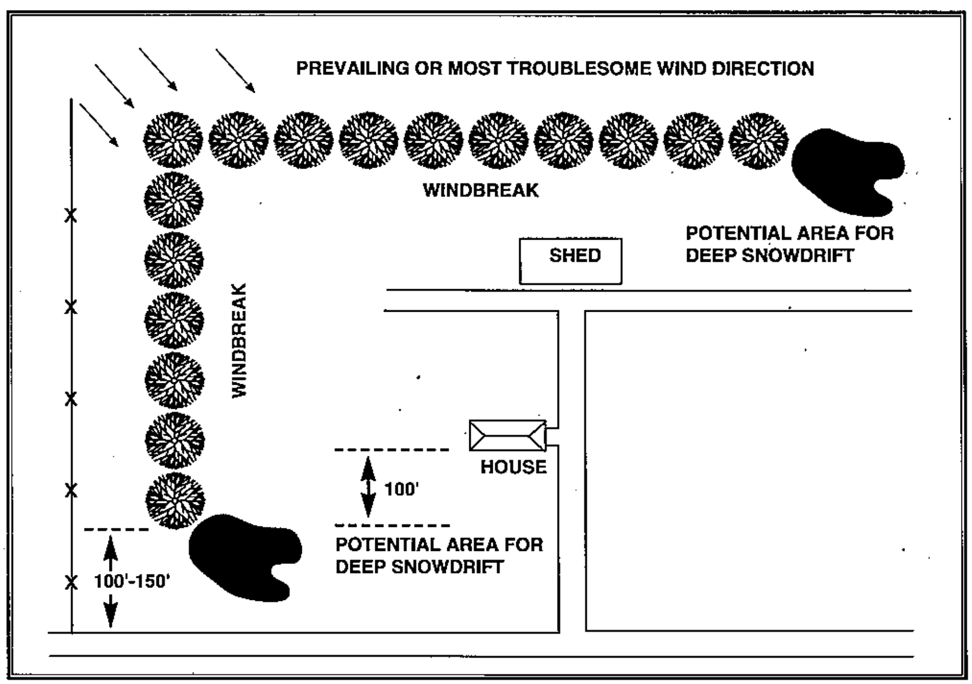


Figure 33
Locate lanes and roads 100 ft. to 150 ft. from windbreaks to avoid typical snowdrift patterns near the end of windbreaks.

A deciduous tree in full leaf has a density of 65 percent or greater. A deciduous tree without leaves has a density of 30-65 percent. These densities vary depending upon the thickness of the tree crown (number of branches and branching pattern).

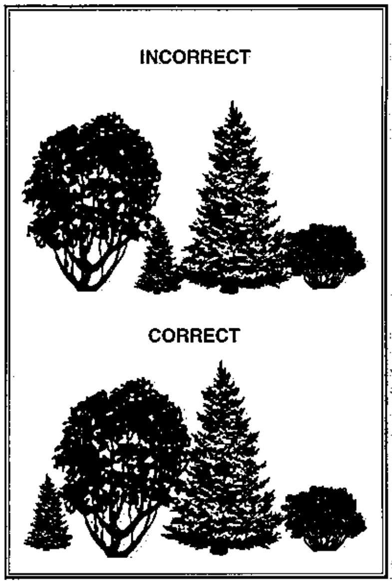


Figure 34
Slower growing and shorter species should be planted in the outer rows.

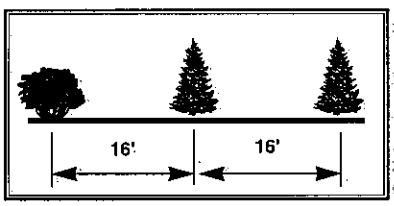


Figure 35
When equipment is used to cultivate plantings, between-row spacing should be equal the width of cultivation equipment plus four feet. For example, if cultivation equipment is 12 feet wide, between-row spacing should be a minimum of 16 feet to prevent damage to trees.

In areas where only wind protection is needed, a single row of evergreens can provide the desired density and protection. However, since trees and shrubs are subject to insect and disease problems, the recommended minimum design is two to three rows. To minimize impacts from insects or disease, each row should be a different species.

Several combinations of evergreen trees, deciduous trees and shrubs can provide desired densities. Where adequate space is available, a variety of species should be used in additional rows. The added species and rows will significantly enhance values of wildlife, aesthetics and general landscaping.

c. Row arrangement

The arrangement of species in plantings should follow these general guidelines. Shrubs, short trees and slower growing trees should generally be located in the outer rows. They should not be positioned between two taller growing species. Placing them in the outer rows assures them of adequate light and allows room for plant development.

d. Between-row spacing

Recommendations for between-row and within-row spacing are varied; however, to determine the spacing between rows, there are some general guidelines to follow. In plantings that are to be cultivated, always leave enough room for the equipment to pass freely between the rows. A safe rule to follow is to space rows at the width of the cultivation equipment plus four feet (see Figure 35).

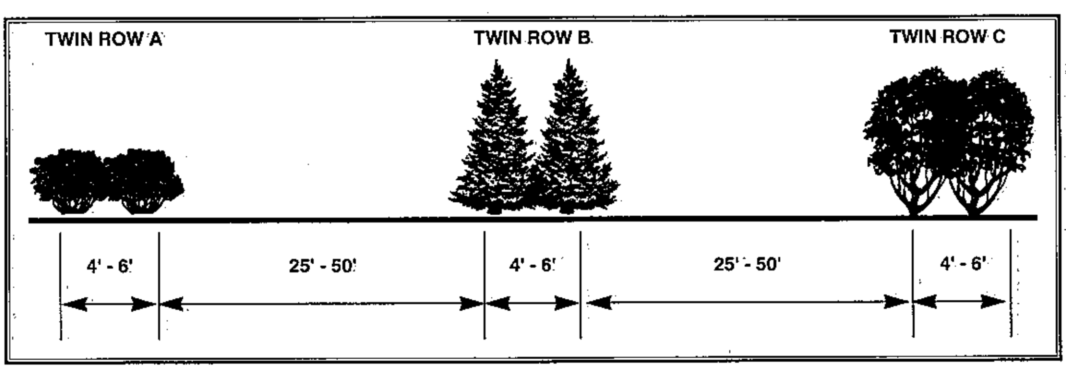
In plantings where competing vegetation is to be controlled by mowing, mulching or herbicides, minimum between-row spacing should not be less than 12 feet. A practical reason for using close (12-to-20 feet) between-row spacings is weed control. Experience has shown that as plants mature, ground shading is an effective way to control competing vegetation.

e. Twin-row high-density windbreaks

To overcome some of the problems associated with renovating existing plantings, at least one new design concept allows for ease of renovation. It is called the twin-row high-density windbreak. Essentially, it is a combination of narrow and wide between-the-row spacings. Figure 36 illustrates the basic concept.

Each twin row contains two rows of the same species planted about 4 to 6 feet apart. The wide between-row spacing of the twin rows provides for easy renovation in the future. For instance, if the rows happen to be planted to a combination of fast-growing, short-lived species (15 to 25 years) for quick protection and long-lived species (25+ years) for long-term protection, renovation problems in the future would be minor and the costs would be low. Figures 37 and 38 illustrate two different methods of renovating a planting if something happens to twin row B.

Figure 36
Basic twin-row high-density windbreak design.



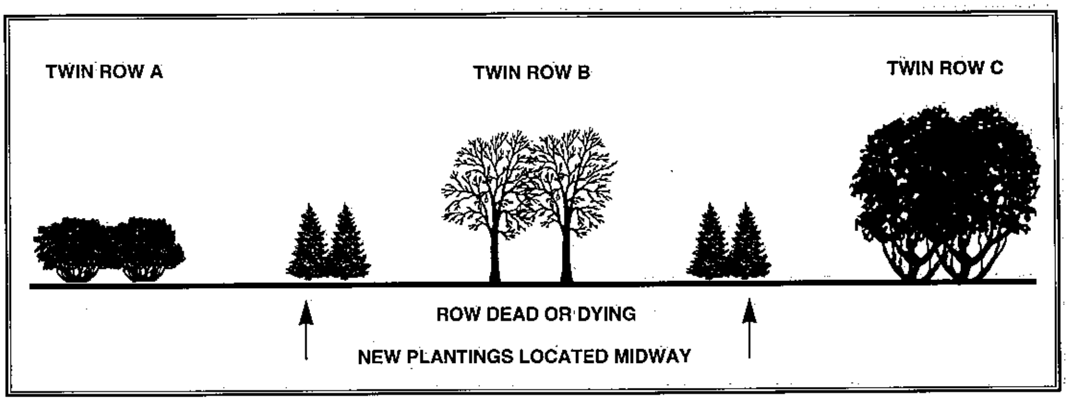


Figure 37
Renovation without removing dead or dying rows.

It is important to note that these forms of renovation can be applied without damaging the remaining rows. This design concept does not generally take any additional space over the older designs; however, the space is utilized differently.

f. Within-row spacing

Table 8
Guidelines for within-row spacing to allow for proper growth of crowns and roots. Actual spacing should, in part, reflect the physical shape or form of the species selected.

Within-row spacing	Single-row plantings	Multiple-row plantings
Small shrubs (less than 10' tall)	3 - 6 feet	3 - 6 feet
Large shrubs (more than 10' tall)	5 - 8 feet	5 - 8 feet
Evergreen trees	6 - 16 feet	8 - 18 feet
Medium deciduous trees (less than 25' tall)	6 - 10 feet	8 - 14 feet
Tall deciduous trees (more than 25' tall)	6 - 12 feet	8 - 18 feet

Twin-row high-density - Use lower value of single-row spacings.

Within-row spacing can vary according to species used and type of planting. Some species may require special within-row spacing. For instance, deciduous species, such as Lombardy Poplar, have a narrow cylindrical crown and may require as little as six feet in spacing to achieve the desired effect. On drought sites where all tree and shrub species grow slowly, additional design modifications will assure a significant amount of protection within 10 years. A complete barrier can be formed within 10 years utilizing narrower within-row spacing in one row.

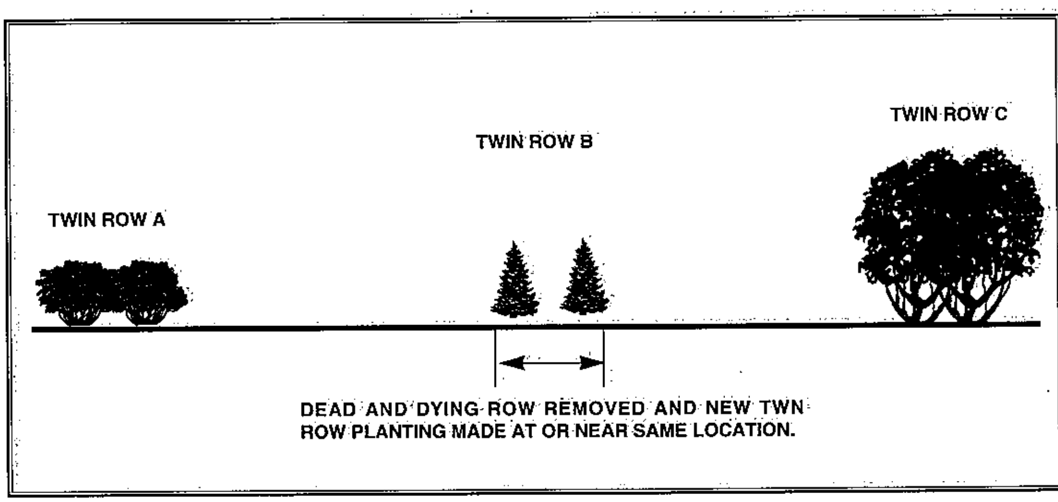


Figure 38
Renovation by removing dead or dying rows and replanting.

g. Species and site adaptation

Tree and shrub species must be adapted to the planting site, have the desired density and have the potential to provide a reasonable amount of protection. Chapter IVa lists species, heights and other attributes for selecting species for the planting.

2. Functional criteria

a. Erosion control and crop protection

Field windbreaks are permanent farm improvements and should be carefully planned. Typically, field windbreaks are designed to enhance crop yields, quality and value. In certain areas, they reduce wind-borne soil erosion.

Location - The location of the primary windbreak should be as close to perpendicular to the prevailing wind as possible and located on the sides where the greatest need for wind protection exists. For example, if canyon winds from the east prevail, a windbreak on the east side of the area is the primary windbreak. Any windbreak legs on the north and south sides or even the west side perform secondary functions. The addition of secondary windbreaks is beneficial. It enhances the effectiveness of the primary windbreak and is recommended to attain maximum benefits of the shelterbelt.

Figure 39
An example of the number and composition of rows in a multiple-row planting.

The most common location of windbreaks is around the perimeter of the field to be protected. Some exceptions that may need to be considered include unique contours, ridgetops and areas with a high water table. Intermittent field windbreaks may be needed if the field is too wide for a single perimeter primary windbreak.

Excessive density in a field windbreak is not desirable. High-density windbreaks distribute snow poorly across the field, creating deep snowdrifts near the windbreak with bare areas toward the center of the field.

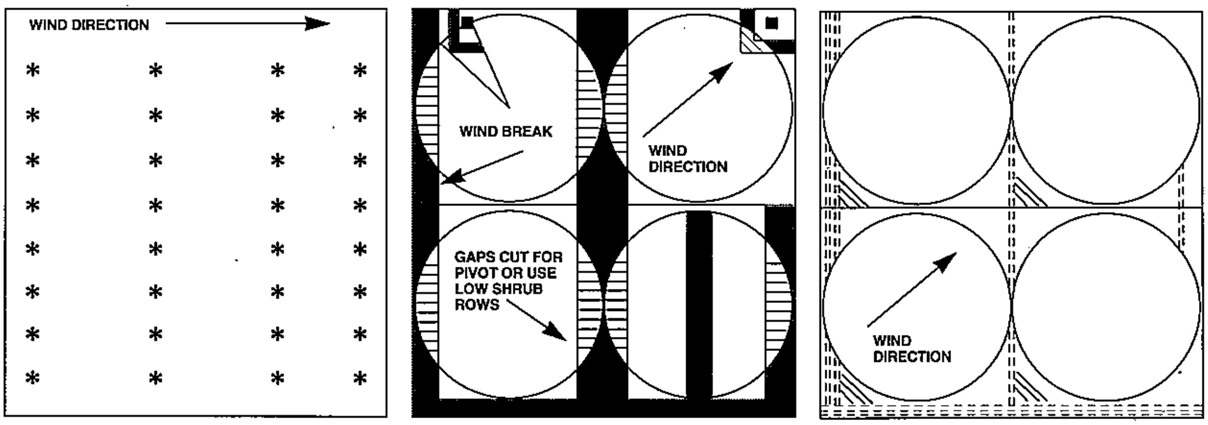
Evergreen species can be used in the third row if damaging winds occur in early spring while deciduous trees are still dormant (see Figure 39). Because of reduced winter densities, deciduous trees aid in the distribution of snow.

Special considerations - When planning shelterbelts, existing features should be taken into account to avoid problems. Access lanes should be located at an angle to the prevailing wind so that "funneling" of wind and snow doesn't occur. Unique land features can be used to the advantage of the farmer by planting wind barriers along contours and using rock outcrops and other non-conformities to enhance the effectiveness of the windbreak. The addition of a secondary leg to the primary windbreaks can increase the area of effective protection with other legs adding still more protection.

Secondary uses of windbreaks are common. By planting species that can be used for firewood, poles, fruit or nut production, windbreaks can be productive as well as protective.

In some instances, windbreaks may depress crop yields in adjacent fields by sapping and shading to a distance of 1/2 to 1 1/2 H. Root pruning will reduce the effect of sapping substantially and is done with a vertical cutting blade mounted on a tractor. A ripper can also be used. Root pruning is normally done parallel to the shelterbelt at a distance of 25-30 feet.

Properly planned, established and maintained field windbreaks will bring decades of protection for the field, enhance aesthetics in the area, increase crop yields and improve soil moisture.



ENTIRE FIELD IS PROTECTED WITH SIX 30 FEET HIGH WINDBREAKS SPACED AT APPROXIMATELY 460 FEET APART (10H + 160)

SHOWN ARE METHODS OF PRESERVING SHELTERBELTS AT THE HALF-MILE AND SECTION LINES OF A FARMSTEAD AND THE STRUCTURE OF WINDBREAKS AT THE FARMSTEAD HEADQUARTERS. FIELD USING CENTER-PIVOT IRRIGATION.

SHOWN ARE LOCATION OF TREE ROWS FOR FIELD WINDBREAKS ON ONE SECTION WITH CENTER-PIVOT IRRIGATION. THE UNUSED CORNERS COULD BE FOR WOODLOTS FOR FENCE POSTS, FIREWOOD OR WILDLIFE HABITAT.

Figure 40
Design examples of windbreaks in typical field applications.

b. Livestock protection

Basic design criteria for feedlot and livestock windbreaks -Feedlot windbreaks are designed to provide protection from wind and blowing snow. Protected areas leeward from such plantings are used extensively by livestock during colder times of the year. Properly designed feedlot and livestock windbreaks will function properly and maximize benefits. Conversely, improperly designed windbreaks may have few, if any, major benefits. The following considerations should be taken into account in the design of any feedlot or livestock windbreak.

- Direction of troublesome and prevailing winds.
- In areas where snowdrifts accumulate within the windbreak, locate the windbreak a sufficient distance away from feedlot and livestock concentration areas to keep drifted snow from getting into the feedlot or interfering with feeding operations.
- Divert water stored in snowdrifts within windbreaks away from the feedlot or livestock concentration area.
- Plant only tree and shrub species that are well-adapted to soils at the planting site.

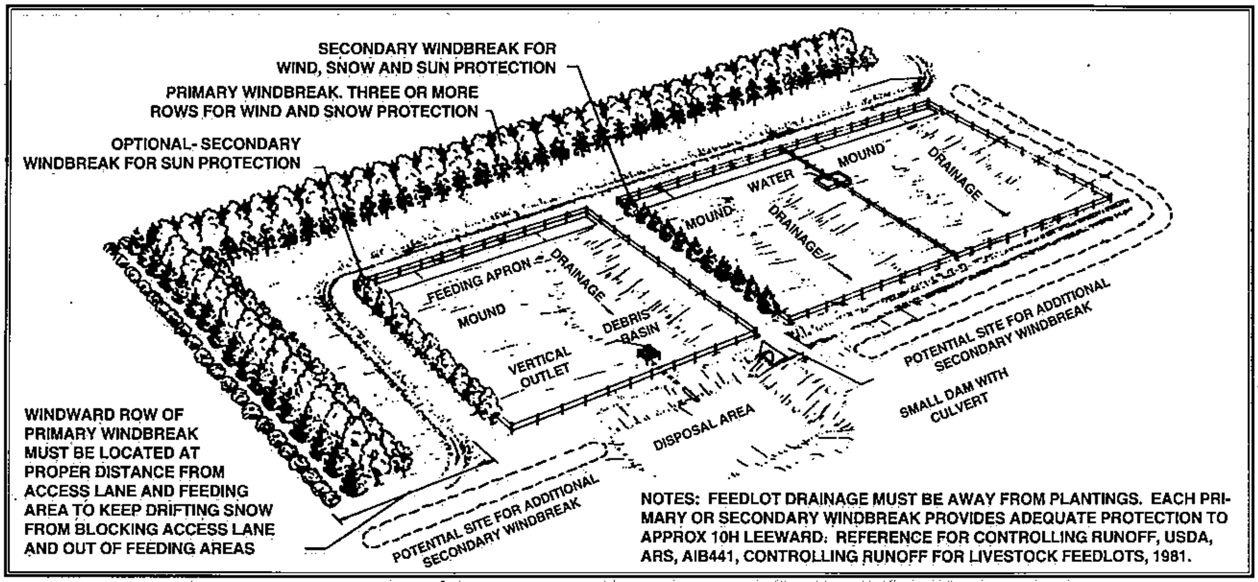


Figure 41
Basic feedlot windbreak design for wind and snow protection.

- Fence all windbreaks to prevent damage from livestock.
- Divert runoff from feedlots and areas where livestock concentrate.
- In areas subject to severe winter storms, consider making plantings sufficiently wide to provide good cover for wildlife.

Figure 42
Cross section of a basic feedlot windbreak designed for wind and snow protection.

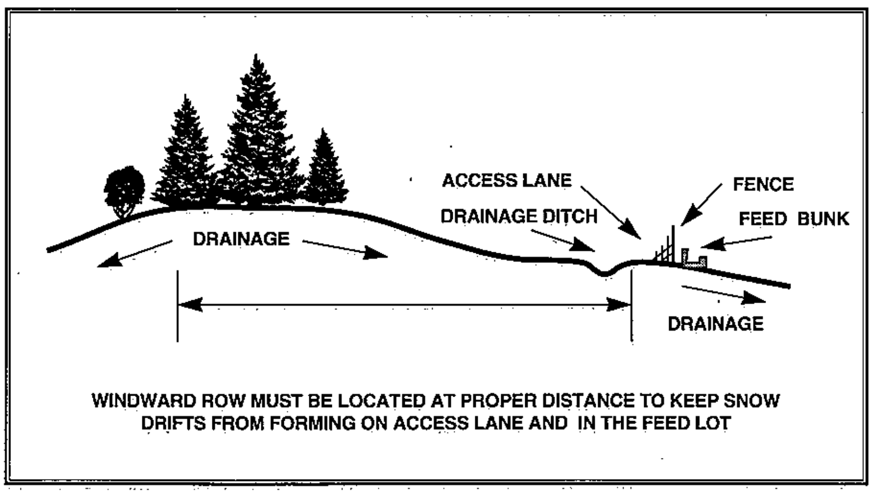


Table 9
Amount of feedlot space needed per animal for feeding, shelter, etc., excluding the space occupied by the windbreak.

Type of Animal		Estimated min. space per head
Beef	Feeders	250 sq. ft.
	Cows	300 sq. ft.
	Calves	200 sq. ft.
Dairy	Cows	400 sq. ft.
	Calves	200 sq. ft.

Figures 41 and 42 illustrate the major design criteria for windbreak and snowbreak plantings. When livestock feeding operations are located at the farm or ranch headquarters, it is important to incorporate these criteria into the windbreak design to protect the entire area (feeding and headquarter areas).

Additional plantings to provide protection from sun and to enhance wildlife values can be added to the basic design. Table 9 lists the minimum space needed per animal within feeding and holding areas. To determine the size of a feedlot (excluding windbreak), multiply the figure in the table times the maximum number of head that will be placed in the feedlot at any one time.

There is some leeway in designing windbreaks to protect and feed livestock during severe storms and during calving or lambing. Where windbreaks are used only for emergency shelter, significantly less protected space per animal is needed. In all cases, runoff from the areas where livestock concentrate should be directed away from the windbreak, and clean water from snowdrifts within the windbreaks should be diverted away from the protected zone. Where space permits, place the windbreak where natural features provide for all or most of the necessary drainage.

Depending on state and other regulations, there may be a need for a waste disposal area. An access lane for the feeding operations is also optional. Follow all other criteria in regard to the distance to outside rows of windbreaks from areas in need of protection.

Figure 43 illustrates possible shapes for livestock windbreaks located away from the farm or ranch headquarters where the protected area will not be used on a continuous basis. These designs provide protection from winds and/or blowing snow from all directions. The size of livestock windbreak plantings can be adjusted to fit the size of the herd or flock involved. Where sufficient land is available, plantings should be made somewhat larger than current needs.

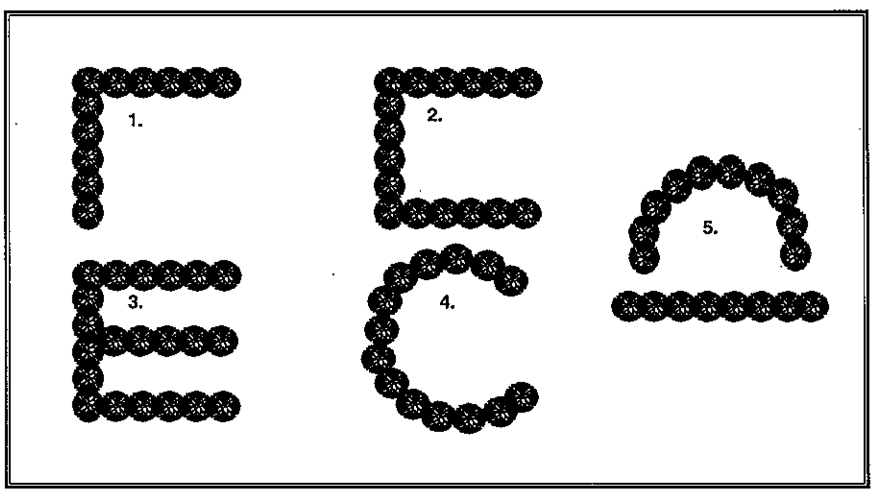


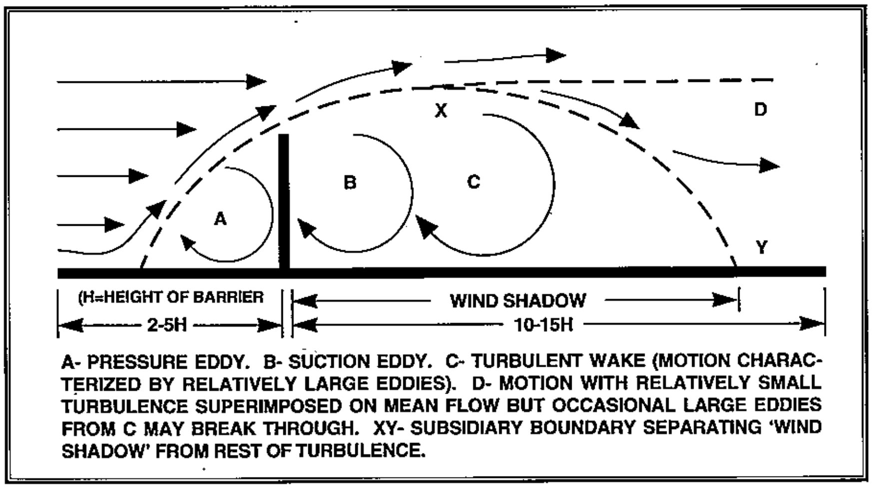
Figure 43
Ideas for the shape of livestock windbreaks.

c. Snow management

Snow Control Basics - A properly located shelterbelt can deposit snow on the lee side and prevent drifting near homes, feedlots, barns and on state and county roads. The snow is "trapped" in the wind shadow. Some snow is also dropped out in front of the barrier.

Generally, a permeable snowfence deposits snow further to the leeward side than a more dense planting. It also keeps snow from getting very deep. Windbreak characteristics of height and density form a pressure eddy. The more permeable the windbreak, the lower the pressure in the pressure eddy. Low pressure in the eddy allows higher through-the-windbreak wind speeds, which moderate the suction eddy and turbulent wake. These lower pressure change gradients allow a longer and more even and shallow snow deposit.

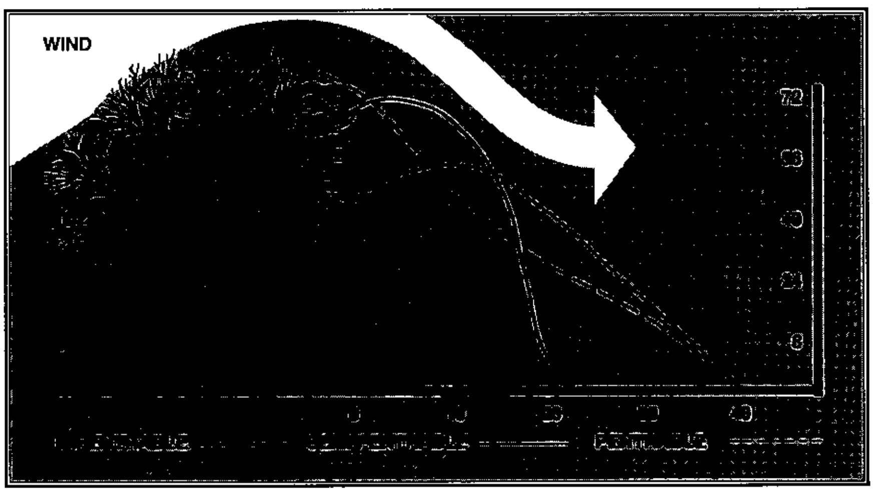
Figure 44
Basic physics of wind barriers.



Of special consideration is the "end effect" or reduced snowtrapping efficiency near the ends of a living snowfence. The funneling of wind around the ends can drift snow for considerable distances.

Local site factors - Winter wind velocity and duration, soil drainage and erodability, topography and expected amounts of snow act together to control the design of living snowfences.

Figure 45
Snow drift patterns adjacent to windbreaks of varied penetrability.



• Landowners in areas of little snow need not take any special precautions for snow control. However, in colder areas living snowfences may be a benefit. As expected snow drift depth increases, additional "setbacks" of barriers are necessary.

• Strong, long-duration winds in snow areas necessitate locating the barrier further away from structures or areas needing protection.

• Poorly drained soils may cause unwanted ponding or runoff of snowmelt. Sheet, rill and gully erosion may occur on erosive soils and sloping sites.

• Hilly topography may cause complex patterns of snowdrifting. Landowners must pay particular attention to historical areas of deposition. It is also important to consider drainage patterns. Like poorly drained soils, downhill areas may become temporary seeps that can impede farm or community activities.

Orientation and location - A living snowfence is placed on the same side of the structure or area to be protected as the prevailing, troublesome winds originate. The outside (windward) row must be a minimum

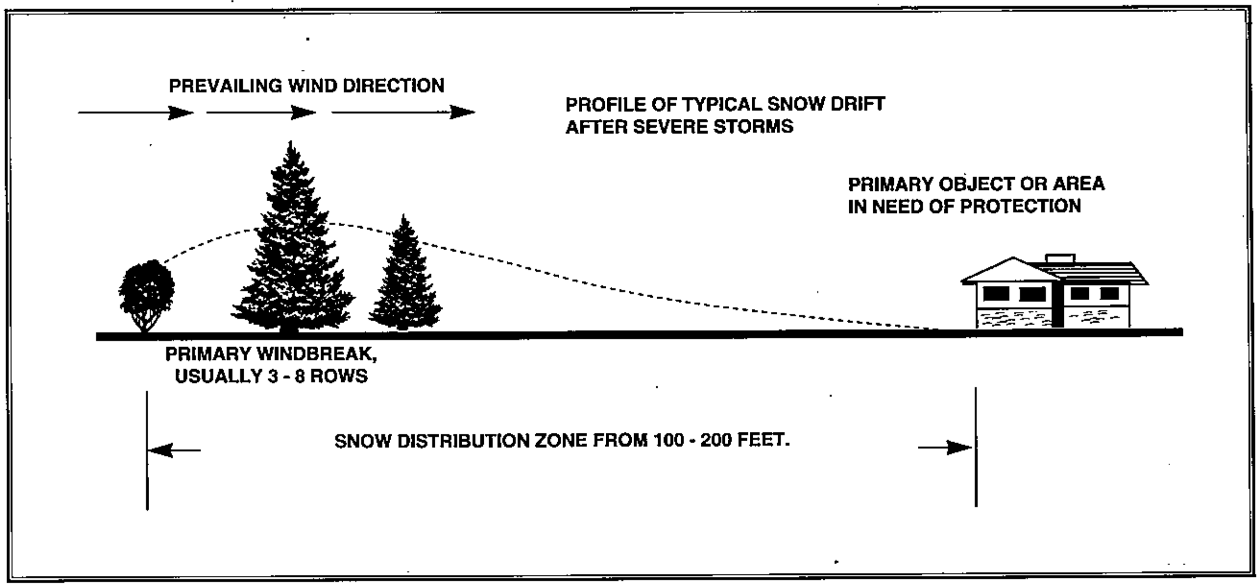


Figure 46
Sufficient space must be provided to store snow that drifts during severe storms. Distances vary from one region to another, but usually range from 100 to 200 feet.

100 feet from the principal area in need of protection (200 feet in heavy snow areas).

All areas needing primary protection should be located within the 2H-5H zone and no further than 10H (10 x height) of the tallest tree row expected at 20 years of age. Estimated 20-year heights for adapted species are listed in Appendix G. Existing access lanes or roads used during winter months in areas subject to severe snow blowing should not cut through a snow-control barrier. Lanes and roads located there are prone to deep snowdrifts. Locate new roads (and relocate existing roads) at least 100 feet from the ends of the windbreak to minimize drifting problems.

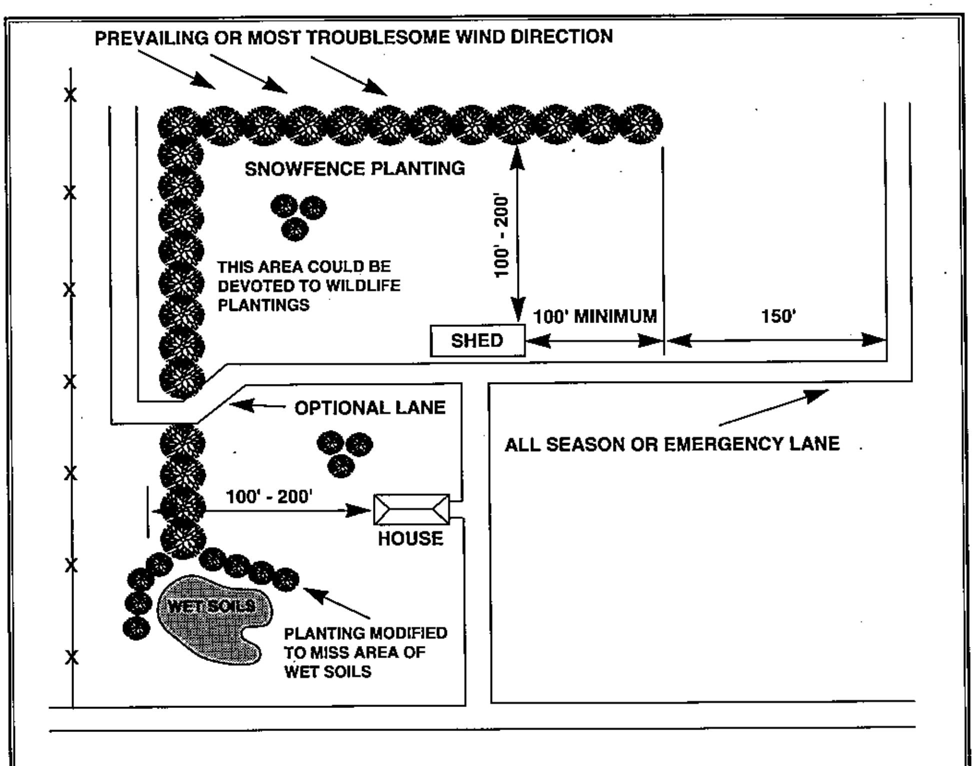


Figure 47
Orientation and location of a living snow fence.

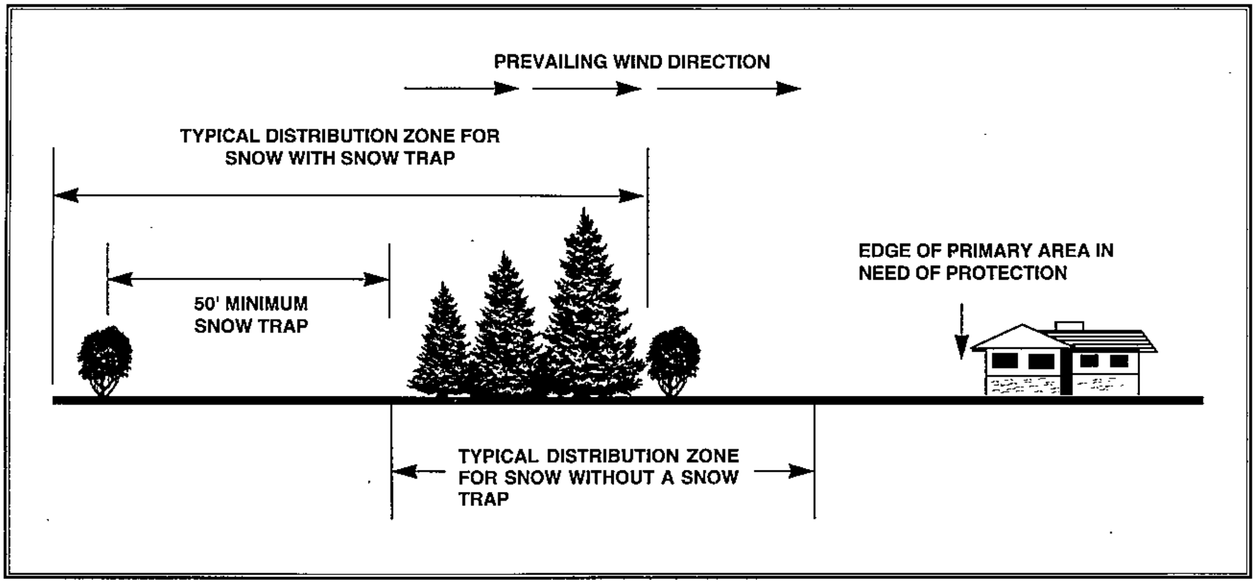


Figure 48
Snow traps significantly change the distribution of snow within and adjacent to snowfence plantings. An additional row of shrubs or conifers can be planted 50 to 60 feet windward of the primary barrier to start the snow trapping effect.

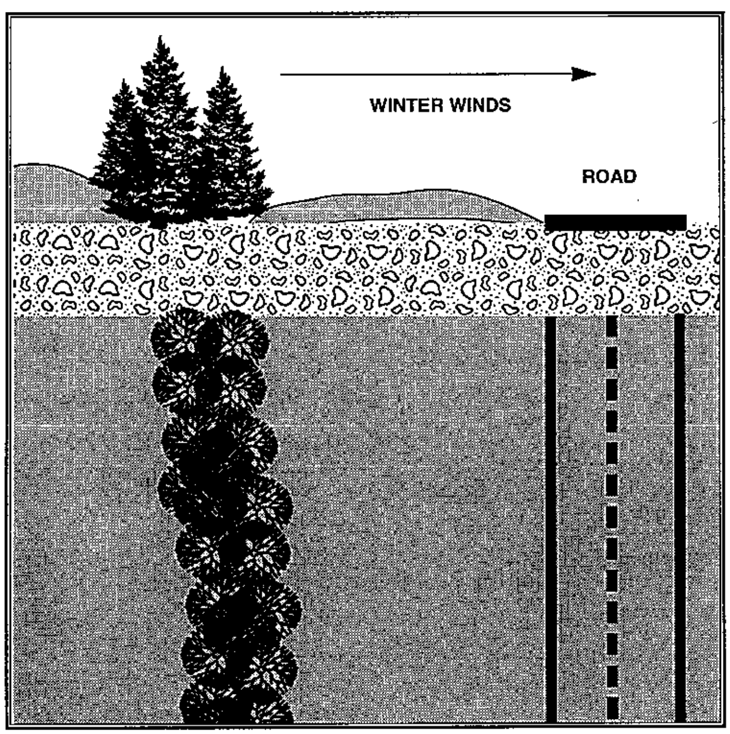
d. Design

•**Number of rows** - Single, multiple or twin-row high-density arrangements are all acceptable depending on available space and the intended degree of snow trapping. Multiple row and twin row-high denisty plantings provide the best overall trapping of snow while providing other benefits.

•**Barrier length** - The length of the snowfence is determined by the area to be protected. Because of the "end effect" of snow drifting (particularly on single-row barriers), the length of the snowfence should extend past either side of the area to be protected by 100 feet.

•**Species composition** - Chapter IV-A identifies trees and shrubs suited for living snowfence plantings.

Figure 49
Windbreak designed to trap snow adjacent to a road.



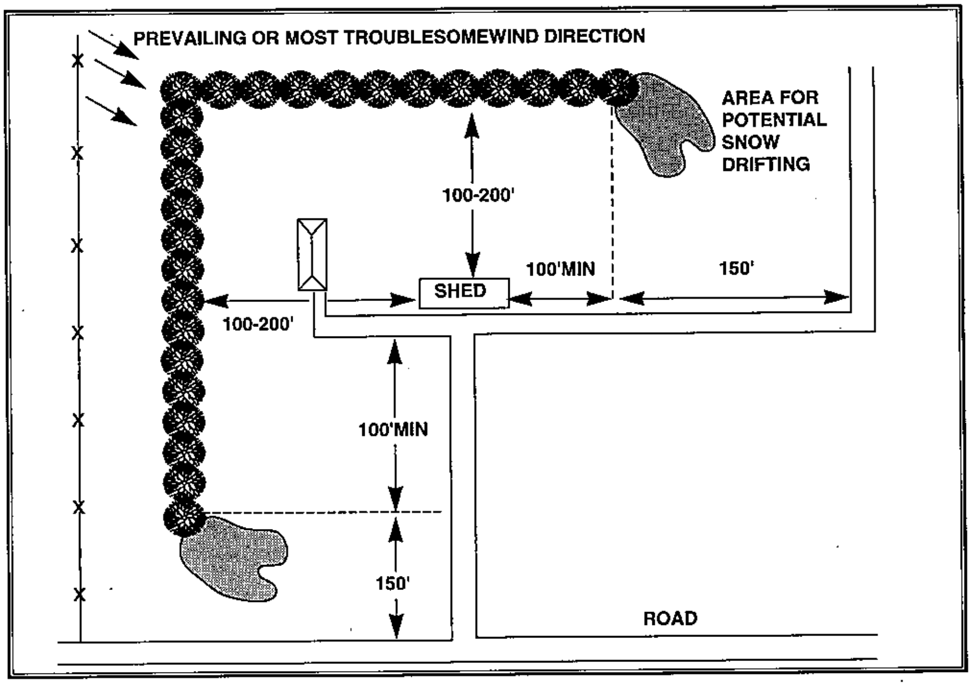


Figure 50
Snowfence planting showing proper length for safe snow deposition.

e. Farmstead protection

Many of the principles of feedlot windbreaks can be carried over to the farmstead by shifting the focus to buildings; however, additional factors need to be considered when planning for farmstead protection.

Planning and design - Windbreaks should be located on the windward side of the area to be protected. For the most effective protection, plant windbreaks on at least two sides of the area to be protected. Extend the planting at least 100 feet beyond the protected area to control wind and drifting snow.

Where space permits, locate windbreaks so there will be at least 2-5 H. distance from the windward row of the windbreak to the building to be protected. If there is a road on the windward side of the windbreak, there should be at least 50 feet between the windbreak and the road. If it is necessary to cross a windbreak with roads, driveways or large ditches, cut crossings at oblique angles to prevent wind from funneling through the planting.

Windbreaks need not be straight, but they should be laid out across the slope or designed to fit the contour of the land to minimize erosion problems.

Layout - Windbreaks should be planned to fit the space available. A five-row planting makes a desirable protective barrier (see Figure 9). Three rows are generally considered to be the minimum necessary for a functional farmstead windbreak.

In a typical windbreak arrangement, a row of shrubs is planted in the windward row. Shrubs 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 an medium-height tree to provide medium-to-high levels of density. The third row is usually composed of a tall, fast-growing tree. Additional interior rows can be planted in long-lived hardwoods or evergreens. Evergreen trees can be planted in any tree row, but there is less problem with snow breakage when planted toward the interior. Slow-growing evergreens or other species should not be placed between other rows of fast-growing species. Evergreens provide year-round density, are very attractive and are among the longest lived species.

If space is limited it is better to have a well-spaced, three-row windbreak than a crowded five-row windbreak. Adequate growing space keeps trees vigorous. Recommended spacings look large at first, but trees grow to fill the space available.

Between-row spacing on dryland and irrigated sites may vary from 16 to 30 feet depending on moisture availability, width of the largest piece of equipment and space requirements of species in adjoining rows. Between-row distances may be narrower on irrigated sites. Spacing between plants within the rows should be three to four feet for most shrubs and about eight to 12 feet for tree species (see Table 8). Mature tree crowns will be larger on irrigated and subirrigated sites, but spacing adjustments are not necessary.

f. Wildlife habitat

All plantings provide wildlife with cover, reproduction areas and food. Figure 9 illustrates the basic components of a good barrier wildlife planting.

Cover - The cover value of row plantings is directly related to the species composition and size of the plantings. Generally, the use of a wider variety of species results in a greater diversification in wildlife species. Windbreaks that contain rows of trees and shrubs, for instance, provide more niches for more species of wildlife than those composed only of tall trees. In particular, low level cover provided by shrubs within 2-3 feet of the ground is very important for a variety of species. The length and width of a windbreak can have an effect on the population of a given species. Width can also have a direct effect on the usefulness of barriers for wildlife. For example, studies have shown that in the northern Great Plains, wide windbreak plantings are more useful to species such as pheasants during severe winter storms. Narrow windbreaks in the same area are prone to severe snow drifting during severe storms, rendering them useless for wildlife.

Landowners who are concerned about the cover value of row plantings can use trees and shrubs of varying heights in large enough numbers to provide adequate cover during critical times of the year. This is especially true in areas that are intensively cropped and where row plantings provide the only significant cover during severe winter and early spring storms.

Figure 51
Use a variety of tree and shrub species with different heights and densities.

Reproduction - To enhance nesting opportunities in row plantings, plant a variety of tree and shrub species. This creates a desirable multistoried effect with a variety of niches for different wildlife species. Increasing the size of a planting; without providing for a greater diversity of habitat, generally increases the numbers of some species and not the numbers of different species.

Food - Some species of trees and shrubs provide food for wildlife. Another way to increase the value of a windbreak is to plant adjacent food plots. Availability of food for most species of wildlife is not a major concern during most of the year. However, food can become scarce during some seasons of the year (often the most critical). Properly designed plantings with food-producing trees and shrubs and food plots with corn, sorghum, sunflowers or millet can help wildlife survive periods of extreme cold and food scarcity.

Enhancing winter wildlife values - In most areas of the country, winter and early spring months are critical for wildlife. Figure 53 illustrates the effect of adding various components to conventional row plantings to enhance wildlife values in areas subject to severe snowstorms. The other illustrations show how the addition of minor components can enhance

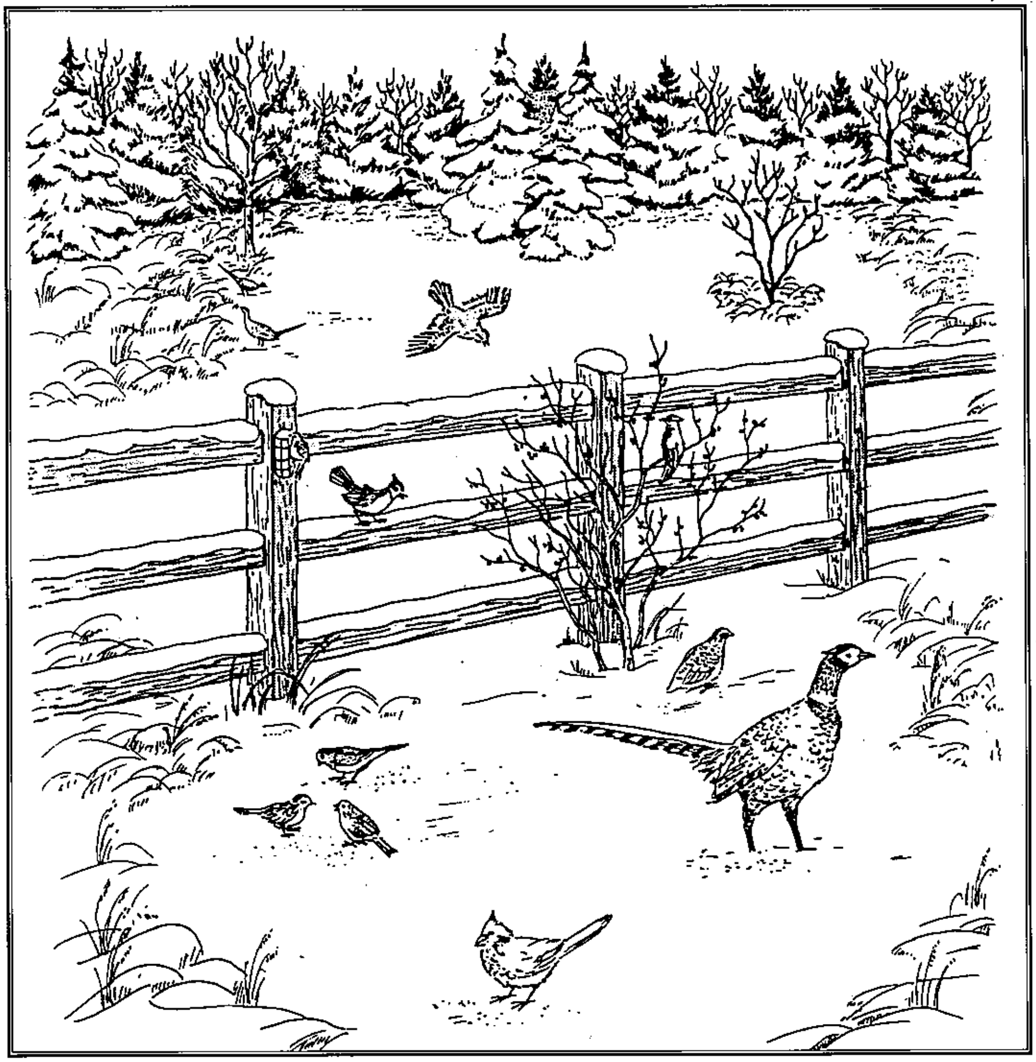


Figure 52
Basic components of a good farmstead, ranch headquarters or residential windbreak provide secondary benefits to wildlife. (Adapted from the Ohio Department of Natural Resources.)

cover and food values. The best design for most areas is represented by the last illustration in Figure 53.

Two alternative methods for enhancing winter wildlife habitat values are illustrated in Figure 54. Both are based on the principles illustrated in Figure 53. The alternatives apply to farmstead, feedlot, ranch headquarters or residential plantings. These types of plantings, although designed for areas with severe snowstorms, also significantly enhance wildlife benefits in more moderate areas.

Both alternatives in Figure 54 enhance wildlife values. Alternative 1 is the least expensive and the easiest to establish and maintain. Alternative 2 offers more opportunities to incorporate landscaping principles into the design to improve appearance. It also provides a greater opportunity to use a wider variety of trees and shrubs.

Feedlot and livestock windbreaks provide cover and food for a wide variety of wildlife. Often by making minor adjustments in the basic design, significant increases can be made in wildlife values. Although wildlife values can be enhanced during all seasons, feedlot and livestock windbreaks can provide meaningful cover during critical climatic events (storms). Figure 55 illustrates an option for enhancing wildlife values in feedlot areas subject to severe winter and early spring storms.

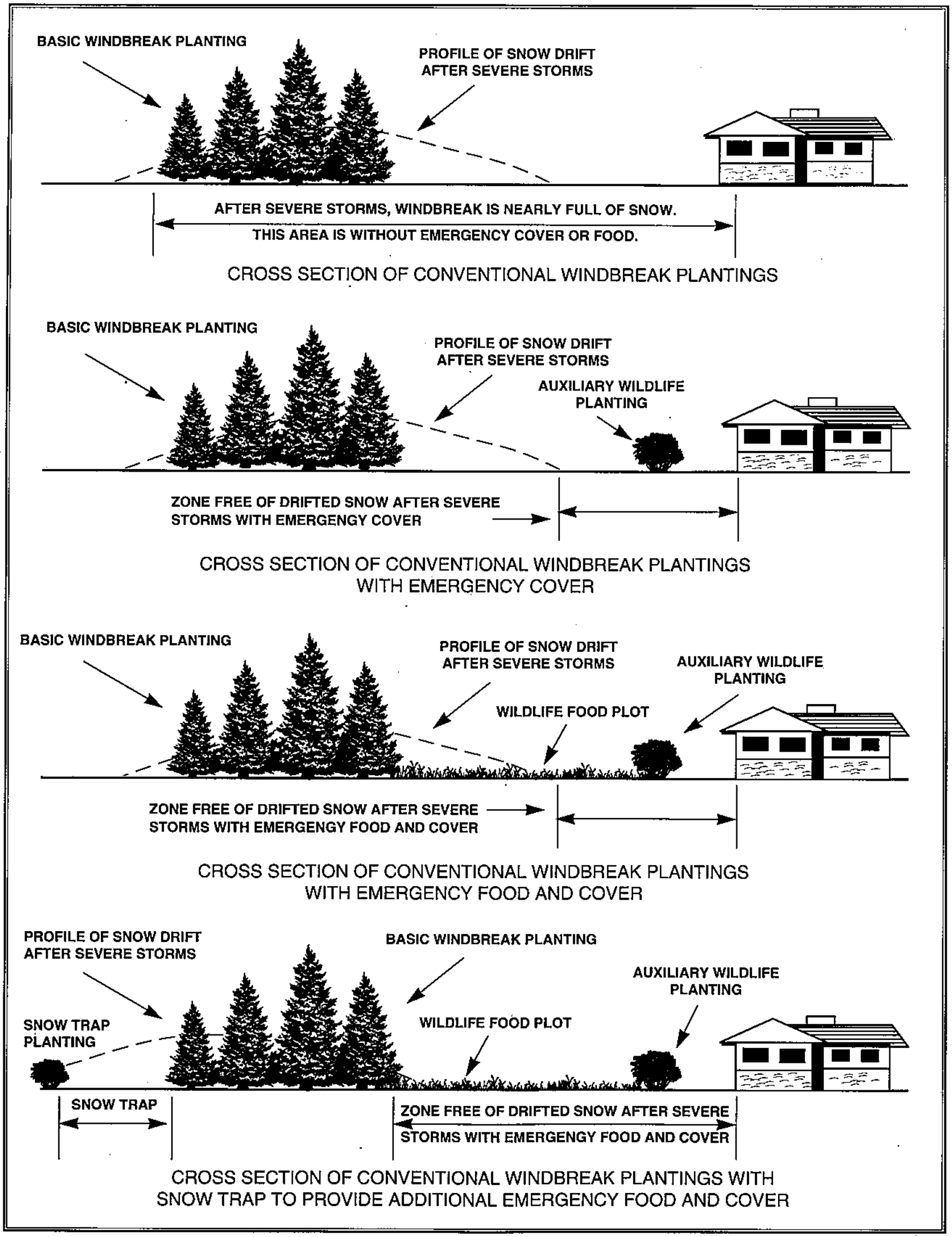


Figure 53
Windbreaks enhance winter wildlife values.

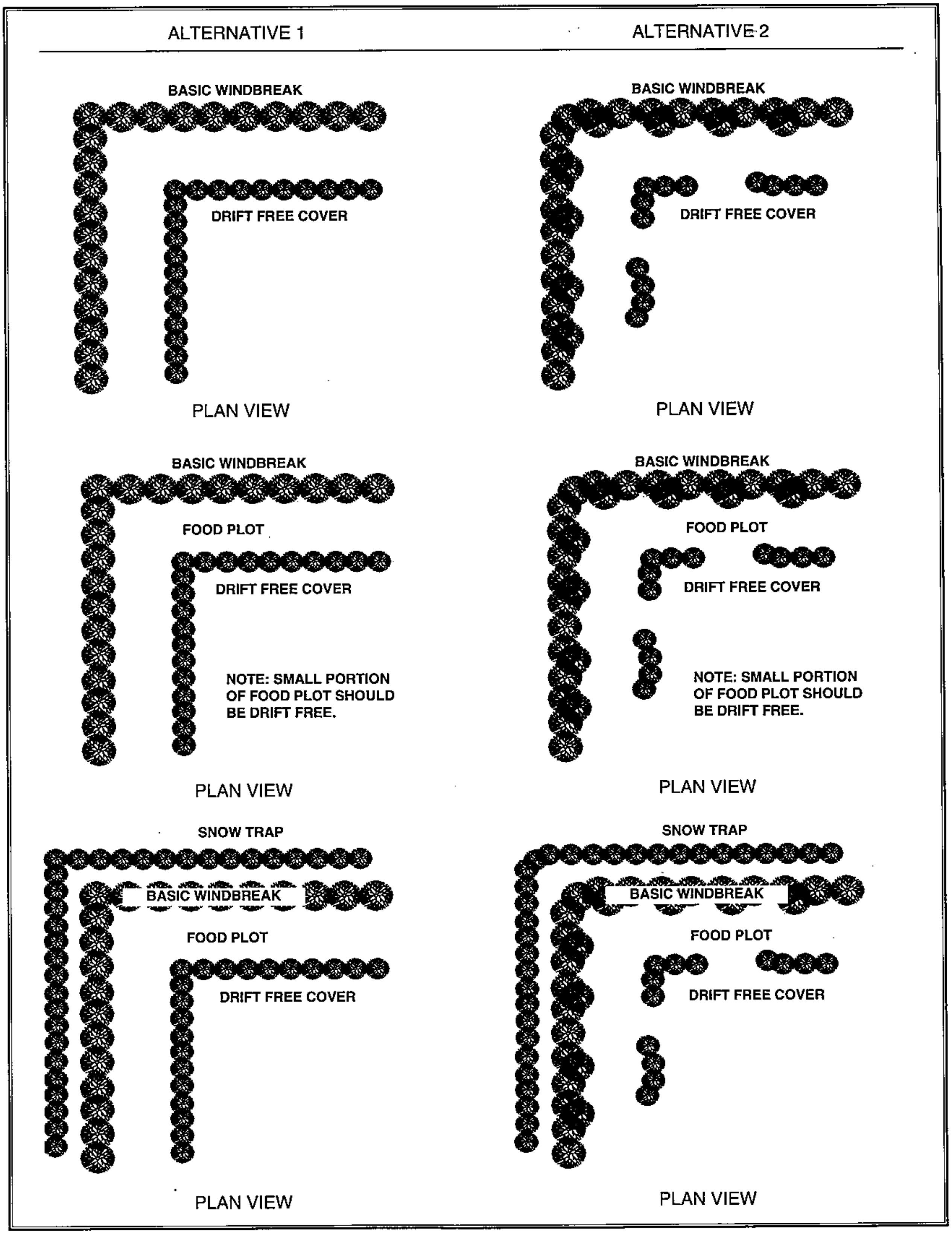


Figure 54
Alternatives for accomplishing principles illustrated in Figure 53.

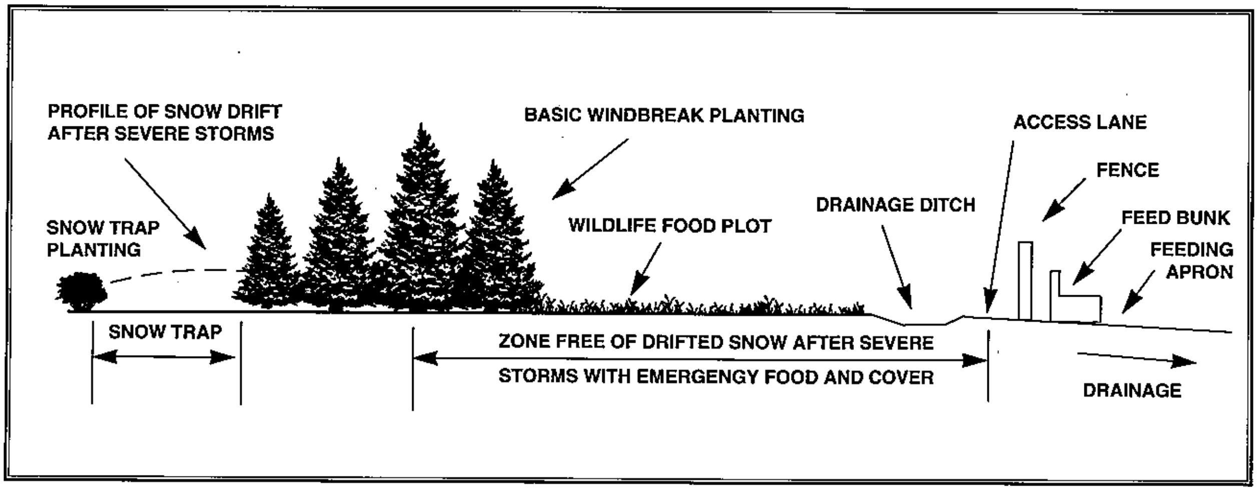


Figure 55
To enhance winter wildlife values of feedlot windbreaks, add extra rows to a conventional planting.

B. Block-type plantings: Christmas trees, fuelwood and ornamentals

Growers and service foresters should consider all facets of planned operations in the design process so management tasks can be accomplished as easily as possible.

1. Land available

An initial decision, regardless of the intended product, involves the total area the landowner is willing to dedicate to the endeavor. In the instance of Christmas trees, a rotation period must be determined. The rotation period, or production cycle, is simply the period of time required to grow a marketable product.

An eight-to-10-year rotation is normally adequate to grow marketable Christmas trees in the Great Basin. This allows for tree growth, management activities, site maintenance and site preparation. In this simple but realistic example, a farmer wishing to devote 10 acres to Christmas tree production should divide the plantation into 10 planting units and plant one unit per year. At year eight or nine, unit one will be ready for harvest. It takes one rotation period before any income is realized. However, after the initial rotation period, one unit will be available for harvest annually.

Plan adequate space to allow for cultural, maintenance and harvesting activities within each unit. Normally 5-10 percent of each planting unit should be devoted to access lanes.

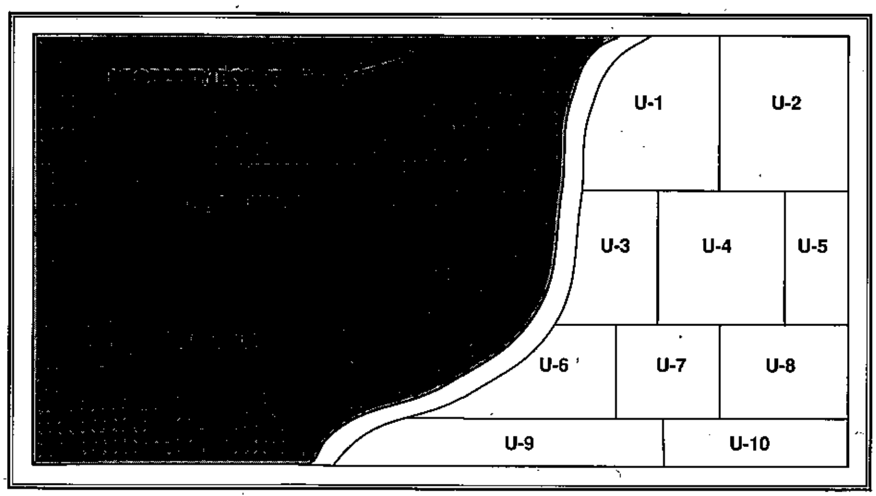


Figure 56
Christmas tree plantations and wood lots should be managed on the basis of an established production cycle or rotation. The total area available is divided into approximately equal management units roughly equivalent to the rotation period.

2. Site selection factors and special consideration

Like any other crop, trees do best on fertile sites. From the standpoint of site quality, trees generally perform better over a wider latitude of sites then will most row crops such as corn; however, in the Great Basin critical factors include water and soil pH.

Accessibility - It is essential that the plantation be accessible during late fall and early winter months. Road development is expensive, so locate plantations close to existing surfaced or graveled roads. An adequate network of access lanes throughout a plantation is necessary for cultural activities and product removal. Management lanes should have a permanent dedication of space. They can be provided by skipping the planting of two adjacent rows (about 20 feet) every 300-400 feet.

Topography - A level site is ideal because it facilitates maintenance and management functions such as irrigation, pruning and planting; however, sloping topography can be used as long as the slopes influence on the means of irrigation, weed control, harvesting and other activities are accounted for in the design process.

In general, be aware of frost pockets such as high-elevation valley bottoms and other areas of poor air drainage. Late spring frosts can damage developing growth and leaders on some species. Poorly drained areas and areas subject to frequent flooding are not well-suited to conifers, while some hardwood species can withstand high water tables and standing water for short durations.

Soil alkalinity - Most soils in the Great Basin have a pH range of about 7.0 to 8.5. Conifers do best in soils that are neutral (pH-7) to slightly acidic (pH 5.5 to 7). Hardwoods will tolerate slightly alkaline (pH 7 to 8.5) soils. Avoid sites with a pH over 8.5.

Soil type - Conifers are best adapted to well drained soils. Sandy to rocky silt loans are ideal. Christmas trees can be planted in sandy soils but will require more frequent watering. Avoid heavy clay loams and clay soils for conifer plantations if possible. However, hardwoods are suited to heavier, more poorly drained soils. The organic content of soils can be improved by plowing in woodchips, leaves, sawdust, straw, manure, sludge or similar materials. This may lower available nitrogen and require applications of supplemental fertilizers. Improvements in the organic content of the soil increase permeability and water-holding capacity. They may also lower alkalinity (a long-term proposition) and leach toxic salts.

Soil fertility - While soils in the Great Basin are normally sufficiently fertile to supply minimum tree nutrients needs, there may be instances in which nutrients are lacking. Nitrogen is not a generic remedy. Although available nitrogen may be lacking, symptoms may indicate other deficiencies. Often times a symptom, such as chlorosis, represents several problems. It is a good idea to get a comprehensive soil nutrient analysis before you doctor your soil.

Past use - Weeds, Insects and Disease - Past use may necessitate insect, disease and weed management. If you plan to market live nursery products, weeds, insects and disease can cause problems in obtaining agricultural permits for interstate and intrastate shipments.

Supplemental watering - In the Great Basin a major consideration in site selection, development and plantation establishment is the availability and delivery of water. If the average annual rainfall is less than 12", plan on irrigating. Generally, you must provide a supplemental source of water between May and September to ensure plantation establishment and optimum performance in the Great Basin. This is the driest period in Nevada and Utah.

There are three primary water delivery systems available: furrow, sprinkle and trickle. To select one, evaluate the pros and cons of each.

For instance:

Furrow irrigation requires a plentiful source of water, needs relatively flat terrain, usually includes odd water turn (use) hours, can be extremely inefficient, can introduce sources of weed seed and requires maintenance of ditches. It is relatively inexpensive to install and involves digging ditches between each or every other row of trees.

Sprinkle irrigation simulates rainfall. Water is sprayed into the air and allowed to fall to the ground in a uniform pattern at a rate approximately equal to the rate that it will be absorbed by the soil. Sprinkler systems can be mechanically simple or complex—the price tag varies accordingly. Sprinkler systems are water efficient and provide the opportunity to move to sites on sloping topography.

Trickle irrigation, commonly referred to as drip irrigation, is the slow but steady application of water to the soil through mechanical outlets. The objective is to provide each tree with just enough water to meet evapo-transpiration needs. This is the most efficient system available. Material costs run $1.50 to $2 per tree. Where water is in short supply or is expensive, savings in water costs can offset the cost of system materials. Although terrain is less of an obstacle, planting, maintenance and mechanized activities can damage a trickle system if it is not properly installed.

3. Spacing

Spacing involves two principal measurements: Within-row spacing is the distance between trees within the row; between-row spacing is the distance between rows of trees.

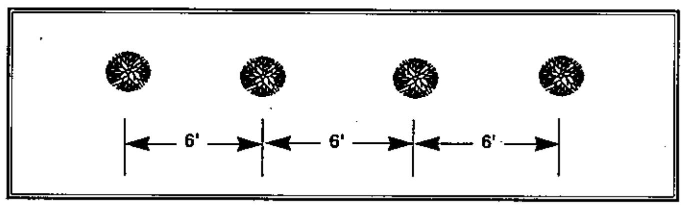


Figure 57
Within-row spacing.

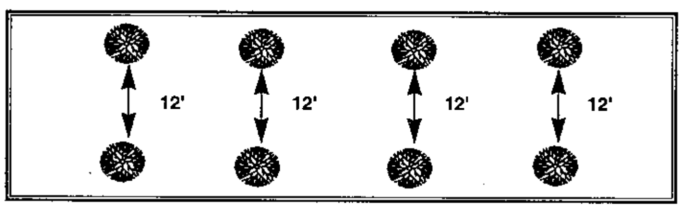


Figure 58
Between-row spacing.

If you intend to remove plantation products periodically, your site must be readily accessible to machinery used for cultural, maintenance and harvesting activities.

One Colorado grower recommends eight-foot spacing between and within rows. He states, "It's a shame to plant trees on five- or six-foot centers only to find out you need to buy a special machine to mow between rows when a machine you already have would work on an eight- or nine-foot center."

On Christmas tree plantations, for example, a six-foot tree will take up four feet at the base. When planning within- and between-row spacing it is important to consider:

- End products to be grown.
- Intermediate products removal before the end of the rotation.
- Size of tractors, disks and mowers—add four feet to the width of the widest piece of equipment used to determine minimum between-row spacing.
- Access needs for cultural practices and the removal of either waste materials or intermediate products.

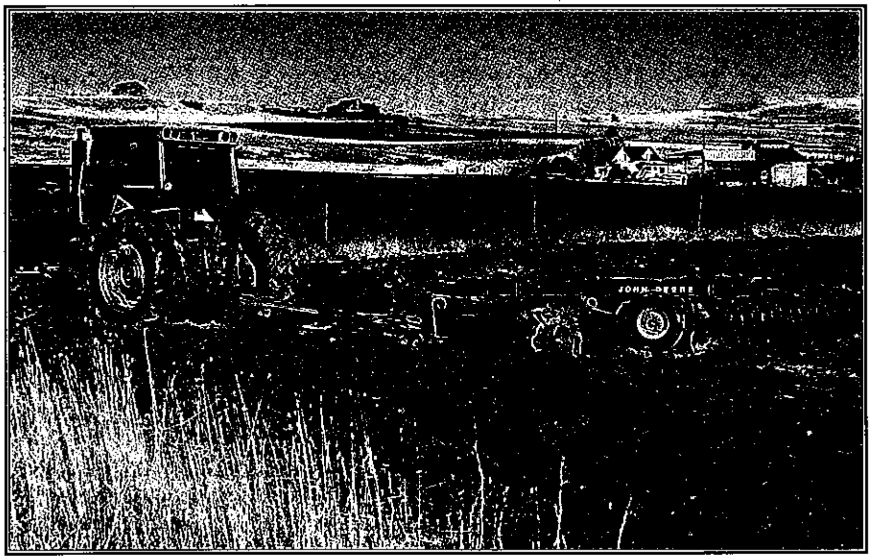


Figure 59
Tractor-mounted mowers, rotovators, sprayers and cultivators are common pieces of equipment used to control competing vegetation and pests.

Table 10. Potential spacing combinations.

Spacing Between rows	Spacing Within rows	Trees Per Acre
6 feet	6 feet	1,210
8 feet	8 feet	680
8 feet	4 feet*	1,361
9 feet	9 feet	537
10 feet	10 feet	435
10 feet	5 feet*	871
12 feet	12 feet	302
12 feet	6 feet	605

*Halving within row spacing allows for removal of intermediate but smaller sized products such as balled and burlapped trees for the ornamental market.

4. Species

Refer to Chapter IV, and appendix H., for species suitability and descriptions.

C. Reforestation

1. Initial considerations

Evaluation and planning are essential in reforesting harvested or other non-stocked lands. Soil moisture, type, condition, texture and pH should be evaluated. Most trees grow well on medium-textured soils. Broadleaf trees usually grow well in heavy (clay) soils and conifers usually grow well in medium (loams) or light (sands) soils. Most trees grow best in slightly acidic soils with a pH range of 5.5 to 6.5. Certain species grow well in soils with pH values both higher or lower.

Existing vegetation (trees, shrubs, forbs and grass) needs to be understood in planning to reforest an area. In mountainous regions of central and northern Utah, forest habitat types have been identified. A habitat type is all land capable of producing similar plant communities at climax, though the concept does not mean that reforestation should be directed at climax tree species. White Fir/Oregon Grape is a major habitat type for example in the forested mountains of central and southern

Utah. Information about this habitat type will help in planning reforestation projects. Because of loamy, silt clay soils and cool, dry mid slopes in the 7,300 to 9,600 foot elevation range, Douglas-fir is well suited for many reforestation projects in Utah.

2. Site evaluation

Successful reforestation requires careful consideration of a site's physical and environmental factors to promote seedling survival and establishment.

Planting site description - Site descriptions include characteristics of the habitat type or vegetation, climate, soil, topography, seed source (if seed is to be collected on or near the site), animals, disease and insects that will influence reforestation. A suggested format for collecting and recording site-description data is found in the Appendix.

To prepare the site description, survey the area and divide it into units with similar characteristics, such as slope, soil type or site-preparation needs. Identify questionable and unplantable units within the total area. Soil Conservation Service soil survey descriptions and maps may be helpful in stratifying sites into units.

Seedling environment - Seedling environment includes moisture, temperature, light, nutrients and physical influences. These five variables provide the on-site differences to which seedlings respond. A brief discussion of each variable will help in interpreting the seedling environment.

Moisture - A seedling's roots absorb water and its shoot and foliage lose water. The rate of these processes is the plant's water balance expressed as plant moisture stress (PMS). Wind speed, leaf temperature, soil temperature and stomatal resistance directly influence water balance in this complex interaction. Plant moisture stress is a good indicator of water balance. It is easily measured in the field or laboratory.

Temperature - A seedling's physiological processes, such as photosynthesis and respiration, are temperature dependent. Temperature and PMS are interdependent. PMS tends to increase with temperature. In turn, as moisture becomes limiting, seedling temperature increases because there is less transpirational cooling. An understanding of optimum temperature range and PMS levels can indicate net photosynthesis (roughly equivalent to growth). For example, optimum temperature for net photosynthesis in Ponderosa pine occurs between 69 and 81 degrees F at 10 bars of PMS or less. In the field, optimum growth days in terms of temperature and PMS have been correlated with the growth rate of seedlings or site productivity. Temperature extremes can physically damage or kill seedlings. Freezing air temperatures may cause frost damage if seedlings are not hardy, and soil surface temperatures above about 130 degrees F may cause physical damage.

Light - Seedlings respond differently to intensity, quality and duration of light. Variation in light quality (amount of different wavelengths or colors) influence a plant's physiological processes, but natural light quality variation does not affect seedling growth significantly. Increases in light intensity usually improve seedling vigor and growth. For example, conifer leader elongation usually increases as light intensity increases. Of course, full or intense sunlight often damages or kills young shade-tolerant or medium-tolerant species. Day length in Great Basin climes is not a significant factor.

Nutrients - Nutrient availability for seedling survival and establishment is not a significantly limiting factor on otherwise favorable planting sites.

Physical influences - Damaging agents include vegetation, people, insects, animals, ice, snow, falling litter and movement of rocks, soil and other debris. In planting plans, recognition and abatement of damaging agents are important considerations.

Control over light and temperature is virtually impossible; however, landowners have limited influence over moisture, nutrient, and to a greater extent, the physical influences depending upon available resources.

Figure 60.
Suggested format for estimating and recording conditions in the seedling environment.

COMPONENTS OF SEEDLING ENVIRONMENT	SITE CHARACTERISTICS AFFECTING SEEDLING ENVIRONMENT	OVERALL RATING OF IMPACT ON SEEDLING SURVIVAL• AND GROWTH#
MOISTURE	Capacity •Soil depth •Rockiness •Soil type •Precipitation: amount, type and timing	
	Demand •Competing vegetation: amount and type •Temperature •Wind	
TEMPERATURE	Average Extremes Slope Aspect Elevation Vegetation: type and amount	
LIGHT	Vegetation •Density •Height Aspect	
NUTRIENTS	Soil depth Limiting conditions	
PHYSICAL DAMAGE	Vegetation Animals Insects Disease Fire potential Snow or ice Erosion	
POTENTIAL PROBLEMS:	Vegetation Animals Disease Insects	

• Specify extreme environmental conditions likely to affect seedling survival. Note conditions contributing to extremes.
Rate the average growing conditions for each component by its level or intensity: excellent, average or poor.

3. Operational constraints

Operational constraints imposed by site characteristics are apparent. Moisture and temperature extremes, high erosion potential or patterns of land use may constrain tree species, site preparation or seedling protection. Other conditions may limit access to the site, planting method and planting density.

Operational constraints should be considered when costing and timing the job. For example, if deer damage is expected to be low but could be high, note the risk and keep contingency plans in mind.

Figure 61.
Suggested format for listing operational constraints.

Operational constraints

Logging restrictions: ______________________

Site preparation: ______________________

Plantability: ______________________

Erosion: ______________________

Other (aesthetics, land use patterns) ______________________

Administrative constraints ______________________

4. Prescribing operations

The steps above provide information to devise a reforestation prescription. It may, however, that some information is missing and needs to be obtained before making prescription decisions.

A single prescription will apply to each homogeneous strata in the planting area. Environmental and operational differences will help stratify larger planting areas.

5. Planting stock

With a planting prescription completed, the tree species, seed source, seedling size and age are known. Ideally, tree seed is collected from superior trees within the transfer zone for the species. The transfer zone is defined within certain distance and elevational limits from the planting site. Seed collection will not be practical for many private and some public land plantings. Thus, seedlings grown from seed collected as near the transfer zone as possible is recommended. Sources of bareroot and containerized stock can be found in Appendix F.

Figure 62.
Suggested format for collecting and recording site description data.

VEGETATION									
HABITAT TYPE	**TREES**			**BRUSH AND GRASSES**					
Species									
Percent composition									
Percent overstory									
Age									
Size									
Productivity									
(BA,VOL,SI)									

SOIL	
Parent material	
Texture (sand, silt, clay, organic matter, etc.)	
Depth	
Rock content	
BIOTIC	
Animals	
Disease	
Insects	
SEED SOURCE	
Zone	
Availability	
TOPOGRAPHY	
Slope	
Aspect	
Elevation	
Major features	
CLIMATE	
Precipitation	
Temperature	
Snowpack	
Growing season	
ACCESS	
Roads	
Timing (weather, other operations)	

6. Spacing

Seedlings must be ordered in advance, especially if many thousands of seedlings are required. The numbers of seedlings required per acre depends upon the spacing specified in the prescription. Stocking levels of less than 1,000 seedlings per acre require a spacing range of from 7' X 7' to 11' x 11' and are usually adequate to stock most Great Basin and Central Rocky Mountain forest lands. A spacing of 11' x 11' allows for establishment of about 300 trees per acre if loss is no greater than 15 percent. This also allows for thinning to remove smaller and deformed trees and latter reduction of stocking to 200 trees per acre in larger, saleable or at least multiple-value sizes. Planting at wider spacing and interplanting of seedlings among established native seedlings is often done at lower cost. Table 10 provides a reference for the number of seedlings needed per acre at a selection of spacing intervals.

D. Mass-type plantings

1. General considerations

a. Planning tree and shrub masses

Mass plantings are considered for any of the eight types discussed in Chapter II (roadside, erosion control, wildlife, aesthetic, buffer, disturbed area, streambank and utility). Planning variations are limited among mass-type plantings even though the function and purpose of different plantings may vary widely.

In approaching the design, it is important to clearly state the purpose and function of the planting. For example, a roadside mass planting may serve the following purposes in a number of locations. Clearly stated purposes could be:

- Reduce glare from oncoming traffic.
- Break motorist vision monotony.
- Focus motorist vision for safety or aesthetic reasons.
- Delineate or screen views.

Function is stated in terms of the configuration and makeup of the planting as it serves a purpose. Thus the shape, area and tree and shrub mix are designed to serve stated purposes. These simple steps are often overlooked in designing areas for mass plantings when the emphasis has been solely on limiting or other important factors. For example, it is important to select environmentally suitable species, but knowing which of these species functions best to serve the intended purpose is also important. In an aesthetic roadside mass planting designed to draw attention, a background of blue spruce and a foreground of white fir would be far more striking than a grove of blue spruce only.

A third simple planning device is to use the landscape architects tool of "bubble diagrams" to tentatively locate and map mass planting areas in the project area. Purpose and function statements can be written on the diagram beside the selected areas. "Bubbles" that include all types of vegetation in early phases of project planning insure that space for trees and shrubs will be planned and not included as an afterthought.

b. Mass-planting design

A variety of mass-planting designs are possible. Common to all of these are a number of considerations. A first consideration in design is that energy in several forms must be concentrated on the area to be planted and maintained. Energy in the form of evaluating, preparing,

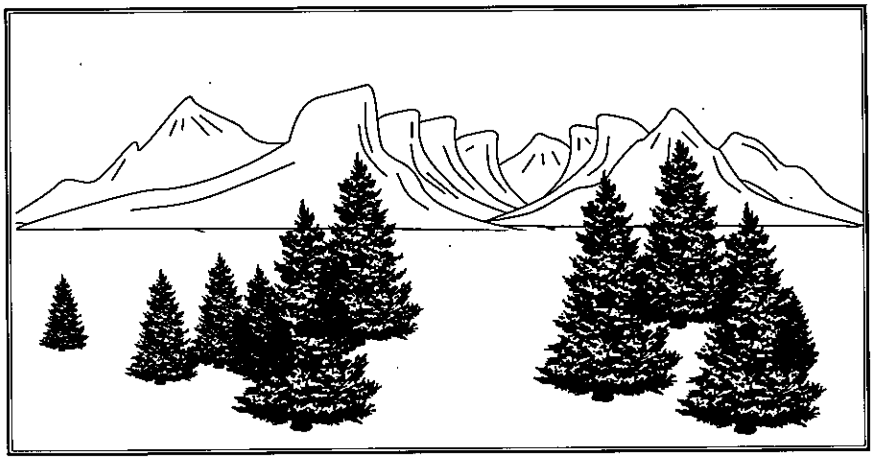


Figure 63
Landscaping with mass plantings to frame a view. Note how one's attention is drawn to the area between the plantings.

planting and maintaining sites for mass plantings must be significantly greater than block or row plantings.

In a project, the best soils, slopes and aspects are the best mass-planting prospects, especially where little tillage, amendment or adequate irrigation is possible. An ideal soil consisting of 50 percent solids - mineral and organic matter - is not typical of most Utah and Nevada rural and wildland areas, but they are found in some prime lowland and streamside areas. Ideal or near ideal soils in terms of volume, texture and structure can hold and make available essential elements required to sustain crowded plants above ground and competing root systems below ground. Where site modification is not possible, the most naturally productive sites should be reserved for massing of plants.

2. Streambank plantings

Woody plants, grasses and forbes can be used in streambank plantings. Most areas disturbed by construction should be planted in grass to provide immediate groundcover. Woody plants can be interplanted into the area.

a. Guidelines

Streambank preparation - Where the area has been disturbed by construction, leave slopes no steeper than 2:1 and preferably 3:1 or flatter. Prepare the best seedbed practical under existing conditions. Where possible, preplan construction to stockpile topsoil for replacement on the area to be planted. A conventional seedbed as used for hay or pasture planting should be specified where ever possible.

Species - Moisture conditions on streambanks may vary from very wet near the shoreline to very arid on the upper portions of the bank. Streambank plantings on live streams usually require the use of water-loving species near the shoreline. The bank above the area affected by beneficial moisture from the stream may require the use of drought-tolerant species. Most plantings will require a mixture of species.

Mulching - Mulch all seedlings on slopes of 3:1 or steeper. Mulching will be beneficial on all seedlings regardless of slopes.

Irrigation - Where feasible, irrigate as needed until plants are well established.

b. Suggested species

Generally, species native to the area will be superior to exotic or introduced species. Usually shrubs are preferred over trees as they stay anchored better and cause less altering of streamflow characteristics. Plants that spread by root sprouts are best.

Shoreline areas	
Redosier dogwood	Root sprouting shrub
Willow species	Root sprouting shrub
Snowberry	Root sprouting shrub
Areas above shoreline affected by stream moisture	
Chokecherry	Root sprouting shrub
American plum	Root sprouting shrub
Buffaloberry	Root sprouting shrub
Siberian crabapple	Small tree
Golden willow	Tall tree
Cottonwoods or poplar	Tall tree
Green ash	Tall tree
Dry upper bank areas	
Atriplex species	
Quailbush	Native shrub - salt tolerant
Fourwing saltbush	
Buffaloberry	Root sprouting shrub
Desert willow	Root sprouting native shrub - Southern Nevada and southern Utah only
Pomegranate	shrub or small tree - Southern Nevada, Central and southern Utah
Russian olive	Small tree
Black locust	Medium tree
Skunkbush sumac	Native shrub
Coyote willow	Native shrub

c. Planting

Coordinate completion of any construction activities with recommended planting dates. In some instances it may be necessary to plant a cover of small grain or sudangrass for temporary site protection until the proper time for planting the permanent species arrives.

Use rooted cuttings, container grown plants or bare root seedlings. Containerized plants have the best survival rate.

Stagger plants to provide even cover. Space shoreline shrubs about 2 x 2 feet, other shrubs 3 x 3 feet, small trees 4 x 4 feet and tall trees 6 x 6 feet. Plant tall trees at least 12 feet from the stream bank, and follow standard procedures for the care of seedling stock and planting of woody plants.

d. Irrigation

If feasible, irrigate as needed to establish the plants. Do not use species that require continued irrigation for maintenance except in special situations where justified.

e. Establishment

Replant dead seedlings at the beginning of the second season. Do not prune, except for those species where clipping promotes spreading.

Maintain fencing to protect seedlings from livestock and provide fire protection.

3. Buffer plantings

Noise pollution, which can be described as any excessive or unwanted sound, is an increasing problem especially in the urban setting. Noise, sometimes referred to as invisible pollution, arises from a number of sources:

Transportation - Including cars, trucks, aircraft and emergency vehicles. These are usually associated with traffic areas such as highways, airports and railroads.

Recreation - Including swimming pools, ball fields, playgrounds, snowmobiles and boats.

Commercial areas - Shopping centers, manufacturing plants, warehouses and industrial areas.

Residential areas - Lawnmowers, radios and loud human noises.

Studies have shown that as noise levels increase, the amount of stress and anxiety among individuals increases and tends to reduce productivity over a period of time. Reducing noise pollution by planting buffers helps minimize stress associated with living in an urban environment. Buffers can improve health, happiness and quality of life.

a. Controlling sound

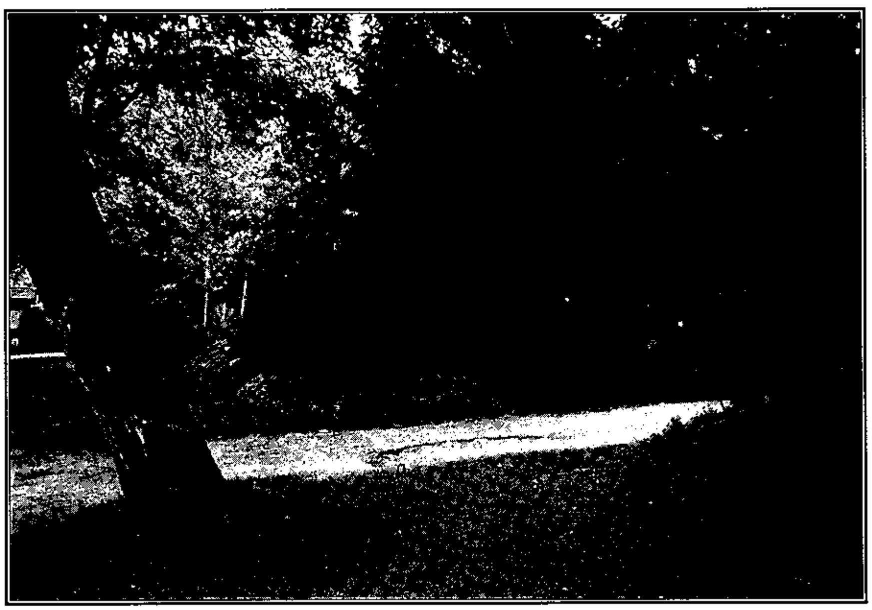


Figure 64
A noise screen in Logan, Utah.

Sound energy usually spreads out from the source and never returns. Means of controlling sound include absorption, reflection, deflection and refraction. The use of vegetative noise barriers either alone or in conjunction with other techniques can be useful in controlling sound. Weather can also be a factor. High humidity, wind and temperature gradients contribute to sound reduction.

Absorption of sound takes place when an element, such as a plant, receives the sound waves, traps them and converts them into other energy forms. Deflection and reflection cause sound to be bounced away. Deflection causes a noise to be bounced to a less offensive area whereas reflection causes sound to be bounced back to the source. Refraction occurs when sound is dissipated, diffused or dispersed after it strikes a rough or moving surface.

b. Plants as noise screens

Trees and shrubs are an integral part of the ecosystem. They modify the microclimate around them through evapo-transpiration and by stabilizing wind and temperature gradients in a wooded setting as compared to an open field.

Trees and shrubs also absorb sound waves with their leaves and branches. Light, flexible panels that vibrate easily can absorb sound by converting the energy to other forms. Likewise a plant having thick fleshy leaves with thin petioles is an effective sound absorber. One of the better sound absorbers is a dense grass cover. However, sound tends to rise from a given source away from grass surfaces. Trees deflect and refract sound with their heavier branches, trunks and irregular bark surfaces. These larger plants can be used in conjunction with a grass cover to deflect the rising sound down to the more absorbent grass.

Plants are effective in screening sound frequencies that impact the human ear. A well-designed noise screen composed of trees, shrubs, and grass can reduce the measurable sound level by 5-10 decibels, an amount which reduces audible noise levels by 50 percent.

c. Design

Layout and design of noise barriers is based on site factors and planning objectives. Some things to remember when designing a noise screen are:

- Grass should be used in conjunction with trees and shrubs. Grass is a good sound absorber, but because it lacks height, it doesn't receive a great deal of sound waves. Trees and shrubs can be used for deflection and reflection of sound down to the grass. Trees and shrubs can also absorb some sounds.
- Put noise barriers as close to the noise source as possible. The quicker sound waves are deflected the greater the noise reduction. If the noise barrier is established to reduce noises from a busy highway, place the vegetation as close to the highway as possible. It's best to allow at least 100 feet between the source of the noise and the receiver.
- The use of well-defined rows are not needed although they make maintenance of the planting easier. If row plantings are used for noise reduction, use at least a three-row planting, and use the narrowest row-to-row spacing possible (12-16 feet). Planting widths of 60-100 feet are most effective.
- The use of grass-covered berms in conjunction with vegetation is very effective in the reduction of noise.
- Deciduous trees are relatively ineffective in a noise barrier planting during winter months. Year-round effectiveness is greater when evergreens are used.
- Plant shrubs on the source side of the planting.
- Center trees should have a mature height of least 45 feet.
- Planting length should equal two times the distance from the source to the receiver and extend an equal distance on each side of the receiver area.

After design, the selection of species can begin. The species can be matched to the site based on characteristics and growth requirements. A diversity of trees, shrubs and grasses should be used for noise barriers. Consultation with local extension agents may offer insight on recommendations for grass species.