NATURAL RESOURCES CONSERVATION SERVICE
CONSERVATION PRACTICE STANDARD

WINDBREAK/SHELTERBELT ESTABLISHMENT

(Feet)

CODE 380

DEFINITION

Linear plantings of multiple rows of trees or shrubs established for environmental purposes.

PURPOSES

* Reduce soil losses from wind erosion.

* Protect growing plants.

* Manage snow deposition.

* Provide shelter for structures, wildlife livestock and people.

* Enhance wildlife habitat by providing travel corridors linking existing habitat.

* Provide noise or visual screens.

* Improve air quality by intercepting air borne particulate matter, chemicals and odors.

* Delineate property and field boundaries.

CONDITIONS WHERE PRACTICE APPLIES

On any area where woody plants are desired and can be grown and where wind, noise, air quality, or visual problems are a concern.

CRITERIA

General Criteria Applicable to All Purposes

The location, layout, and density of the planting will accomplish the purpose and function intended within a 20-year period.

The design height (H) for the system shall be the expected height of the tallest row of trees or shrubs at age 20 for the site.
Species must be suitable and adapted to the soils, climate, and purpose.

Site preparation shall be sufficient for establishment and growth of selected species and appropriate for the site.

Only viable, high quality and adapted planting stock will be used.

Multiple species, within rows, may be used if heights and growth forms are similar.

The planting shall be done at a time and manner to ensure survival and growth of selected species.

The planting will be protected from livestock grazing and fire.

Trees and/or shrubs will not be planted where they will interfere with structures and/or above or below ground utilities. Woody plants will be established without compromising the integrity of property lines, fences, utilities, roads, legal drains, easements, or rights of way. Call Iowa One Call for underground utility clearance.

Moisture conservation or supplemental watering shall be provided for plant establishment and growth where natural precipitation is too low for the selected species.

Spacing between individual plants shall be based on the needed growing space for plant type and species, the accommodation of maintenance equipment, and the desired characteristics of the stem(s), branches, and canopy as required for a specific purpose.

Allow at least a 16-foot maintenance strip from the outside row of trees or shrubs to adjacent property lines or contrasting land use areas. Comply with applicable federal, state and local laws and regulations during the installation, operation, and maintenance of this practice.

Appropriate cultural resources review will be conducted before beginning any tree planting practice.

Where subsurface drains (tile lines) cross a tree/shrub planting, and where these drains will remain functional, sealed conduit will be installed through the planting and extend a minimum of 100 feet from rows of large trees (capable of reaching heights greater than 60 feet) and 75 feet from all other trees and shrubs.

Trees and shrubs will not be planted within 50 feet of either side of subsurface drains.

When placing an opening through a windbreak, make the opening on an angle to reduce the loss of wind protection and not in the prevailing wind direction, if possible. Whenever possible locate access roads at the ends of windbreaks, beyond the area where snowdrifts form.

Additional Criteria to Manage Snow
The windbreak will be oriented as close to perpendicular to the snow-bearing wind as possible.

For snow distribution the interval between barriers will not exceed 20H.

For snow accumulation the windward row will be at least 100 feet from the area to be protected.

Windbreaks will be located so that snow deposition will not adversely impact the area to be protected.

Windward rows will be a maximum of 250 feet and not closer than 100 feet from the centerline of the transportation route.

For "living snow fences" adjacent to roads or lanes:

Snow barriers should extend 100 feet beyond the ends of roadway areas to be protected.

Snow trap areas should be no less than 75 feet wide.

{See diagrams, Appendix A and Appendix B}

To reduce potential snow damage to the windbreaks, use widest spacings and/or locate a shrub row windward 40-75 feet windward of the primary windbreak.

Additional Criteria to Provide Shelter for Livestock
The windbreak will be oriented as close to perpendicular to the troublesome wind as possible.

For wind protection, the area to be protected will fall within 10H of the design height.

Additional Criteria for Noise Screens
Noise screens shall be dense, as tall and as close to the noise source as practicable and legal.

Evergreen trees and shrubs are most effective for year-round protection. Plantings should be twice as long as the distance from the noise source to the receiver, extending equal distances on each side of the receiver.

Additional Criteria for Visual Screens
Visual screens shall be located as close to the observer as possible. Use plants that will add color, texture, and diversity to the site.

For high-speed traffic: The edge of the planting should be 100-150 feet from the center of the nearest traffic lane. The tallest tree row should be capable of attaining a mature height of at least 45 feet.

For moderate-speed traffic: The edge of the planting should be 50-80 feet from the center of the nearest traffic lane. The tallest tree row should be capable of attaining a mature height of at least 30 feet.

Additional Criteria to improve air quality by reducing and intercepting air borne particulate mater, chemicals and odors

Minimize the movement of odor from an odor-producing source toward a sensitive area. Tree varieties and placement for the windbreak shall be managed to maximize odor interception and dilution of air, and reduce odor leaving the source.

Where site conditions allow, establish plants around the entire perimeter of the odor source.

Adjust species and spacing to meet air movement needs for naturally ventilated livestock confinement systems.

Keep the inner row of windbreak plantings from all buildings and waste storage areas at least 10 times the exhaust fan diameter or 50 feet, whichever is greater.

Use wide “between row spacing” to increase particle surface area contact and foliage light levels.

For additional information, see attached “Missouri NRCS Conservation Practice Information Sheets.”

Additional Criteria to Provide Wildlife Habitat

Add rows to a planting to increase wildlife benefits. Optimum wildlife usage occurs with ten or more rows.

Use plants of different sizes, growth forms, food-bearing capabilities, and densities to increase plant diversity. A minimum of one evergreen and one shrub row should be included among the additional windbreak rows. *(If there are no evergreen species recommended, based on soil type, a minimum of three additional hardwood or shrub rows should be included.)* Shrub rows should be located on outside rows.

The windbreak layout should include a partial east-west orientation. During the winter months, direct sunlight is available on southern rows throughout the day. The opportunity to "sun" in a protected southern exposure decreases food needs for wildlife.

Additional Criteria to Reduce Wind Erosion and Protect Growing Plants

The windbreak will be oriented as close to perpendicular to the critical wind direction as possible.

The interval between windbreaks shall be determined using current, approved wind erosion technology to achieve the quality level desired for the soil or plant resource. The maximum distance sheltered by the barrier shall be ten times the design height (H).

CONSIDERATIONS

Spacing between windbreaks and rows of windbreaks may be adjusted to accommodate widths of equipment, within limits of the criteria.

Plantings should compliment natural features.

When placing an opening through a windbreak, make openings on an angle that minimizes the loss of wind protection. Whenever possible, locate access roads at the ends of windbreaks beyond where snowdrifts form.

Where water erosion, feedlot runoff, or runoff from melting snow is a hazard, runoff should be controlled by supporting practices.

Where early wind and snow protection is desired, use close spacing guidelines within the rows.

Vegetation diversity will reduce insect or disease problems, enhance wildlife values, and improve aesthetics.

Consider the effects of the windbreak on adjacent landowners when plantings are on or near property boundaries.

The distance that protection extends from the windbreak's leeward side is proportional to its height. The zone of most effective protection extends to a distance two to five times (2H - 5H) its height, while significant protection extends to 10H.

To ensure desired species will be available, order trees and shrubs well in advance of anticipated planting time.

When considering species, base selection(s) on soil type, desired height, growth rate, wildlife needs, landowner objectives,

hardiness, growth form, and tree/shrub life expectancy.

Where odor control is the primary purpose, design layout should consider future expansion facility needs and the placement of natural or artificial barriers near exhaust fans on tunnel-ventilated livestock buildings. Consult with an Iowa DNR Forester and/or an environmental engineer.

When feedlot runoff will flow through the planting, consider the species selection to survive the concentrated nutrient source.

PLANS AND SPECIFICATIONS

Species For recommended species refer to: http://www.ia.nrcs.usda.gov/plants.html and click on "Iowa Woodland Suitability Recommendations" or refer to "Woodland Suitability Guide at: http://www.iowadnr.com/forestry/soils.htm

Density Windbreak densities can be controlled through the type of plants and the number of rows used. Using the row guidelines below will achieve the desired barrier densities.

Number of Rows: For minimum effectiveness, windbreaks for most purposes will contain two rows of trees. Three or more rows may be used to enhance wildlife values, meet landowner objectives, increase diversity, improve natural beauty, and increase density.

For windbreak row minimums, use the following chart to achieve desired densities.

WINDBREAK TYPE	MINIMUM NUMBER OF ROWS	COMPOSITION
Farmstead/Shelterbelt	3	A
Feedlot	3	A
Odor	3	AG
Screens		
High traffic	6	C
Low-Med traffic	3	B
Visual	2	A
	~or~	
	3	D
Wildlife	5	AG
Field	2	E
Living Snow Fence		
Unsheltered distance < 1000 feet	1	F
Unsheltered distance > 1000 feet	2	A

A= One row must be evergreen *(If there are no evergreen species recommended, based on soil type, a minimum of two additional hardwood or shrub rows should be planted.)*
B= Two rows must be evergreen *(If there are no evergreen species recommended, based on soil type, a minimum of three additional hardwood or shrub rows should be added.)*
C= Three rows must be evergreen *(If there are no evergreen species recommended, based on soil type, a minimum of four additional hardwood or shrub rows should be added.)*
D= All deciduous species are used
E= Two rows of deciduous tree/shrubs or evergreens
F= One row of either shrubs or evergreens
G= One row must be shrubs (For odor, the inside row)

These are minimum designs to meet the stated purpose. Consider increasing the number of rows and species diversity in order to provide additional benefits.

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Plant Spacing. If using equal spacings in adjacent rows, stagger tree spacing so the trees in one row will be planted opposite the opening in the other row.

Example:

```
      X     X     X
   X     X     X     X
      X     X     X
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Spacing Between Rows
Spacing between adjacent rows can vary or can be uniform. If plantings are to be cultivated, plan the row spacing wide enough for maintenance equipment to operate freely between rows. Usually this requires about four feet more than the width of cultivation equipment, not to exceed the maximum allowed spacing.

Row Type/Heights	Minimum Between Row Spacing
Between shrubs less than 10 feet in height	10 ft.
Between shrubs and trees from 10-25 feet in height	12 ft.
Between trees greater than 25 feet in height	16 ft.
Between any wide crowned trees or conifers	20 ft.

Maximum row spacing will depend on site conditions and planner barrier function but will not exceed 20 feet. Exceptions to these spacings include the use of vegetation as a snow catch and where the landowner plans to remove every other row before crowding starts.

Spacing Within Rows
Spacing between plants is generally uniform, unless clumps are desired to minimize the linear appearance or provide better wildlife habitat.

Plant Type 20-year Heights	Plant-to-Plant Spacing within Rows
Shrubs < 10' tall	3' - 6'
Shrubs and trees 10'-25' tall	5' – 10'
Trees > 25' tall	8' – 16'
Wide species	16' – 20' if additional rows (more than the minimum number) are added.

Closer spacing results in providing protection in the shortest period of time. Where appropriate, the narrowest spacing can be used with a thinning required to achieve the ultimate spacing.

Site Preparation. Competing vegetation will be controlled by one or more of the following methods:

If cover is sod, alfalfa, or weedy cropland cover, control competing vegetation by:
- Strip tilling with tillage equipment;
- Chemical treatment of the planting strip;
- ~or~
- Chemical or mechanical spot treatments.

If cover is non-weedy cropland:
- Plant in stubble without prior preparation;
- ~or~
- Lightly disk the area to evenly distribute crop residues.

All spot or strip treatments shall be four to five feet in diameter or width.

Fall site preparation prior to spring planting is preferred. A fall seeding of oats may be used where needed to control soil erosion.

All chemicals will be used in accordance with label guidelines. If chemicals are handled or applied improperly or if unused portions are not disposed of safely, they may be injurious to humans, domestic animals, desirable plants, and fish or wildlife.

Planting.
Refer to Tree/Shrub Establishment (612).

Weed Control
Refer to Tree/Shrub Establishment (612).

OPERATION AND MAINTENANCE

The following actions shall be carried out to ensure that this practice functions as intended.

These actions include normal repetitive activities in the application, operation, repair, and upkeep of the practice.

Control competing vegetation for the life of the planting or until plants close the area and shade out competition. If using herbicides, follow all label directions.

All plantings will be protected from livestock. Protect plantings from wildlife as needed in order to ensure adequate survival.

Replace dead trees and shrubs as necessary in order to maintain planting function. Replant with the same species or species with similar growth form and potential.

Supplemental water will be provided as needed.

Protect plantings from fire. Maintain necessary firebreaks around all plantings.

Pruning should be done only for the purposes of removing dead, injured, or diseased wood. Inspect windbreaks at least every six months for insect and disease problems.

REFERENCES

Tree Planting: Establishment and Care, Iowa State University Extension, PM 1677, Reviewed and Reprinted March 2004.

Farmstead Windbreaks: Establishment, Care and Maintenance, Iowa State University Extension, PM 1717, Revised February, 2005.

How Windbreaks Work, University of Nebraska Extension EC 91-1763-B.

Windbreaks for Snow Management, University of Nebraska Cooperative Extension EC 96-1770-X.

Windbreaks for Conservation, USDA NRCS Agriculture Information Bulletin 339.

Windbreak Establishment, University of Nebraska Extension EC 91-1764-B.

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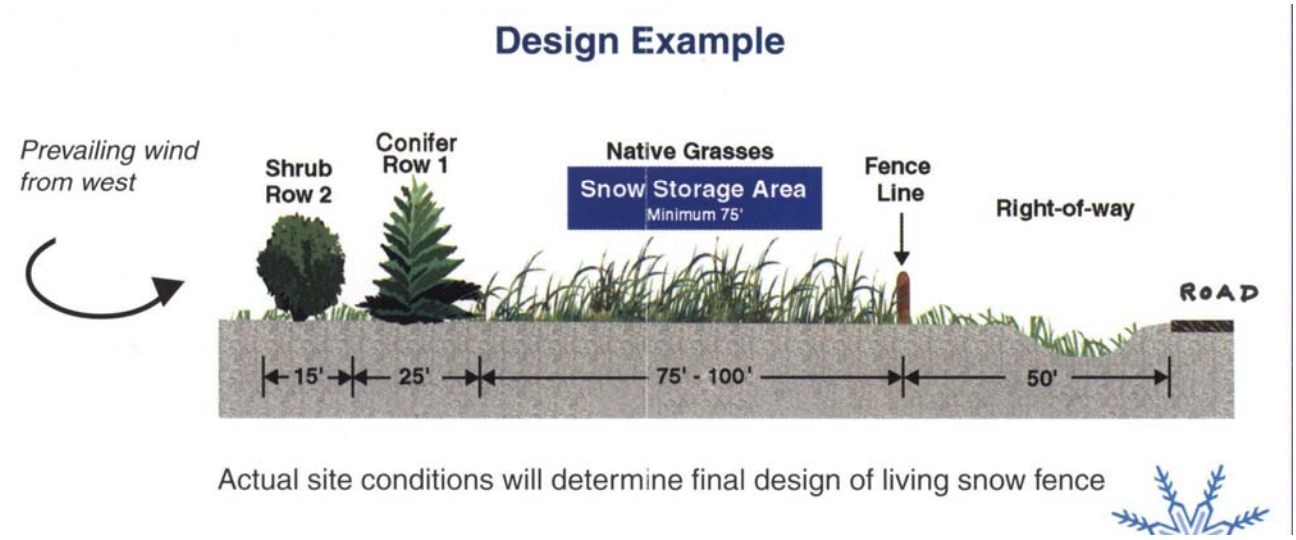
Appendix A


Design Example
Prevailing wind from west
Shrub Row 2
Conifer Row 1
Native Grasses
Snow Storage Area
Minimum 75'
Fence Line
Right-of-way
ROAD
15'
25'
75' - 100'
50'
Actual site conditions will determine final design of living snow fence

Appendix B

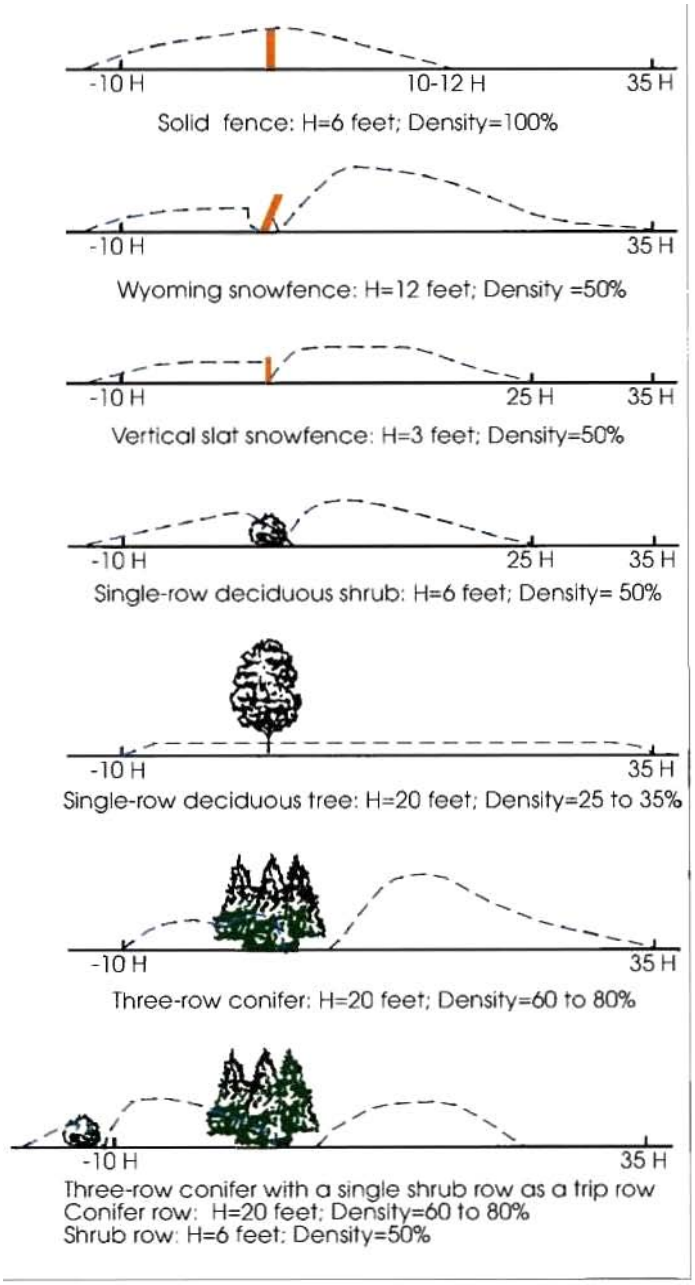


Figure: The height and density of the snow fence or windbreak will determine how much snow can be stored in the system.

Windbreak/Shelterbelt–Odor Control

Conservation Practice Information Sheet ***(IS-MO380)***

Using Windbreaks to Reduce Odors Associated with Livestock Production Facilities [1]

Introduction

Preliminary research and observations made by farmers suggest that windbreaks placed around livestock production facilities may effectively reduce movement of odors emitted by manure to neighboring properties. Essentially, trees can be 'put to work' to reduce the movement of livestock production odors off-site.

Although the idea of placing vegetative windbreaks and shelterbelts around agricultural buildings and farm fields is not new, additional benefits from farm windbreaks continue to be learned and tested. Windbreaks alone will not prevent odor problems associated with intensive livestock production but may provide farmers with one more tool to help reduce negative visual perceptions and detection of smell by neighbors and surrounding communities.

Figure 1. A windbreak of maturing conifers can significantly change the appearance of livestock production facilities and help filter out odor particles.

An odor-emitting source can include a livestock production barn, manure storage or a farm field where manure is being spread. Windbreaks have the ability to reduce odor concentrations significantly at or very near the source, which greatly improves the effectiveness of separation distances.

There are six ways that windbreaks and shelterbelts can reduce the effects of livestock odor and improve visual perception of production buildings:

1. Dilution and dispersion of gas concentrations of odor by a mixing effect created by windbreaks.
2. Deposition of odorous dusts and other aerosols (like snow fencing) to the windward and leeward sides of windbreaks.
3. Collection and storage (sinks) within tree wood of the chemical constituents of odor pollution.
4. Physical interception of dust and aerosols odor particles on leaves, needles and branches.
5. Containment of odor by placing windbreaks fore and/or aft of the odor source.
6. Aesthetic appearance:
   - Trees create a visual barrier to livestock barns
   - Trees can make cropped fields and pastures more pleasing to look at
   - Trees represent an 'environmental statement' to neighbors that the producer is making every effort to resolve odor problems in as many ways as possible.

[1] This information sheet is adapted from the following references: "Using Shelterbelts to Reduce Odors Associated with Livestock Production Barns" (January 2004) by Todd Leuty, Horticulture/Agroforestry Specialist, Ontario Ministry of Agriculture and Food. "Air Quality and Shelterbelts: Odor Mitigation and Livestock Production – A Literature Review" 1999. John Tyndall and Joe Colletti; Iowa State University."Designs for Windbreak Walls for Mitigating Dust and Odor Emissions from Tunnel Ventilated Swine Buildings" 2000. R. Bottcher, R. Munilla, G. Baughman, and K. Keener. North Carolina State University.

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Dilution and dispersion

Without wind management, odors emitted from livestock facilities and manure storage areas tend to travel along the ground as a plume with air movement, especially during atmospheric inversions with little or no dilution of odor occurring.

Figure 2. Without windbreaks and without wind management, the odor plumes are picked up by passing air masses and travel near the ground with little or no dilution or filtration.

Windbreaks create an obstacle for moving air masses. When designed properly, windbreaks force turbulent fresh air up and over the tree row and will also moderate and evenly distribute a more gentle airflow through the trees. Less air movement past barns will mean less pickup and movement of odor off site.

It is believed that windbreaks have the ability to lift some of the odor plume into the lower atmosphere where winds aloft mix and dilute the odor. The greatest dilution of odor occurs above and downwind from the quiet zone created by the action of wind passing over the windbreak. Beyond the quiet zone, more fresh air and less odorous air returns to the ground, thereby reducing movement of livestock odors off site.

Approximately 60 percent of the wind should be deflected up and over the windbreak and 40 percent should pass through the canopy of the trees. Two to three rows of trees can provide an ideal 60 percent density (or 40 percent porosity) through the tree canopy. Windbreaks are less effective for odor reduction when wind is minimal but the visual appearance remains in place.

Windbreaks create a 'quiet zone' of air that measures a distance of 8 to 10 times the height of the tree row downwind of the windbreak, and an additional moderation of wind speeds 10 to 25 times tree height, beyond the windbreak. Back-pressure created by the blocking effect of the tree row also creates a small quiet zone upwind of the tree line that is equal to 2 to 3 times the height of the trees.

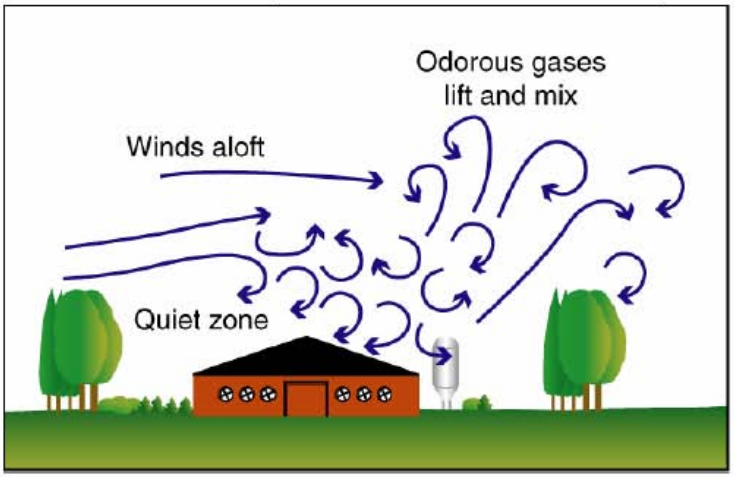

Figure 3. Windbreaks located upwind and downwind of livestock facilities will reduce and manipulate air flow around the facility to reduce the spread of odors. Overhead winds can lift particles and gases into the lower atmosphere to help dilute and disperse odors. Also, more clean air diverts up and over the source of odor.

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Livestock barns and manure storage areas are best located in the quiet zone 50 to 100 feet downwind of windbreaks. In addition, windbreaks located downwind of the odor source are also important for filtering, absorption and trapping odors. Therefore, placing windbreaks around the entire perimeter of livestock production areas is ideal. Windbreaks should also be at least 75 to 100 feet from access roads and driveways to prevent snowdrifts from blocking farm vehicles during winter.

Deposition of odorous dusts

Windbreaks create a physical barrier to wind and air movement. The trees absorb wind energy and reduce its speed near the ground. As a result, fewer dust particles and less odorous gases will be picked up by the air coming from livestock facilities. Also in calmer air, dusts and gases already caught up in the air will be more likely to settle back to the ground on the downwind side of the windbreak. This deposition effect is commonly seen with snow fencing where snow settles downwind of the fencing or trees due to reduced wind speed.

Figure 4. Reduced wind speed in the quiet zone that is created downwind from a windbreak allows odorous dusts and particles to settle to the ground, similar to what happens with settling and drifting of snow.

To be most effective for deposition of odorous dust, windbreaks need to be located upwind and downwind of odorous livestock facilities. Upwind windbreaks reduce the quantity of dust and odor that is picked up by wind, and windbreaks located downwind of the facilities will further reduce wind speeds to allow settling of odorous dusts that have become airborne.

For cropland, the same may hold true for reduction of odor movement where manure is being spread onto farm fields. Windbreaks established around the full perimeter of farm fields should reduce movement of odor and can accommodate winds that are approaching the farm from any direction.

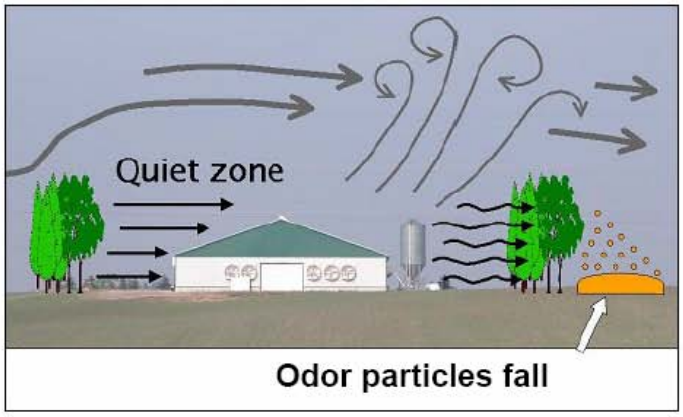

Figure 5. Windbreaks located downwind of livestock production barns allow settling of odorous wind-borne dust particles. Windbreaks should be located 75 to 100 feet away from barns.

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Wind tunnel studies of mass transport have shown that windbreaks can remove 35 to 55 percent of dusts being carried in moving air which would provide a substantial reduction of offensive odors carried off-farm. The amount of dust that is picked up or allowed to settle will depend on wind speed, direction of the wind, density of windbreak trees, height of windbreak trees and number of windbreaks.

Figure 6. Mature windbreaks around cropped fields may help lift and disperse odors during application of manure as nutrient soil amendment, in addition to sheltering crops from damaging wind.

Collection and storage of pollutant odors within trees (sink)

Scientific evidence of plant intake of livestock odors in field situations is limited, however there have been many studies done on the ability of plants to absorb air-polluting odors and chemicals. Trees and shrubs clean the air of micro-particles of all sizes by interception. Interception of air pollutants may be 20 times higher in treed or forested areas than non-forested cropped or barren lands. Conifers show a better ability to absorb air pollutants than deciduous trees.

Figure 7. In air pollution research, odorous gases and particles can be absorbed into the foliage of conifers and deciduous trees during the growing season. Pollutants diffuse inside leaves and needles through tiny openings called stomata or adsorb into waxy coatings that naturally cover leaf surfaces.

Odorous gases, chemicals and dust particles can become fixed to plant surfaces and can enter into the plant tissue in three ways: 1) gaseous diffusion through open stomata, 2) on wet leaves, soluble air pollutants can enter through stomata in a dissolved liquid form, 3) pollutants can absorb directly into plant tissues.

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Windbreak trees and shrubs absorb air pollutants when they are healthy and not under drought stress. Trees and shrubs absorb more air pollutants when leaf surfaces are wet. Higher humidity can increase uptake of air pollutants into trees, which is commonly measured within tree canopies.

Micro-organisms cover plant surfaces and there is evidence that these micro-organisms associated with windbreak trees also contribute to absorbing odorous chemicals. Forests are often referred to as pollutant air filters. This may also apply to windbreaks trees.

Physical interception of odor particles

Trees are highly effective at physically intercepting dusts, gases and microbial particles that are carried in the wind. Windbreaks are commonly used to intercept and drop blowing snow, act as barriers to trap blowing sand and soil caused by wind erosion, catch spray drift of agricultural chemicals, and reduce and catch pollen drift from agricultural crops.

As leaf surface roughness increases, the capture ability of particles and odor increases. Leaves with complex shapes (large circumference to area ratios) collect particles most efficiently. Therefore, conifers may be more effective at intercepting livestock odors than deciduous tree and shrub species. Conifers also have leaves (needles) year around.

Figure 8. Like the air filters of home furnaces, windbreak trees, especially conifers, physically catch wind-borne odorous particles. Conifers have foliage year-round.

Windbreak design and planting

Selecting the species of trees and shrubs to plant will vary at each livestock facility and farm field site. Species selection should be based on the characteristics of each site including: soil type, natural drainage, common wind conditions, annual precipitation, natural range of each tree and shrub species and site needs. In addition, to maximize particulate trapping, select species based on high leaf surface roughness (plants with leaf hairs, leaf veins, small leaf size), complex leaf shapes, large leaf circumference to area ratios and medium to rapid growth rates.

It is usually best to select several species of trees and shrubs for use in windbreaks to prevent loss or destruction of the entire windbreak if attacking insect pests or tree diseases occur. Having diversity also offers a better chance for tree survival during alternating seasons of drought and wet soil conditions.

Windbreaks should consist of one to three rows of alternating conifer and deciduous species while windbreaks may be wider with more tree rows. Shrubs are generally planted in the outside or inside rows, followed by conifers with deciduous hardwoods towards the middle or along the downwind side where they can grow more efficiently. Tree varieties and placement for the windbreak should be managed to maximize odor interception and dilution of air, and reduce odor leaving the source.

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Where site conditions allow, place plantings around the entire perimeter of the odor source.

Adjust windbreak porosities/densities to meet air movement needs for naturally ventilated livestock confinement systems.

Keep the inner row of windbreak plantings from all buildings and waste storage areas at least 10 times the exhaust fan diameter or 50 feet, whichever is farther.

Use wide "between row spacing" to increase particle surface area contact and foliage light levels.

Ideally once established, the tree barrier should have a density of about 60 percent for best results for wind management. Conifers such as spruce will provide uniform branch coverage from the ground level up. Tree rows should be spaced wide enough apart to allow access by a small tractor for mechanized management of vegetation.

Weed management is important during the first five years of tree establishment using herbicides, or plastic or organic mulch. Weed management is important until the young windbreak trees have overtopped most weed competition and are free to grow.

Managing Odor

Odor management is a result of the overall management of the farm operation. General maintenance of the buildings and the nutrition of the feed ration are normal farm management needs that can influence odor emissions. Waste management plans have become a standard part of livestock operations in recent years. Livestock odor management techniques fall into three areas:

1. *Preventing the generation of odor*, including feed additives, aeration, manure additives, etc.
2. *Capturing and destroying the odor*, including biofilters, waste storage covers, organic mats, etc.
3. *Dispersing or disguising the odors*, including vegetative or structural windbreaks, setback distances, site selection, etc.

In particular, structural or vegetative windbreaks placed near exhaust fans on tunnel-ventilated livestock and poultry buildings appear promising, primarily because the air jets issuing from the exhaust fans are diverted upward. This effect promotes mixing of the odorous, dusty airflow with the wind passing over the building, so that the plumes of air pollutants originating from the fans are made larger (extend higher) in addition to the physical trapping of odor particles on the windbreak.

Figure 9. Relevant design considerations and low-cost designs using UV-resistant tarpaulin or plastic material, roofing, or wood fastened to anchored pipe frames or posts are potential options for windbreak walls.

Windbreak structures may either be designed to withstand the same wind speeds as the buildings and be insured with the buildings, or lower wind speeds at reduced cost. If the windbreaks are not designed for maximum design wind speeds, a method of ensuring non-catastrophic failure is needed, such as breakaway ties fastening material to frames. The location of the

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windbreak affects the diversion of airflow from exhaust fans. Observations of windbreak action in several locations suggest that the windbreaks should be placed two to four fan diameters downwind from the fans to deflect fan airflow without back pressures, (Figure 11) and extend high enough to fully intercept the plumes of airflow issuing from the fans (e.g. 10-12 feet high for typical buildings).

Biofilters using biomass and microorganisms to treat ventilation air as it leaves the building have been used in the U.S. Some producers have installed windbreak walls using straw or other biomass. Windbreaks made from or incorporating straw have been installed on swine farms in North Dakota, Minnesota and Missouri and received favorable results. One facility in Minnesota with a biofilter achieved odor and H_2S reduction of 80-90% and NH_3 reduction of 50-60%. Weed control and rodent control were the primary problems experienced. A critical element in the use of biofilters is their dependence on power ventilated buildings where fans push the air through the filter. They don't work on naturally ventilated buildings.

Other benefits

In addition to odor management, vegetative windbreaks also act to reduce the seasonal cost of heating and cooling of farm buildings without disrupting ventilation in livestock barns.

Windbreaks may also reduce the spread of specific infectious disease of livestock by blocking, intercepting or diverting wind-borne infectious organisms away from buildings.

Windbreaks placed around farm fields reduce damage to forage and crops (preserve crop yield potential) caused by damaging turbulent winds while allowing normal air circulation to continue. Windbreaks reduce soil erosion by wind. Around pastures, mature windbreaks will relieve livestock of stress during hot summer days and cold windy winter conditions. Avoid planting trees and shrubs around livestock that are known to be poisonous.

Figure 10. Where barns are surrounded by solid forest plantation, it is important not to block ventilation fans with excessive tree growth. Thinning the plantation and pruning off lower branches can improve air circulation. Fifty to 100 feet is a good separation distance between trees and barn.

Acknowledgements

References used in this information sheet:

"Using Shelterbelts to Reduce Odors Associated with Livestock Production Barns" (January 2004) by Todd Leuty, Horticulture/Agroforestry Specialist, Ontario Ministry of Agriculture and Food.

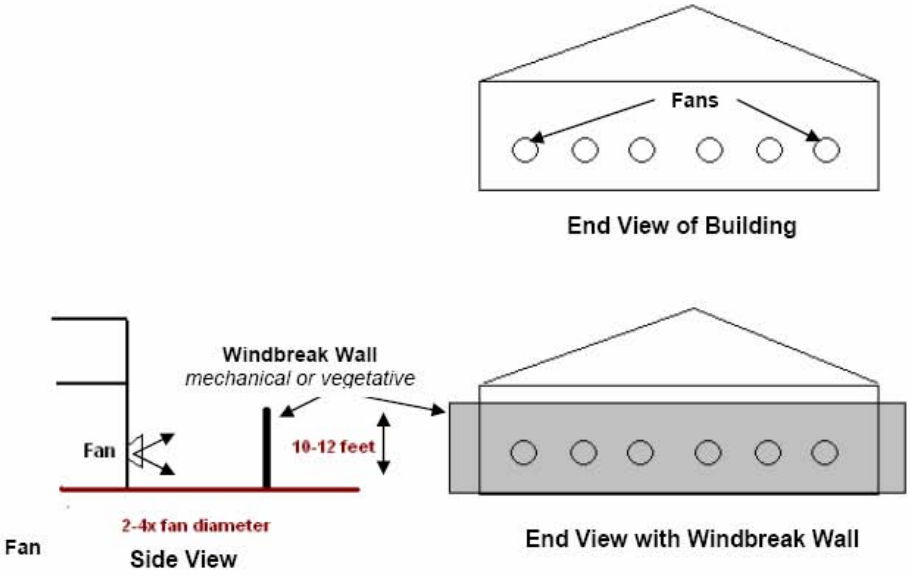
"Air Quality and Shelterbelts: Odor Mitigation and Livestock Production – A Literature Review" 1999. John Tyndall and Joe Colletti; Iowa State University.

"Designs for Windbreak Walls for Mitigating Dust and Odor Emissions from Tunnel Ventilated Swine Buildings" 2000. R. Bottcher, R. Munilla, G. Baughman, and K. Keener. North Carolina State University.

Windbreak/Shelterbelt–Odor Control

Conservation Practice Information Sheet ***(IS-MO380)***

Figure 11. Example layout of windbreak wall or biofilter for typical tunnel ventilated building.



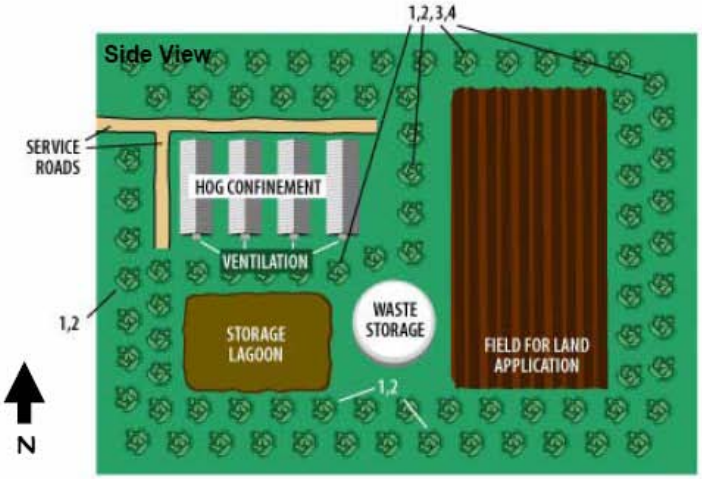


Figure 12. A hypothetical windbreak design for a swine facility. The numbers refer to the interaction and means by which the windbreak will mitigate livestock odor.

1. *Creation of air mixing turbulence*
2. *Dust deposition*
3. *Particulate interception*
4. *Pollution sinks*

Other important design considerations include: livestock type, odor sources, air/wind patterns, tree/shrub species, and aesthetics.