

**NATURAL RESOURCES CONSERVATION SERVICE
CONSERVATION PRACTICE STANDARD**

WINDBREAK/SHELTERBELT ESTABLISHMENT

(Ft.)

CODE 380

DEFINITION

Windbreaks or shelterbelts are single or multiple rows of trees or shrubs in linear configurations.

PURPOSE

This practice may be applied for one or more of the following purposes:

1. To provide shelter for structures, animals, and people;
2. To improve air quality by reducing and intercepting airborne particulate matter, chemicals, and odors;
3. To provide noise screens;
4. To provide visual screens;
5. To reduce energy use;
6. To reduce wind erosion;
7. To protect plants from wind related damage and alter the microenvironment for enhancing plant growth;
8. To improve irrigation efficiency;
9. To manage snow deposition;
10. To enhance wildlife habitat;
11. To increase carbon storage in biomass and soils;
12. To delineate property and field boundaries.

CONDITIONS WHERE PRACTICE APPLIES

This practice may be applied on any areas where linear plantings of woody plants are desired and are suitable for the intended purpose.

This practice does not apply to plantings that are intended to function primarily as field borders, hedgerows, or riparian forest buffers, for which other standards are applicable. Refer to the conservation practice standards for Field Border, (386), Hedgerow Planting (422), and Riparian Forest Buffer (391).

CRITERIA

General Criteria Applicable to All Purposes

The location, layout, and density of the planting shall be planned to accomplish the purpose and function intended within a 20-year period, or sooner as necessary.

The maximum design height (H) for the windbreak shall be the expected height of the tallest row of trees or shrubs in 20 years.

Design the windbreak to be as close to perpendicular to the prevailing damaging wind as possible. The length of the windbreak shall be sufficient to protect the site, including consideration for the “end effect” and changes in wind direction.

Spacing between and within rows 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. Refer to Table 2 for spacing recommendations.

Refer to Table 3 to determine the minimum number of rows and type of plants needed to meet density requirements for the planned purpose(s) of the windbreak. Use staggered spacing in multiple row plantings. Plant taller-growing species in center rows and medium or lower growing species in outer rows.

Select plant species based on the planned purpose(s) of the windbreak, preferences of the client, and conditions of the site. Within a row, use only one species or select a mix of species that have similar growth forms and growth rates.

Use plant species that are native to Delaware or are introduced and are non-invasive (i.e., not likely to spread beyond the planted area and displace native species). Plantings consisting of two or more species shall be encouraged. For best results, use species and varieties with proven conservation traits. Refer to Table 4 for a selected list of tree and shrub species that can be used.

Site preparation and planting to establish windbreaks shall be done at a time and manner to insure survival and growth of selected species. If needed and feasible, apply supplemental moisture to assure early survival and establishment of selected species.

Only viable, high quality seed and planting stock shall be used. The method of planting shall include hand or machine planting techniques, suited to achieving proper depths and placement for the selected plant species.

Do not plant windbreaks where they will interfere with structures, operation of agricultural equipment such as irrigation systems, and above or below ground utilities.

Control or exclude livestock as needed to establish and maintain the planting. Control plant and animal pest species to the extent feasible to achieve and maintain the intended purpose of the practice. Control noxious weeds as required by state law.

Additional Criteria to Provide Shelter for Structures, Animals, and People

The windbreak shall have a minimum density of 65 percent during the months when protection is needed. The area to be protected shall be located within a downwind distance of 10H from the planting.

Do not allow drainage of livestock waste from a confined livestock area to flow into the windbreak. Use supporting practices, such as diversions or filter strips, as needed to redirect or reduce runoff.

Additional Criteria to Improve Air Quality by Reducing and Intercepting Airborne Particulate Matter, Chemicals, and Odors

The windbreak shall be located within a distance of 10H from the source area. Locate windbreaks upwind of the source area to decrease air movement across the site and minimize dispersal of particulates, chemicals, and odors. Locate windbreaks downwind of the source area to intercept airborne contaminants coming from the site. To control odors, place plantings around the entire perimeter of the odor source if site conditions allow.

Select tree and shrub species with foliar and structural characteristics to optimize interception, adsorption, and absorption of airborne particulates, chemicals, or odors.

Plant density on the upwind side shall be at least 50 percent at maturity. On the downwind side, plantings shall have a minimum density of 65 percent during the months when protection is needed.

Additional Criteria to Provide Noise Screens

Noise screens shall have a minimum density of 65 percent during the months when noise abatement is needed, and shall be as close to and as tall as the noise source as practicable. The length of the noise screen shall be twice as long as the distance from the noise source to the receiver.

For high-speed traffic noise, the barrier shall not be less than 65 feet wide. For moderate speed

traffic noise, the barrier width shall not be less than 20 feet wide. Species selected for traffic noise screens shall be tolerant of noxious emissions, sand and gravel depositions, and salt spray from traffic areas.

Additional Criteria to Provide Visual Screens

Visual screens shall be located as close to the observer as possible with a density, height, and width to sufficiently block the view.

For year-round screening, use at least one row of evergreens. Alternatively, one row of densely branched deciduous species may be sufficient to provide the desired amount of screening. The use of deciduous species alone for year-round screening requires prior approval by the State Resource Conservationist.

Additional Criteria to Reduce Energy Use

Use proper plant density to meet energy reduction needs. Select plants with a mature height that will be taller than the structure or facility being protected. If the windbreak is intended to provide shade, select trees that will develop wide crowns and sufficient height to shade the site.

Additional Criteria to Reduce Wind Erosion and Protect Growing Plants

The interval between windbreaks shall be determined using current approved wind erosion technology. Interval widths shall not exceed that permitted by the soil loss tolerance (T) or other planned soil loss objectives. Calculations shall account for the effects of other practices in the conservation management system.

Select windbreak species that are taller than the crops being protected. As appropriate, use temporary measures to supplement the windbreak until it is fully functional.

Additional Criteria for Improving Irrigation Efficiency

For sprinkler irrigation systems, the windbreak shall be taller than the spray height to minimize wind-blown spray, allow uniform distribution

over the coverage area, and reduce evaporation. Plan the windbreak so that it does not interfere with the operation of the irrigation system.

Additional Criteria to Manage Snow Deposition

For even snow distribution across a field, the windbreak density during expected snow-producing months shall be from 25 to 50 percent. The interval between windbreaks shall not exceed 20H.

For snow accumulation, the minimum barrier density shall be at least 50 percent during expected snow-producing months.

Windbreaks shall be located so that snow deposition will not pose a health or safety problem or obstruct human, livestock, or vehicular traffic. Snow will be heavily deposited downwind within 100 to 200 feet from the planting. Be sure that roads or buildings are not located in this zone.

Additional Criteria to Enhance Wildlife Habitat

Select trees and/or shrubs that will provide food, nesting cover, and/or protective cover for the desired wildlife species.

Windbreaks that will serve as travel corridors shall be at least 50 feet wide and shall be used to connect two or more habitat areas that are each at least 500 feet wide.

Height, length, location, and number of rows shall be determined based on the primary purpose of the windbreak. For additional information concerning the wildlife value of various native tree and shrub species, refer to the Delaware conservation practice standard for Tree/Shrub Establishment (612).

Additional Criteria for Increasing Carbon Storage in Biomass and Soils

Select appropriate species and stocking rates for site conditions, and maximize the width and length of the windbreak to fit the site. For optimal carbon sequestration, select fast-growing

species (see Table 4 for growth rates). Prediction of carbon sequestration rates shall be made using current, approved carbon sequestration modeling technology.

Design and manage the appropriate plant spacing for the site that will maximize above and below ground biomass production.

Note: Specific programs or other funding sources may impose criteria in addition to, or more restrictive than, those specified in this standard.

CONSIDERATIONS

Assess site conditions including surrounding land uses, soils, residual herbicides (to the extent known), available moisture during the growing season, and existing vegetation on the site and in adjacent areas, including any noxious weeds that may be present.

Consider the time of year when wind protection is needed and the direction of the prevailing wind. Sites can be protected within an area 10 times the design height (H) on the downwind side of the windbreak, and two times the design height (H) on the upwind side of the windbreak.

Consider plant growth rates, shade tolerance, soil moisture requirements and tolerances, and other plant characteristics considered when selecting tree and shrub species.

Also consider the length of time needed to achieve the desired purpose. Slow-growing species will take longer to reach the design height than fast-growing species. Seedlings will take longer than containerized or balled-and-burlapped stock.

Avoid selecting plant species or planting near existing species that may be alternate hosts to undesirable pests, or that may be considered invasive or undesirable. Species diversity, including use of native species, should be encouraged in order to minimize problems due to species-specific pests.

Consider wildlife when selecting tree and shrub species. Consider using plants that have multiple wildlife values such as those suited for nesting habitat, fruit, seeds, browse, and protective cover.

Consider the need for weed control within and between rows. For windbreaks that will be maintained with mowing, consider that plant spacing will need to accommodate mowing equipment.

Consider access routes and the need to maintain space for future expansion when designing windbreaks near buildings. Take note of other constraints such as economic feasibility, regulatory or program requirements, and visual aspects.

Consider that establishing visual screens for animal production and waste facilities may result in fewer odor complaints by neighbors. Windbreaks for controlling odor and dust particles will be more effective as the amount and density of foliage increases. Multiple row plantings are preferable because they provide greater interception than single row plantings. Windbreaks planted near animal facilities may also provide water quality benefits by intercepting nutrients in surface and subsurface water.

This practice has the potential to affect National Register listed cultural resources or eligible (significant) cultural resources. These may include archeological, historic, or traditional cultural properties. Care should be taken to avoid adverse impacts to these resources. Follow NRCS state policy for considering cultural resources during planning.

PLANS AND SPECIFICATIONS

Plans and specifications for this practice shall be prepared in accordance with the previously listed criteria. Plans and specifications shall contain sufficient detail to ensure successful implementation of this practice and may be recorded in narrative form, on Implementation Requirements (IR) worksheets, or other approved forms.

Follow the establishment recommendations provided in the Delaware fact sheets for Tree and Shrub plantings, or other applicable fact sheets. Completed fact sheet(s) and 380 IR worksheet can serve as the planting plan for the windbreak.

The following items shall be addressed, as appropriate:

1. Purpose of the windbreak;
2. Method of site preparation;
3. Species selected for establishment and planting dates;
4. Length of the windbreak, number of rows, and spacing within and between rows;
5. Rate and type of soil amendments to be applied (if any);
6. Method(s) used to protect plantings from animal damage (e.g., fencing, repellents, tree shelters, etc.) or for weed control (e.g., weed mats, mulch).

OPERATION AND MAINTENANCE

An Operation and Management (O&M) plan shall be prepared and is the responsibility of the client to implement. The appropriate fact sheet(s) and IR worksheet may serve as the management plan, as well as supporting documentation, and shall be reviewed with and provided to the client.

At a minimum, the following components shall be addressed in the O&M plan, as applicable:

1. Inspect the windbreak at least annually. Shape and replant areas damaged by heavy rainfall, animals, chemicals, tillage, or equipment traffic, and any other areas where the vegetation is not adequate;
2. If survival is less than expected during the first two years, replant as needed to achieve the intended purpose of the practice. If native trees and/or shrubs (other than what was planted) become established, and this cover meets the intended purpose of the practice, the cover should be considered adequate. Follow the maintenance recommendations in the attached fact sheet for additional information;
3. Nutrients may be applied after the first year, but only if needed based on soil test results;

4. If tree shelters are used, remove them before they impede the growth of the trunk. Removal should not occur until the seedling has adequate girth to support itself (usually 3 to 5 years after planting);
5. Check for insects and diseases, and if an incidence threatens stand survival, take corrective action to keep the pest under control;
6. Control undesirable plants by pulling, mowing, or spraying with a selective herbicide. Control noxious weeds as required by state law;
7. Protect the planting from wildfire and damage from livestock, wildlife, and equipment, to the extent feasible;
8. Describe the acceptable uses (e.g., occasional removal of some tree and shrub products, etc.) and time of year or frequency of use restrictions, if any.

Pay particular attention to program requirements as they relate to acceptable vs. restricted uses and other management restrictions.

SUPPORTING DATA AND DOCUMENTATION

The following is a list of the minimum data and documentation to be recorded in the case file:

1. Location of the practice on the conservation plan map;
2. Assistance notes. The notes shall include dates of site visits, name or initials of the person who made the visit, specifics as to alternatives discussed, decisions made, and by whom;
3. Completed IR worksheet, and copy of the appropriate fact sheet(s) or other specifications and management plans.

REFERENCES

1. Belt, Shawn. 2015. *Plants Tolerant of Poultry House Emissions in the Chesapeake Bay Watershed*. Maryland Plant Materials Final Report. USDA-NRCS Norman A. Berg National Plant Materials Center, Beltsville, MD.
2. Belt, S.V., M. van der Grinten, G. Malone, P. Patterson and R. Shockey, 2007. *Windbreak Plant Species for Odor Management around Poultry Production Facilities*. Maryland Plant Materials Technical Note No. 1. USDA-NRCS National Plant Materials Center, Beltsville, MD. 20p.
3. Brandle, James R., Xinhua Zhou, and Laurie Hodges, 2006. *How Windbreaks Work*. Publication EC1763, University of Nebraska, Lincoln Extension.
4. Kuhns, Mike. May, 2012. *Windbreak Benefits and Design*. Utah State University Cooperative Extension. Utah Forest Facts, NR/FF/005 Revised.
5. Scott, James D., Jr., 2007. *VEB Tool-Kit: A Guide to Vegetative Buffers for Tunnel-Ventilated Poultry Houses*. Delmarva Poultry Industry, Inc., Georgetown, Delaware.
6. USDA, National Agroforestry Center. September, 2007. *Windbreak Density: Rules of Thumb for Design*. AF Note - 36.
7. USDA, National Agroforestry Center. April, 2011. *Windbreaks: A "Fresh" Tool to Mitigate Odors from Livestock Production Facilities*. AF Note - 41.
8. USDA, Natural Resources Conservation Service. *Conservation Practice Standards*. Delaware Field Office Technical Guide, Section IV.
9. Wight, Bruce, and Kimberly Stuhr, March, 2002. *Windbreaks: An Agroforestry Practice*. USDA, National Agroforestry Center, AF Note - 25.

FIGURE 1: USDA Plant Hardiness Zones for Delaware



TABLE 1: Recommended Planting Dates for Delaware ^{1/}	
Type of Plant Material	Plant Hardiness Zones
	7a and 7b
Dormant Cuttings	Feb 1 to Feb 28 Nov 15 to Nov 30
Bare-Root Seedlings ^{2/}	Feb 1 to Apr 30 <i>May 1 to Jun 30*</i>
Container Plants; Balled-and-Burlapped Stock	Feb 1 to Apr 30 <i>May 1 to Jun 30*</i> <i>Oct 1 to Dec 15*†</i>

TABLE 1 NOTES:

1. The planting dates listed are averages for each zone. These dates may require adjustment to reflect local conditions, especially near the boundaries of the zones.
 2. When planted during the growing season, these materials must be purchased and kept in a dormant condition until planting.
- * Additional planting dates during which supplemental watering may be needed to ensure plant establishment.
- † Frequent freezing and thawing of wet soils may result in frost-heaving of materials planted in late fall if plants have not sufficiently rooted in place. Large container plants and balled-and-burlapped stock may be planted into the winter months as long as the ground is not frozen and soil moisture is adequate.

TABLE 2: Recommended Spacing Within and Between Rows ^{1/}			
Plant Type	Spacing (feet) Within Rows		Spacing (feet) Between Rows ^{2/}
	<i>Single Row</i>	<i>Multiple Rows</i>	
Small Shrubs (4 – 12 feet tall)	3 - 5	4 - 6	10 - 15
Large Shrubs and Small Deciduous Trees (12 – 30 feet tall)	6 - 8	8 - 10	10 - 20
Large Deciduous Trees (more than 30 feet tall)	10 - 12	12 - 14	15 - 20
Evergreen Trees (columnar form)	6 - 8	8 - 10	10 - 20
Evergreen Trees (conical and broad forms)	8 - 10	10 - 14	15 - 20

TABLE 2 NOTES:

1. Use spacings at or near the lower end of the range to create a dense barrier in a shorter period of time.
2. Spacing between rows shall be at least four feet wider than the mechanized maintenance equipment used, and may be increased beyond what is shown in this table to accommodate the equipment. Where space (width) is limited and a two-row planting is needed to meet density requirements, the same spacing within and between rows may be used with staggered plantings. Maintenance during plant establishment may be more difficult with close spacing between rows.

TABLE 3: Number of Rows and Type of Plants Needed to Meet Density Requirements		
Purpose	Required Density and Location of Planting^{1/}	Minimum Number of Rows and Type of Plants^{2/}
Provide shelter for structures, animals, and people	At least 65%; upwind and within 10H of area to be protected	Plant two rows of medium and/or high density species. If year-round protection is needed, use at least one row of evergreens.
Improve air quality (reduce airborne particulates, chemicals, odors)	At least 50%; upwind and within 10H of the source area	Plant one row of medium and/or high density species, or two rows of low density species. If year-round protection is needed, use at least one row of evergreens.
	At least 65%; downwind and within 10H of the source area	Plant two rows of medium and/or high density species. If year-round protection is needed, use at least one row of evergreens.
Noise screens	At least 65%; downwind as close to the noise source as feasible	Plant two rows of medium and/or high density species. Select species with a mature height that is as tall as the noise source as feasible. If year-round protection is needed, use at least one row of evergreens. Plant as close together as practical to form a tight barrier.
Visual screens	Dense enough to block the view; located as close to the observer as possible	For year-round screening, plant one row of evergreens. Alternatively, one row of densely branched deciduous species may be sufficient to provide the desired amount of screening. The use of deciduous species alone for year-round screening requires prior approval by the State Resource Conservationist.
Reduce energy use; reduce wind erosion; improve irrigation efficiency; increase carbon storage	Density and location as appropriate for the purpose	Minimum one row. Select plants with a mature height that will be taller than the structures or crops to be protected. For carbon sequestration, design the windbreak to maximize above and below ground biomass production. Refer to Additional Criteria for specific requirements.
Manage snow	25 to 50%; within 20H upwind of an area for snow distribution	Plant one row of low, medium, or high density species to distribute snow across a field or other area. To achieve the overall specified density, use a closer spacing for low density species, and wider spacing for high density species.
	At least 50%; within 20H upwind of an area for snow accumulation	Plant one row of medium and/or high density species, or two rows of low density species to reduce wind velocities sufficiently for snow to accumulate within 100-200 feet on the downwind side of the windbreak.
Enhance wildlife habitat	Density and location as appropriate for the primary purpose	Minimum one row. Select trees and/or shrubs that will provide food, nesting cover, and/or protective cover for the desired wildlife species. Refer to Additional Criteria for specific requirements.

TABLE 3 NOTES:

1. The maximum design height (H) for the windbreak is the expected height of the tallest row of trees or shrubs in 20 years. Select species with an appropriate mature height to provide protection.
2. For higher levels of protection (at a density $\geq 50\%$), use at least three rows of trees and shrubs, with at least one row being evergreen trees.

TABLE 4: Selected List of Trees and Shrubs for Windbreak/Shelterbelt Plantings

Plant Names	Plant Hardiness Zones ^{1/}	Geographic Distribution in Delaware ^{1/}	Delaware Native Species	Soil Drainage Class ^{2/}	Height at 20 Years	Growth Rate ^{3/}	Density ^{4/} - Summer	Density - Winter	Remarks
DECIDUOUS TREES									
ASH, GREEN <i>Fraxinus pennsylvanica</i>	All	Statewide	Yes	SP -P	35 ft.	Moderate	Medium	Low	Naturally occurring on streambanks and floodplains. Susceptible to emerald ash borer.
ASH, WHITE <i>Fraxinus americana</i>	All	Statewide	Yes	W - SP	35 ft.	Moderate	Medium	Low	Attractive fall color (yellow to maroon). Susceptible to emerald ash borer.
BIRCH, RIVER <i>Betula nigra</i>	All	Mostly Coastal Plain	Yes	W - P	30 ft.	Fast	Low	Very Low	Naturally occurring on streambanks and floodplains. Unique peeling reddish bark. Attractive for landscaping.
BLACKGUM <i>Nyssa sylvatica</i>	All	Statewide	Yes	W - P	30 ft.	Moderate	Medium	Low	Foliage turns bright red in early fall.
CYPRESS, BALD <i>Taxodium distichum</i>	All	Coastal Plain	Yes	MW - P	30 ft.	Fast	Medium to High	Low	Naturally occurring on streambanks and in swamps.
HONEYLOCUST <i>Gleditsia triacanthos</i> var. <i>inermis</i>	All	Statewide	Yes	W - SP	40 ft.	Fast	Low to Medium	Very Low	Prefers well-drained sites, but will tolerate brief inundation. Drought-resistant and somewhat tolerant of salinity.
MAPLE, RED <i>Acer rubrum</i>	All	Statewide	Yes	W - P	35 ft.	Fast	Medium	Low	Red fall color and blooms.
OAK, PIN <i>Quercus palustris</i>	All	Statewide	Yes	MW - P	35 ft.	Fast	Medium	Low	Bronze or red fall foliage. Widely planted as an ornamental. Produces small acorns.
OAK, NORTHERN RED <i>Quercus rubra</i>	All	Mostly Piedmont	Yes	W - SP	35 ft.	Fast	Medium	Low	Excellent red fall color. Tolerates urban conditions; perhaps the fastest-growing oak for landscapes.
OAK, SAWTOOTH <i>Quercus acutissima</i>	All	Introduced; not native to U.S.	No	W - SP	60 ft.	Fast	Medium	Low	Native to eastern Asia. Good shade tree. Tolerates adverse conditions.

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DECIDUOUS TREES (continued)									
OAK, SOUTHERN RED <i>Quercus falcata</i>	All	Mostly Coastal Plain	Yes	W - SP	35 ft.	Slow	Medium	Low	Excellent red fall color. Tolerates poor, dry soil.
OAK, SWAMP WHITE <i>Quercus bicolor</i>	All	Mostly Coastal Plain	Yes	SP - P	30 ft.	Fast	Medium	Low	Good choice for wet sites. Requires acid soils.
OAK, WHITE <i>Quercus alba</i>	All	Statewide	Yes	W - SP	35 ft.	Slow	Medium	Low	Variable fall color, stately tree.
OAK, WILLOW <i>Quercus phellos</i>	All	Mostly Coastal Plain	Yes	MW - P	30 ft.	Fast	Medium	Low	Frequently used as an ornamental planting. Produces small acorns. Red fall color.
POPLAR, HYBRID <i>Populus deltoides x nigra</i> 'Spike'	All	Introduced; hybrid of native U.S. and European species	No	MW - SP	40 ft.	Fast	Medium	Low	Sterile hybrid.
POPLAR, TULIP <i>Liriodendron tulipifera</i>	All	Statewide	Yes	W - SP	40 ft.	Fast	Medium	Low	Flowers produce abundant nectar, much used by bees. Dropped flowers and fruits can be messy. Tends to be weak-wooded; not recommended near buildings.
SWEETGUM <i>Liquidambar styraciflua</i>	All	Mostly Coastal Plain	Yes	MW - P	40 ft.	Fast	Medium	Low	Excellent yellow-red fall color. Widely planted as an ornamental. Fallen seed heads are a nuisance on lawns. Fruitless types are available.
WILLOW, HYBRID <i>Salix matsudana x alba</i> 'Austree'	All	Introduced; hybrid of Chinese and European species	No	W - P	60 ft.	Very Fast	Medium to High	Medium	Sterile hybrid. Due to its extremely fast growth (>3 ft/yr), can provide visual screen in 1 – 2 years. Dense branch structure.
WILLOW, PURPLEOSIER <i>Salix purpurea</i> 'Streamco'	All	Introduced from Europe	No	MW - P	20 ft.	Fast	Medium to High	Low	Non-invasive shrub. Streamco is a male clone, does not root sucker, and does not spread readily beyond the planting site.

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EVERGREEN TREES									
ARBORVITAE <i>Thuja occidentalis</i>	All	Mostly Piedmont	Yes	W - P	25 ft.	Slow	Very High	Very High	Frequently planted statewide as an ornamental. Prefers moist, well-drained soil, but tolerates a wide range of conditions. Prone to bagworms.
ARBORVITAE <i>Thuja plicata x standishii</i> 'Green Giant'	All	Introduced; hybrid of Western U.S. and Japanese species	No	W - MW	40 ft.	Fast	Very High	Very High	Prefers well-drained soil, but tolerates a wide range of conditions. No serious pest or disease problems.
CEDAR, EASTERN RED <i>Juniperus virginiana</i>	All	Mostly Piedmont	Yes	W - SP	20 ft.	Moderate	Very High	Very High	Should not be planted near apple orchards; alternate host of cedar-apple rust.
CYPRESS, LEYLAND <i>x Cupressocyparis leylandii</i>	All	Introduced; not native to U.S.	No	W - SP	40 ft.	Very Fast	Very High	Very High	This is a hybrid of <i>Cupressus macrocarpa</i> and <i>Chamaecyparis nootkatensis</i> . Adaptable to adverse sites; growth is best on good sites. Prone to bagworms, canker, and windthrow. Use in multiple-row plantings to minimize windthrow. Green Giant arborvitae is a preferred alternative to Leyland cypress.
HOLLY, AMERICAN <i>Ilex opaca</i>	All	Mostly Coastal Plain	Yes	W - P	20 ft.	Slow	High	High	Need male and female plants for fruit production. Shade tolerant.
JUNIPER, CHINESE <i>Juniperus chinensis</i>	All	Introduced; not native to U.S.	No	W - SP	12 ft.	Fast	High	High	Height varies with cultivar. Cultivars with similar shapes & heights include Hetzii, Hetzii Columnaris, Pyramidalis, Fairview, Keteleeri, Mountbatten, Spartan, Torulosa (Hollywood Juniper), and Robusta Green. In cool wet springs, Chinese Juniper is susceptible to phomopsis and kabatina blights which can cause severe damage.

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EVERGREEN TREES (continued)									
PINE, AUSTRIAN <i>Pinus nigra</i>	All	Introduced; not native to U.S.	No	E - P	35 ft.	Moderate	Low to Medium	Low to Medium	Frequently planted statewide as an ornamental. Prefers moist, well-drained soil, but tolerates a wide range of conditions. Withstands dryness better than other pines. Fairly salt tolerant.
PINE, LOBLOLLY <i>Pinus taeda</i>	All	Mostly Coastal Plain	Yes	MW - P	45 ft.	Fast	Low to Medium	Low to Medium	Self-prunes lower limbs, so best suited in a multiple-row planting.
PINE, PITCH <i>Pinus rigida</i>	All	Mostly Piedmont	Yes	W - SP	30 ft.	Fast	Low to Medium	Low to Medium	Tolerant of dry, rocky, sandy soils. Mature trees are resistant to fire. Will reproduce from stump sprouts.
PINE, WHITE <i>Pinus strobus</i>	All	Mostly Piedmont	Yes	W - MW	40 ft.	Fast	Low to Medium	Low to Medium	Frequently planted statewide as an ornamental.
SPRUCE, NORWAY <i>Picea abies</i>	All	Introduced; not native to U.S.	No	W - MW	35 ft.	Fast	High	High	Fast growth rate when young, slows down with age. Prefers moderately moist, well-drained soil.
SPRUCE, WHITE <i>Picea glauca</i>	7a (Piedmont only)	Introduced; native to Northern U.S.	No	W - MW	30 ft.	Moderate	High	High	Good ornamental and shade tree. Tolerates heat, drought, and wind better than most spruces.

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SHRUBS									
ABELIA, GLOSSY <i>Abelia x grandiflora</i>	All	Introduced; not native to U.S.	No	W - SP	6 ft.	Fast	High	High	Semi-evergreen foliage. Stems may be killed to the ground in cold winters. No serious pests or diseases. Many cultivars are available with different height and width characteristics.
ARROWWOOD <i>Viburnum dentatum</i>	All	Statewide	Yes	W - P	10 ft.	Fast	Medium	Low	Suckers freely. White flowers, bluish-black berries.
BAYBERRY, NORTHERN <i>Morella pensylvanica</i> (formerly <i>Myrica pensylvanica</i>)	All	Coastal Plain	Yes	W - SP	10 ft.	Moderate	Medium	Low	Need male and female plants for fruit production. Salt tolerant (0-20 ppt.) Suckers to form colonies.
BUSH, HIGH TIDE (GROUNDSEL) <i>Baccharis halimifolia</i>	All	Coastal Plain	Yes	MW - P	10 ft.	Moderate	Medium	Low	Usually in brackish and coastal marshes, above MHW. Salinity 0-15 ppt. Has fluffy white seeds. Male flowers & female flowers on separate plants.
BUSH, HIGH TIDE (MARSH-ELDER) <i>Iva frutescens</i>	All	Coastal Plain	Yes	MW - P	10 ft.	Moderate	Medium	Low	Usually in brackish and coastal marshes, above MHW. Salinity 0-15 ppt.
DOGWOOD, REDOSIER <i>Cornus sericea</i>	All	Statewide; uncommon	Yes	MW - P	8 ft.	Fast	Medium	Low	Attractive red stem color. White flowers and fruit.
DOGWOOD, SILKY <i>Cornus amomum</i>	All	Statewide	Yes	MW - P	10 ft.	Fast	Medium	Low	Produces fruit at 3-5 years of age. White flowers with blue berries. Prefers some shade.
EUONYMUS, SPREADING <i>Euonymus kiautschovicus</i> 'Manhattan'	All	Introduced; not native to U.S.	No	W - SP	10 ft.	Moderate	High	High	Semi-evergreen foliage that may be damaged in cold winters. Not as susceptible to scale as other euonymus. Flowers attract bees and flies.

TABLE 4: Selected List of Trees and Shrubs for Windbreak/Shelterbelt Plantings

Plant Names	Plant Hardiness Zones ^{1/}	Geographic Distribution in Delaware ^{1/}	Delaware Native Species	Soil Drainage Class ^{2/}	Height at 20 Years	Growth Rate ^{3/}	Density ^{4/} - Summer	Density - Winter	Remarks
SHRUBS (continued)									
HAZELNUT or AMERICAN FILBERT <i>Corylus americana</i>	All	Statewide	Yes	W - SP	10 ft.	Moderate	Medium	Low	Good for wildlife, ornamental; not many diseases/pests. Monecious flowers (needs both male and female plants to produce nuts).
HOLLY, JAPANESE <i>Ilex crenata</i> 'Steeds'	All	Introduced; not native to U.S.	No	MW - SP	8 ft.	Fast	High	High	Evergreen. Need male and female plants for fruit production. Tolerates partial shade.
HOLLY, NELLIE STEVENS <i>Ilex cornuta x aquifolium</i> 'Nellie Stevens'	All	Introduced; not native to U.S.	No	MW - SP	15 ft.	Fast	High	High	Evergreen. Need male and female plants for fruit production. Tolerates partial shade.
LESPEDEZA, SHRUB <i>Lespedeza bicolor</i>	All	Introduced; not native to U.S.	No	E - SP	8 ft.	Fast	Medium	Low	Perennial semi-woody legume. Cut back periodically to maintain dense, shrubby growth. May become weedy in some habitats and may displace desirable vegetation if not properly managed. Does not tolerate shade or wet soils.
WAXMYRTLE, SOUTHERN <i>Myrica cerifera</i>	All	Coastal Plain	Yes	W - SP	10 ft.	Moderate	Medium	Medium	Evergreen. Need male and female plants for fruit production. Salt tolerant (0-10 ppt).

TABLE 3 NOTES:

- The **Plant Hardiness Zones** designate where a species can be successfully planted in Delaware, while the **Geographic Distribution** describes where the species usually occurs under natural conditions.
- Soil Drainage Class** (refer to the county soil survey for further information):
E - Excessively Drained; W - Well Drained; MW - Moderately Well Drained; SP - Somewhat Poorly Drained; P - Poorly Drained.
- Growth Rate:** Slow = less than 1 ft/year; Moderate = 1–2 ft/year; Fast = 2-3 ft/year; Very Fast = more than 3 ft/year.
- Density:** For an individual plant species, defined as the amount of space that is occupied by foliage, twigs, and branches, and can be estimated by the amount of light that can be seen through the plant. Low density – 25-35% of space occupied by plant material (with 65-75% open space through which air can travel); Medium density – 40-60% of space occupied by plant material; High density - 60-80% of space occupied by plant material; Very High – more than 80% of space occupied by plant material. The overall density of a windbreak is affected by the species selected, number of rows, and spacing between plants.