WINDBREAK/SHELTERBELT ESTABLISHMENT

Conservation Practice Standard 380 Guidance

Natural Resources Conservation Service (NRCS) **August 2008**

Slash pine and red cedar at Florida Dep. Agric. and Consumer Services foundation grove in Dundee.

PURPOSE

The purpose of this guidance is to provide additional information for Florida NRCS Conservation Practice Windbreak/ Shelterbelt Establishment, Code 380.

BACKGROUND INFORMATION

Windbreaks/shelterbelts are either natural (e.g., strips of trees and/or shrubs, but in Florida may be made up of tall, perennial herbaceous materials such as bamboo or sugarcane) or artificial structures that are used to alter windflow and microclimate, resulting in the protection of a specific area. For the purposes of this guidance, only windbreaks/ shelterbelts established from living plants are considered.

Windbreak is the term used when strips of trees or shrubs (as opposed to herbaceous, annual material used in Florida NRCS Conservation Practice Standard Herbaceous Wind Barriers, Code 603) are planted at the edges of fields or in the fields themselves to protect crops. Shelterbelts are similar plantings that are used to provide shelter for wildlife, livestock, houses, and farm buildings. This conservation practice often is planted and managed as part of livestock or crop production operations, but can be used to benefit wildlife and human wellbeing.

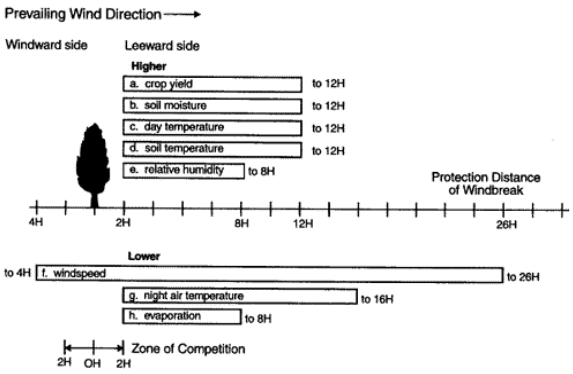
Wind damage is one of the leading causes of crop damage across the US. Although tree/shrub windbreaks are not used widely in Florida, recent experience has shown that fields protected by these types of windbreaks have suffered less damage during hurricane events. Windbreaks of trees or sugarcane are recommended by the University of Florida for vegetable crops such as eggplant that are subject to wind scaring or scratching.

Even livestock operations in Florida can benefit from windbreaks/shelterbelts. Research has shown that when wind chill temperatures dip below 59^{o} F, cattle with short coats must expend energy to keep warm. Therefore, nutritional requirements increase when wind chill dips below that temperature. It also is thought that shelterbelts can help to reduce nuisance odors associated with confinement production systems

Properly designed shelterbelts also can reduce both heating and cooling needs in Florida homes and businesses (http://hort.ifas.ufl.edu/gt/reducenrg/reducnrg.htm).

Function

Windbreaks function by reducing wind speeds on both sides of the planting, but the distance



wind speed is effectively reduced is greater on the downwind (leeward) side than the windward side (see figure above). As a result of these changes to downwind wind speed, research has shown that windbreaks increase crop yield, soil moisture, daytime air and soil temperatures, and relative humidity. Windbreaks also decrease night air temperatures and evaporation on the downwind side. The effects on these different factors vary with the distance from the windbreak planting and is expressed as a function of windbreak height (H). Downwind benefits from windbreaks are usually found between 8 to 12 times H (see figure above) or on average 10 times H (10H). This accounts for the specification in the conservation practice standard that the downwind area protected needs to fall within 10H (e.g., a 10-ft tall plant will have an effective protection zone of 100 ft downwind, 20-ft tall = 200 ft, etc.)

Continuity

For a windbreak to have maximum effectiveness, it is essential that it be continuous down its entire length and that the windbreak have no large gaps. Gaps can create a funnel effect that concentrates wind flow and result in a wind speed in excess of those that would be experienced in open fields. If a windbreak must be crossed by a road, lane, or large ditch, try to make the crossing at an angle to the prevailing wind (i.e., some angle other than perpendicular to the windbreak).

Density

The terms 'density' and 'porosity' both can be found in windbreak literature and they mean the exact opposite of each other. Density refers to the structures of the plant that block the wind (e.g., leaves, branches, and trunk), while porosity refers to the amount of space not occupied by structures that block the wind. With densities of less than 100% (e.g., 100% density = solid fence), wind can go over, around, and through a windbreak.

Table 1. Wind speed reduction downwind of different density windbreaks based on 20 mph open wind speed[1].

H distance from windbreak	5H	10H	15H	20H	30H
Single Row Deciduous Trees (25-35% density)					
Miles per hour	10	13	16	17	20
% open wind speed	50	65	80	85	100
Single Row Evergreen Trees (40-60% density)					
Miles per hour	6	10	12	15	19
% open wind speed	30	50	60	75	95
Double Row Evergreen Trees (60-80% density)					
Miles per hour	5	7	13	17	19
% open wind speed	25	35	65	85	96
Solid Fence (100% density)					
Miles per hour	5	14	18	19	20
% open wind speed	25	70	90	95	100

[1]Adapted from USDA, NAC, Agroforestry Notes. March 2002. Windbreaks: An Agroforestry Practice. AF Note-25.

The ability to flow through a windbreak has a great impact on the functional characteristics of a windbreak. In Table 1, you can see the differences in the wind speed reduction expected from windbreaks of different densities. Clearly, the windbreak that is more solid or has a greater density will reduce the initial wind speed the most, but low pressure downwind of the barrier pulls air coming over the barrier downward creating turbulence, which reduces the effective distance. Lower densities, by allowing the air to flow through, result in greater distances protected by moderating the low pressure and reducing turbulence.

In the Table 1, with an initial wind speed of 20 mph, the wind speed downwind of the solid windbreak is back to 70% of the open wind

speed (14 mph) at 10H. For 40 to 60% density windbreak, similar reductions in wind speed still occur between 12H and 15H and for 60 to 80% density windbreak between 15H and 20H. Even a single row of deciduous trees, which is estimated to be only 25 to 35% density, produced a 10% slower wind speed at 15H and 20H than a solid fence at the same distance.

Choice of species, deciduous vs. evergreen, tree spacing, and number of rows are all factors that affect density and need to be considered when designing a windbreak to meet performance goals. Thus, it is important to know how much and for how far downwind you want wind speed to be reduced before designing a windbreak system.

Orientation

Windbreaks are most effective when they are oriented at right angles to troublesome winds. Because wind directions may shift, they are often planted in multiple directions such as 'L', 'U', or 'E' shapes. Prevailing winds in Florida shift with season; more often coming from the north during the winter and from the east, southeast, or northeast in the spring and fall, and from the southeast or southwest in the summer. More information on wind direction for different locations in Florida can be found on Table 15 Wind Direction and Prepond-erance in the Florida Erosion Control Hand-book and at http://edis.ifas.ufl.edu/EH105. Additional real-time wind information can be found at the Florida Agricultural Weather Network (FAWN, http://fawn.ifas.ufl.edu). It is important to design the windbreak so that one or more legs is perpendicular to the prevailing winds during the season that creates the greatest problem (e.g., north or northwest to provide shelter for livestock in the winter, south or southwest to divert warm winds away from houses in the summer, etc.) Future management issues such as interference with utilities and road visibility also need to be considered.

Information Applicable to All Purposes

Within and between row spacing

Because for most circumstances windbreaks are planted using long-lived perennials, windbreak design (location, layout, and density of the planting) needs to meet the purpose and function of the practice optimally by 10 years after planting, up to a maximum of a 20-year period. This means that within-row and between row tree/shrub spacing need to be close enough that crown closure will occur within this period. Thus, the spacing between individual plants needs to be based on the growth requirements of the plant type and species and the desired characteristics of the stem(s), branches, and canopy as required for a specific purpose.

See Florida NRCS Conservation Practice Standard, Tree/Shrub Establishment, Code 612, and Univ. of Florida, Native Plants for Home Landscapes (http://edis.ifas.ufl.edu/EP011) for information regarding expected heights, adaptation, etc., of common trees and shrubs used in Florida. Additional information on specific trees and shrubs can be found at: http://edis.ifas.ufl.edu/DEPARTMENT_ENVIRONMENTAL_HORTICULTURE .

Unless specific recommendations are known for a given species, suggested within row spacing for multiple row plantings for farmstead or animal confinement areas are:

- 3 to 6 feet for shrubs and eastern red cedar (*Juniperus virginiana*).
- 6 to 12 feet for trees less than 25-feet tall at 20 years.
- 10 to 16 feet for tall evergreen and deciduous trees.
- 2 feet for sugarcane (*Saccharum officinarum*).

For single-row plantings including field windbreaks, within row spacing needs to be closer. For tall shrubs and cedar, a spacing of no more than 8 feet is suggested and tall evergreen or deciduous trees, should be no further apart than 12 feet.

For 2-row field windbreaks, recommended within row spacing should be:

- 4 to 6 feet for shrubs and eastern red cedar.
- 8 to 12 feet for tall shrubs and trees less than 25 feet at 20 years.

- 12 to 16 feet for tall evergreen and deciduous trees.
- 2 feet for sugarcane

If there is a requirement for rapid crown closure, higher density plantings can be used. This design can be thought of as a series of closely spaced, paired windbreak rows within the larger windbreak planting. "Twin-row" refers to two closely spaced rows of the same tree or shrub species. Normal suggested between-row spacing for twin-row planting is 6 feet (as little as 4 feet for shrubs and up to 10 feet for trees) but standard within-row spacing of the plants is used. "High-density" utilizes the twin-row arrangement but also uses closer than normal within-row spacing (3 to 10 feet depending on mature size.)

Although between and within-row spacing with such planting arrangements may be higher than recommended for normal development of a given tree or shrub, row spacing between the paired twin rows is usually much wider than for normal multiple-row windbreaks which allows for normal root development. With this planting arrangement, common distances between twin rows for shrubs are 25 feet and 40 to 50 feet for trees. Once seedlings are established, between twin-row areas may need to be clean tilled to ensure good tree/shrub vigor. In some cases, annual crops can be grown in the large areas between twin-row plantings which can be used for production or wildlife food/cover.

For windbreak plantings, plant spacing is largely determined by plant growth, requirements for a particular species of tree/shrub to mature properly, and any long range management of windbreaks needs. These may include thinning and other maintenance operations (e.g., pruning, mowing, disking, etc., see Florida NRCS Conservation Practice Standard, Tree/Shrub Pruning, Code 660). So the spaces between windbreak rows or between windbreak and crop need to be wide enough to accommodate expected maintenance equipment plus 4 feet. Where mulches are used around the tree/shrub, the between-row distance should include the width of the mulch and the width of the equipment. Often after canopy closure, shading will control vegetative competition and mowing or cultivation between rows will not be necessary.

Planting stock and species selection

Use only high quality planting stock. The levels of nutrients and carbohydrate reserves in a woody plant are critical a plant's ability to extend roots into the landscape soil. Low nutrient status in plants generally can not be overcome by application of fertilizers at planting. Thus, it is important to use vigorous, healthy plants.

Species used for windbreak/shelterbelt plantings need to be adapted to the soils, climate, and site conditions. Additionally species used in windbreak plantings need to be tolerant of commonly used pesticides associated with the crop production system. In addition to the pesticide label, some information regarding tolerance of common woody species to different herbicides can be found in the Univ. of Florida, IFAS publication ENH-97 "Ornamentals Tolerant of Pre- and Postemergent Herbicides" http://edis.ifas.ufl.edu/WG062).

Another consideration when selecting species to use in windbreak/shelterbelt plantings is that they should not be listed as a Category I invasive species by the Florida Exotic Pest Plant Council (http://fleppc.org). Consult Florida Plant List for Conservation Alternatives [FOTG II (g) (1)] for approved trees and shrubs. Other plant material not found on the list may be suitable, but they need to be approved by the Plant Materials Specialist before use.

Location

Do not plant trees or shrubs in locations where they may interfere with structures and above or below ground utilities. For plantings adjacent to overhead lines, plant shrubs or trees so that the projected crown height and diameter at 20 years of age are at least 20 feet from the nearest line or structure. When space is limited, species with mature heights less than the height of the facility can be used beneath aboveground utilities. Avoid planting trees and shrubs within 20 feet of underground septic lines where possible.

Site preparation and planting

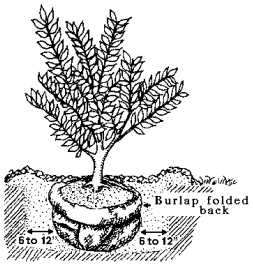
Proper site preparation prior to planting trees and shrubs is critical to their survival. Site preparation needs to be sufficient for establishment and growth of selected species, but not contribute to erosion and be appropriate for site. Mechanical, manual, or chemical methods can be used for site preparation. Properly prepared sites need to be free of living sod and weeds. Minimally for each tree or shrub a 3-foot diameter circular site or a 3-foot wide strip needs to be prepared and soils need to be in a settled condition at planting. Where grass sod is present, a nonselective herbicide application can be used to kill the sod and tree/shrub planted in residue. Trees and shrubs can also be transplanted directly into crop stubble without prior site preparation as long as the site is reasonably free of weeds. It may be necessary to till or disk a narrow strip to kill existing weeds or volunteer weeds, or to prevent residue from clogging a tree planter.

- **Containerized or balled and burlapped plants**

  Container-grown and balled and burlapped plants can be planted anytime of the year in Florida provided proper soil moisture levels are maintained. Avoid plants that have grown too long in containers because they can become root bound. This condition is difficult to overcome; there is no strong scientific evidence to support the benefit of cutting or disturbing the root mass of root bound plants.

  Always move plants by the container or root ball only. Never use the trunk as a handle to pick up or move these plants. Care should be taken not to disturb the root ball, as this would severely damage the root system. Until ready to plant, store plants in the shade and keep the soil around the roots moist.

  Remove container of containerized plants prior to planting. Removal of all the burlap before planting is not necessary, although the top one-third of the burlap should be pulled back from the stem (see following illustration).



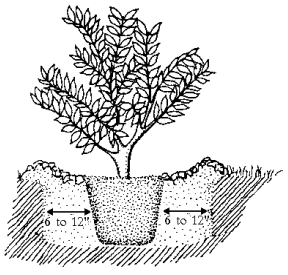
Remove woven plastic wraps and any other plastic material completely after setting the plant in the hole. If specific instructions for planting a given containerized or balled and burlapped tree or shrub are unavailable, use the following steps (see illustration below):

1. Dig the planting hole 1 foot wider and as deep as the container is tall.

2. Place the plant straight in the hole and be sure the top of the root ball is no deeper that the existing landscape soil surface. Fill around the ball with soil and gently firm the soil. Do not pack the soil. Water thoroughly while planting to remove air pockets.

3. Form a saucer-like catchment basin around the edge of the root ball with a soil ridge 3 to 6 inches high to facilitate watering. Do not mound soil over root ball.

4. Mulch with 3- to 4-inch layer of organic material but be sure to keep the mulch layer approximately 3 inches away from the plant stem.



- **Bare rooted material**

  Bare-root plants are generally available only during winter and early spring and should only be planted at these times.

Plan on picking up seedlings immediately after they are lifted at the nursery. Pine seedlings can be stored at cool temperatures (33-35°F) for 1-2 weeks. If cold storage facilities are not available, seedlings should be stored in the shade (with good air circulation), kept moist, and planted as soon as possible. Sand pine and longleaf pine seedlings should not be stored but should be planted immediately (within a week) after lifting. Consult with seedling producer for storage options for species other than pine.

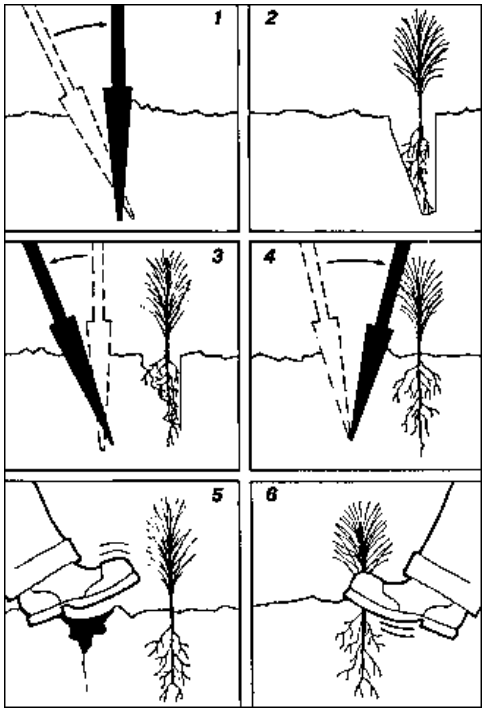
When seedlings get too warm, they may dry out or use up their food reserves and die. If possible transport seedlings in a cooler or refrigerated vehicle. If this is not possible, transport them at night in a canopy-covered truck or other covered vehicle with the bales or bags arranged so that air circulates among them. Do not transport seedling in open trucks which can cause excessive drying.

The main consideration during planting is protection of the seedlings, especially the root systems. Do not allow seedling roots to become dry. Place seedlings in buckets of water or cover them with wet burlap until they are in the ground. When planting, it may be helpful to leave a depression around the seedling to catch water. Of course, if feasible, watering after planting will aid survival.

Bare rooted seedlings can be either hand or machine planted. Proper hand planting of pine seedlings is shown in the adjacent illustration.

Before a machine planting operation, check that the planter makes the furrow deep enough for the entire root system, that desired within row spacing is met, and that the planting depth is correct (at or just below root collar).

Regardless of the planting method used, during the planting operation check to make sure the seedlings are: 1) planted at the proper depth, 2) planted straight up and that the roots are straight in the hole, and 3) that the seedlings are firmly packed in the hole. To check the latter for pine seedling, grab the top needles of the



seedling and firmly pull upward; if the seedling is too loosely planted, it will come out of the soil.

If specific planting instructions for a given barerooted tree or shrub are unavailable, use the following when hand-planting bare-root plants:

1. For other than pine seedlings, dig a hole 1-foot wider than the root spread and about the same depth as the root system. Seedlings should be planted so that the root collar is at or within ½ inch below ground level.

2. Inspect the root system and cut off roots broken or damaged.

3. Make a shallow, rounded mound of soil in the bottom of the planting hole and place the plant on the mound and spread the roots to their natural, nearly horizontal position. Set the plant upright and at the same depth it was grown in the nursery.

4. Hold the plant upright and fill the hole half to two-thirds full of soil. Work the soil around the roots to eliminate air pockets.

5. Settle the soil around the roots with water before filling the remainder of the hole. Do not compact the soil around the roots with your foot because it could damage the root system.

6. Form a saucer-like catchment basin around the edge of the planting hole to aid in watering.

See Florida NRCS Conservation Practice Standard, Tree/Shrub Establishment, Code 612, and the Univ. of Florida, IFAS publication ENH-856, "Specifications for Planting Trees and Shrubs in the Southeastern U.S." (http://edis.ifas.ufl.edu/EP112) for more information on planting trees and shrubs.

Mulching

Mulches reduce soil temperature fluctuations, prevent packing and crusting, help conserve moisture and control weeds, and add organic matter to the soil. Provide a 2- to 3-inch layer of mulch at the base of newly installed plants. Generally, a 2-foot circle of mulch per inch of tree trunk caliper will give adequate mulch area for newly planted trees. Entire beds of mass-planted shrubs should be mulched. See Florida NRCS Conservation Practice Standard Mulching, Code 484, and Univ. of Florida, IFAS publication ENH-103, "Mulches for Landscape" (http://edis.ifas.ufl. edu/MG251) for more information on mulches.

Supplemental Water

When natural precipitation is too low for plant establishment and growth, supplemental water needs to be provided. Supplemental water can be applied by hand or by means of an irrigation system. See Florida NRCS Conservation Practice Standards Irrigation System, Sprinkler, Code 442, and Irrigation System, Microirrigation, Code 441, for more information on designing irrigation systems for Florida.

Regardless of the method of applying supplemental water, transplanted plants need to be watered thoroughly after planting and "as needed" during the establishment period. The length of the establishment period can vary from a few months for one-gallon size plants to several years for trees 6 inches or greater in trunk diameter. The amount and frequency of water application will depend on the tree species and size, site water table depth, soil type, slope, and the amount of irrigation the existing system can supply to the recent transplant. Across-the-board recommend-ations are not practical; however, except on a poorly drained site, it is probably safe to err on the wet side for several months to a year following planting.

When watering, apply water directly to the root ball by filling the catchment basin constructed around each plant. In well drained sands, small trees and shrubs should be watered daily for the first week, every two days for the next 4 to 6 weeks and one day per week for weeks 7 to 12. Continue once-a-week watering for 1 to 2 years for transplanted trees with trunks larger than 4 inches in diameter. A less frequent irrigation schedule may be suitable for soils that retain more moisture than deep sands.

Container-grown plants require frequent irrigation when planted in well-drained soils. Water will not move from the soil into container media until the soil is almost saturated with water. Water should be directed on the root ball surface at least until the root system is established.

Fertilizer

Several of the essential plant nutrients, especially nitrogen and potassium, readily leach from Florida's sandy soils. Because it will be several weeks to months before root growth will be sufficient to adsorb applied nutrients, a general broadcast application of fertilizer at transplanting is not recommended (See exception for citrus windbreak establishment). Proper irrigation is much more important to plant establishment than applications of fertilizers at the time of planting. If a fertilizer is added at the time of planting, make it a light application of a slow-release fertilizer to deliver nutrients over an extended period. Optimally, fertilizer application would begin a few months after planting. See Florida NRCS Conservation Practice Standard, Tree/Shrub Establishment, Code 612, and Univ. of Florida, IFAS publication ENH-858,

"Fertilizer Recommendations for Landscape Plants" (http://edis.ifas.ufl.edu/EP114).

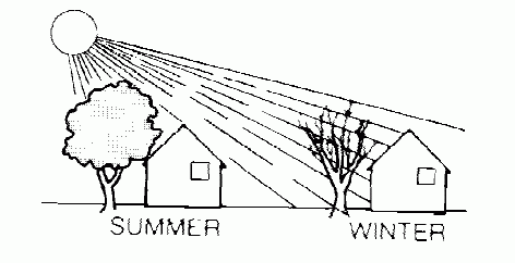
Windbreak/Shelterbelt Measurement

When it is necessary to report the acreage occupied by a windbreak/shelterbelt, calculate the area (length x width) using length as the length of the windbreak plus 20 feet at each end and width as the total distance between the rows plus 20 feet on either side of the windbreak. In this case, a single row windbreak will have a 40-foot width.

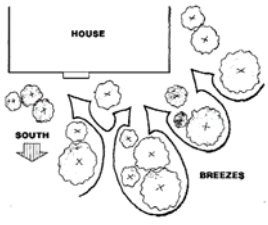
Example: A four-row windbreak, 1,000 feet long with a 20 foot spacing between rows would have linear measurement of 1,040 feet (20 + 1,000 + 20) and a width of 100 feet (20 + 20 [between rows 1 and 2] + 20 [between rows 2 and 3] + 20 [between rows 3 + 4] + 20). Acreage = (1,040 x 100)/43,560 sq. ft per acre, in this case 2.39 (2.4) acres.

Additional Information to Provide Shelter for Structures, Livestock, and Recreational Areas

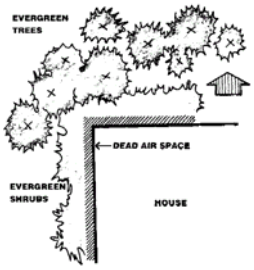
Deciduous trees or shrubs located on the southern side of a structure will offer some shade and wind diversion during the summer and reduce air conditioning costs, but allow maximum sunlight to warm the structure in the winter.



Additionally, placement of trees and shrubs can be used to channel cooling breezes toward non air conditioned structures.



In Florida, significant heating energy savings can be provided in the winter when shelterbelts situated on the north, northwest and, to a lesser extent, northeast exposures of the home or other structure. A multilayered canopy of shrubs and trees of moderate density planted in 2 to 5 rows is the most effective shelterbelt design, but even a single row of trees provides some shelterbelt action. Locate the tallest row of the shelterbelt approximately 2 to 5H from the primary area to be protected.



Locate livestock protection so that animals have access to the protection from fall/winter/spring winds. With L-shaped belts, downwind side protection is available during most storms. Due to the shifting nature of wind, where property boundaries allow, extend the ends of rows a minimum of 150 feet past the edge of the area needing protection. Minimally one row of trees is used, but if multiple rows are planted, for year round protection at least one row should be evergreen trees. Do not situate the shelterbelt where animal waste from a livestock area will flow into the shelterbelt.

Additional Information for Controlling Odors and Particulates

Although use of windbreaks or shelterbelts for odor abatement in livestock production systems has been suggested, there is no research data to support their effectiveness. Several monitored plantings have been established. See http://www.forestry.iastate.edu/res/odor_mitigation.html for more information on this subject.

To trap particulates from tunnel fans, such as those used in poultry houses, plant at least one row of evergreen trees/shrubs within 25 feet of the fans. Other permanent barriers (e.g., fencing, earthen berms, walls, etc.) may be needed to control particulates. Temporary barriers of netting, tall grass, or straw bales may be necessary until permanent vegetation is established. Structural particulate barriers will need to be cleaned with water periodically;

establish or maintain a grass cover around the barrier to filter rinse water.

Additional Information for Citrus Canker Control

The citrus canker eradication program in Florida ended on January 10, 2006. Citrus producers in Florida will now rely on a combination of resistant varieties, chemical sprays, and windbreaks to manage the impact of the disease (http://edis.ifas.ufl.edu/FE286). The citrus canker research community believes that windbreaks are the most critical component of this three-pronged management effort. For this reason, Florida NRCS received a variance to include pathogen control as a purpose in Florida NRCS Conservation Practice Standard, Windbreak/Shelterbelt Establishment, Code 380.

Current recommendations for using windbreaks for citrus canker control are to establish windbreaks with adapted plant species (Table 2) that will achieve a 50 to 70% density ideally within 5 years or less, but by no more than 10 years after planting. This density can be achieved by planting one or two rows of adapted evergreen trees or a single row of evergreen trees and a second row of shrubs. Single or double rows of bamboo also may be suitable in some circumstances.

Due to the need to provide protection throughout the year, windbreaks for citrus canker control need to be planted on all sides of the citrus block. Maximum size of each citrus block protected by a windbreak planting cannot be more than 20 acres. Thus, groves larger than 20 acres need to be divided into blocks as close to, but not exceeding, 20 acres as is practical, each surrounded by a windbreak planting.

The decision of which species to use is dependent on many factors including plant availability, cost, growth rate, soil type, and the

Table 2. Plant species for Florida Citrus Groves.

Common name	Scientific name	For use in citrus production area	Height at 2 yr	Mature height	In row spacing
Trees and other					
Slash pine	*Pinus elliottii*	Flatwoods	8-10 ft	80 ft	3-6 ft
Sand pine	*Pinus clausa*	Ridge	6 ft	70 ft	3-6 ft
Eucalyptus	*Eucalyptus grandis* or *Corymbia torelliana* (=*E. torelliana*)	Those soils not suited for pine and ridge soils with irrigation	15-20 ft	90 ft	3-6 ft
Silk oak	*Grevillea robusta*	Flatwoods	10 ft	40 ft	6 ft
Red cedar	*Juniperus viginiana* or *J. silicola*	Ridge and flatwoods	6 ft	40 ft	4-6 ft
Bamboo	*Bambusa* spp. (non running species only)	Ridge and flatwoods	20-30 ft	40-60 ft	4-6 ft
Shrubs					
Walter's viburnum	*Viburnum obovatum*	Ridge and flatwoods	6-10 ft	20 ft	6 ft
Sweet viburnum	*Viburnum odoratissimum*	Ridge and flatwoods	6-10 ft	20 ft	6 ft
Saw palmetto	*Serenoa repens*	Ridge and flatwoods	4 ft	6 ft	3 ft
Crape myrtle	*Lagerstroemia indica*	Flatwoods	10 ft	30 ft	3-6 ft
Wax myrtle	*Myrica cerifera*	Ridge and flatwoods	6-10 ft	10-15 ft	6 ft
Simpson's stopper	*Myrcianthes fragrans*	Ridge and flatwoods	6 ft	20-30 ft	3-5 ft

location of the grove to be protected (Table 2). Slash pine is recommended only for flatwoods sites, while sand pine is recommended only for groves located on the central Florida ridge. Both pine species are available as field grown seedlings which makes them relatively inexpensive.

Eucalyptus (either *E. grandis* and *Corymbia tortelliana*) is the fastest growing species listed but is likely to be the most expensive because there are no field grown seedlings available and all plantings will be made using containerized plants. Eucalyptus is suited for many soil types including those soils not suited for pine production due to high pH (pH >6.5), but should not be planted on ridge sites unless supplemental irrigation is provided.

Red cedar has excellent wind speed reducing characteristics and can be used alone or in combination with taller growing pine species. It is relatively expensive and slow growing.

Bamboos are expensive to establish because they are vegetatively propagated as divisions, but are relatively fast growing and offer good wind speed reducing characteristics. If bamboo is to be used, only bunch type bamboos, such as *Bambusa ventricosa* 'Buddha's Belly' or *B. oldhamii* 'Oldham' should be planted.

Many of the taller tree species tend to self prune (i.e., loose their lower limbs as they age), thus,combinations of tall trees and shrubs may be necessary to provide acceptable wind speed reductions throughout the profile of the windbreak. Shrubs listed in Table 2 can easily be found at commercial nurseries or ones specializing in native plants (www.afnn.org).

Because citrus canker control windbreaks need to reach functional height and density as soon as possible, use of slow release fertilizer at planting and supplemental irrigation are recommended for all new plantings.

More detailed information on windbreaks for citrus canker control can be found at http://www.crec.ifas.ufl.edu/.

Additional Information for Providing or Enhancing Wildlife Habitat

When possible, plant two or more rows of trees or shrubs in the windbreak to enhance the benefit of the windbreak for wildlife. Increasing the number of rows (above the minimum) and diversity of plant species in a windbreak/ shelterbelt planting will increase the variety of wildlife that utilize the site.

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