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Windbreak Benefits, Design, and Management

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Introduction

Windbreaks are single or multiple rows of plants strategically placed to protect an area from winds that may hinder crop and livestock production, including potential damage to structures. Also known as shelterbelts, windbreaks may consist of living (plants) or structural (non-living or synthetic materials) barriers that filter and slow potential damaging winds that enter a specific area.

This factsheet emphasizes the importance of windbreaks and on how to establish a windbreak according to landowner objectives and land, weather, and wind conditions. It also covers site preparation, planting, and maintenance for long-term protection of crops, livestock, and structures against potentially damaging winds.

More Benefits of Windbreaks

Besides protecting plants and structures, windbreaks:

- Improve the crop/pasture quality
- Conserve moisture
- Reduce erosion
- Intercept potential salt spray, dust, and chemical drift
- Reduce noise levels
- Increase the total value of on-site resources (other plant products that may be harvested from the plants in the windbreak)
- Reduce unpleasant odors
- Serve as visual screen/living barrier (aesthetics)

Federal programs can help farmers establish windbreaks

Through participation in the Natural Resource Conservation Service's (NRCS) Environmental Quality Incentive Program (EQIP) farmers may receive cash reimbursements for establishment costs of recommended conservation practices, including propagation and planting labor costs. Planting windbreaks using fruits or other trees are one of the many recommended practices when farm families enroll and meet the EQIP program requirements. They have the opportunity to implement sound environmental practices like windbreaks on their farms and receive partial cost reimbursement for doing so. Establishing perennial plantings, implementing conservation plans and getting paid for doing so add up to an attractive farm program. On our island windbreaks are a key component in most farm conservation plans. For participation in government programs, it is important to verify that the program requirements are met and plans are in place prior to planting. For more information on the EQIP program contact the local NRCS field office at (671)300-8591.

Windbreak Design Considerations

Windbreak design is generally based on the landowner's objective(s) and land, weather, and wind conditions. The benefits listed above help in identifying landowner objectives for windbreak establishment. There are seven (7) key components to consider when preparing a long-living and productive windbreak design.

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1. Recommended Orientation

For effective protection of the plants, crop(s) or animal(s), and/or structures, orient the windbreak perpendicular to the prevailing wind direction.

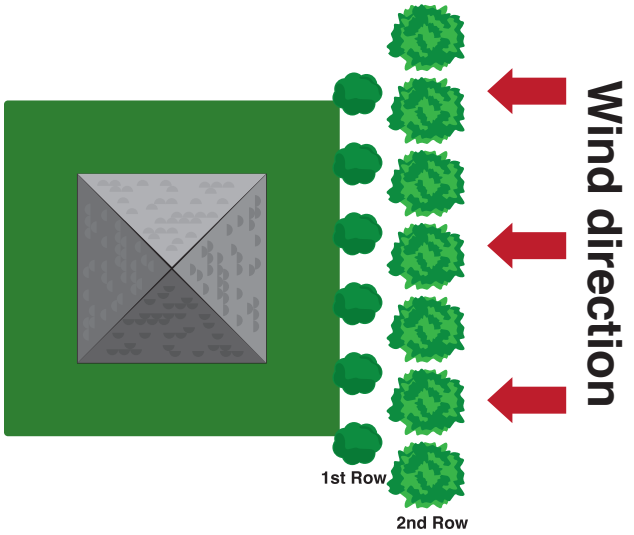

Figure 1. Windbreaks should be perpendicular to prevailing winds.

On Guam, the prevailing winds come from the east-northeast but wind direction can change at any time throughout the year. It is also documented that westerly trade winds generally occur from December through February however, easterly trade winds are dominant throughout the year. In this case, it is recommended to use multi-leg windbreaks (L-shape, U-shape, surrounding) to protect the area against potentially damaging winds from multiple directions.

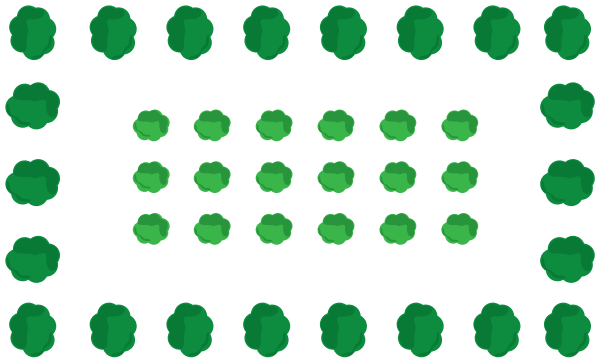

Figure 2a. Design sample of a surrounding windbreak on a property.

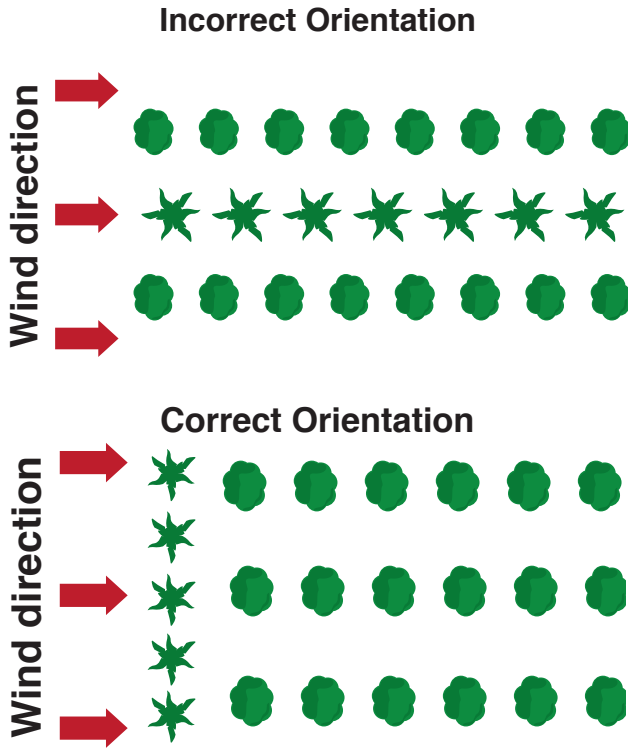

Figure 2b. Example of incorrect and correct orientation of windbreaks.

2. Height

Ideally, windbreaks should be twice as tall as the height of the object being protected. Consider the height of the windbreak in 20 years – it could be very tall. In general, a windbreak tree will reduce wind speed for a front distance of 10 times its height. Using the formula 10 x H (height of the tree), a 10-foot tall windbreak will protect an area of up to 100 feet in front of it.

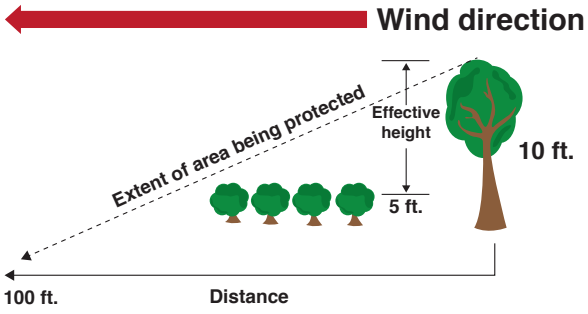

Figure 3. A windbreak 10-foot tall can protect an area of up to 100 ft.

3. Length

Planting trees past the sides of the area to be protected reduces wind from whipping around the ends and hitting the plants, animals, and structures that need protection. It is recommended that the windbreak be made as wide as five times the height of the windbreak (maturity height in 20 years). This can be done if the area is wide enough for expansion on the sides. Otherwise, establish a surrounding design to protect the area from whipping winds on the ends.

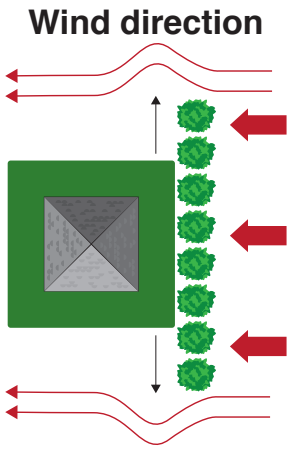

Figure 4. Windbreak extension reduces wind from whipping around the ends of the area to be protected.

4. Density

The amount of leaves, branches, and trunks of the windbreak makes up its density. The denser the windbreak, the higher the wind-speed reduction. However, the windbreak should only reduce the wind speed and not completely block because air circulation regulates temperature around the plants, animals, and structures being protected. Consider proper spacing and the right species to plant to allow favorable growth of plants and avoid early foliage deterioration when plants are planted too close to each other.

The following are density recommendations for specific windbreak objectives. The protection of:

- Crops – 40-60% density
- Noise reduction, structures, and livestock – at least 65% density
- Air quality – 50-65% density

5. Number of Rows

Windbreaks may be single or multi-row depending on the strength of winds, the area to be protected, and the amount of space available on the lot. The larger the area, the more rows can be established while a smaller area may only allow 1 or 2 rows depending on the landowner's objectives and other site conditions. When multiple rows are established, it provides greater flexibility which means that trees are stronger and stiffer, reduces gaps which are sources of stronger winds, and provides more plant products to be harvested (if the plants are ones that provide secondary benefits). When establishing multi-rows, use different species to promote diversity and reduce plant pests and diseases; especially if certain plants are known host of pests. Species compatibility between rows should be taken into consideration by looking at the number of rows and sizes of species to be planted such that, the rows will be a combination of shrubs or small trees (first row) and medium to tall trees (second row). The shrubs or small trees gives protection from damaging winds entering on the lower part of the property, while the medium to tall trees blocks damaging winds on the upper portion.

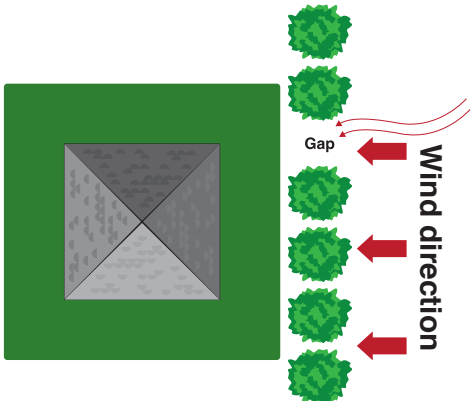

Figure 5. Two rows of windbreak.

6. Continuity

A windbreak is more efficient when there are no large or unplanned gaps. Avoid gaps by replanting early and replace dead trees right away since gaps will serve as tunnels where potentially damaging concentrated wind flow will enter the protected area. Allow trees and shrubs to grow together to form a continuous barrier but not too dense because this will reduce some needed air circulation. If the windbreak is too dense, concentrated wind flow will climb on top of the barrier and enter the field with greater force rather than being dispersed.

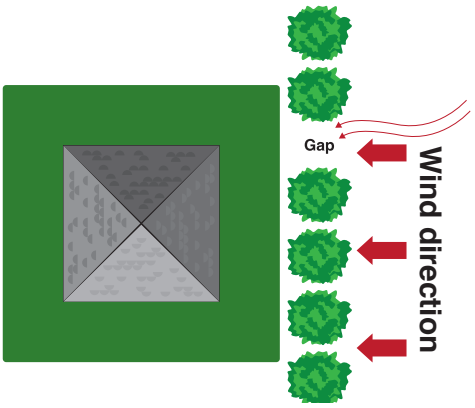

Figure 6. A gap in the windbreak accelerates wind-force to enter the protected area.

7. Species

Tree species should be flexible, long-lived, and well-adapted to the site where they are being considered for planting. Understand the growth characteristics of the desired species for proper spacing and density. When selecting a species to plant, consider the invasiveness, potential competition with field crops, resistance or attraction to pests and diseases, growth rate, canopy widths, and average short and long-term height. Depending on the landowner objectives, the species to be planted may vary according to the other six factors listed above. Tables 1 and 2 lists trees that are frequently used as windbreaks on Guam and provides some attributes related to site suitability.

Farmers on islands with limited land area should consider implementing a multi- purpose windbreak. Multi-purpose windbreaks provide wind protection as its main function, while also serving other valuable functions like fruit, timber, or nut-production that can be sold for additional income or use for family food or livestock feed.

If fruit trees are used as windbreaks, a farmer may enjoy the returns generated, a crop of breadfruit for example. On Guam, breadfruit, jackfruit, mango, soursop, calamansi, and coconuts have been used as windbreaks. Many other fruit and fodder trees have potential as windbreaks as well.

Table 1. Fruit trees used as windbreaks on Guam.

Common Name	Scientific Name	Height at Maturity	Spacing (ft.)	Site Suitability
Avocado	*Persea americana*	M	15-20	well-drained soil, large crown
Breadfruit	*Artocarpus altilis*	H	20-30	sand, sandy loam, loam or sandy clay loam soil, large crown
Calamansi	*Citrofortunella microcarpa*	S	8-10	well-drained, sandy or clay loam soil, small crown
Coconut	*Cocos nucifera*	H	10-12	laterite, coastal sandy, alluvial, and marshy lowlands, moderate crown
Dwarf coconut	*Cocos nucifera*	M	10-12	well-drained soil, moderate crown
Guava	*Psidium guajava*	S	5-8	well-drained soil, small crown
Jackfruit	*Artocarpus heterophyllus*	H	20-30	porous and well-drained sandy loam soil, large crown
Lemon China	*Citrus limon*	S	10-15	well-drained soil, small crown
Mango	*Mangifera indica*	H	5-20	well-drained sandy or loamy soil, large crown
Mulberry	*Morus sp.*	M	10-15	well-drained, fertile and moist soil, small crown
Noni	*Morinda citrifolia*	S	6-10	well-drained, sandy loam soil, small crown
Pomegranate	*Punica granatum*	S	5-8	well-drained, loamy, sandy, or clay soil, small crown
Saba Banana	*Musa sp.*	S	8-14	well-drained, loamy soil, large crown
Soursop	*Annona muricata*	S		well-drained, loamy clay soils, medium crown
Surinam cherry	*Eugenia uniflora*	M	8-10	well-drained, sand, sandy loam, stiff clay, and soft limestone soil, small crown
Tamarind	*Tamarindus indica*	M	15-20	well-drained, loamy soil, large crown

Table 2. Non-fruit trees used as windbreaks on Guam.

Common Name	Scientific Name	Height at Maturity	Spacing (ft.)	Site Suitability
Alahe'e	*Psydrax odorata*	S	2-6	well-drained, clay, cinder, and organic soil, small crown
Areca palm	*Chrysalidocarpus lutescens*	M	3-10	well-drained, any type of soil, medium crown
Binalo	*Thespesia populnea*	M	10-20	well-drained, sandy coastal soils as well as volcanic, limestone, and rocky soils, medium crown
Croton	*Codium variegatum*	S	2-6	well-drained, moist soil, small crown
Da'ok	*Calophyllum inophyllum*	H	8-20	well-drained, coastal sand, clay, or even degraded soil, large crown
Eucalyptus	*Eucalyptus spp.*	H	10-15	well-drained, any type of soil, large crown
Fasa	*Pandanus tectorius*	M	3-10	sandy, clay, loamy, sandy loam, clay loam, medium crown
Hibiscus	*Hibiscus spp.*	S	2-6	well-drained, sandy loam, small crown
Hunik	*Tournefortia argentea*	S	8-15	well-drained, sandy and sandy loam soil, large crown
Ifit	*Intsia bijuga*	H	10-40	well-drained, sandy, loamy, and limestone soil, large crown
Lampuye	*Dodonaea viscosa*	S	2-6	well-drained, rocky or sandy soils, small crown
Lumbang	*Aleurites moluccana*	H	6-15	can grow in a variety of soil and poor soil, large crown
Nanaso	*Scaevola sericea*	S	2-6	well-drained, sandy soil, small crown
Niyoron	*Cordia subcordata*	M	3-10	well-drained, basalt, limestone, clay, and sandy soil, medium crown
Sea grape	*Coccoloba uvifera*	M	3-10	well-drained, alkaline soil, small crown
Soapberry	*Sapindus saponaria*	H	6-15	moist, tolerates sandy or rocky soil, large crown
Talisai	*Terminalia catappa*	H	6-15	well-drained, clay, loam, and sandy soil, large crown
Ti	*Cordyline fruticosa*	S	2-6	well-drained, moist soil, small crown

Notes: Small – 20 ft. and below. Medium – 20-50 ft. High – 50+ ft.

Site Preparation and Planting

To begin the process of planting a windbreak, assess the existing natural vegetation that may be able to serve as a natural windbreak before clearing the area; no windbreak may be needed. But, if one is needed, it is recommended that windbreaks be established before planting any crops, housing any animals, or building any structure. Consider the topography (features such as mountains, hills, creeks, and other significant lumps in the land), ensure that there is a water source, and make sure that the planned windbreak will not disrupt existing and planned infrastructure both below (water and drain pipes) and above ground (power lines).

Before planting, landowners choose healthy, site-appropriate plants that meet the landowner objectives. Site-appropriate plants means that the plants should be able to thrive in the area (see Tables 1 and 2 for species recommendations). During planting, the top of the root ball should be even with the existing soil surface. At the very least, ensure holes are as deep as two times the diameter of the root ball width, if possible. Consider the recommended spacing when planting seedlings. Secondary rows can be planted after a few years depending on the growth rate of the first established row.

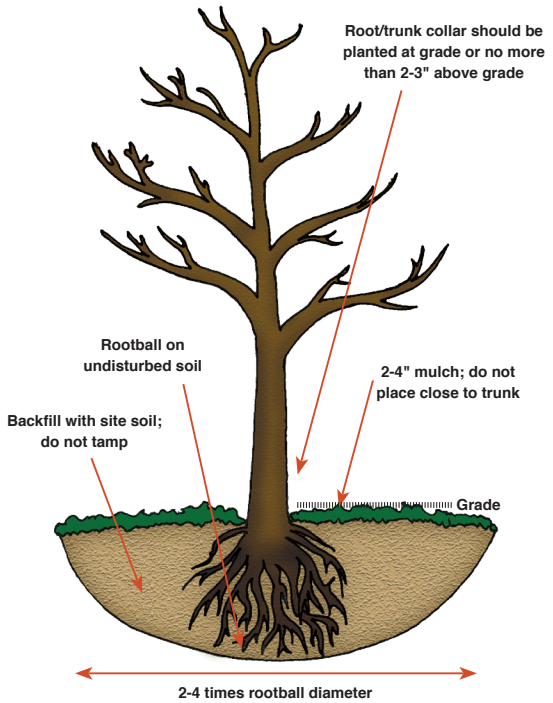

Figure 7. Planting a tree.

Maintenance

Ensure plants are watered regularly, mulch if possible (e.g. bark, composted manure, grass clippings, or leaves) to conserve moisture, and fertilize according to plant needs. All windbreaks need regular maintenance to be effective wind barriers. Keep in mind the primary objectives (i.e. landowner objectives) and determine the secondary benefits that may be derived from the windbreak. Different maintenance tasks include pruning, irrigation, fertilization, weeding, and pests/disease control. The following questions serve as hints on when to do maintenance:

- Are there insect pests, dead branches, and dead or dying trees?
- Is there a large gap in the windbreak?
- Are there sod-forming grasses or noxious weeds present?
- Is the windbreak overcrowded?

Pruning

- Remove dead branches.
- When windbreak is too dense, prune back density to recommended density.
- Use sharp tools for clean cuts at all times, have proper tools for each pruning job, and keep tools clean.
- Never use paints or tars over wounds after pruning.
- Bark at edges of all pruning cuts should be firmly attached.
- Always promote wide-angled rather than narrow-angled crotches.
- Prune young trees less severely than mature trees.
- Prune the upper portion of the tree more heavily than the lower portion.
- Thin out the outer portion of a branch more severely than the inside portion.
- Equipment that will damage the bark (such as climbing spurs or hooks) should not be used.
- Hire professionals for large jobs.
- For more information on pruning, http://cnas-re.uog.edu/wp-content/uploads/2016/06/Tree_Pruning_Guide_5_23_2016.pdf

Irrigation
- Irrigate frequently to ensure sufficient soil moisture and avoid saturation, particularly with new plantings.
- If plants are adapted and well-established on site, irrigation requirements may decrease depending on the age and species of plants.

Fertilization
- Fertilizing windbreak plants depends on plant species.
- A general recommendation for trees and shrubs is to fertilize with a complete fertilizer like 16-16-16 every three (3) to four (4) months.
- Fertilizer facts are available at http://cnas-re.uog.edu/wp-content/uploads/2016/06/Fertilizer-Facts.pdf.

Weeding
- Weed control is key upon establishment of new plantings to reduce competition for water and nutrients; weeds extract nutrients just as desired plants do.
- Practices such as sheet mulching and mulching will reduce weed control costs and conserve soil moisture.
- If herbicides are to be used, follow label directions completely.
- Do not use bush cutters near your plants as they may critically damage your windbreak and crops. Sheet mulch, mulch, or herbicide under the windbreak.

Pest/Disease Control
- If possible, identify pests and/or diseases associated with infested plant species.
- If you are unable to identify a pest or disease, submit a sample of the pest along with the affected plant to the CNAS Extension & Outreach Office at the University of Guam.
- If pesticides are to be applied, ensure that the pesticide is registered for specific plant species as indicated on pesticide labels.
- Ensure appropriate pesticides are used for targeted pests and diseases.
- For commercial fields, certain pesticide applicator licenses may be required. Call Guam EPA at (671) 300-4751.
- Publications on pest/disease control measures are available on the website at www.cnas-re.uog.edu

Key Points
- Ensure your desired plants are site-appropriate and are good windbreak species.
- Make sure that the windbreak height is taller than what is to be protected; at least twice the height as possible.
- The wider the windbreak, the more effective it is. Close gaps as soon as possible.
- Place windbreak perpendicular to prevailing winds.
- For Guam, multi-leg windbreaks surrounding the entire area may be required.
- Proper planting, care, and maintenance is essential for a successful windbreak establishment and long-term care.

For Support
Contact the College of Natural & Applied Sciences' Extension and Outreach at 735-2080 for help or more information. Additional publications can be found on our website at: www.cnas-re.uog.edu under the Publications tab.

References
Cruz, Jose, I. Quitugua, and L.R. Barber. 2006. Calamansi. Economic Plants for Conservation. NF06-04. New Farmer Publication. University of Guam, Cooperative Extension Service. 2 pp.

Elevitch, Craig, and Kim M. Wilkinson. 2000. Agroforestry Guides for Pacific Islands. Permanent Agriculture Resources, Holualoa, Hawaii, USA.

Marler, Thomas E., Michael V. Mickelbart, and Christine Bucayu-Laurent. 2016. Pruning of Trees and Shrubs on Guam. College of Natural & Applied Sciences (CNAS), University of Guam.

Quitugua, Ilene, and L.R. Barber. 2006. Avocado. Economic Plants for Conservation. NF06-06. New Farmer Publication. University of Guam, Cooperative Extension Service. 2 pp.

Santos, Justin, I. Iriarte, M. Acosta, F. Cruz, and L.R. Barber. 2006. Fruit Trees as Multi-Purpose Windbreaks. NF06-03. New Farmer Publication. University of Guam, Cooperative Extension Service. 2 pp.

Technical Note 7. September 2012. Pacific Islands Area Vegetative Guide. USDA Natural Resources Conservation Service. Pacific Islands Area. 35 pp.

https://nac.unl.edu/documents/workingtrees/infosheets/wb_info_050712v8.pdf
https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_037139.pdf
ns.gov.gu/climate.html

PowerPoint Presentations

Barber, L. Robert, F. Cruz, R., and I. Quitugua. 2006. Fruit Trees, Income Generating Plant Materials for Windbreaks, Vegetative Barriers, and Hedgerows. PowerPoint Presentation. University of Guam, Cooperative Extension Service, and Chamorro Land Trust Commission.

Barber, L. Robert, F. Cruz, R., and I. Iriarte. 2006. Windbreaks. PowerPoint Presentation. Guam Cooperative Extension Service & Chamorro Land Trust Commission.

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This factsheet was originally based on 2006 Fruit Trees as Multi-Purpose Windbreaks by Santos, Justin, I. Iriarte, M. Acosta, F. Cruz, and L.R. Barber, though significantly enhanced in this version.