“Well-researched, concise, user-friendly...an invaluable practical resource for those working to conserve and expand the use of trees in agricultural systems.”
—APANews, The Asia-Pacific Agroforestry Newsletter
FAO Regional Office, Bangkok, Thailand

“A significant contribution to public education, advancing the cause of integrated agriculture and forestry...a resource of lasting value.”
—The Permaculture Activist, North Carolina

“A most excellent handbook...a wonderful resource.”
—Developing Countries Farm Radio Network, Toronto, Canada

“Eloquently makes a case for reintroducing and emphasizing trees in our island agriculture.”
—Dr. Bill Raynor, Program Director, The Nature Conservancy, Pohnpei, Federated States of Micronesia

“Provides a real clearinghouse on traditional and modern agroforestry not only for Pacific Islands, also very useful for other regions.”
—ILEIA Newsletter for Low External Input and Sustainable Agriculture, The Netherlands

**Purchase the book at [http://www.agroforestry.net/afg/](http://www.agroforestry.net/afg/)**

Agroforestry Guides for Pacific Islands
edited by Craig R. Elevitch and Kim M. Wilkinson

Price: $24.95 (plus shipping)

Availability: Usually ships within one business day.

Paperback - 240 pages, illustrated and fully indexed
Release date: September, 2000
ISBN: 0970254407
Publisher: Permanent Agriculture Resources, P.O. Box 428, Holualoa, HI, 96725, USA. Tel: 808-324-4427, Fax: 808-324-4129, email: par@agroforestry.net
Multipurpose Windbreaks: Design and Species for Pacific Islands

by Kim M. Wilkinson and Craig R. Elevitch

www.agroforestry.net
Multipurpose Windbreaks: Design and Species for Pacific Islands

Abstract: Effective windbreaks can improve crop production and health, while conserving soil and water. Pacific Island farmers face a number of challenges in windbreak design, including a scarcity of land that makes efficient land use essential. Planting a multipurpose windbreak can increase the benefits of the windbreak by providing commercial or farm products.

This guide covers the criteria of basic windbreak design, including orientation, spacing, density, height, length, number of rows, and continuity. Additional design criteria for multiple uses and products, including timber, fruit, fodder, mulch, and wildlife habitat, are also presented. A species chart of over ninety multipurpose trees suitable for windbreaks in Pacific Islands is included.

Keywords: windbreak, shelterbelt, multipurpose, design, fodder, fruit, mulch, multi-use, planning, sustainable, timber, trees, wildlife, wind

Contents
Introduction 3  
Effects of Wind on Crops 3  
What is a Windbreak? 3  
What is a Multipurpose Windbreak? 3  
Potential Benefits of Windbreaks 4  
Additional Benefits of Multipurpose Windbreaks 5  
Potential Drawbacks of Windbreaks 5  
An Introduction to Basic Windbreak Design 5  
Orientation 5  
Spacing/Density 6  
Height/Distance Protected 7  
Length 8  
Profile and Number of Rows 9  
Continuity 10  
Summary: Checklist for an Effective Windbreak 11

Multipurpose Windbreak Design 12  
General Guidelines for Multipurpose Windbreak Design 12  
Fruit or Nut Production in a Windbreak 12

Timber Production in a Windbreak 15
Nitrogen Fixing Trees as a Windbreak Component 17  
Wildlife Habitat 19  
Other Potential Products or Services from Multipurpose Windbreaks 22  
Bees/Honey Production 22  
Floral Products: Cut Foliage, Flowers, or Decorative Branches 22  
Medicinal/Natural Health Products 23  
Living Fence 23

Species Selection for Multipurpose Windbreaks 23  
Resources and Recommended Reading 27  
Local Assistance 27  
Publications 27  
Acknowledgments 28  
About the Authors 29  
References 29

Authors: Kim M. Wilkinson and Craig R. Elevitch, Illustrator: Christi A. Sobel

Reproduction: We encourage you to share this information with others. All or part of this publication may be reproduced for noncommercial educational purposes only, with credit given to the source. For commercial reproductions, contact the publisher. © 2000 Permanent Agriculture Resources. All rights reserved.

Electronic distribution: Download this publication and others in the series at http://www.agroforestry.net

Publisher: Permanent Agriculture Resources, P.O. Box 428, Holualoa, HI 96725 USA; Tel: 808-324-4427; Fax: 808-324-4129; E-mail: par@agroforestry.net; Web site: http://www.agroforestry.net


Sponsor: Publication of this guide was made possible through a grant from the U.S. Department of Agriculture’s Western Region Sustainable Agriculture Research and Education (WSARE) Program. This material is based upon work supported by the Cooperative State Research, Education, and Extension Service, U.S. Department of Agriculture, and Agricultural Experiment Station, Utah State University, under Cooperative Agreement under 98-COOP-1-6481.

Sustainable Agriculture Research and Education
Introduction

This guide discusses the planning of productive, multipurpose windbreaks in Pacific Island environments. Pacific Island farmers face a number of challenges in windbreak design. These include variable wind patterns (prevailing winds, trade winds, storms, etc.) a scarcity of land, and a shortage of practical information on windbreak design and species for tropical climates.

This guide introduces the basic principles of windbreak design, layout, and management. It examines design criteria of multipurpose windbreaks, including uses for fruit/nut production, timber, mulch/animal fodder, and wildlife habitat. Issues that must be incorporated in the planning process to maximize secondary yields while maintaining effective wind protection are featured. A species table of over ninety multipurpose plants that are suitable components in Pacific Island windbreaks is included.

Effects of Wind on Crops

In Pacific Island environments, wind can be detrimental to crop production in many ways:

- Wind stresses plants, reducing their growth, vitality, and yield.
- Wind physically damages plants by breaking stems or branches, stripping leaves, or tearing fruit or flowers from crop plants.
- Wind dries the air around plants, causing them to lose moisture.
- Wind pulls moisture from soil pores on the surface, drying soil.
- Wind removes topsoil and organic matter from exposed soil.
- Wind carries salt, especially near coastal areas or on small islands, which draws moisture out of the soil and can harm plant tissue (AIS 1993).

Windbreaks prevent crop damage, conserve moisture in plants and the soil, and reduce soil wind erosion and salt spray.

What is a Windbreak?

Windbreaks (sometimes known as shelterbelts) are rows of vegetation, usually trees, strategically placed to protect an area from wind damage. A windbreak works by filtering and slowing the wind that enters the protected area. Effective windbreaks provide protection from prevailing winds, and can also limit damage from storms.

What is a Multipurpose Windbreak?

Planting windbreaks is a long-term investment for landowners. The benefits of planting a windbreak can be increased by creating a multipurpose windbreak. A multipurpose windbreak is designed to provide multiple functions and/or products, in addition to wind protection. Multiple products or uses from a windbreak can include fruit, timber, animal fodder, wildlife habitat, and other economic or farm products. Adding multiple functions or products to a windbreak can make the installation and management more satisfying and economically viable for the landowner.

Multipurpose windbreaks require additional care in planning and management to maintain the primary function of wind protection while maximizing secondary yields. The desire for additional yields from a multipurpose windbreak must always be balanced by the need to maintain the integrity of the wind protection.
Potential Benefits of Windbreaks

As with any farm practice, landowners must weigh the potential benefits and costs of designing, installing, and managing a windbreak as it relates to their goals and site conditions. The primary benefits of planting windbreaks are:

- To improve crop quality and yield by protecting crops from wind damage.
- To conserve moisture by reducing evaporation and transpiration.
- To protect from extremes of salt spray or hot, dry winds and dust.

Other benefits of windbreaks can vary depending on the area to be protected, the severity of wind in the region, and other factors. The types of benefits and the degree of each based on past experience in the mainland United States is summarized in Table 1.

### Benefits of Farm Windbreaks

<table>
<thead>
<tr>
<th>Benefits</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Property value</td>
<td>Improved 6-12%</td>
</tr>
<tr>
<td>Crop production</td>
<td>Improved 6-44%</td>
</tr>
<tr>
<td>Working conditions</td>
<td>Variable</td>
</tr>
<tr>
<td>Irrigation</td>
<td>Variable</td>
</tr>
<tr>
<td>Equipment/Structure maintenance</td>
<td>Variable</td>
</tr>
<tr>
<td>Noise levels</td>
<td>Reduced 10-20%</td>
</tr>
<tr>
<td>Wind erosion</td>
<td>Reduced 50-100%</td>
</tr>
</tbody>
</table>

Adapted from (Wight and Townsend 1995)

Some specific examples of how production can be improved by windbreaks follow:

- Fresh vegetables and fruits get premium prices based on appearance; crops that are bruised, blemished, or damaged by wind usually have to be sold at a lower price. Protecting specialty crops improves their appearance and allows them to fetch top dollar in the marketplace (Brandle et al 1995).

- Orchards for fruit production benefit from wind protection. In a fruit orchard protected by a windbreak, more fruit can be produced because flowers and young fruits sustain less wind damage; stress on the trees can be reduced, improving their growth and productivity; and in some cases fruit set can improve because insect pollinators tend to be more active in the protection of a windbreak.

- Animal production can also be improved by windbreaks. For example, when animals such as swine, cattle, and goats are protected from wind, stress on the animals is significantly reduced. A windbreak for livestock can result in lower mortalities, improved health, and lowered feeding costs (Hintz 1983).

- Windbreaks may allow the landowner to cultivate more valuable crops in the protected area than in an area unprotected by a windbreak, because the windbreak will create a more mild and hospitable microclimate. This can expand business and marketing opportunities that would otherwise not be open to the farmer (AIS 1993).

- A windbreak can create a more pleasant living and working environment for the farmer and farm workers, which can lead to improved productivity.

Although results are variable, there are a number of statistically documented cases of windbreaks improving the quality and quantity of yields for many different kinds of crops. For example, windbreaks installed to protect specialty crops like fruit trees and vegetables in the mainland United States improved yields.
between 5-50% (Brandle et al 1995). The use of windbreaks with crops like corn, millet, rice, and soybeans in Africa and China increased yields between 10-74% (Pimentel and Wightman 1999). In these studies, the increased yields per acre usually include the area occupied by the windbreaks.

Well-designed and managed windbreaks have in many cases been shown to protect the health, productivity, and quality of crops enough to make the practice economically viable.

**Additional Benefits of Multipurpose Windbreaks**

Designing windbreaks for multiple products or functions as discussed in this guide can expand the benefits of the windbreak beyond improving the productivity of their current crops. For example, multipurpose windbreaks can:

- Provide additional economic products such as fruits, nuts, or timber.
- Increase on-site resources for farm use such as animal fodder, mulch, food, poles, fuelwood.
- Improve the aesthetic value, property value, and/or recreational value of the property.
- Provide greater ecological and economic stability through the addition of diverse species to the farm system.

**Potential Drawbacks of Windbreaks**

Landowners must also consider the potential drawbacks of installing a new practice like a windbreak. Advance planning can prevent some of these factors from becoming problematic.

- A windbreak installed or managed incorrectly can create wind damage rather than preventing it.
- Windbreaks take up space and land that could be used for production of the primary farm product.
- Windbreaks may compete with crops in the root zone and may also create shading or other competition problems.
- Windbreaks are a long term investment in trees, planning time, and installation. The benefits will usually not begin for at least a year or more after installation.
- Windbreaks planned or installed improperly can interfere with access, view planes, power lines, and neighbor’s borders.

**An Introduction to Basic Windbreak Design**

A windbreak has to form a physical structure that will, in time, slow and filter wind. This section introduces the basic physical/structural design criteria essential to planning an effective windbreak.

Planning of a windbreak is necessary to optimize its effectiveness and avoid future problems. Appropriate species selection is also a key factor in creating an effective windbreak. The essential physical factors to consider are:

- Orientation
- Spacing/Density
- Height/Distance Protected
- Length
- Profile/Number of Rows
- Continuity

**Orientation**

Correct windbreak orientation is essential for effective protection from wind damage. The ideal windbreak is oriented perpendicular to the prevailing wind, on the windward side of the land-area to be protected.
If the prevailing winds come from only one direction, a single-leg windbreak can be effective when oriented properly. Single-leg windbreaks oriented perpendicular to prevailing wind will also provide protection if the wind varies within 45 degrees of the perpendicular (Figure 1). Note that single-leg windbreaks must also have enough length to prevent wind from coming around the ends into the crop area (as discussed in the section on length below).

In some Pacific Island locations, trade winds may shift direction throughout the year, and damaging storm winds can come from almost any direction. In these situations, the orientation and pattern must provide protection from strong variable winds as well as from the prevailing winds. A windbreak pattern surrounding the property may be more effective in these situations (Figures 3a-3c).

**Spacing/Density**

A windbreak should be designed to slow and filter the wind, but not to block it entirely (Figure 4a). A windbreak that is too dense can lead to severe turbulence over the crop area (Figure 4b).

Ideally, windbreaks are about 20-50% permeable (Joy 1993). This can be achieved with correct spacing of the species in the windbreak. Spacing within rows should be laid out so that when mature in about ten...
years, the crowns of the trees will touch or overlap slightly, but not crowd each other. Planting trees too closely can cause early deterioration of windbreaks, especially on dry, unirrigated sites, due to excessive competition for water between the trees. Wider spacing may mean additional time for the windbreak to become effective, but will prolong the effective life of the windbreak (Joy 1993). Species choice will also affect the density of a windbreak, as foliage and canopy density varies.

### Spacing Guidelines

<table>
<thead>
<tr>
<th>Spacing within row</th>
<th>2-6 ft (0.6-2 m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Short trees (up to 20 ft (6 m))</td>
<td>2-6 ft (0.6-2 m)</td>
</tr>
<tr>
<td>Medium trees (20 -50 ft (6-15 m))</td>
<td>3-10 ft (1-3 m)</td>
</tr>
<tr>
<td>Tall trees (over 50 ft (15 m))</td>
<td>6-15 ft (2.5 m)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Spacing between rows</th>
<th>5-10 ft (1.8-3 m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>If adjacent row is short</td>
<td>5-10 ft (1.8-3 m)</td>
</tr>
<tr>
<td>If adjacent row is medium</td>
<td>6-15 ft (2-5 m)</td>
</tr>
<tr>
<td>If adjacent row is tall</td>
<td>8-20 ft (2.5-6.2 m)</td>
</tr>
</tbody>
</table>

(source: USDA NRCS 1991)

For multiple-row windbreaks, trees should be on staggered and varied spacing, as depicted in Figure 5a. This filters and slows the wind.

### Height/Distance Protected

Windbreaks reduce wind speed for a distance of about ten times their height (10 X height, or 10H). For example, a windbreak whose tallest trees are 30 ft (9 m) tall will protect a field area up to about 300 ft (90 m) downwind. Windbreaks also provide some protection on the windward side—usually, about one to three times their height (Figure 6a). The wind will begin to regain speed as the distance from
the windbreak increases (Figure 6b). Plants will receive the most protection within 7H of the windbreak. If plants are not very wind-sensitive, the protected zone could be considered to extend up to 15H in some cases.

For large properties, secondary wind strips may be necessary within the property to adequately protect the entire area (Figure 7).

The height of the windbreak should also be determined by the expected height of the crops. Windbreaks should be taller than the crop plants—ideally at least twice as tall as the crop (Figure 8).

**Length**

Windbreaks should be designed to prevent damaging wind from coming around the ends. This involves either additional length beyond the area to be protected, or additional legs that prevent wind from whipping around the end and into the crop area.

For a single-leg windbreak, the length of the windbreak should extend about 5 times the height of the windbreak beyond the area needing protection (Figure 9). For example, a windbreak 30 ft (9 m) high should extend 150 ft (45 m) on either side past the crop area to be protected.
Where damaging winds come from several directions, windbreaks surrounding the protected area may be more appropriate. If a windbreak completely surrounds the crop area (Figure 12), crops are protected on all sides. For large crop areas, secondary internal wind strips are necessary to supplement the surrounding windbreak (Figure 13).

**Profile and Number of Rows**

The wind protection provided by a windbreak should be effective from the ground up. This usually requires at least two rows of trees. Tall trees will protect a larger area of the field, but they usually have high canopies which can create an understory gap (Figure 14). Smaller trees with lower canopies are planted in an additional row to fill this gap (Figure 16).

A single row windbreak can be effective if the species used has uniform, semi-permeable, wind-strong branches to the ground (Figure 15). However, there are a number of drawbacks to single-row windbreaks. Desirable species that fit this description are limited. Single row windbreaks must be carefully maintained to avoid gaps. And, as with any single-species planting, there is greater risk of loss of the entire investment in the event of pest or disease problems that affect that one species. However, they have the advantage of taking up less space on the property.

Multiple-row windbreaks consist of three or more rows, and of several kinds of species (Figure 17). These kinds of windbreaks take up more space than single-row windbreaks. However, there are a number of advantages to multiple-row windbreaks, particularly when secondary products or functions are desired from the windbreak. These include:

- Greater flexibility in species selection, layout, and management, while maintaining the necessary structure.
- Reduced maintenance burden because multiple rows help prevent gap problems.
- Greater opportunities for harvest—some trees or products may be harvested from the windbreak without compromising its function.
- Increased opportunity for secondary yields with several species and levels of
protection in the windbreak.
• Decreased risk of loss of the entire investment in the windbreak through pest or disease problems that affect a single species.

The landowner must decide how much land and resources can be devoted to a windbreak to determine how many rows will be appropriate for their situation.

**Continuity**

It is essential to maintain continuity in a windbreak, because any gaps can become “wind tunnels” that funnel and accelerate the wind through them, increasing wind damage. For this reason, roads, paths, gates, and...
other necessary openings in the windbreak should be taken into account when planning the windbreak, and the windbreak designed carefully to eliminate gaps. When an opening in the windbreak is needed for access or other reasons, the effects can be ameliorated. The windbreak should overlap the gap to maintain the continuity of the windbreak and prevent the opening from becoming a wind tunnel (Figure 18).

Summary: Checklist for an Effective Windbreak

Orientation:
- Oriented perpendicular to prevailing damaging winds?
- One leg sufficient?
- Additional legs or surrounding planting necessary to protect from shifting winds?

Spacing/density:
- Number of rows sufficient for proper density (50-80% dense)?
- Spaced adequately for healthy growth?
- Crown closure in about 10 years?
- Trees on variable/staggered spacing?

Height/distance protected:
- Crops area to be protected located within 10 H zone?
- Secondary wind strips planted if crop area exceeds ten times the height of the tallest windbreak trees?
- Tallest trees in windbreak at least twice as tall as the crops?

Length:
- If single-leg windbreak, does the length extend 5 H beyond crop area on either side?
- Additional legs necessary to protect from variable winds?

Profile/number of rows:
- Understory gaps eliminated by short rows?
- Shrubs and short trees in outer rows?
- If single-species, has uniform branches to the ground?

Continuity:
- Wind funnel effects minimized (no gaps)?

Other variables such as soil type, soil depth, topography, and other localized site and climatic conditions will impact the effectiveness of a windbreak in different situations. Windbreak planners should consult other references for more information on designing an effective windbreak (see resource section for recommended sources of information). The assistance of local experts, including resource professionals and experienced neighbors, is invaluable in designing a windbreak optimally suited to the needs and site conditions.
Multipurpose Windbreak Design

The previous section introduced basic design criteria for any windbreak. A multipurpose windbreak must have effective wind reduction as its primary goal, and meet all the above criteria.

Adding multiple functions or products to a windbreak can provide more benefits, making the installation and management more satisfying and economically viable for the landowner. However, maintaining the primary windbreak function while managing for additional uses or products requires more careful planning at the outset, and special management practices for the life of the windbreak. This section is intended as a design guide for maintaining windbreak effectiveness while maximizing a secondary yield from windbreaks. It discusses four multiple uses: fruit/nut production, timber production, mulch/fodder production, and wildlife habitat. It also introduces some other multiple uses that can be provided by a windbreak.

General Guidelines for Multipurpose Windbreak Design

While the multiple uses discussed here have different characteristics that must be considered in the planning process, there are a number of factors that are common to any multipurpose windbreak design:

• The species used should be selected first for their wind tolerance and appropriateness for the site (climate, soils, etc.); the products should be a secondary consideration in selecting species.
• The productive trees in the windbreak should be supplemented by windbreak species that do not need to be managed for production. This affords some protection of the producing trees by the other trees in the windbreak.
• Windbreaks designed for multiple products should have multiple rows and multiple stories. This enables more flexibility in management and harvest of products without compromising wind protection by creating gaps.
• Trees yielding products such as fruit, food, fodder, or mulch should ideally be located in the interior or more sheltered rows of the windbreak for greatest productivity.
• A diversity of species should be used to allow for greater flexibility in management and for reduced risk of damage to the windbreak as a whole from pest or disease problems.

Landowners must also consider the possible drawbacks of including any kind of production in a windbreak. For example, species that are used for commercial production are often not eligible for government cost-sharing. Planning and managing for multiple products can also be more time-consuming. An analysis of the potential drawbacks or problems associated with attaching part of productivity to a windbreak will help determine the appropriateness of the practice in a given situation.

Fruit or Nut Production in a Windbreak

Including fruit or nut-bearing trees in a windbreak can provide additional economic yields or family food in addition to wind protection.

Fruit trees in the windbreak will usually have reduced yields due to poorer pollination and increased damage to flowers and young fruits. The fruits may also be damaged or ruined if they are blown off. In areas where winds are only seasonal or not too strong, fruit production may be a good combination in a windbreak. In windier areas, produce from windbreaks is generally useful only
for family consumption, or marketed in a processed form such as jam where bruising or appearance is not as important as in the fresh fruit market. In areas with strong, constant winds, fruit production from a windbreak may not be feasible.

To maintain the windbreak’s primary function, wind-tolerant fruit tree species should be used. These should be integrated with other wind-tolerant species that are not managed for production. Also, keep in mind that fruit trees in a windbreak should be pruned only very sparingly, as pruning can compromise wind resistance.

There are a number of things that can be done to improve the productivity and quality of yields from fruit trees in a windbreak:
- If strong winds are seasonal, choose species that flower and bear in calmest months.
- Plant fruit trees in the more sheltered windbreak rows to maximize fruit production and quality (Figure 21).
- Select trees which bear fruit on main branches, trunk, or interior of tree, rather than on outer branches (for example, fruits like jackfruit (Artocarpus heterophyllus) or jaboticaba (Myrciaria cauliflora), as these kinds of fruits are less susceptible to wind damage than fruits borne on the more mobile outer branches.
- Know the cultural requirement of the fruit trees and care for them appropriately with fertilizers, irrigation, etc. as necessary.

Examples of Fruit or Nut Production in a Windbreak
Location: Barrigada, Guam. 280 ft (90 m) elevation
Primary windbreak species and fruit-bearing species: *Musa balbisiana* (dwarf Brazilian banana)
This windbreak consists of three rows of bananas on staggered spacing.

<table>
<thead>
<tr>
<th>Banana example—Guam</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Row</strong></td>
</tr>
<tr>
<td>---</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
</tbody>
</table>

(Lawrence, personal communication 1999)

Location: Barrigada, Guam. 280 ft (90 m) elevation
Primary windbreak species: *Casuarina equisetifolia* (ironwood)
Fruit-bearing windbreak species: *Annona muricata* (soursop), *Randia formosa* (blackberry jam fruit)

### Soursop/blackberry jam example—Guam

<table>
<thead>
<tr>
<th>Row</th>
<th>Species</th>
<th>In row spacing</th>
<th>Distance from Row 1 (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><em>Casuarina equisetifolia</em></td>
<td>10 ft (3 m)</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td><em>Annona muricata</em></td>
<td>10 ft (3 m)</td>
<td>15 ft (4.5 m)</td>
</tr>
<tr>
<td>3</td>
<td><em>Randia formosa</em></td>
<td>2 ft (0.6 m)</td>
<td>30 ft (9 m)</td>
</tr>
</tbody>
</table>

(Lawrence, personal communication 1999)

Location: Molokai, Hawaii

Primary windbreak species and fruit-bearing species: *Musa balbisiana* (dwarf Brazilian banana)

This windbreak consists of one row of bananas on 6 ft (2 m) spacing.

### Banana example—Hawaii

<table>
<thead>
<tr>
<th>Row</th>
<th>Species</th>
<th>In row spacing</th>
<th>Distance from Row 1 (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><em>Musa balbisiana</em></td>
<td>6 ft (2 m)</td>
<td>0</td>
</tr>
</tbody>
</table>

(Joy, personal communication 1999)

Examples of fruit or nut-bearing tree species used as windbreak components in Pacific Islands: (see Species Selection for Multipurpose Windbreaks for more information for each species):

### Fruit/nut-bearing windbreak species

#### Short—under 20 ft (6 m)

- *Annona muricata* soursop
- *Averrhoa carambola* starfruit
- *Citrus reticulata* tangerine
- *Coccoloba uvifera* seagrape
- *Eugenia uniflora* Surinam cherry
- *Morus nigra* mulberry
- *Myrciaria cauliflora* jaboticaba
- *Psidium guajava* guava

#### Medium—20-50 ft (6-15 m)

- *Anacardium occidentale* cashew
- *Casimiroa edulis* white sapote
- *Chrysophyllum cainito* cainito/star apple
- *Cocos sp.* dwarf coconut palm
- *Dimocarpus longan* longan
- *Eriobotrya japonica* loquat
- *Macadamia integrifolia* macadamia
- *Mammea odorata* mammee apple
- *Manilkara zapota* sapodilla
- *Musa balbisiana* dwarf Brazilian banana
- *Persea americana* avocado
- *Syzygium malaccense* mountain apple
- *Tamarindus indica* tamarind

#### Tall—50 or more ft (15 m)

- *Aleurites moluccana* kukui
- *Artocarpus altlis* breadfruit
- *Artocarpus heterophyllus* jackfruit
- *Cocos nucifera* coconut
- *Litchi chinensis* lychee
- *Mangifera indica* mango
- *Syzygium jambos* rose apple
Timber Production in a Windbreak

Since planting a windbreak involves a long-term investment, including trees that can be harvested in the future for timber appeals to many landowners. There are many design options for timber production from a windbreak that landowners can explore.

The main drawback of having timber as a secondary yield from a windbreak is that wind stress or damage may compromise the timber tree’s form or produce timber of reduced quality. Also, since windbreak trees should be pruned only sparingly or not at all, the lack of pruning may reduce timber yields on certain species that require extensive pruning for optimal timber production.

To Maximize Timber Yield

There are a range of design options that can enable the harvest of timber from a windbreak. These include:

- The harvest and removal of the entire windbreak at maturity, to be replanted if the wind protection is still necessary.
- The harvest of interior rows of timber trees from the windbreak, while leaving several outer rows for permanent protection.
- The careful selective harvest of rows or individual trees within the windbreak.

Some of these options can be relatively simple, such as planning to remove the entire windbreak at maturity. Plans involving selective harvest are more complex, as the planting, harvesting, and replanting must be coordinated to maintain the correct density and structure of the windbreak. It is especially important to avoid creating gaps.

In some of these cases, the areas that were harvested will be replanted. In other cases, the removal of trees may be predominantly a thinning practice, where the existing trees will fill in the space as they mature. Figure 23 gives an example of a more complicated timber/windbreak plan.

When considering timber production in a windbreak, landowners must also recognize the skills required for felling and harvesting trees for timber. If skilled tree fellers are unavailable in the region, a simpler plan will be more feasible. The harvest must be planned to avoid damage to the adjacent crop area.

Many other factors are important to consider when planning a viable timber harvest, including tree growth rates, soil conditions, spacing, maintenance, and other issues that are beyond the scope of this guide. Consultation with a professional forester is recommended.

Field Examples of Timber Species in a Windbreak

Location: Dededo, Guam 500 ft (160 m) elevation

Primary windbreak species: *Casuarina equisetifolia* (ironwood)

Timber windbreak species: *Swietenia macrophylla* (mahogany)

Other windbreak species: *Leucaena leucocephala* (haole koa)

<table>
<thead>
<tr>
<th>Mahogany windbreak example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Row</td>
</tr>
<tr>
<td>-----</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
</tbody>
</table>

(Lawrence, personal communication 1999)
Location: Barrigada, Guam 280 ft (90 m) elevation
Primary windbreak/timber species: *Pterocarpus indicus* (narra)
Secondary windbreak/timber species: *Dalbergia sissoo* (sissoo rosewood)

### Narra and sissoo rosewood windbreak

<table>
<thead>
<tr>
<th>Row</th>
<th>Species</th>
<th>In row spacing</th>
<th>Distance from Row 1 (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><em>Pterocarpus indicus</em></td>
<td>8 ft (2.5 m)</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td><em>Dalbergia sissoo</em></td>
<td>8 ft (2.5 m)</td>
<td>15 ft (4.5 m)</td>
</tr>
</tbody>
</table>

(Lawrence, personal communication 1999)

Examples of timber species used as windbreak components (see table at the back of this guide for other information for each species):

### Timber-producing windbreak species

**Short—under 20 ft (6 m)**
- *Acacia koaia*
- *Thespesia populnea*

**Medium—20-50 ft (6-15 m)**
- *Azadirachta indica*
- *Bambusa oldhamii*
- *Cordia subcordata*
- *Intsia bijuga*
- *Melia azedarach*
- *Pithecellobium dulce*
- *Senna siamea*
- *Thyrostachys siamensis*

**Tall—50 or more ft (15 m)**
- *Acacia koa*
- *Acacia mangium*
- *Acrocarpus fraxinifolius*
- *Azadirachta excelsa*
- *Calophyllum inophyllum*
- *Dendrocalamus asper*
- *E. dunnii or E. microcorys*
- *Guadua angustifolia*
- *Metrosideros polymorpha*
- *Pterocarpus indicus*
- *Swietenia macrophylla*
- *Tristania conferta*

**A Note on Timber Bamboos in a Windbreak**

Some bamboos are excellent multiple-purpose plants, and a number of species are wind-resistant and provide quality timber or construction materials. Timber bamboo can be an effective windbreak component, as harvesting a small percentage of bamboo stems (culms) will not compromise the function of the windbreak.

When selecting bamboo species, it is recommended to always choose clumping rather than running types, as the running types spread easily and can create problems from competition and invasiveness. All bamboo species listed in this guide are clumping types. Also, landowners should find out how wide and tall the clumps will become, as this is important for proper spacing.
Nitrogen Fixing Trees as a Windbreak Component

Nitrogen fixing trees (NFTs) are used widely in agriculture in the tropics, mainly to provide fertility and mulch for crops, or fodder for animals.

Nitrogen fixing trees are a major source of nitrogen fertility in tropical ecosystems. When integrated with a farm, orchard, or garden, some species of NFTs provide a major source of nitrogen fertilizer and mulch for crops. The fertility is transferred from the NFTs to the crops by pruning the NFTs and applying the pruned foliage and young stems to the soil as a nutrient-rich mulch.
Some species of nitrogen fixing trees provide an important source of nutritious animal fodder. The foliage of the trees is used to supplement the diets of livestock, as well as some kinds of small animals and poultry such as rabbits, chickens, and other animals. NFTs for use as animal fodder must be researched carefully, as some NFTs can be harmful or toxic to some kinds of animals. The rate at which NFTs can supplement other kinds of fodder ranges between 5 and 30% of the animal’s daily diet, depending on the species of tree and the species of animal to be fed. The practice of planting property borders with NFTs and cutting the trees back to feed the foliage to animals is common in intensive agricultural areas of Asia and Africa (Gutteridge and Shelton 1994). (See reference section for further reading on the uses of nitrogen fixing trees).

For either mulch/fertility or animal fodder uses, nitrogen fixing trees can be integrated into a windbreak. Because they will be kept pruned in a hedge-like fashion, they are included as the short row or rows of a multi-row windbreak.

Although as a general rule, severe pruning or pollarding should be avoided for most windbreak trees, the practice of cutting back NFTs and allowing them to resprout can be successfully integrated with windbreak management. It is important to prune the trees regularly, usually every 3-6 months depending on site conditions and species (Figure 23). If they are allowed to regrow to a large size, however, pruned NFTs will be much more susceptible to wind damage (Figure 24). Therefore, to maintain the windbreak’s primary function with this
practice, it is essential to prune the NFTs regularly. Regular pruning is also an excellent practice to maximize the secondary yield as well, because the younger regrowth is the most nutritious and palatable for animal fodder and the most nutrient-rich and beneficial as mulch for plants, as compared to the older, woody material that comes from older regrowth.

**To Maximize Secondary Yields:**
- Use productive NFT species selected for the characteristics most desired (different species are suitable for different sites and uses. For example, some species make better fodder, some are best for mulch/fertility).
- Use NFT species that are known for their wind tolerance (see table in this section and at the end of this guide).
- Prune regularly to keep the sprouting branches from reaching a large a size. This will maintain the wind resistance capability of the tree’s branches and also result in a more valuable mulch or fodder.
- Place the NFT rows closest to where they will be used, for ease of cutting and carrying to crops or animals.
- If possible, plant the NFTs on the most sheltered side of the windbreak to improve their productivity.

See reference section at the end of this guide for further reading on the use and management of NFTs.

<table>
<thead>
<tr>
<th>Nitrogen fixing windbreak species</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cajanus cajan</td>
<td>pigeon pea</td>
</tr>
<tr>
<td>Calliandra calothyrsus</td>
<td>calliandra</td>
</tr>
<tr>
<td>Erythrina variegata*</td>
<td>coral tree</td>
</tr>
<tr>
<td>Gliricidia sepium</td>
<td>madre de cacao</td>
</tr>
<tr>
<td>Leucaena leucocephala</td>
<td>giant haole koa, K636</td>
</tr>
<tr>
<td>Senna siamea**</td>
<td>pheasantwood</td>
</tr>
<tr>
<td>Sesbania sesban</td>
<td>sesban</td>
</tr>
</tbody>
</table>

* This species is an alternate host for mango fruit-piercing moth. If mango crops are in the area, select an alternate species.

** Senna siamea is not a nitrogen-fixer, but is used successfully in the same way for fertility/mulch.

While the nitrogen fixing species listed above vary in height class when allowed to grow to their full size, for the purpose of this practice all NFTs will be pruned, maintaining a hedge-like structure that is considered a short row.

**A Note about Species Selection for Nitrogen Fixing Trees:**
By their nature many NFTs grow vigorously under adverse conditions and can seed prolifically. Species selection and management of NFTs is critical to avoid the introduction of a new weedy species into an area. When selecting NFTs for a particular use and site, it is recommended to select species that do not seed prolifically, and prune regularly to eliminate seed production. If an NFT species is already naturalized or common in the area, its use may be considered as well, although it should still kept pruned to eliminate seed production.

**Wildlife Habitat**

The ability of windbreaks to provide wildlife habitat in farmlands is one of the most documented, both in tropical and temperate areas. In some areas of the tropics, for example Central America, windbreaks on farmlands have been shown to harbor not only native wildlife, but also to foster native tree seedlings and ecosystem regeneration processes within the windbreak (Harvey 1999). The fragile
and specialized nature of native plant and animal life in Pacific Islands makes this occurrence less common in the region. However, Pacific Island windbreaks can be designed to foster a diversity of exotic and native wildlife, from soil organisms to insects, birds and larger mammals. Windbreaks can also be part of a plan to cultivate and preserve remnants of native species or forests that landowners may have on their property.

Many landowners enjoy providing important ecological benefits from their windbreak. There are a number of benefits to planning a windbreak which is hospitable to wildlife:

- A windbreak with wildlife in it can add to the beauty and interest of the property.
- The harvest of wild game or the expansion of recreational opportunities on the property may be a potential additional source of income the farm.
- The windbreak may harbor beneficial insects and birds that help to balance out populations of crop pests, reducing needs for pesticides (Stace 1995).

In many cases, some forms of wildlife will be attracted to the windbreak regardless of the landowner’s intention. It is important to recognize that the same strategies that attract desirable wildlife may also attract birds, rodents, or other life forms that may be considered pests that interfere with crop production. Landowners should consider this issue as it relates to their crops when planning a windbreak.
Following the guidelines below to attract wildlife to windbreaks will not compromise the windbreak’s primary function. Wildlife will be attracted to windbreaks that can meet their needs for food and forage, travel corridors, reproductive habitat/nesting sites, and shelter from weather and predators. Here are some strategies that help maximize the benefit of a windbreak to wildlife (Figure 27):

1. Create a variety of habitats for wildlife within the windbreak. Tall trees, understory species, shrubs, and herbaceous plants provide important niches where different animals can find their preferred shelter, forage for food, nest, and so forth.

2. Avoid clean culture management practices when possible, as long as it does not pose a safety problem. Instead, some leaf litter, scrub, dead logs, and snags can be left, which are important to many kinds of wildlife.

3. Plant a variety of species. Complex, multi-storied plantings are more attractive wildlife than plantings of just a few species.

4. Create wildlife corridors—contiguous areas where wildlife can live or travel through in safety. Ideally, the corridors should be contiguous, avoiding large gaps. If the property is near a larger forest, riparian area, wood lot, or other refuge for wildlife, creating a corridor between this area and the windbreak will help species colonize the windbreak area (Figure 28).

5. If additional width can be added to the windbreak, that will make it even more beneficial to wildlife. Cooperation with neighbors may also help create larger corridors.

6. If a specific wildlife species is desired, learning about the intended guest’s needs for food, habitat, and other necessities will help tailor the windbreak to provide for it. Plant the known food/pollen sources for target species. Native plant species are most likely to support native life, from soil fauna to birds. However, some native wildlife may also have become accustomed to exotic species for food or habitat as well.
Other Potential Products or Services from Multipurpose Windbreaks

With careful research and planning, windbreaks can be productive and versatile. Aside from the multiple uses listed above, there are many other products or services that windbreaks can provide. Some examples follow.

Bees/Honey Production

Honey production can be an additional yield from a windbreak. Bees are more active in sheltered areas, and the protected edges of windbreaks can be excellent places to keep bee colonies (Brandle et al 1995).

Good honey production requires that the bees have access to nectar-producing flowers. There are a number of tree species in the tropics that produce good nectar for honey bees and are also wind-tolerant.

### Honey forage windbreak species

<table>
<thead>
<tr>
<th>Short—under 20 ft (6 m)</th>
<th>Medium—20 to 50 ft (6-15 m)</th>
<th>Tall—50 or more ft (15 m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cajanus cajan</td>
<td>Albizia lebbeck</td>
<td>Eucalyptus species</td>
</tr>
<tr>
<td>Calliandra calothyrsus</td>
<td>Azadirachta indica</td>
<td>Mangifera indica</td>
</tr>
<tr>
<td>Cassia spectabilis</td>
<td>Cocos sp.</td>
<td>Prosopis pallida</td>
</tr>
<tr>
<td>Citrus sp.</td>
<td>Melia azedarach</td>
<td></td>
</tr>
<tr>
<td>Gliricidia sepium</td>
<td>Pithecellobium dulce</td>
<td></td>
</tr>
<tr>
<td>Pimenta dioica</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Psidium cattleianum</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Psidium guajava</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sesbania sesban</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Good honey production requires that the bees have access to nectar-producing flowers. There are a number of tree species in the tropics that produce good nectar for honey bees and are also wind-tolerant.

### Floral Products: Cut Foliage, Flowers, or Decorative Branches

Cut foliage, flowers, or decorative branches used by the floral industry can also be produced in a windbreak. A number of species are wind-strong enough to serve as a windbreak component. These can produce saleable foliage, branches or flowers if they are in the more sheltered areas of the windbreak or if they are productive in a season of milder winds.

In addition to the species listed below, cultural plants for leis or other uses can be integrated in windbreaks as vines or understory crops.

### Cut Flower/Foliage Windbreak Species

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Alpinia nutans</td>
<td>shell ginger</td>
</tr>
<tr>
<td>Codiaeum variegatum</td>
<td>croton</td>
</tr>
<tr>
<td>Cordyline terminalis</td>
<td>ti</td>
</tr>
<tr>
<td>Dracaena species</td>
<td>dracaena</td>
</tr>
<tr>
<td>Heliconia species</td>
<td>heliconias</td>
</tr>
<tr>
<td>Pandanus odoratissimus</td>
<td>hala</td>
</tr>
<tr>
<td>Various bamboo species</td>
<td>bamboos</td>
</tr>
</tbody>
</table>
Medicinal/Natural Health Products

A number of wind-tolerant species are valued for their medicinal properties. Their products may find markets with traditional healers, or in the growing herbal supplement industry. Some of these products may be marketed fresh, or can be processed into dried products, juices, extracts, concentrates, or oils for added market value.

<table>
<thead>
<tr>
<th>Medicinal Windbreak Species</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Aleurites moluccana</em></td>
</tr>
<tr>
<td><em>Azadirachta excelsa</em></td>
</tr>
<tr>
<td><em>Azadirachta indica</em></td>
</tr>
<tr>
<td><em>Eucalyptus species</em></td>
</tr>
<tr>
<td><em>Morinda citrifolia</em></td>
</tr>
<tr>
<td><em>Morus nigra</em></td>
</tr>
<tr>
<td><em>Saccarum species</em></td>
</tr>
<tr>
<td><em>Syzygium aromaticum</em></td>
</tr>
</tbody>
</table>

Living Fence

When the proper windbreak orientation corresponds well with the boundaries of the property, the windbreak can also double as a “living fence.” A living fence is a line of trees or shrubs that controls the movements of animals or people (Westley 1993). It may be used to keep them in (such as for livestock, chickens, small children) or out (such as dogs, feral animals, teenagers!). In some situations, the use of thick or thorny species can create adequate boundary protection. Other situations may require that wire or other nonliving fence materials be strung between “living fence posts” to supplement the effectiveness of the fence.

<table>
<thead>
<tr>
<th>Living Fence Windbreak Species</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Agave americana</em></td>
</tr>
<tr>
<td><em>Bamboo species</em></td>
</tr>
<tr>
<td><em>Carissa grandiflora</em></td>
</tr>
<tr>
<td><em>Erythrina variegata</em></td>
</tr>
<tr>
<td><em>Gliricidia sepium</em></td>
</tr>
<tr>
<td><em>Prosopis pallida</em></td>
</tr>
</tbody>
</table>

Species Selection for Multipurpose Windbreaks

The many varied climates and conditions found in the Pacific Islands makes species selection for windbreaks challenging. The table below is meant to be used as a general guide only in selecting species for use as components in a windbreak. It includes the height class, growth rate, and climatic zone for over 90 species, as well as their potential products including fruit, fodder, medicine, timber, and more. Tolerances to salt, drought, and water logging are also noted.

When selecting species, the guidance of local experts, including knowledgeable neighbors as well as resource professionals, is invaluable in making wise decisions. Local guides should be consulted for a history of species use, availability, and their adaptability/appropriateness to the site.
## Multipurpose Windbreak Species

<table>
<thead>
<tr>
<th>Botanical Name</th>
<th>Common Name</th>
<th>Products</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acacia koaia</td>
<td>koaia</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Alpinia nutans</td>
<td>shell ginger</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Annona muricata</td>
<td>SOURSOP</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Averrhoa carambola</td>
<td>STARFRUIT</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Cajanus cajan</td>
<td>pigeon pea</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Calliandra calothyrsus</td>
<td>calliandra</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Carissa grandiflora</td>
<td>N volunteered</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Cassia spectabilis</td>
<td>golden shower</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Citrus mitis</td>
<td>calamondin</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Citrus reticulata</td>
<td>tangerine</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Coccoloba uvifera</td>
<td>seagrape</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Codiaeum variegatum</td>
<td>croton</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Cordyline terminalis</td>
<td>ti</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Dracaena spp.</td>
<td>dracaena</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Eugenia braziliensis</td>
<td>gruminchama</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Eugenia uniflora</td>
<td>Surinam cherry</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Feijoa sellowiana</td>
<td>feijoa</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Heliconia spp.</td>
<td>heliconia</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Hibiscus rosa-sinensis</td>
<td>hibiscus</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Morinda citrifolia</td>
<td>noni</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Morus nigra</td>
<td>mulberry</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Myrciaria cauliflora</td>
<td>jaboticaba</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Omatea acuminata</td>
<td>Mex. weep. bamboo</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Pimenta dioica</td>
<td>allspice</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Psidium cattleianum</td>
<td>strawberry guava</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Psidium guajava</td>
<td>guava</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Saccharum officinale</td>
<td>sugarcane (Haw’ n)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Scævola sericea</td>
<td>beach naupaka</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Sesbania sesban</td>
<td>sesban</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Sophora tomentosa</td>
<td>silver bush</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Thespesia populnea</td>
<td>milo</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

**Key**
- • means experience for this purpose
- > means potential for this purpose
- blank means not used or not known

**Legend**
- Nitrogen fixer: fixes atmospheric nitrogen
- Crop shade: used for shading other crops
- Erosion control: erosion control, soil holding
- Fruit/Nut/Food: human food
- Leaf vegetable: leaves used for vegetables
- Medicine: medicinal uses for various parts
- Fodder: used for animal feed
- Bee forage: good/prolific bee forage for honey production
- Organic matter/mulch: prolific source of organic matter/mulch
- Wood/timber: solid wood or timber products
- Fuel wood: wood easily burned for fuel
- Drought: tolerates drought
- Water logging: tolerates water logged soils
- Salt/saline: tolerates salt spray
- Potential weed/invasive: N = extremely invasive in some areas, P = spreads, but rarely causes problems
- Growth rate: S = slow, M = medium, F = fast
- Climatic zone: H = humid lowland, A = arid/semi-arid, U = upland
<table>
<thead>
<tr>
<th>Botanical Name</th>
<th>Common Name</th>
<th>Nitrogen fixer</th>
<th>Crop shade</th>
<th>Erosion control</th>
<th>Fruit/Nut/Food</th>
<th>Leaf vegetable</th>
<th>Medicine</th>
<th>Fodder</th>
<th>Bee forage</th>
<th>Organic matter/mulch</th>
<th>Wood/timber</th>
<th>Fuel wood</th>
<th>Salt/saline</th>
<th>Water logging</th>
<th>Drought</th>
<th>Water logging</th>
<th>Potential weed/invasive</th>
<th>Growth rate</th>
<th>Climatic zone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acacia confusa</td>
<td>Formosa koa</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>&gt;</td>
<td>•</td>
<td></td>
<td>&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acacia holosericea</td>
<td>holosericea</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td></td>
<td>&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Albizia lebbek</td>
<td>Tibet tree</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td></td>
<td>&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anacardium occidentale</td>
<td>cashew</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>&gt;</td>
<td>•</td>
<td></td>
<td>&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Artocarpus integer</td>
<td>champedak</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>&gt;</td>
<td>•</td>
<td></td>
<td>&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Azadirachta indica</td>
<td>neem</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>&gt;</td>
<td>•</td>
<td></td>
<td>&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bambusa multiplex</td>
<td>hedge bamboo</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>&gt;</td>
<td>&gt;</td>
<td>•</td>
<td></td>
<td>•</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bambusa oldhamii</td>
<td>Oldhamii</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>&gt;</td>
<td>•</td>
<td></td>
<td>&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Casimiroa edulis</td>
<td>white sapote</td>
<td>•</td>
<td>&gt;</td>
<td>&gt;</td>
<td>•</td>
<td>&gt;</td>
<td>•</td>
<td></td>
<td>&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ceratonia silqua</td>
<td>carob</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td></td>
<td>&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chrysalidocarpus lutescens</td>
<td>areca palm</td>
<td>&gt;</td>
<td>&gt;</td>
<td>&gt;</td>
<td>&gt;</td>
<td>&gt;</td>
<td>•</td>
<td></td>
<td>&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chrysophyllum caimito</td>
<td>caimito</td>
<td>•</td>
<td>&gt;</td>
<td>&gt;</td>
<td>&gt;</td>
<td>&gt;</td>
<td>•</td>
<td></td>
<td>&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cocos sp.</td>
<td>dwarf coconut palm</td>
<td>&gt;</td>
<td>&gt;</td>
<td>&gt;</td>
<td>&gt;</td>
<td>&gt;</td>
<td>•</td>
<td></td>
<td>&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cordia subcordata</td>
<td>kou</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td></td>
<td>&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dimocarpus longan</td>
<td>longan</td>
<td>•</td>
<td>&gt;</td>
<td>&gt;</td>
<td>•</td>
<td>&gt;</td>
<td>•</td>
<td></td>
<td>&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eriobotrya japonica</td>
<td>loquat</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td></td>
<td>&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Erythrina poeppigiana</td>
<td>poro</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>&gt;</td>
<td>&gt;</td>
<td>•</td>
<td></td>
<td>&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Erythrina variegata</td>
<td>coral tree</td>
<td>•</td>
<td>•</td>
<td>&gt;</td>
<td>&gt;</td>
<td>&gt;</td>
<td>•</td>
<td></td>
<td>&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gliricidia sepium</td>
<td>madre de cacao</td>
<td>&gt;</td>
<td>&gt;</td>
<td>&gt;</td>
<td>&gt;</td>
<td>&gt;</td>
<td>&gt;</td>
<td></td>
<td>&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intsia bijuga</td>
<td>Borneo teak</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>&gt;</td>
<td>&gt;</td>
<td>•</td>
<td></td>
<td>&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lansium domesticum</td>
<td>langsat</td>
<td>•</td>
<td>•</td>
<td>&gt;</td>
<td>&gt;</td>
<td>&gt;</td>
<td>•</td>
<td></td>
<td>&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Macadamia integrifolia</td>
<td>macadamia</td>
<td>•</td>
<td>•</td>
<td>&gt;</td>
<td>&gt;</td>
<td>&gt;</td>
<td>&gt;</td>
<td></td>
<td>&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mammea odorata</td>
<td>mammee apple</td>
<td>•</td>
<td>&gt;</td>
<td>&gt;</td>
<td>&gt;</td>
<td>&gt;</td>
<td>•</td>
<td></td>
<td>&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manilkara zapota</td>
<td>sapodilla</td>
<td>•</td>
<td>•</td>
<td>&gt;</td>
<td>&gt;</td>
<td>&gt;</td>
<td>•</td>
<td></td>
<td>&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Melia azedarach</td>
<td>chinaberry</td>
<td>•</td>
<td>&gt;</td>
<td>&gt;</td>
<td>&gt;</td>
<td>&gt;</td>
<td>•</td>
<td></td>
<td>&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Musa balbisiana</td>
<td>dwf Brazilian banana</td>
<td>&gt;</td>
<td>&gt;</td>
<td>&gt;</td>
<td>&gt;</td>
<td>&gt;</td>
<td>&gt;</td>
<td></td>
<td>&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pandanus odoratissimus</td>
<td>hala, screwpinea</td>
<td>&gt;</td>
<td>&gt;</td>
<td>&gt;</td>
<td>&gt;</td>
<td>&gt;</td>
<td>&gt;</td>
<td></td>
<td>&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Persea americana</td>
<td>avocado</td>
<td>&gt;</td>
<td>&gt;</td>
<td>&gt;</td>
<td>&gt;</td>
<td>&gt;</td>
<td>&gt;</td>
<td></td>
<td>&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pithecellobium dulce</td>
<td>Manila tamarind</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>&gt;</td>
<td>&gt;</td>
<td>&gt;</td>
<td></td>
<td>&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pouteria campechiana</td>
<td>canistel</td>
<td>&gt;</td>
<td>&gt;</td>
<td>&gt;</td>
<td>&gt;</td>
<td>&gt;</td>
<td>&gt;</td>
<td></td>
<td>&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Schinus molle</td>
<td>Brazilian pepper tree</td>
<td>&gt;</td>
<td>&gt;</td>
<td>&gt;</td>
<td>&gt;</td>
<td>&gt;</td>
<td>&gt;</td>
<td></td>
<td>&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Senna siamea</td>
<td>pheasantwood</td>
<td>&gt;</td>
<td>&gt;</td>
<td>&gt;</td>
<td>&gt;</td>
<td>&gt;</td>
<td>&gt;</td>
<td></td>
<td>&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Syzygium aromaticum</td>
<td>clove</td>
<td>&gt;</td>
<td>&gt;</td>
<td>&gt;</td>
<td>&gt;</td>
<td>&gt;</td>
<td>&gt;</td>
<td></td>
<td>&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Syzygium jambo</td>
<td>rose apple</td>
<td>&gt;</td>
<td>&gt;</td>
<td>&gt;</td>
<td>&gt;</td>
<td>&gt;</td>
<td>&gt;</td>
<td></td>
<td>&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Syzygium malaccense</td>
<td>mountain apple</td>
<td>&gt;</td>
<td>&gt;</td>
<td>&gt;</td>
<td>&gt;</td>
<td>&gt;</td>
<td>&gt;</td>
<td></td>
<td>&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tabebuia pentaphylla</td>
<td>pink tecoma</td>
<td>&gt;</td>
<td>&gt;</td>
<td>&gt;</td>
<td>&gt;</td>
<td>&gt;</td>
<td>&gt;</td>
<td></td>
<td>&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tamarindus indica</td>
<td>tamarind</td>
<td>&gt;</td>
<td>&gt;</td>
<td>&gt;</td>
<td>&gt;</td>
<td>&gt;</td>
<td>&gt;</td>
<td></td>
<td>&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thyrostachys siamensis</td>
<td>monastery bamboo</td>
<td>&gt;</td>
<td>&gt;</td>
<td>&gt;</td>
<td>&gt;</td>
<td>&gt;</td>
<td>&gt;</td>
<td></td>
<td>&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Key**
- • means experience for this purpose
- > means potential for this purpose
- blank means not used or not known

- Nitrogen fixer - fixes atmospheric nitrogen
- Crop shade - used for shading other crops
- Erosion control - erosion control, soil holding
- Fruit/Nut/Food - human food
- Leaf vegetable - leaves used for vegetables
- Medicine - medicinal uses for various parts
- Fodder - used for animal feed
- Bee forage - good/prolific bee forage for honey production
- Organic matter/mulch - prolific source of organic matter/mulch
- Wood/timber - solid wood or timber products
- Fuel wood - wood easily burned for fuel
- Drought - tolerates drought
- Water logging - tolerates water logged soils
- Salt/saline - tolerates salt spray
## Tall Species 50 feet (15 meters) and taller

<table>
<thead>
<tr>
<th>Botanical Name</th>
<th>Common Name</th>
<th>Nitrogen fixer</th>
<th>Crop shade</th>
<th>Erosion control</th>
<th>Fruit/Nut/Food</th>
<th>Leaf vegetable</th>
<th>Medicine</th>
<th>Fodder</th>
<th>Bee forage</th>
<th>Organic matter/mulch</th>
<th>Fuel wood</th>
<th>Salt/saline</th>
<th>Drought</th>
<th>Water logging</th>
<th>Potential weed/invasive</th>
<th>Growth rate</th>
<th>Climatic zone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acacia auriculiformis</td>
<td>auri</td>
<td>*</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>P F H</td>
</tr>
<tr>
<td>Acacia koa</td>
<td>koa</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>P F H, U</td>
</tr>
<tr>
<td>Acacia mangium</td>
<td>mangium</td>
<td>*</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>P F H</td>
</tr>
<tr>
<td>Acrocarpus fraxinifolius</td>
<td>pink cedar</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>F H, A, U</td>
</tr>
<tr>
<td>Aleurites moluccana</td>
<td>kukui, candlenut</td>
<td>*</td>
<td>&gt;</td>
<td>&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>P M H, A</td>
</tr>
<tr>
<td>Araucaria heterophylla</td>
<td>Norfolk Island Pine</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>P S H, U</td>
</tr>
<tr>
<td>Artocarpus altiss</td>
<td>breadfruit</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>S H</td>
</tr>
<tr>
<td>Artocarpus heterophylus</td>
<td>jackfruit</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>S H</td>
</tr>
<tr>
<td>Azadirachta excelsa</td>
<td>sentang</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>M H, U</td>
</tr>
<tr>
<td>Calophyllum inophyllum</td>
<td>kamani</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>S H</td>
</tr>
<tr>
<td>Casuarina cunninghamiana</td>
<td>ironwood (small cone)</td>
<td>&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>N F H, A, U</td>
</tr>
<tr>
<td>Cocos nucifera</td>
<td>coconut</td>
<td></td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>P S H</td>
</tr>
<tr>
<td>Cryptomeria japonica</td>
<td>Japanese Sugi Pine</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>S U</td>
</tr>
<tr>
<td>Dendrocalamus asper</td>
<td>giant bamboo</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>M H</td>
</tr>
<tr>
<td>Eucalyptus dunnii</td>
<td>Dunn's white gum</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>F H, U</td>
</tr>
<tr>
<td>Eucalyptus microcorys</td>
<td>tallowood</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>F H, U</td>
</tr>
<tr>
<td>Grevillea robusta</td>
<td>silk oak</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>N M H, A, U</td>
</tr>
<tr>
<td>Guadua angustifolia</td>
<td>guadua bamboo</td>
<td></td>
<td></td>
<td>&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>M H</td>
</tr>
<tr>
<td>Litchi chinensis</td>
<td>lychee</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>S H, U</td>
</tr>
<tr>
<td>Mangifera indica</td>
<td>mango</td>
<td>*</td>
<td>&gt;</td>
<td>&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>P S H, A</td>
</tr>
<tr>
<td>Meterosideros polymorpha</td>
<td>ohia-lehua</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>P S H, A, U</td>
</tr>
<tr>
<td>Pinus caribaea</td>
<td>Caribbean pine</td>
<td></td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>M U</td>
</tr>
<tr>
<td>Prosopis pallida</td>
<td>kiawe</td>
<td>*</td>
<td></td>
<td>&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>N S A</td>
</tr>
<tr>
<td>Pterocarpus indicus</td>
<td>narra</td>
<td>*</td>
<td>&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>M H, A, U</td>
</tr>
<tr>
<td>Sandoricum koetjape</td>
<td>santol</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>S H</td>
</tr>
<tr>
<td>Swietenia macrophylla</td>
<td>mahogany</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>M H</td>
</tr>
<tr>
<td>Terminalia catappa</td>
<td>false kamani</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>M H</td>
</tr>
<tr>
<td>Tristania conferta</td>
<td>Brisbane boxwood</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>P F H, U</td>
</tr>
</tbody>
</table>

### Key

- **•** means experience for this purpose
- **>** means potential for this purpose
- **blank** means not used or not known

### Nitrogen fixer
- - - - - - - - - - - - - fixes atmospheric nitrogen

### Crop shade
- - - - - - - - - - - - used for shading other crops

### Erosion control
- - - - - - - - - - - - - erosion control, soil holding

### Fruit/Nut/Food
- - - - - - - - - - - - - leaves used for vegetables

### Leaf vegetable
- - - - - - - - - - - - medicinal uses for various parts

### Medicine
- - - - - - - - - - - - - - - - for animal feed

### Bee forage
- - - - - - - - - - - - - good/prolific bee forage for honey production

### Organic matter/mulch
- - - - - - - - - - - - - prolific source of organic matter/mulch

### Wood/timber
- - - - - - - - - - - - - solid wood or timber products

### Fuel wood
- - - - - - - - - - - - - wood easily burned for fuel

### Drought
- - - - - - - - - - - - - tolerates drought

### Water logging
- - - - - - - - - - - - - tolerates water logged soils

### Salt/saline
- - - - - - - - - - - - - tolerates salt spray

**Agroforestry Guides for Pacific Islands**

[www.agroforestry.net](http://www.agroforestry.net)
Resources and Recommended Reading

Local Assistance

There are government agents, professional forestry consultants, computer models, and informed neighbors that can assist landowners in designing windbreaks for their situation. There is no substitute for direct, locally appropriate assistance.

The Natural Resources Conservation Service (NRCS, formerly the Soil Conservation Service) provides assistance with conservation practices such as windbreaks and contour plantings. They also have a Forest Incentive Program, to increase the supply of timber products from nonindustrial private forest lands. They have offices throughout the American-affiliated Pacific. To find the one nearest you, contact:

NRCS State Office
P.O. Box 50004, Honolulu, HI 96850-0050
Tel: 808-541-2600, Fax: 808-541-1335 or 541-2652

The Cooperative Extension Service (CES) of the University of Hawaii can assist landowners with further information. There are CES offices throughout the State of Hawaii; to local one near you contact:

Cooperative Extension Service Main Office
3050 Maile Way, Gilmore Hall 203, Honolulu, HI 96822
Tel: 808-956-8397, Fax: 808-956-9105
E-mail: extension@ctahr.hawaii.edu
Web site: http://www2.ctahr.hawaii.edu

The State of Hawaii Department of Land and Natural Resources Division of Forestry and Wildlife provides information, education, and support for forestry. Some cost-sharing and other partnerships with private landowners are available. Contact:

Division of Forestry and Wildlife
1151 Punchbowl St. Room 325, Honolulu, HI 96813-3089
Tel: 808-587-0166, Fax: 808-587-0160
Web site: http://www.hawaii.gov/dlnr/dofaw/

The USDA National Agroforestry Center has brochures on agroforestry which can be ordered from:

National Agroforestry Center
USDA-NRCS, East Campus—UNL, Lincoln, NE 68583-0822
Tel: 402-437-5178
Web site: http://www.unl.edu/nac/

Publications

FACT Sheets (formerly NFT Highlights)
For a concise summary of information about a multipurpose tree or shrub species, see the appropriate FACT Sheet at http://www.winrock.org/forestry/factpub/factsh.htm or order hard copies from FACT Net, Winrock International, 38 Winrock Drive, Morrilton, Arkansas 72110-9370, USA; Tel: 501-727-5435; Fax: 501-727-5417; E-mail: forestry@winrock.org. Many available in Spanish, French, Indonesian, Chinese, Vietnamese, and Khmer.

Nitrogen Fixing Tree Start-up Guide by C.R. Elevitch and K.M. Wilkinson covers selection, propagation and uses of many important agroforestry trees, including many wind hardy species. Download from:
http://www.agroforestry.net
The USDA National Agroforestry Center’s Windbreaks and Wildlife brochure provides more detail on managing windbreaks for wildlife. Order from:
National Agroforestry Center
USDA-NRCS, East Campus—UNL, Lincoln, NE 68583-0822 USA
Phone: 402-437-5178
Web page for brochure: http://www.unl.edu/nac/pubs/ec/ec1771.htm

Agroforestry database: a tree species reference and selection guide is a selection guide for agroforestry trees covering more than 300 species. Valuable for field workers and researchers who are engaged in activities involving trees suitable for agroforestry systems and technologies. Available as CD-ROM from ICRAF, P.O. Box 30677, Nairobi, Kenya; Tel: +254-2-521450 or +1 650 833 6645; Fax: +254-2-521001 or +1-650-833-6646; E-mail: ICRAF@cgiar.org; or view online at:
http://198.93.235.8/cfdocs/examples/treebdd/AFT/AFT.htm

Trees on the Treeless Plains: Revegetation Manual for the Volcanic Landscapes of Central Victoria by D. Holmgren covers design of revegetation systems in detail including windbreaks and farm forestry. Order through Permaculture International LTD, P.O. Box 6039, South Lismore, NSW 2480, Australia; Tel: +61-2-66220020, Fax: +61-2-66220579; E-mail: pij@nor.com.au

Windbreaks in Sustainable Agricultural Systems
Windbreak Establishment
Windbreaks for Rural Living
Windbreaks and Wildlife
Windbreak Systems (Field, Livestock, Farmstead)
Publisher: National Agroforestry Center (NAC), Lincoln, NE
Available from: USDA Forest Service/Natural Resources Conservation Service, East Campus—UNL, Lincoln, Nebraska 68583-0822, USA; Tel: 402-437-5178; Fax: 402-437-5712; Web site: http://www.unl.edu/nac/windbrks.htm

Acknowledgments
Special thanks are due to the experienced resource professionals who provided valuable review and feedback for this publication including: Karl Dalla Rosa, Forester, Institute of Pacific Islands Forestry, U.S. Forest Service, Honolulu, Hawaii; J.B. Friday, Assistant Specialist, Tropical Forestry Extension, CTAHR, University of Hawaii at Manoa, Hilo, Hawaii; Robert Joy, Plant Materials Specialist, USDA Plant Materials Center, Hoolehua, Hawaii; John H. Lawrence, Soil Conservationist/Plant Materials Specialist, USDA NRCS, Guam; Steve Skipper, District Conservationist, USDA NRCS, Kealakekua, Hawaii; Robert Wescom, Agroforester, USDA NRCS, Guam; and Bruce Wight, Agroforester, National Agroforestry Center, Lincoln, Nebraska.

The input of all reviewers contributed immensely to this guide. The authors accept full responsibility for any errors or omissions.
About the Authors

Kim M. Wilkinson is the Education Director for Permanent Agriculture Resources and editor of The Overstory, an international tropical agroforestry journal. She has B.A. degrees in Anthropology and Ecology from Emory University.

Craig R. Elevitch is an agroforestry specialist with more than ten years of public and private sector experience in tropical agroforest and forest management. He has a M.S. degree in Electrical Engineering (Dynamical Systems) from Cornell University.

Christi A. Sobel is a freelance scientific illustrator and artist who has been published by the Royal Botanic Gardens, Kew, and Educational Concerns for Hunger Organization (ECHO). She holds a graduate degree in Scientific Illustration from University of California, Santa Cruz.

References

Agroforestry Information Service (AIS) Technology Fact Sheet, April 1993.
Windbreaks for Pacific Islands, by Karl Dalla Rosa. C/O FACT Net (Farm, Community, and Tree Network), Winrock International, Morrilton, Arkansas.


Agroforestry Guides for Pacific Islands

Multipurpose Windbreaks: Design and Species for Pacific Islands is the eighth in a series of eight Agroforestry Guides for Pacific Islands, published by Permanent Agriculture Resources with support from the U.S. Department of Agriculture's Western Region Sustainable Agriculture Research and Education (WSARE) Program. The guides can be downloaded from the internet free of charge from http://www.agroforestry.net. Master copies are also available to photocopy free of charge from Pacific Island offices of the Natural Resources Conservation Service (NRCS) or the Cooperative Extension Service (CES) of the University of Hawaii.

Each guide includes a resource section with books, periodicals, and web links for further information on the subject.

1. Information Resources for Pacific Island Agroforestry
Provides an introduction to agroforestry, followed by descriptions and contact information for books, guides, periodicals, organizations, and web sites useful to practitioners of agroforestry in Pacific Islands.

2. Multipurpose Trees for Agroforestry in the Pacific Islands
Introduces traditional Pacific Island agroforestry systems and species. Provides a species table with over 130 multipurpose trees used in Pacific Island agroforestry, detailing information on uses (food, fodder, timber, etc.) and tree characteristics such as height, growth rates, and habitat requirements.

3. Nontimber Forest Products for Pacific Islands: An Introductory Guide for Producers
Discusses the environmental, economic, and cultural role of nontimber forest products. Provides planning suggestions for those starting a nontimber product enterprise. Includes a species table of over 70 traditional Pacific Island nontimber forest products.

4. Integrating Understory Crops with Tree Crops: An Introductory Guide for Pacific Islands
Introduces planning considerations for planting crops with forestry, orchard, or other tree-based systems. Examples of understory intercropping systems in the tropics are included, as well as a species list of over 75 trees, shrubs, and vines used as understory crops in the region.

5. Introduction to Integrating Trees into Pacific Island Farm Systems
Presents eight Pacific Island agroforestry practices that integrate trees into farm systems. Includes silvopasture (trees and livestock), windbreaks, contour hedgerows, live fences, improved fallow, woodlots, sequential cropping systems, and understory cropping.

6. Choosing Timber Species for Pacific Island Agroforestry
Discusses seven steps for choosing timber species that meet the project goals, product requirements, and environmental conditions for a farm forestry or agroforestry project. Includes a species table of over 50 Pacific Island agroforestry species that provide quality wood products, detailing environmental tolerances and multiple uses.

7. Economics of Farm Forestry: Financial Evaluation for Landowners
Introduces strategies for determining the financial returns of small-scale forestry and farm forestry projects. Includes a discussion of the advantages and disadvantages of investing in farm forestry, and the steps in determining the costs involved, estimating returns, and comparing farm forestry with other land uses. Also explores the potential of improving economic picture through value-added strategies or agroforestry practices.

8. Multipurpose Windbreaks: Design and Species for Pacific Islands
Covers information on windbreak design, followed by a discussion of planning considerations for multiple-use windbreaks for timber, fruit/nut production, mulch/fodder, or wildlife habitat. Includes species table of over 90 windbreak species for Pacific Islands, detailing environmental requirements and uses/products.

Agroforestry Guides for Pacific Islands
from: http://www.agroforestry.net