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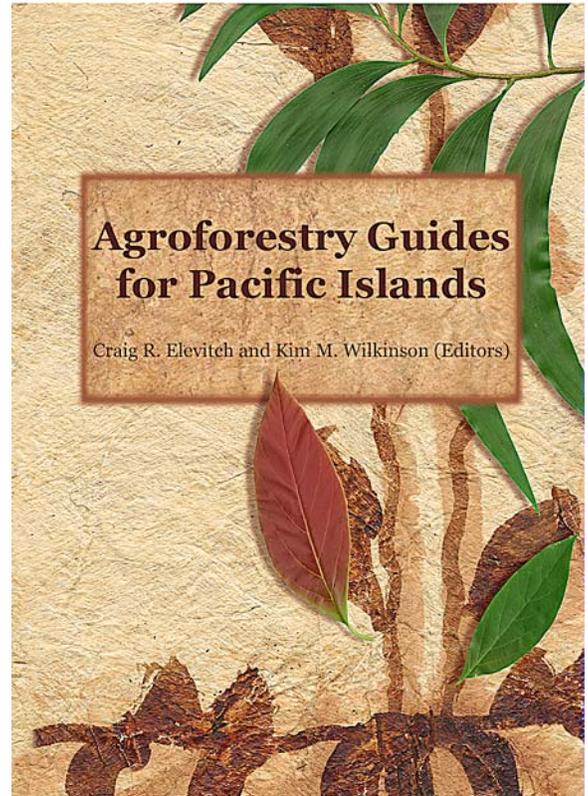
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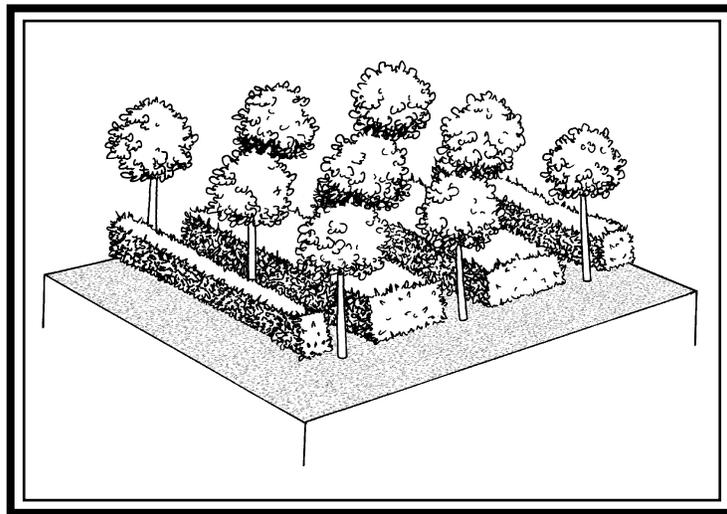
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# Choosing Timber Species for Pacific Island Agroforestry

by Kim M. Wilkinson, Craig R. Elevitch and Randolph R. Thaman



# Choosing Timber Species for Pacific Island Agroforestry

**Abstract:** Timber products can be a sustainable and high-value yield from farms, agroforests, and small-scale forestry projects. Like any other business venture or investment, careful advanced planning can make a difference in terms of economic success or failure. Planning prior to planting includes choosing species that will meet the commercial objectives, management requirements, and environmental conditions of the project.

This guide introduces some ways to integrate timber trees into a farm system, as well as basic guidelines for choosing suitable species for planting. A species chart of over sixty species used for timber production in Pacific Island farm forestry and agroforestry is included.

**Keywords:** agroforestry, timber, farm forestry, small-scale, harvest, production, traditional species

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# Introduction

When many people think of growing timber trees, they picture large, monocultural (single-species) plantations. Indeed, much of the scientific and economic study of forestry has been devoted to the needs of this industrial form of forestry. However, small-scale projects known as farm forestry, agroforestry, tree farms or nonindustrial private forestry also have the potential to profitably produce quality timber products.

Planting timber trees on farms can serve several functions. As an investment timber trees can:

- provide economic returns from a long-term timber crop;
- diversify yields (financial risk management); and
- broaden opportunities for rural enterprises.

For enhancing the farm environment timber can:

- improve conditions for crop plants and animals;
- protect the land from wind and erosion; and
- support a diversity of soil microlife.

For ecological benefits, timber trees can:

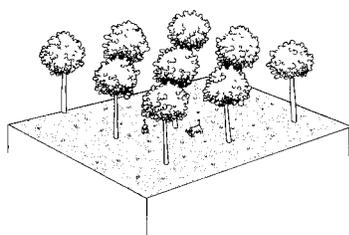
- support biodiversity by enhancing wildlife habitat on agricultural land;
- reduce carbon dioxide pollution by storing carbon from the air in trees; and
- improve watershed health.

## Agroforestry Systems with Timber Trees

Timber production on farms can take many different forms. Some plantings resemble small-scale, single-species plantations or woodlots. Others combine timber trees with pasture, orchard, windbreaks, or other crops in mixed agroforestry systems. Some of the ways timber trees are integrated in farm systems are summarized below.

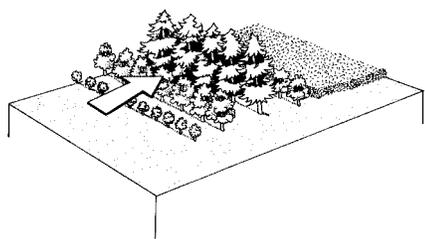
### Silvopastoral systems (trees and livestock)

When trees are combined with pasture forage and livestock production, it is called silvopasture. In silvopasture, the interactions among timber trees, forage, and livestock are managed to simultaneously produce timber commodities, a high quality forage resource, and efficient livestock production (Klopfenstein et al 1997). For silvopastoral systems, timber tree species are usually spaced wider than standard to promote healthy pasture forage underneath. Trees can be evenly distributed over the area to optimize growing space and light for both trees and forage. Alternatively, grouping trees into rows or clusters concentrates their shade and root effects while providing open spaces for pasture production. The trees benefit livestock by providing shelter and shade. The livestock can be managed to maintain the understory of the forest, thus reducing the need for mowing, herbicides or other weed control.



### Windbreaks

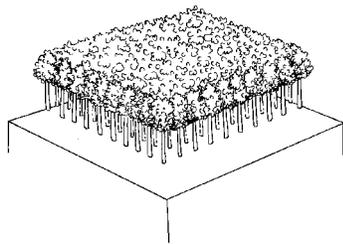
Windbreaks are rows of trees strategically placed to protect an area from wind damage. A windbreak slows the wind that enters the protected area. Depending on the site conditions, windbreaks may consist of single or multiple rows. They may be oriented to protect from winds coming from one direction, or they may be planted in a pattern that protects from variable or shifting winds. Well-designed and managed windbreaks have in many cases been shown to significantly improve the health, productivity, and quality of the crops or livestock they protect. There are a number of hardwood species that can be used as components in



windbreaks, including some *Eucalyptus* species, mahogany (*Swietenia macrophylla*), narra (*Pterocarpus indicus*), and neem (*Azadirachta indica*).

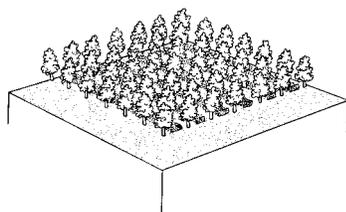
### Woodlots

Sometimes farmers may devote small parts of the farm to solid stands of trees, called woodlots. Woodlots can be a productive use of hard-to-access farmland, such as steep slopes, river banks, borders, etc. Depending on the design and the species used, woodlots can be managed to provide products such as timber, poles, or firewood. When nitrogen fixing trees are used, woodlots may also serve to accelerate rehabilitation of degraded land while providing a timber product. Woodlots usually consist of trees planted close together and uniformly spaced. Although woodlots can be large, they often occupy small parcels of land, in some cases as small as 5m x 5m (15 ft X 15 ft) (FACT Net 1999).



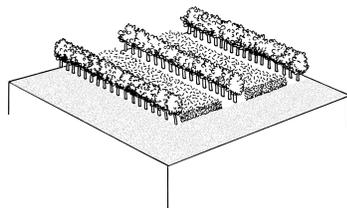
### Sequential cropping systems

Sequential cropping is a practice wherein short-term crops are planted with, and eventually replaced by, long-term timber trees. This strategy may be used during the establishment phase of a forestry or orchard project, or in cases where annual or short-term crops are being phased out in favor of long-term tree crops. For either purpose, sequential cropping is a system that enables farmers to harvest short-term crops while waiting for the tree crops mature.



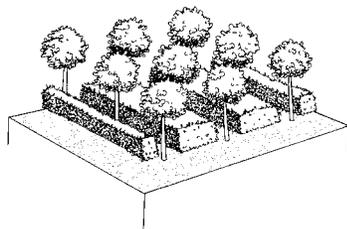
### Wide Row Intercropping

Wide row intercropping integrates the production of trees for poles or timber with annual or perennial crops. Trees are planted with wide spacing between rows usually of about 10-20 m (30-60 ft), and crops are cultivated between the rows. If land is sloping, the rows of trees are often planted on the contour. Tree canopies can be managed through periodic pruning to reduce shade competition.



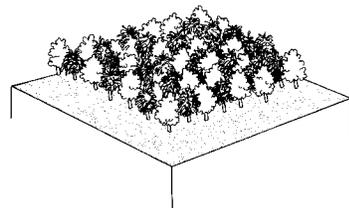
### Dispersed trees (Shade trees)

Some farmers may choose to integrate timber trees with shade-tolerant crops in a permanent arrangement. Unlike sequential cropping systems, shade trees with understory crops are installed and managed to produce for many years as the trees mature. Usually the number of trees per acre is 25-75% less than when timber trees are planted alone, to make space for the understory crops. The shade trees may be planted in a uniform pattern (as in wide row intercropping), or in a more scattered pattern. There are many valuable cash and subsistence crops that thrive in the shadier climate under trees. Thus the introduction of trees on the farm cultivated in combination with understory crops enables farmers and foresters to diversify their yields, reap earlier returns than with forestry alone, and make more efficient use of land.



### Land Rehabilitation

Some species of timber trees can be used in land rehabilitation, on land that has been overgrazed, eroded, or depleted of nutrients, in order to gradually increase the future production potential of the site. Degraded land is planted with seeds or seedlings. Often nitrogen fixing trees are used, because of their ability to take up and recycle nutrients. Over time, the trees will increase soil productivity, add organic matter, accumulate nutrients, and suppress the growth of undesirable weeds. When the trees are removed, they can provide a source of income from wood products. In Costa Rica, for example, land rehabilitation with *Acacia mangium* has helped to control erosion and improve nutrient reserves, while supplying a timber product (FACT Net 1999).



# Choosing Timber Species for the Farm System

## What Species Should We Plant?

The most common question asked by those embarking on a project with timber trees is: “What species should we plant?” The process of selecting species is not a precise science. Instead, it is reliant on personal knowledge, priorities, judgments, and experience, guided by literature reviews, the advice of other growers and resource professionals, and other information (Turnbull 1986). Knowledge of project goals, end-use requirements, planting site conditions, and the range of potentially suitable species is essential in the species selection process. Guidelines for choosing suitable species for a particular site and purpose are introduced below.

### Summary of Selection Process:

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1 What products and services are desired?	Determine the end-use requirements/products and set production objectives.
2 What type of environment does the planting site have?	Describe the planting site using the best available sources.
3 What is known of similar environments?	Review local experiences and relevant literature with other trees and crops.
4 What timber trees grow well under these conditions?	Review local experiences, relevant literature, species trials from similar conditions.
5 What land-use practices are found under similar conditions?	Review literature, observe local practices.
6 Select candidate list of species based on all available data.	Assemble and analyze information on end uses, environment and species requirements.
7 Narrow down species list.	Conduct test plantings on intended planting sites. Plant trees from a range of seed sources in either formal or informal experiments.

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Source: MacDicken 1994

## Defining Desired End Products

As with any other business venture, planting timber trees for commercial returns must begin with the end in mind, essentially asking, “What products are desired?” The more specific the objective is, the greater the chance of successfully planning the project. Instead of stating objectives vaguely, they should be specific, such as, “high-value native hardwoods for furniture,” “small dimension saw timber for the local sawmill,” or “finely-figured woods for local crafts market.”

Because of the unpredictable and long-term nature of the timber market, landowners may want to keep several options open for end-products. Most trees yield multiple products, for example large boles for saw timber, and smaller remnants for crafts, and/or slabs and edging for firewood. Species are often chosen based on their most valuable or desirable wood product, with consider-

ation given to the other potential products as well. However, in some cases, particularly in regions where infrastructure is not yet in place for forestry, growers may select several species chosen for greatest flexibility in end-uses.

Different characteristics of trees will result in different products. Examples of these for several types of wood products are summarized below.

End Product	Tree Characteristics	Property Requirements
Sawn Timber	Large size, moderate to fast growth, good form, ease of pruning	Strength, stability, wood uniformity, good seasoning, working, and finishing
Sheet products/ veneer	Very large size, good natural pruning, wounds cover over quickly (for few knots)	Figure, peeling or slicing quality, few knots, good adhesive bonding strength (if for plywood)
Wood chips, pulp, and paper	Rapid growth, straight stems, easy to grow, coppicing desirable	Fiber length, light color, low extractives content, density
Posts and Poles (Roundwood)	Straight stems, strong apical dominance, few or thin branches, preferably self-pruning (without knots), little taper from top to bottom, bark should strip easily.	Durable in contact with the ground or in water, capable of taking high cross-loads, have minimal spiraling, resistant to termites and wood-borers (Turnbull 1986)

Source: Evans 1992 and Turnbull 1986

## Defining Desired Services

Just as commercial products should be defined in advance, the desired services, functions or multiple uses of the trees must also be specified in advance. Suitable species have to meet certain criteria, as well as be planned and managed appropriately, if they are to provide timber and serve a useful function in the farm system.

Selecting trees for multiple products or services may involve some compromise. Prioritizing the desired products and services in order of their importance to the grower is valuable in choosing the best species (Franzel et al 1996). For example, if maximizing timber production is the primary goal, species and management strategies that meet this objective should be chosen, and other effects of trees considered side-benefits. On the other hand, if wind protection is the most important function of the trees, then species should be selected for their wind-firmness first, with timber production as a secondary consideration. In mixed cropping systems, timber production per acre is usually reduced, in order to make room for livestock or other crops. In these cases, the system is planned so that the benefits of additional crops balance out the reduction in timber yield.

Certain trees are unsuitable in mixed cropping systems due to their characteristics, for example aggressive surface root systems, extensive water requirements, and/or allelopathic (inhibitory) effects. Some of the desirable characteristics for trees in certain agroforestry practices are outlined below.

### **Silvopastoral systems (trees and livestock)**

- Tolerant of livestock impacts (resistant to damage to root systems, bark, etc.)

- Not poisonous/toxic to livestock
- Have large crowns above livestock reach
- Thin canopy (allows light to enter for pasture forage)

#### **Windbreaks**

- Wind firm root systems
- Bushy deep crown that allows some wind penetration
- Wind strong, pliable branches (not brittle or easily breakable)
- Delayed shedding of lower limbs
- Branching to the ground (if single-species windbreak is used)
- Salt-tolerant (if near coastal area)
- Rapid growth (if early protection is required)
- Long life
- Should not harbor pests of neighboring crops
- Root systems should not compete excessively for water with adjacent crops

#### **Woodlots**

- Fast-growing
- Provide useful products
- Able to coppice, resprout, or otherwise regenerate easily (if rotational harvest are desired)
- Hardy, tolerant of harsh conditions (if planted on marginal land)

#### **Sequential cropping systems, Dispersed trees, or Wide row intercropping**

- Trees not excessively fast-growing or competitive with crops
- No allelopathic effects on crops
- Canopy allows acceptable light penetration to crops
- Not damaged by cultivation or harvest of surrounding crops

#### **Land Rehabilitation**

- Tolerant of drought, poor soils, and neglect
- Fast-growing
- Deep-rooted
- Nitrogen fixing and/or produces litter with high nutrient content (for soil improvement)
- Removable, does not resprout after cutting (if area is to be planted in other crops after rehabilitation)

### **Defining the Site Characteristics**

A description of the planting environment is essential in selecting appropriate species for the site. Certain environmental data will be collected at the site, for example, a soil sample, survey of existing vegetation, etc. Other data will need to be gathered from reference materials, local weather stations, and local experts.

At a minimum, the description of site characteristics should include the following information (MacDicken 1994):

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#### **Required Site Data**

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Elevation

Slope (i.e., flat or gentle 0-5 degrees; intermediate 5-10 degrees; steep 11-45 degrees; very steep >45 degrees)

Mean annual rainfall

Rainfall regime (summer, winter, uniform)

Maximum length of dry season (months less than 50 mm rainfall)

Mean annual temperature

Mean minimum temperature of coldest month (including risk of frost days)

Mean maximum temperature of hottest month

Absolute minimum temperature (risk of frost)

Soil nutrient analysis (done by soil testing)

Surface soil texture: sand, loam, clay

Soil depth to impermeable layer (i.e., <25 cm, 25-50 cm, 50-100 cm, >100 cm)

Soil drainage (excessively well-drained, well-drained, impeded, waterlogged)

Soil pH

Wind direction and severity

Survey of existing vegetation: health and vigor, presence of indicator plants, weediness, etc.

History of land use

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Any other information that can be obtained about the site will also be valuable. Other especially useful information includes:

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#### **Additional Site Data**

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Soil salinity analysis (done by soil testing)

Climatic classification system and description

Solar radiation

Land capability class rating

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The process of evaluating the project site can be as comprehensive as desired. Growers should allow sufficient time for this process—several months to a year is not excessive. The time consumed by a detailed site evaluation is rewarded by more informed planning decisions.

## **Determining Similar Environments**

The more comprehensive the understanding of the project site, the easier it will be to limit species choices to the most promising species from similar environments. However, the many varied climates, soils, and management capabilities found in Pacific Islands complicate the task of matching species even to similar local environments. For example, sites separated by only a few miles may have very different soil types, wind directions, or rainfall patterns. Assistance is available locally from extension agents and other resource professionals to help growers identify comparable environments in the region. The successful species and practices from similar environments can then be evaluated for their suitability for the project.

When considering exotic species, the most common method is to attempt use species that are successful in similar environments and latitudes elsewhere. This technique involves comparing the climate of the planting area with other equivalent climatic areas around the world. Then species can be evaluated based on their performance in species trials with similar conditions, or based on performance in their native range (Turnbull 1986).

For certain species extensive trials have already been done, and information is exchanged among scientists and professionals. Some organizations are developing data banks of information on species, which can be used to match species with certain environments, products, or uses (see Resources and Recommended Reading).

### **What Timber Trees Might be Suited?**

After determining the desired end-uses/services and the environmental conditions, information about timber species can be gathered from relevant literature, databases, local experiences, and species trials from similar conditions. Growers should consult diverse information sources, keeping in mind that some species information may be subject to local variables that may not apply to their situation. Recommendations can also be obtained with the assistance of a professional forester or extension agent. Species that potentially could perform well on the site and that meet the end-use and management objectives of the project create a preliminary list of potential species.

This initial candidate list may be quite long. It can be narrowed down by eliminating species based on practical considerations and personal preferences. Growers may choose to eliminate species from their list for any number of other reasons, for example: lack of adequate testing and data on the performance of that species in the area; difficulty in obtaining quality plant materials for that species; processing or marketing unknowns that make the species a more risky investment; and so forth. It is important not to eliminate species too readily, as growers will want to test a range of promising candidate species on the site before making their final selections (see Testing and Trials). After elimination, the short list of candidates usually contains a minimum of four to six species (Franzel et al 1996).

### **Note on Native Species and the Risks of Exotics**

In general, if a native species can fill the need, it should be given priority over introduced species in the selection process. The use of natives often has some advantages: native species are already adapted to the environment; plant materials may be readily available; and growth of natural stands can provide some indications of possible performance in cultivation (Evans 1992). There may also be commercial benefits when indigenous species fill a small but high-value market niche, and local industries may already be familiar with the species.

When appropriate, native and exotic species may be used in the same project. Growers may choose exotic species due to the conditions of their planting site, or in order to meet economic goals. For example, degraded soil conditions or the presence of new pests may preclude establishment of certain native species. Certain exotic trees achieve faster growth and earlier returns. Exotic trees can also provide important ecological and conservation functions, including wildlife habitat, watershed improvement, soil conservation, and many other benefits.

However, growers must use caution when planting exotic trees. Pacific Islands native forests and plant communities are particularly vulnerable to invasion, and many trees are capable of reproducing themselves and becoming potential threats. Naturally, growers should select species that are not known to be

invasive. If forestry plantings with exotic species (even ones not known to be invasive) are established near native forests, buffer strips of natives should be established between the plantation and the native area (Ching 1994).

## Land-use Practices under Similar Conditions

Many species combinations have not yet been subject to scientific study. However, some have been tested by local farmers, often over many generations. Traditional agroforestry practices and crop combinations can provide an effective foundation for future agroforestry development (Thaman and Whistler 1996). Observing local practices as well as reviewing literature from similar climates can point to workable strategies. Reviewing plantings under similar environmental conditions may also provide practical information about appropriate spacing and management techniques.

Field surveys of the local environment, existing forests, and agroforests help determine what trees already successfully grow in a similar area, what trees are already known and culturally acceptable to the local community, and what planting materials are available. Making lists of existing trees, their habitats, associated trees, plants, and animal uses or functions can be one of the best ways to find out what trees and assemblies of trees work well.

## Genetic Variability

There are dramatic differences in growth rates and performance from different seed sources from a single species. These genetic variations can affect productivity as much as variation among species (Wadsworth 1997). For this reason, it is recommended to test several different selections of a species to determine which is optimal for the project.

Where possible, select or improved plant material should be used. The genetic quality of tree seed used in plantings is a major factor in the economic success and productivity of a project. Select seed will produce plants that are more productive, better adapted to local site conditions, and better suited to achieve the results planned for the project. The long-term ecological viability and future contribution of a planting is also at stake, as projects should contain enough diversity to reproduce healthy and productive offspring for future generations, while remaining resilient to environmental stresses. The short and long term impacts of genetic seed quality warrant careful consideration and planning when collecting or purchasing plant materials (Dawson and Were 1997).

## Testing and Trials

For the sake of expediency, a small timber grower may want to limit their choices to species and provenances that have already been tested locally. University programs, government forestry organizations, extension agents, and private research organizations may have already tested species in their area. Some growers may choose to plant lesser-known species, or selections of native or exotic species that have not yet been locally tested. In these cases, a year or two of small-scale testing is recommended before planting the entire project.

The long-term nature of timber production usually precludes the possibility of testing a new species for a full rotation, from planting through to harvest and market. The most reliable information comes from species trials conducted in formal, designed experiments (MacDicken 1994). However, since extensive trials are usually not feasible, even one or two years of informal species trials by the grower is invaluable. No amount of research and advice can substitute for test plantings on the intended planting sites.

The trial period typically involves planting a number of species, and a range of seed sources (varieties and provenances) within each species. At a minimum, ten to twenty seedlings of each species under consideration should be planted in the test.

The performance of these species can then be observed. Some general early indicators that the species may be suitable for timber production on the site include the following (after Wadsworth 1997):

- Uniform growth of individual trees denotes favorable conditions.
- Self-pruning is a sign of a favorable site.
- Susceptibility to insects and diseases is minimal on sites to which trees are well-adapted.
- Early height growth is a good indication of adaptation of species to a site.

It should be noted that these indicators are generalizations, and do not apply to all species. For example, for species whose wood is valued for figure or grain, fast early growth may not necessarily mean the best timber product.

The time and expense devoted to testing candidate species should be viewed as an investment. As with any other business venture, starting on a small scale and observing the results will aid in successful expansion to a larger scale planting. It is also an important form of risk-management, preventing growers from staking scarce time, land, and resources on species that do not perform as expected. One or two years of species trials will serve to eliminate more species from the list, and narrow the candidates down to those with a high possibility for success on the site. Then the necessary additional information about these species, including silvicultural practices, spacing, management, etc., can be compiled for use in planning the project.

## Planting Lesser-known Timber Trees

Currently, eucalypts, pines, and teak are the most commonly planted timber trees, accounting for 86% of all plantation timber in the tropics (Evans 1992). However, efforts to improve conservation and sustainable land use in the tropics are leading to the improved management and diversification of timber plantations, the planting of trees in agroforestry systems, and the promotion of sustainably grown native timber and nontimber forest products. Expanding the use and planting of lesser-known timbers is part of this trend (Sosef et al 1998). Simultaneously, new technologies for processing, wood preservation, and treatments have extended the potential uses and market opportunities for lesser-known species (Lemmens et al 1995).

The smaller scale of agroforestry and farm forestry plantings may enable the grower to exploit market niches of specialty timbers for which there is a small but high-value market. However, those working with lesser-known and minor timbers are faced with a shortage of information, data, and sound advice, as well as the challenge of introducing their product in the market. In these cases, learning about local knowledge and traditional uses are an important part of understanding the potential for the species.

A lesser-known timber species has a better chance on the market if (Lemmens et al 1995):

- there is an adequate, sustainable supply;
- the wood properties are known;
- processing problems with the new species can be solved; and
- if the wood can resemble one currently in demand.

Lesser-known species, many of them native or traditional in Pacific Islands, are emphasized in the species table that follows.

## Species Information

The following species table compiles information on timber species that have been used in the Pacific Islands in forestry or agroforestry. Emphasis is on lesser-known or minor timbers of the region, since information about major commercial timbers is readily available from other sources. Because of the diverse climates and soil types found in the Pacific Islands, the environmental data such as elevation and rainfall should be used only as a general guide. Information on traditional uses was compiled from throughout the Pacific in order to provide the reader with details about additional products or functions available from the species. Some of the information in the table is unknown or unavailable, as indicated by blank areas.

# Timber Species Pacific Island Uses

Species	Common Names	TIMBER USES							NONTIMBER PRODUCTS							AGROFORESTRY USES														
		Major commercial timber	Minor timber	Sawlogs/Solid wood products	Posts/poles	Pulp/fiber	Carving/turning/crafts	Canoe/Boat/Raft Making	Traditional wood/timber use	Staple Food	Fruit/Nut	Leaf Vegetable	Medicinal	Domestic Animal Fodder	Bee Forage/honey production	Resin/Gum/Glue/Latex/Caulking	Tannin/Dye	Oil/Lubricant	Fuel Wood	Organic Matter/Mulch	Fallow Improvement/Pioneer	Nitrogen fixation	Windbreak	Shade	Erosion Control	Fencing/Hedges/Boundaries	Reforestation/Agroforestation	Planted Ornamental	Protection from Salt-spray	Animal Habitat
Acacia auriculiformis	northern black wattle	•		•	•	•	•	•	2					1	2		2	2	2	2	2	1	2		1		1			
Acacia koa	koa	•		•				•	•			2		1				3	2	3	3				4	2		4	4	
Acacia koaia	koaia		•	•				•	2					1					1	2					2	3				
Acacia mangium	mangium; brown salwood	•		•	•	•	•	•	2									2	2	1	1	1	2		1	1		1		
Adenanthera pavonina	red bead tree		•	•				•	3		3	1	2			1	3		2	3		1	2	2		1	2	2		
Agathis macrophylla	kauri; kauri pine		•	•				•	4				2		3		2						2		3	2	2	2		
Agathis robusta	Queensland kauri		•	•			•	•	2						1		2						2		2	2		1		
Agathis vitiensis	Fiji kauri		•	•				•	4				2		4		2						2		2		2	2		
Albizia lebbeck	albizia; siris tree		•		•			•	3				1	1	2	1	1	3		2	2	3	2	2		3	1	2		
Albizia saman	rain tree; monkeypod		•	•				•	3		1			2	2	1		4		2	3	3	2	4	3	2	4		2	
Alphitonia zizyphoides	toi		•		•			•	4				4		2		4		3	3			3	2				3		
Araucaria cunninghamii	hoop pine; Moreton Bay pine	•		•	•	•	•	•	4									2				2	2		3	2		3	2	
Araucaria heterophylla	Norfolk Island pine		•	•				•	2									2				3	2	2	2	3	2		2	
Artocarpus altilis	breadfruit		•	•	•			•	3	5	5	2	4	5	3		2		4		1	3				2		2	3	
Artocarpus heterophyllus	jakfruit; jackfruit		•	•	•			•	2	3	3	1	2	2	1	1	2					3	1		1	2		2		
Azadirachta indica	neem		•	•	•				1				3	1	1		1	2				2	2	1		2		2		
Barringtonia asiatica	fish-poison tree		•	•	•	•	•	•	3								2					3	2		2	2	3	2		
Bischofia javanica	Java cedar		•	•	•	•	•	•	3				4	2		4	4			4	4		2	3	2	2	1	1	3	2
Bruguiera gymnorrhiza	Oriental mangrove		•	•	•	•	•	•	4		2		3	2	3	4	4					5				1		4	2	
Calophyllum inophyllum	portia tree		•	•				•	4				3		2	1	3	3				3	4	3	2	2	2	5	3	3

**Key**

• = used for this purpose; 1 = potential, underutilized; 2 = minor importance; 3 = important; 4 = very important some areas; 5 = very important, widespread; blank = no importance or information unavailable





# Timber Species Tolerances

Species	Common Names	Elevation (meters)	Climatic Zones	Means of Propagation	Growth Rate	Height at Maturity (meters)	Weediness/Invasiveness	Salt Tolerance	Drought Tolerance (months)	Waterlogging Tolerance
Acacia auriculiformis	northern black wattle	0–500 m	H, SH	S	F	20–30 m	W		7	yes
Acacia koa	koa	600–2000 m	U	S	F	20–40 m	P	no	3-4	no
Acacia koaia	koaia	300–1500 m	U	S	S	3–5 m			5-8	no
Acacia mangium	mangium; brown salwood	0–1200 m	H	S	F	15–30 m	P		1-2	
Adenanthera pavonina	red bead tree	0–400 m	H	S	F	20–30 m	P		3-4	
Agathis macrophylla	kauri; kauri pine	50–550 m	H	S	M	30–40 m				
Agathis robusta	Queensland kauri	100–900 m	U	S,C	S	20–35 m			2-3	
Agathis vitiensis	Fiji kauri	0–1150 m	H	S	M	25–33 m				
Albizia lebbek	albizia; siris tree	0–1500 m	H, SH, A	S	M	25–30 m	P	yes	4-6	
Albizia saman	rain tree; monkeypod	0–300 m	H, A	S	M	20–35 m	P		2-4	
Alphitonia zizyphoides	toi	0–300 m	H, SH	S	M	20–30 m	P			
Araucaria cunninghamii	hoop pine; Moreton Bay pine	0–1500 m	H, SH, U	S	M	40–50 m				
Araucaria heterophylla	Norfolk Island pine	0–2000 m	H, SH, C	S,C	M	20–40 m		yes	3-4	
Artocarpus altilis	breadfruit	0–800 m	H, SH	S,R,V	S	20–30 m			3-4	
Artocarpus heterophyllus	jakfruit; jackfruit	400–1000 m	H, SH	S,G	M	30–40 m			2-4	
Azadirachta indica	neem	0–500 m	H, SH, A	S,C,G	F	20–30 m	P		3-6	no
Barringtonia asiatica	fish-poison tree	0–20 m	C	S	M	15–25 m		yes		
Bischofia javanica	Java cedar	0–900 m	H, SH	S	M	20–30 m		no		yes
Bruguiera gymnorrhiza	Oriental mangrove	0 m	C	S	M	15–20 m	P	yes		yes
Calophyllum inophyllum	portia tree	0–100 m	C	S	S	20–25 m		yes		

**Elevation**

in meters (1 foot = 0.3 meters)

**Climatic Zones**

H = Humid tropics ( >1000 mm rainfall; >20 C° mean temp.; >40 inches; >68°F)  
 SH = sub-humid ( >500 mm rainfall; >20 C° mean temp.; >20 inches; >68°F)  
 A = Arid/semi-arid ( <500 mm rainfall; >20 C° mean temp.; <20 inches; >68°F)  
 U = Upland ( >1000 mm rainfall; <20 C° mean temp.; >40 inches; <68°F)

C = Coastal

**Means of Propagation**

S = Seeds  
 C = Cuttings  
 G = Grafting  
 A = Air layering  
 B = Budding  
 V = suckers  
 R = Root cutting

**Growth Rate**

S = Slow growth rate, less than 0.75

meters (2 ft) per year

M = Medium, 0.75-1.5 meters (2–5 ft) per year

F =Fast, 1.5+ meters (5+ ft) per year

**Height at Maturity**

in meters (1 foot = 0.3 meters)

**Potential Invasiveness**

W = Weedy or extremely invasive in some areas; often problematic

P =Potentially weedy; naturalized in some areas, but rarely causing problems

**Salt tolerance**

yes or no

**Drought tolerance**

in months

**Waterlogging tolerance**

yes or no

**blank**

information unavailable

# Timber Species Tolerances (continued)

Species	Common Names	Elevation (meters)	Climatic Zones	Means of Propagation	Growth Rate	Height at Maturity (meters)	Weediness/Invasiveness	Salt Tolerance	Drought Tolerance (months)	Waterlogging Tolerance
Canarium indicum	red canarium; galip	0–600 m	H	S	S	40 m				
Canarium spp./harveyi	pili nut; canarium almond	0–600 m	H, SH	S	S	15–25 m				
Casuarina cunninghamiana	ironwood; she oak	0–1700 m	H, SH, A, C	S	F	25–30 m	W	yes	4-6	no
Cocos nucifera	coconut palm; coconut	0–800 m	C, H	S	M	10–20 m	yes	yes	3-4	yes
Cordia subcordata	beach cordia; sea trumpet	0–300 m	C, H	S	M	10 m	yes	yes	3-4	
Cryptomeria japonica	sugi pine	1500-2400	S, C	S	M	40 m				
Eucalyptus citriodora	lemon-scented gum	0–200 m	H, SH	S	F	15–20 m				
Eucalyptus deglupta	Mindanao gum	0–1800 m	H	S,C	F	30–50 m			2-3	no
Eucalyptus pellita	red mahogany	900-1500 m	H, SH	S	F	50 m				
Eucalyptus saligna	flooded gum	100–1000 m	U	S	F	40–55 m				
Eucalyptus tereticornis	forest red gum	0–1800 m	SH, C, U	S	F	30–50 m		yes	3-5	yes
Flueggea flexuosa		5–350 m	H	S	F	3–10 m				
Gliricidia sepium	gliricidia; madre de cacao	0–800 m	H, SH	S,C	F	10 m	P	yes	6-8	yes
Guettarda speciosa	guettarda	0–10 m	C	S	S	5–20 m	yes	yes		
Hernandia nymphaeifolia	lantern tree	1–20 m	C	S	M	15–20 m	yes	yes		
Inocarpus fagifer	Tahitian chestnut	1–400 m	H, C	S	S	15–25 m	yes	yes		yes
Intsia bijuga	ipil; Borneo teak; island teak	0–600 m	C, H	S	S	30–50 m	yes	yes		yes
Kleinhovia hospita	kleinhovia; guest tree	10–100 m	H, SH	S	F	10–15 m				
Lumnitzera littorea		0 m	C	S	S	5–10 m	yes	yes		
Macadamia integrifolia	macadamia nut	100–1000 m	H, SH	S,G	S	15–18 m			3-4	

**Elevation**  
in meters (1 foot = 0.3 meters)

**Climatic Zones**  
H = Humid tropics ( >1000 mm rainfall; >20 C° mean temp.; >40 inches; >68°F)  
SH = sub-humid ( >500 mm rainfall; >20 C° mean temp.; >20 inches; >68°F)  
A = Arid/semi-arid ( <500 mm rainfall; >20 C° mean temp.; <20 inches; >68°F)  
U = Upland ( >1000 mm rainfall;

<20 C° mean temp.; >40 inches; <68°F)

C = Coastal

**Means of Propagation**  
S = Seeds  
C = Cuttings  
G = Grafting  
A = Air layering  
B = Budding  
V = suckers  
R = Root cutting

**Growth Rate**  
S = Slow growth rate, less than 0.75 meters (2 ft) per year  
M = Medium, 0.75-1.5 meters (2–5 ft) per year  
F =Fast, 1.5+ meters (5+ ft) per year

**Height at Maturity**  
in meters (1 foot = 0.3 meters)

**Potential**

**Invasiveness**  
W = Weedy or extremely invasive in some areas; often problematic  
P =Potentially weedy; naturalized in some areas, but rarely causing problems

**Salt tolerance**  
yes or no

**Drought tolerance**  
in months

## Timber Species Tolerances (continued)

Species	Common Names	Elevation (meters)	Climatic Zones	Means of Propagation	Growth Rate	Height at Maturity (meters)	Weediness/Invasiveness	Salt Tolerance	Drought Tolerance (months)	Waterlogging Tolerance
Macaranga spp.	macaranga	3–500 m	H, SH	S	F	10–15 m	W			
Mangifera indica	mango	0–1000 m	H, SH	S,B,G	S	15–45 m			4-6	yes
Melia azedarach	Chinaberry; pride of India	0–1000 m	H, SH, A	S	M	10–20 m	P		4-6	
Paraserianthes falcataria	albizia; white albizia	0–1200 m	H, SH, U	S	F	20–30 m	W		2-3	
Pinus caribaea	Caribbean pine	0–1000 m	H, SH	S	M	30–40 m	P		3-4	yes
Pipturus argenteus		0–1000 m	H, C	S	M	2–6 m		yes		
Pithecellobium dulce	Manila tamarind; sweet inga	0–1600 m	A, SH	S	M	5–22 m	W	yes	4-6	
Pometia pinnata	Oceanic lychee	0–500 m	H	S	S	25–40 m				
Premna serratifolia		0–400 m	H, SH, C	C,S	M	4–7 m		yes		
Pterocarpus indicus	narra; New Guinea rosewood	0–900 m	H, SH	S,C	M	30–40 m				
Rhizophora spp.	red mangrove	0 m	C	S	M	2–15 m	W	yes	no	yes
Santalum spp.	sandalwood	0–200 m	H, SH	S	S	2–12 m				
Senna siamea	kassod; pheasantwood	0–600 m	H, SH	S	F	15–20 m		yes	4-6	no
Swietenia macrophylla	West Indian mahogany	0–1500 m	H, SH	S	M	30–40 m				
Tectona grandis	teak	0–1000 m	H	S,C	M	30 m			no	no
Terminalia catappa	tropical almond	0–300 m	C, H, SH	S	F	15–25 m		yes	2-3	
Terminalia samoensis/littoralis	tropical almond	0–10 m	C	S	M	3–5 m		yes		
Thespesia populnea	Pacific rosewood; milo	0–600 m	C, H, SH	S	S	10–18 m	P	yes	6-8	yes
Toona ciliata var. australis	Australian red cedar	0–2000 m	H, SH, U	S	M	30–35 m	P			no
Tournefortia argentea	beach heliotrope	0–10 m	C	S	S	3–8 m		yes		

### Elevation

in meters (1 foot = 0.3 meters)

### Climatic Zones

H = Humid tropics ( >1000 mm rainfall; >20 C° mean temp.; >40 inches; >68°F)  
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 A = Arid/semi-arid ( <500 mm rainfall; >20 C° mean temp.; <20 inches; >68°F)  
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### Means of Propagation

S = Seeds  
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 A = Air layering  
 B = Budding  
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 R = Root cutting

### Growth Rate

S = Slow growth rate, less than 0.75

meters (2 ft) per year

M = Medium, 0.75-1.5 meters (2–5 ft) per year

F =Fast, 1.5+ meters (5+ ft) per year

### Height at Maturity

in meters (1 foot = 0.3 meters)

### Potential Invasiveness

W = Weedy or extremely invasive in some areas; often problematic

P =Potentially weedy; naturalized in some areas, but rarely causing problems

### Salt tolerance

yes or no

### Drought tolerance

in months

### Waterlogging tolerance

yes or no

### blank

information unavailable

# Resources and Recommended Reading

## Local Assistance

Landowners are encouraged to contact the local offices of the Natural Resources Conservation Service and/or Cooperative Extension Service for personal assistance.

**The Natural Resources Conservation Service (NRCS, formerly the Soil Conservation Service)** provides assistance with conservation practices such as windbreaks, contour plantings and erosion control. 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  
Web site: <http://www.hi.nrcs.usda.gov>

**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](mailto: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/>

## Species Information

### **Agroforestry database: a tree species reference and selection guide**

Authors: A.S. Salim, A.J. Simons, A. Waruhiu, C. Orwa, and C. Anyango, 1998  
Publisher: International Centre for Research in Agroforestry (ICRAF), Nairobi, Kenya

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 and online at:

<http://198.93.235.8/cfdocs/examples/treesd/AFT/AFT.htm>

### **Agro-Forestry in the Pacific Islands: Systems for Sustainability**

Editors: W.C. Clark, R.R. Thaman, 1993  
Publisher: United Nations University Press, Tokyo  
ISBN: 92-808-0824-9

Very thorough treatment of agroforestry practices in the Pacific. Includes tables and descriptions of many traditional agroforestry species.

### **Choosing the Right Trees--Setting Priorities for Multipurpose Tree Improvement Research Report No. 8**

Authors: S. Franzel, H. Jaenicke, and W. Janssen, 1996

Publisher: ISNAR, The Hague, The Netherlands

ISBN: 9-29118-025-4

Provides a procedure for selecting species based on maximizing potential benefits. Order from ISNAR Publication Services, P.O. Box 93375, 2509 AJ The Hague, The Netherlands; Fax: +31-70-381-9677; E-mail: [isnar@cgiar.org](mailto:isnar@cgiar.org), or download from <http://www.cgiar.org/isnar/publications/enviro.htm>

### **Common Forest Trees of Hawaii (Native and Introduced)**

Agriculture Handbook No. 679

Authors: E.L. Little, Jr. and R.G. Skolmen, 1989

Publisher: USDA Forest Service, Washington, DC

Agriculture Handbook No. 679

An illustrated reference for identifying common trees of Hawaii, including wood and other products. Order from: Hawaii Forest Industry Association, P.O. Box 10216, Hilo, HI 96721; Web site: <http://www.hawaii-forest.org>

### **Domestication of Agroforestry Trees in Southeast Asia**

Editors: J.M. Roshetko and D.O. Evans, 1999

Publisher: Winrock International, Morrilton, Arkansas

ISBN: 1-57360-019-9

Presents detailed reports concerning tree domestication in smallholder agroforestry systems and specific tree species.

### **FACT Sheets (formerly NFT Highlights)**

Authors: various, 1987–1999

Publisher: FACT Net, Winrock International, Morrilton, Arkansas

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 (see Organizations). Many available in Spanish, French, Indonesian, Chinese, Vietnamese, and Khmer.

### **Farm, Community, and Tree Network (FACT Net) research journals, conference proceedings, field manuals, and training manuals**

Authors: various

Publisher: FACT Net, Winrock International, Morrilton, Arkansas

Particularly valuable for the practical agroforester, these are some of the best species resources available at a reasonable cost. For a list of the many publications available, see <http://www.winrock.org/forestry/factnet.htm>, or order from FACT Net (see Organizations).

### **A Field Guide to the Families and Genera of Woody Plants of Northwest South America (Colombia, Peru, and Ecuador)**

Author: A.H. Gentry, 1993

Publisher: Conservation International and The University of Chicago Press, Chicago, Illinois

ISBN: 0-226-28943-5

Covers the extraordinarily diverse flora of Colombia, Ecuador, and Peru. Order from: The University of Chicago Press, 11030 S. Langley Avenue, Chicago, IL 60628, USA; Tel: 800-621-2736; Fax: 800-621-8471; Web site:

<http://www.press.uchicago.edu>

### **Forest Production for Tropical America**

Agriculture Handbook 710

Author: F.H. Wadsworth, 1997

Publisher: USDA Forest Service, Washington, DC

A very useful text on tropical forestry. Includes extensive species data for about 150 forestry species, including wood uses. Order from: International Institute for Tropical Forestry, Publications, USDA Forest Service, P.O. Box 5000, Rio Piedras, Puerto Rico 00928-5000; Web site:

<http://www.fs.fed.us/global/iitf/welcome.html>

### **International Institute of Tropical Forestry Species Notes**

Authors: various, 1989-1998

Publisher: International Institute of Tropical Forestry, USDA Forest Service, Puerto Rico, and the University of Puerto Rico.

Very informative four to eight page fact sheets covering about 100 tropical forestry species, detailing habitat, native range, life history, growth and yield, special uses, and genetics for each species. Order from: International Institute for Tropical Forestry, Publications, USDA Forest Service, P.O. Box 5000, Rio Piedras, Puerto Rico 00928-5000; Web site:

<http://www.fs.fed.us/global/iitf/welcome.html>

### **Manual of the Flowering Plants of Hawaii**

Authors: W.L. Wagner, D.R. Herbst, S.H. Sohmer, 1990

Publisher: Bishop Museum, Honolulu

ISBN: 0-8248-1152-6

A two-volume set describing the flora of Hawaii.

### **Plant Resources of South-East Asia (PROSEA) Handbooks**

**Vol. 5(1)** Major Commercial Timbers

**Vol. 5(2)** Minor Commercial Timbers

**Vol. 5(3)** Lesser-Known Timbers

Authors: various

Publisher: PROSEA Foundation, Bogor, Indonesia

A valuable series on plant resources for Southeast Asia which is useful to all tropical regions. Order from: PROSEA Network Office, c/o Research and Development Centre for Biology (RDCB-LIPI), Jalan Ir. H. Juanda 22, P.O.Box 234, Bogor 16122, Indonesia; Tel: +62-251-322859, 370934; Fax: +62-251-370934; E-mail: [prosea@indo.net.id](mailto:prosea@indo.net.id); Web site: <http://www.bib.wau.nl/prosea/home.html>

### **Plantation Forestry in the Tropics**

Author: J. Evans, 1992 (2nd edition)

Publisher: Oxford University Press, New York, NY

ISBN: 0-19-854257-7

This comprehensive text covers plantation, community, and social forestry, tree planting to control erosion, and agroforestry.

### **A Review of the Uses and Status of Trees and Forests in Land-Use Systems in Samoa, Tonga, Kiribati, and Tuvalu**

Authors: R.R. Thaman and W.A. Whistler, 1996

Publisher: South Pacific Forestry Development Programme, Suva, Fiji

Information on the status of existing agroforestry systems, with extensive species information on important agroforestry trees and their products, including timber and other wood uses.

### **Selection and Management of Nitrogen-Fixing Trees**

Author: K.G. MacDicken, 1994

Publisher: Winrock International, Morrilton, Arkansas

ISBN: 0-933595-86-7

A very useful reference for agroforestry uses of nitrogen fixing trees, including species selection, plant inoculation, growth characteristics, and potential uses.

### **A Tree for All Reasons: the introduction and evaluation of multipurpose trees for agroforestry**

Authors: P.J. Wood and J. Burley, 1991

Publisher: ICRAF, Nairobi, Kenya

ISBN: 92-9059-075-0

Available in English, French or Spanish, this book provides guidance on researching and evaluating agroforestry trees for their suitability to a specific need, site, and purpose.

### **Tree Seed Suppliers Directory: Sources of Seeds and Microsymbionts**

Authors: R. Kindt with S. Muasya, J. Jimotho and A. Waruhiu, 1997

Publisher: International Centre for Research in Agroforestry (ICRAF), Nairobi, Kenya

ISBN: 92-9059-127-7

Provides contacts for potential seed or microsymbiont suppliers for agroforestry trees.

### **Tropical Timbers of the World (USDA Forest Service Agriculture Handbook 607)**

Author: M. Chundoff, 1984

Publisher: USDA Forest Service Agriculture Handbook 607, Washington, DC

Presents brief summaries of the properties of better-known tropical woods from throughout the world.

### **Vegetation of the Tropical Pacific Islands**

Authors: D. Mueller-Dombois and F.R. Fosberg, 1998

Publisher: Springer-Verlag, New York

ISBN: 0-387-98313-9

The flora and landscapes of the islands of the Pacific, with color photographs, maps, and climate diagrams.

### **Woods of the World**

Authors: various

Publisher: Tree Talk, Burlington, Vermont

A multimedia information source about wood on CD-ROM. Order from: Tree Talk, Inc., P.O. Box 426, 431 Pine Street, Burlington, VT 05402, USA; Tel: 800-858-6230, Fax: 802-863-4344.

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# Agroforestry Guides for Pacific Islands

**Choosing Timber Species for Pacific Island Agroforestry** is the sixth 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 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.

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