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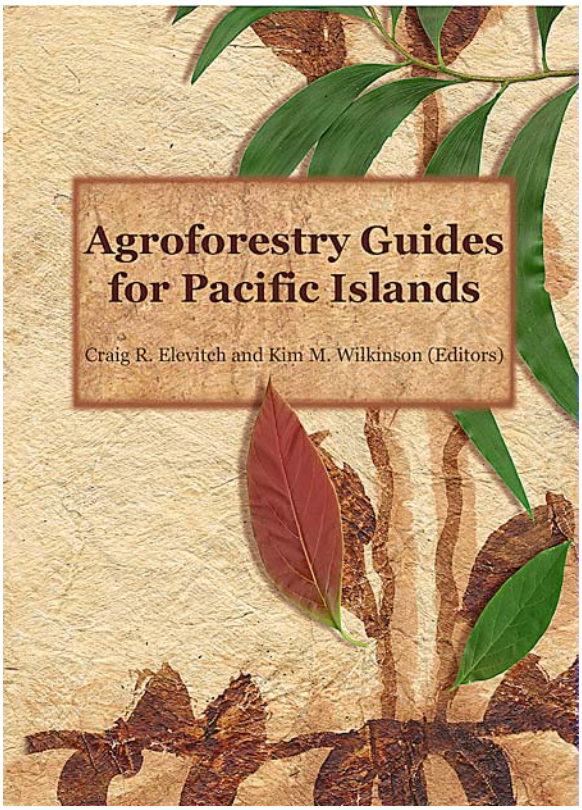

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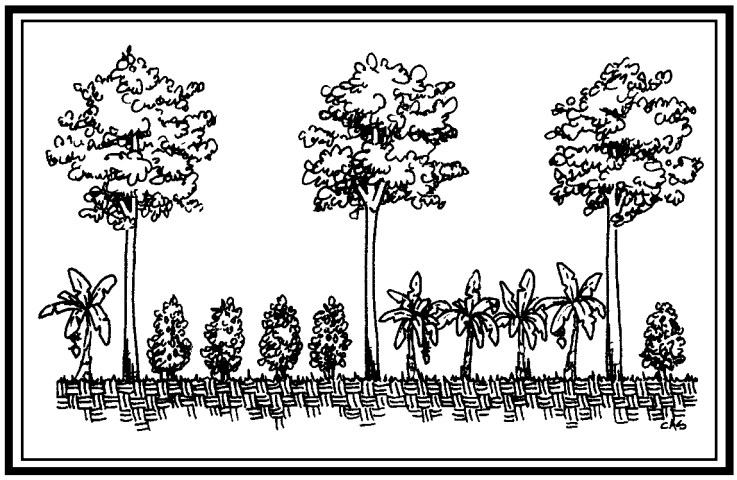
Agroforestry Guides for Pacific Islands #4

Integrating Understory Crops with Tree Crops

An Introductory Guide for Pacific Islands

by Kim M. Wilkinson and Craig R. Elevitch



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Integrating Understory Crops with Tree Crops

Abstract: Understory crops can be integrated with forestry, orchard, or other tree crop systems. Farmers use understory crops to provide earlier returns, diversify products, and/or to make more efficient use of land and labor. However, combining understory crops with tree crops requires careful planning. Planning helps to avoid problems, minimize risks, and maximize benefits in crop combinations. The needs of each crop to be planted should be fully understood, as well as the effect each species will have on the other species in the system. Issues that should be considered include species selection, spacing, scheduling, and management. This guide introduces key planning issues in integrating understory crops with tree crops. Examples of understory intercropping systems in the tropics are included, as well as a species table of over 75 trees, shrubs, and vines used as understory crops.

Keywords: understory, agroforestry, nurse trees, shade tolerance, nontimber forest products, special forest products, indigenous agriculture, farm forestry

Contents

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Introduction

Most tree crops require a long term investment of land, labor, and other farm resources. For example, fruit trees can take two to fifteen years to bear. Timber trees usually need to grow fifteen or more years before they can be harvested.

Understory crops can be integrated with forestry, orchard, or other tree crop systems. While there is usually a reduction in the number of tree crops per acre, understory crops can provide earlier returns and diversify farm yields. Understory cropping systems can also mean more efficient use of land, labor, and resources, while increasing the total productivity of a planting.

However, intercropping understory crops with tree crops is more complicated than growing tree crops alone, and practical information on this subject has been scarce. This guide provides an introduction to planning understory cropping systems. Examples of understory intercropping systems from throughout the tropics are presented. Planning issues such as spacing, scheduling, and crop selection are introduced. For practitioners researching potential understory crops, a species table of over 75 shade-tolerant trees, shrubs, and vines used as understory crops in the tropics is included.

What Are Understory Crops?

Understory crops are trees, shrubs, vines, or other plants that can thrive in the environment under the canopy of taller trees. Understory crops are grown with forest, orchard, or other tree crops. They may also be cultivated in a natural forest or conservation area.

There are many kinds of understory intercropping systems. They range from simple systems consisting of one species in the overstory and one in the understory (Fig 1b), to complex systems with many layers of trees, shrubs, and herbaceous plants stacked together (Fig 1d) (after Staver 1999).

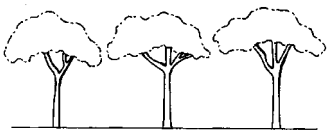


Fig 1a. Single species tree crops (e.g., forestry, orchard, etc.)

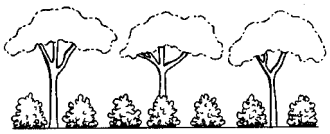


Fig 1b. Tree crops with single understory crop

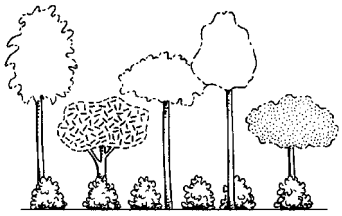


Fig 1c. Multiple tree crops with understory crop

Fig 1d. Multi-species, multi-storied system

Why Do Farmers Plant Understory Crops?

Some farmers prefer not to devote their resources entirely to a single, long-term tree crop such as an orchard or timber stand. Instead, they diversify their planting, utilizing the area between the tree crops to cultivate understory crops.

Normally the addition of understory crops means a reduction in timber or fruit trees per acre, resulting in lowered yields from the tree crops as compared to single-species plantings. However, the earlier and diversified yields from understory crops can result in a higher net yield over time. Understory intercropping can also improve efficiency in land, labor, and other farm resources. In monocultural (single-species) tree crop systems (Fig 1a), the area between the trees must be maintained by weeding, mowing, or other means. With understory intercropping, the costs of weed control and maintenance for the overstory trees are shared with productive crops.

Some benefits of understory cropping systems may include:

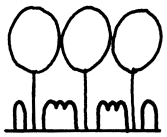
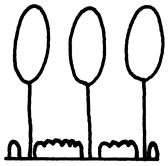
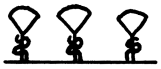
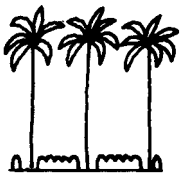
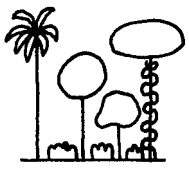
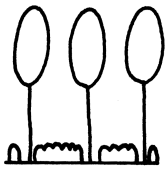
- greater efficiency in land use (more environmental niches are exploited);
- increased efficiency in labor (because tree and crop maintenance can overlap);
- diversified products;
- increased total yields over time; and
- reduced risk of losing entire investment to a pest or disease problem that affects only one species.

Example Understory Crops

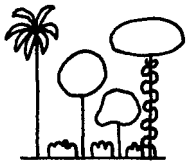
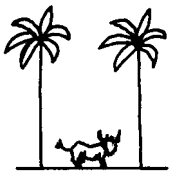
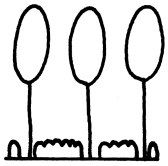
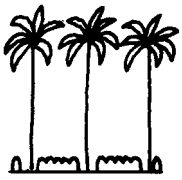
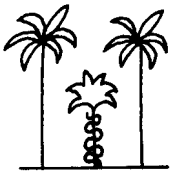
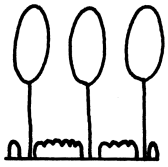
There are many valuable cash and subsistence crops that thrive in the shady climate under trees. A few examples of shade tolerant understory crops follow. Some are highly shade-loving, some tolerate light shade only. (See Species Chart on Page 12 for more understory crops.)

Product Category	Example Understory Species
Essential oils	lemon grass, vetiver, patchouli
Spices	pepper vine, cinnamon, ginger, vanilla, cardamom, wild turmeric
Fruits	pineapple, annona species, guava
Root crops and vegetables	taro, arrowroot, yams, long bean, velvet bean
Herbs	oregano, basil, chili pepper
Building/fiber materials	rattan, fan palms
Mushrooms	many culinary and medicinal mushrooms
Other	coffee, tea, cacao, betel vine, kava

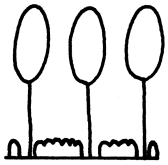
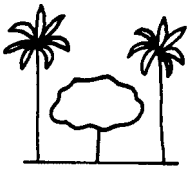
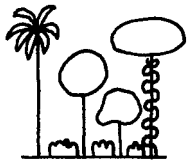
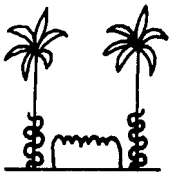
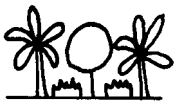
Understory cropping systems examples from the tropics

Overstory Species	Understory Species	Description	Configuration	Location & Reference
Macadamia nut (*Macadamia integrifolia*)	Coffee (*Coffea* species)	Macadamia nut trees with coffee understory		Hawaii
Laurel (*Cordia alliodora*)	Sweet potatoes (*Ipomea batatas*), cassava (*Manihot esculenta*), yam (*Discorea* species), kava (*Piper methysticum*), and cardamom (*Elettaria cardamomum*)	Cash crops such as sweet potatoes, cassava, yam, kava, coffee, and cardamom grown between line plantings laurel, of a commercial hardwood		Vanuatu (Clarke and Thaman 1993)
Sesban (*Sesbania sesban*)	Passion fruit (*Passiflora* species)	A nitrogen fixing tree (for firewood, mulch, or animal fodder) supporting and shading passion fruit vines		Africa
Coconut (*Cocos nucifera*)	Kava (*Piper methysticum*) and taro (*Colocasia esculenta*)	Coconut trees with kava (awa, yanqona) and sometimes taro underneath		Fiji (Clarke and Thaman 1993)
Native forest	Garland/lei plants (e.g., maile (*Aylxia* sp.) or medicinal plants	Native forest areas cultivated underneath for traditional medicinal or culturally valuable plants (in Hawaii, these can include maile for leis, kava, and a variety of herbaceous medicinals)		Hawaii
Teak (*Tectona grandis*)	Patchouli (essential oil crop) (*Pogostemon* sp.)	Teak plantations with patchouli (an essential oil crop) underneath		Indonesia

Understory cropping systems examples from the tropics (Continued)

Erythrina, *Inga*, or *Senna* species	Coffee (*Coffea* spp.)	Nitrogen-fixing or organic-matter producing trees with coffee		Uganda (Wadsworth 1997)
Wet lower montane forest	Anthurium flowers (*Anthurium* species)	Native/primary forest with cut flower/foliage as understory crop		Dominica (Wadsworth 1997)
Coconut (*Cocos nucifera*)	Pasture	Coconut with pasture and livestock underneath		Polynesia (Dalla Rosa 1993)
Rubber (*Hevea brasiliensis*)	Coffee (*Coffea* spp.), cocoa (*Theobroma cacao*), bananas (*Musa* spp.), tea (*Camellia* spp.), oil palms	Rubber trees in combination with food crops		Malaysia (Wadsworth 1997)
Leucaena (*Leucaena leucocephala*), coconuts (*Cocos nucifera*), and bananas (*Musa* species)	Cocoa	Bananas provide initial shade, intercropped with cocoa, leucaena, and coconuts; bananas phased out and cocoa continues to be shaded by coconuts and leucaena		Papua New Guinea (Clarke and Thaman 1993)
Coconuts (*Cocos nucifera*) and physic nut (*Jatropha curcas*)	Vanilla (*Vanilla fragrans*)	Coconuts for shade, physic nut as the support for vanilla vines		Tonga (Clarke and Thaman 1993)
Kamarare (*Eucalyptus deglupta*)	Cocoa (*Theobroma cacao*) and coffee (*Coffea* species)	Wide-spaced eucalyptus for timber with cocoa and coffee underneath		Papua New Guinea (Clarke and Thaman 1993)

Understory cropping systems examples from the tropics (Continued)

Laurel (*Cordia alliodora*), ear pod (*Enterolobium cyclocarpum*) or monkeypod (*Albizia saman*)	Coffee (*Coffea* species)	Timber trees with coffee		Costa Rica (Wadsworth 1997)
Coconut (*Cocos nucifera*)	Cashew (*Anacardium occidentale*)	Cashew under coconut		Kenya (Nair 1993)
Coconut (*Cocos nucifera*), *Parkia speciosa*, *Aglaia domestica*, and *Areca catechu*	*Annona* species, guava (*Psidium* spp.), mango (*Mangifera* spp.), papaya (*Carica* sp.), and banana (*Musa* spp.)	A multi-storied home-garden with fruit trees under palms and large trees		Java (Nair 1993)
Peach palm (*Bactris gasipaes*)	Black pepper vine (*Piper nigrum*) and cocoa (*Theobroma cacao*)	Peach palm over cocoa and supporting black pepper vines		Brazil (Nair 1993)
Banana (*Musa* species)	Citrus (*Citrus* species) and pineapple (*Annanas comosus*)	Banana over citrus and pineapple		Nepal (Hart 1991)
Erythrina (*Erythrina* species)	Cocoa (*Theobroma cacao*)	Nitrogen-fixing tree with cocoa		Costa Rica (Wadsworth 1997)
Silky oak (*Grevillea robusta*)	Coffee (*Coffea* species)	Silky oak as windbreak and frost protection for coffee understory		NE Brazil (Primavesi, 2000)

Planning Considerations

Combining understory and tree crops requires careful planning. The needs of the species to be planted should be well understood, as well as the effect each species will have on the other species in the system. Careful planning helps to avoid problems, minimize risks, and maximize returns from crop combinations. Key issues in planning understory cropping systems are introduced below.

The Understory Environment

The understory is a unique environment, involving more than just shade. The shade influences air temperature, humidity, soil temperature, soil moisture content, wind movement, and more. These factors impact plants.

The shadier environment in the understory can have the following effects (Nair 1993):

- Reduces evapotranspiration (evaporation of water through the leaves and branches of the plant), conserving moisture.
- Buffers crops from temperature extremes and fluctuations.
- Protects crops from winds.
- Suppresses many invasive problem weeds, which tend to prefer open conditions and full sun.
- Supports a range of beneficial soil microlife that do not thrive in the open.
- Provide more habitat niches for wildlife.

Overstory (Canopy) Species Selection

The upper strata of a multi-layered planting is called the overstory, or canopy. The trees that make up this layer play the key role in creating the understory environment. When planning an understory intercropping system, the overstory is a crucial element. The most influential factors are canopy shape/tree form, canopy foliage type, and tree spacing.

Canopy shape/Tree form

The shape and form of the overstory trees is an important consideration in planning an intercropped system. Some trees have very wide, spreading canopies. In contrast, some trees have a very narrow, columnar form. There are a range of canopies shapes (see figure below). The form and canopy shape of the overstory trees should be used to help determine appropriate spacing for the trees and understory crops. In some cases, the form of the trees can be altered by pruning.

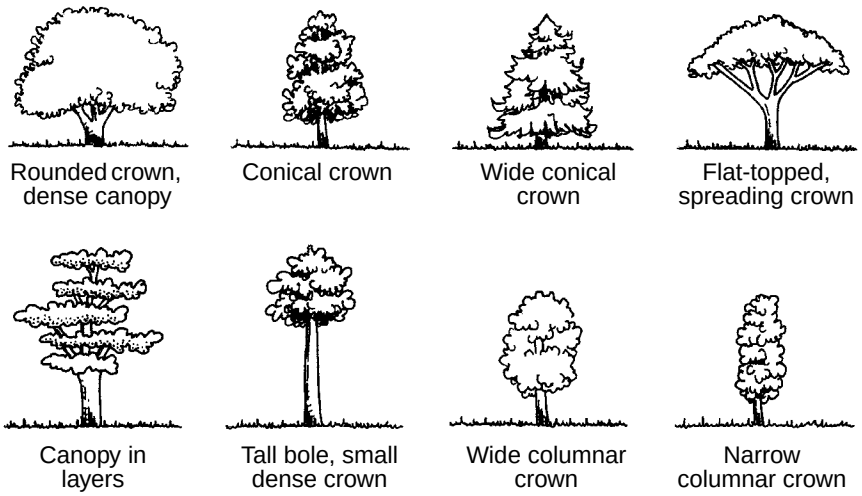


Fig 2. Examples of tree canopy shapes—different tree forms create different shade conditions (after Mbuya et al 1994).

Canopy foliage

Some types of tree foliage create dappled sunlight or light shade (e.g. coconut, sesbania, shower tree); others create a thick canopy with dense, heavy shade beneath (e.g. eucalyptus). Although understory crops can tolerate some degree of shade, some light must be available in order for the crops to be productive. The type of foliage should be considered along with canopy shape/tree form, to determine the spacing needed to create an optimal understory environment for the crop.

Spacing

The spacing of the overstory trees is important in creating the understory environment. If the standard, close spacing of single-species monocultures of forestry or orchard trees is used, usually the understory crops are phased out after few years due to competition. Compared to single-species plantings for timber or fruit trees, understory cropping systems normally involve a reduced number of trees per acre. The number of trees per acre is usually 25-75% less then when timber or fruit trees are planted alone. This wider spacing may be in a uniform pattern, or in a more random pattern of dispersed trees (see Fig 3).

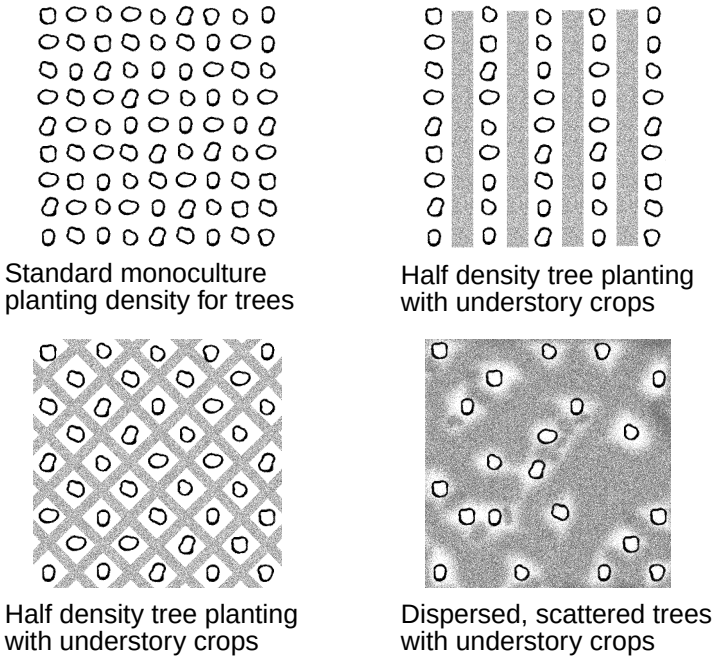


Fig 3. Various densities of tree plantings with understory crops.

For timber plantings, a disadvantage of fewer trees per acre is fewer opportunities for selecting high quality trees and removing poorly formed or less vigorous individuals. For this reason, it is often preferable to initially plant on a more dense spacing, and add understory crops later, after the stand has been selectively thinned to a more open spacing.

In all cases, spacing should be planned to provide the most favorable environment for the understory crops, and to minimize competition for water, light, and nutrients. The species growth rate, form, rooting patterns, and other factors should be taken into account when planning.

Competition Issues

Understanding the rooting habits, potential allelopathic effects, and growth rates of the overstory species is part of good planning, to ensure that the trees chosen will create a suitable environment for the understory crops. Some tree species may be too fast-growing or have allelopathic (suppressant) effects on crops, making them inappropriate for this kind of system. For example, ironwood (*Casuarina* species) have been reported to have allelopathic effects on crops including sorghum, sunflower, and cowpea (Nair 1993). Other trees, such as *Eucalyptus globulus*, have very competitive surface-feeding root systems that make them unsuitable for intercropping (Macmillan 1991). Likewise, understory crops chosen should not be overly competitive with the overstory tree crops.

Environmental Transition of Understory

As the overstory species mature, the understory environment will become shadier, cooler, and more humid. One of the important considerations in planning for an integrated understory cropping system is the rate at which the understory environment changes. The challenge is to predict when the optimum environmental conditions will occur and how long they will last (Arakaki 2000).

The duration of favorable environmental conditions influences expectations of optimum output from understory crops. The rate of change should be taken into account for selection and spacing of overstory and understory crops. Determining the time frame for optimum environmental conditions also affects the understory planting schedule. For example, if understory crops thrive in shade but cannot tolerate full sun, then they should not be planted until the overstory trees have grown enough to provide sufficient shade.

As overstory trees continue to mature, the understory conditions can be maintained by pruning or thinning the overstory trees. Determining the net benefits of maintaining a set environmental condition by pruning or thinning will help in decision making (Arakaki 2000).

Sequential Cropping

Because the understory environment changes over time, some farmers may choose to cultivate a series of different understory crop species over time. This practice is sometimes called sequential cropping, when short-term crops are eventually replaced by longer-term crops. Sequential cropping of understory crops optimizes the productivity of the understory as the environmental conditions change.

A classic example of sequential planting comes from farmers in Cavite, Philippines, who have devised ways to profit off the land while their permanent tree crops become established. There are many local variations, but the basic model results in a rice paddy being converted permanently into coffee, fruit trees, and other perennials (Arizala and Gonsalves 1990):

Sequential Planting in a Multistoried System	
Year One	Rice is planted. Pineapple and papaya are interplanted with the rice. Rice is harvested, phased out.
Year Two	Papayas are harvested. Coffee and fruit trees are planted.
Year Three	Pineapples and papayas are harvested.
Year Four	Pineapples and papayas are harvested, phased out. Coffee and fruit trees begin to bear.

Some of the variations of this model increase short and long term profits even more, by incorporating bananas, corn, and other crops (Arizala and Gonsalves 1990). Sequential cropping of understory crops is intended to maximize the benefits of the understory environment as it changes over time.

Understory Crop Selection

Whether the understory crops are integrated for continuous yields or in a sequential cropping system, species selection is important. When selecting species, growth and rooting habits should be understood so plants are compatible and not overly competitive. Understory crops should be integrated in a way that maximizes available light, space, and nutrients.

In relation to the overstory trees, understory crops should (after Wadsworth 1997):

- tolerate partial shade;
- exploit, at least partially, different soil horizons than the overstory trees;
- be shorter than the overstory trees when mature (although some trees may be integrated to use the shade as seedlings, but eventually overtake and become part of the canopy);
- be less susceptible than the overstory trees to diseases they may have in common; and
- not involve damage to the overstory trees during cultivation or harvest of understory crops.

Diversity and Number of Strata

The number and variety of species that can be grown together successfully is an important planning consideration. Climate may be the most crucial factor in determining the appropriate amount of diversity, and the spacing between the species. In traditional systems, it has been observed that complex, multistoried species assemblies are generally found in more humid climates, while drier areas tend to have less diverse systems consisting of only two stories (one tree species plus one shrub layer) (Nair 1993). This may be due to increased competition for water that takes place in drier climates.

Other factors also determine how many kinds of crops will be grown together. Mechanization, the ability to market or use diverse products, the amount of landowner involvement, and many other considerations play a part in determining what is appropriate in a particular the situation. There is a shortage of information about crop combinations, and generally the more complex the system, the less information is available.

Microclimates/Edge Effects

In any tree crop or forest system, there are variations in the understory conditions. Edges, for example the borders of the project or near roads or clearings, will have more light penetration. If desired, the edge effect can be remedied somewhat by planting trees more densely on the edges to increase the shade in that area.

Alternately, growers may plan to make optimal use of the variety of environments and light conditions found in the understory. Different kinds of crops can be cultivated in these different microclimates. For example, on the edges of the planting, near paths, roads, or clearings, light-demanding crops can be planted. More shade-loving crops can be grown in areas with deeper shade.

Although understory crops can tolerate shade, some light must penetrate the canopy to ensure their productivity. The amount of light necessary depends on the crop. For example, crops such as pineapple or chili pepper tolerate only light shade, while crops like the essential oil plant patchouli can thrive in heavy shade.

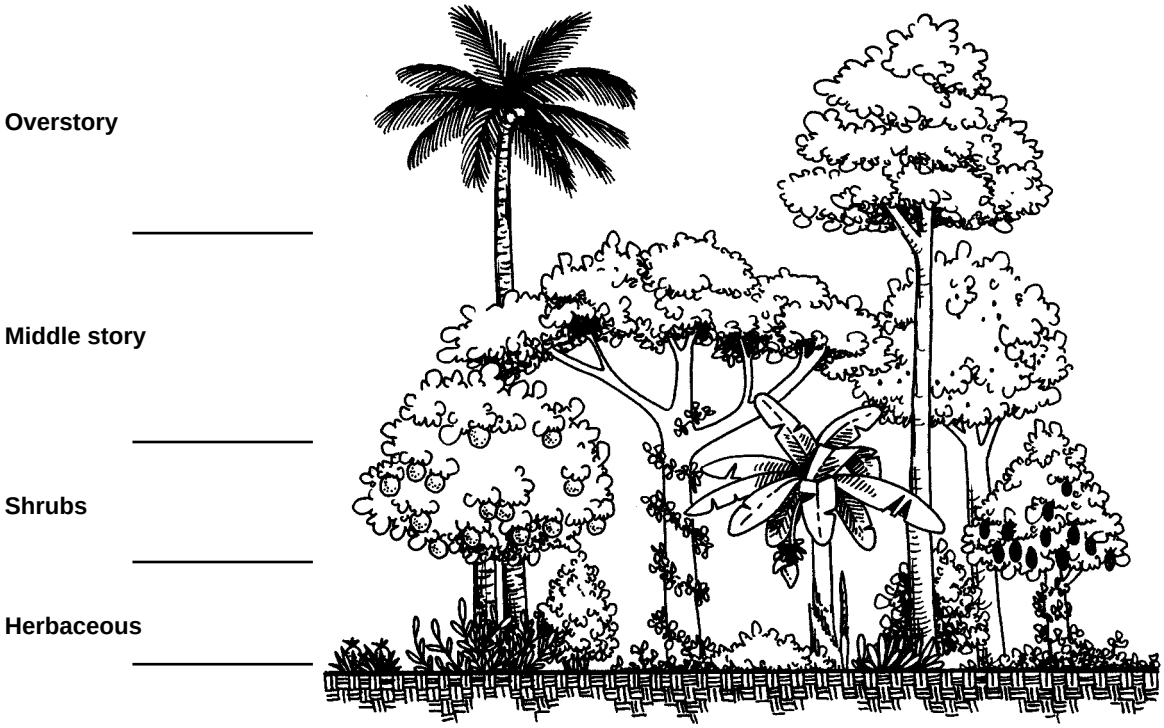


Fig 4. Stacked forest showing vegetation layers

Special Management Issues

In certain situations, special management issues may need to be addressed. These should be incorporated in the planning phase. For example, when understory crops are cultivated under native forest or conservation areas, it may be important to provide for regeneration of the trees in the overstory as well.

The greater diversity of mixed cropping systems have in many cases been shown to provide greater diversity of habitats for animals. This can be beneficial for conservation and wildlife purposes, and some growers may choose to enhance the habitat value of their planting to encourage wildlife. In some cases, however, the presence of certain kinds of wildlife may also pose a problem, if the system attracts wildlife that damage the crops. Growers will want to consider this issue as they plan their project.

As another special management issue, some farmers have developed understory intercropping innovations, such as systems that involve coppicing or cutting back the overstory trees periodically. For example, nitrogen-fixing trees over coffee provide shade during certain phases, but are pruned back to allow more sunlight to encourage flowering and fruiting. The prunings are then applied as a nutrient-rich mulch to fertilize the coffee trees.

A Note on Varieties for Understory Crops

Much of modern agricultural research has focused on growing crops in fully exposed, monocultural (single-species) systems. In fact, many new varieties of crops have been especially selected for high light intensity tolerance and high productivity. For example, coffee trees evolved a shady understory environment. Traditional varieties of coffee are grown under the shade of other trees, usually nitrogen-fixing trees that also add nitrogen, control erosion, recycle nutrients, and provide habitat for wildlife. Coffee has been grown as an understory crop for centuries (Wadsworth 1997).

However, recent agricultural science focused on maximizing coffee production has developed coffee varieties that require full sun. Growers exploring potential understory crops may benefit from researching traditional varieties of crops, which may be better adapted to the understory environment than recent crop selections.

Understanding Limitations

As with any farm practice, growers should also understand the potential limitations of understory intercropping. These include:

- Shortage of scientific study and information about tree/understory crop interactions.
- Lack of economic data about the trade-offs of mixed cropping systems.
- Risk of unforeseen competition or allelopathic effects.
- Greater complexity in management of multiple species and multiple products.
- Potential damage to overstory from harvest of the understory, or vice-versa.
- Increased challenges of marketing diversified products.

With adequate research and good planning, many of these limitations can be overcome to effectively integrate understory crops with tree crops.

Tables of Example Understory Crops

Vines

Botanical Name	Common name(s)	Principal product
Alyxia olivaeformis	maile	floral (garlands)
Calamus merillii	rattan	fiber
Cucurbita maxima	pumpkin	vegetable
Discorea species	yam	root crop
Ipomea batatas	sweet potato	root crop, leaf vegetable
Momordica charantia	bitter melon	vegetable/condiment
Passiflora edulis	passionfruit	fruit
Piper betel	betel vine	medicinal
Piper nigrum	black pepper	herb/spice
Psophocarpus tetragonolobus	wing bean	vegetable
Sechium edule	choko; chayote	vegetable
Vanilla fragrans	vanilla	herb/spice
Vigna sesquidepedalis	yardlong bean	vegetable

Woody Shrubs and Trees

Botanical Name	Common name(s)	Principal product
Anacardium occidentale	cashew	nut
Annona cherimola	cherimoya	fruit
Annona muricata	soursop	fruit
Annona reticulata	bullock's heart	fruit
Annona squamosa	cherimoya; sugarapple	fruit
Areca catechu	Betel nut palm	medicinal
Artocarpus altilis	breadfruit	fruit
Artocarpus mariannensis	Marianas breadfruit	fruit
Averrhoa bilimbi	bilimbi	fruit
Averrhoa carambola	carambola, starfruit	fruit
Barringtonia edulis	cut nut, katnut	nut
Calliandra calothyrsus	calliandra	organic matter
Cananga odorata	ylang-ylang; perfume tree	essential oil
Coffea sp.	coffee	beverage
Durio zibethinus	durian	fruit

Woody Shrubs and Trees

Eucalyptus microcorys	tallowwood	timber
Eugenia sp.	“apples” (mountain apple, etc.)	fruit
Euodia hortensis	island musk	floral
Garcinia mangostana	mangosteen	fruit
Hibiscus cannabinus	kenaf	fiber/cordage
Hibiscus rosa-sinensis	ornamental hibiscus	floral
Hibiscus sabdariffa	roselle	medicinal
Moringa oleifera	horseradish tree; drumstick tree	vegetable
Pandanus sp.	Pandanus, screw pine	fruit/fiber
Pipturus albidus	mamake	medicinal
Pithecellobium dulce	Manila tamarind; sweet inga	timber, fruit
Polyscias sp.	panax; hedge panax	floral/cut greens
Psidium guajava	guava	fruit
Salacca edulis	Salak palm	fruit
Spondias dulcis	Polynesian vi-apple	Fruit/medicinal
Theobroma cacao	cacao	seeds (cocoa/ chocolate)

Herbaceous Plants and Nonwoody Shrubs

Botanical Name	Common name(s)	Principal product
Abelmoschus esculentus	okra	vegetable
Abelmoschus manihot	bush spinach; hibiscus spinach	vegetable
Acalypha wilkesiana	shiso; beefsteak plant	vegetable
Alocasia macrorrhiza	giant taro	root crop
Amaranthus sp.	amaranth spinach	vegetable
Amomum cardamomum	Indonesian cardamom	herb/spice
Amorphophallus campanulatus	elephant-foot yam	vegetable
Ananas comosus	pineapple	fruit
Bidens pilosa	Spanish needle	medicinal

Herbaceous Plants and Nonwoody Shrubs

Bixa orellana	annatto	colorant, medicinal
Camellia sinensis	tea	beverage
Canna edulis	edible canna	root crop
Capsicum sp.	chili pepper	herb/spice
Carica papaya	papaya; paw-paw	fruit, vegetable
Cibotium spp.	Hawaiian tree fern	ornamental
Codiaeum variegatum	croton	floral/cut greens
Coleum amboinicus	oregano	herb/spice
Coleus sp.	coleus	ornamental
Colocasia esculenta	taro	root crop
Cordyline fruticosa	ti	floral/cut greens
Curcuma domestica	tumeric	herb/spice
Cyrtosperma chamissonis	giant swamp taro	root crop
Elettaria cardamomum	cardamom	herb/spice
Fungi	various edible mushrooms	edible/medicinal
Heliconia indica	heliconia	floral/cut greens
Ipomea aquatica	water convovulis	vegetable
Manihot esculenta	cassava	root crop
Maranata arundinacea	arrowroot	root crop
Musa sp.	banana	fruit
Nephrolepis acutifolia	Sword fern	ornamental
Nicotiana tobaccum	tobacco	leaves (smoking tobacco)
Ocimum basilicum	basil	herb/spice
Otatea acuminata aztecorum	Mexican weeping bamboo	ornamental
Physalis peruviana	poha berry	fruit
Piper methysticum	kava, ava	medicinal
Pogostemon cablin	patchouli	essential oil
Sauropus androgynus	katuk	vegetable
Scaevola serica	scaevola; saltbrush; naupaka	medicinal
Solanum quitoense	naranjilla	fruit
Tacca leontopetaloides	arrowroot	root crop
Zingiber aromaticum	wild ginger	medicinal

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 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 office 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
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/

Books on Agroforestry Species

Abbott, I.A. 1992. La`au Hawai`i: Traditional Hawaiian Uses of Plants. Bishop Museum Press, Honolulu, Hawaii

ADAP Project. 1994. Pacific Islands Farm Manual, ADAP Project, Tropical Energy House, University of Hawaii, Honolulu, Hawaii 96822

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Smith, A.C. 1979-1991. Flora Vitiensis Nova: A New Flora of Fiji (Spermatophytes Only): Vol 1-5. Pacific Tropical Botanical Garden, Lawai, Kauai, Hawaii.

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Verheij, E.W.M., and R.E. Coronel, Eds. 1992. Plant Resources of Southeast Asia No. 2: Edible Fruits and Nuts. PROSEA, Bogor, Indonesia.

Whistler, W. A. 1991. The Ethnobotany of Tonga: The Plants, Their Tongan Names, and Their Uses. Bishop Museum Press, Honolulu, Hawaii.

Books on Agroforestry, Systems Design, and Tree Selection

International Institute of Rural Reconstruction. 1990. Agroforestry Technology Information Kit, IIRR, Room 1270, 475 Riverside Dr., New York, New York 10115.

Landauer, K., and M. Brazil, Eds. 1990. Tropical Home Gardens. United Nations University Press, Tokyo.

Mollison, B. 1990. Permaculture: A Practical Guide for a Sustainable Future, Island Press, Washington, DC.

Mollison, B., and R. M. Slay. 1991. Introduction to Permaculture, Tagari Publications, Tyalgum, Australia.

Nair, P.K.R. 1993. An Introduction to Agroforestry. Kluwer Academic Publishers, Dordrecht, The Netherlands.

Organizations

Appropriate Technology Transfer for Rural Areas (ATTRA) provides technical assistance to farmers, extension agents, market gardeners, agricultural researchers, and other ag professionals in the US with primarily a temperate orientation. Address: ATTRA, P.O. Box 3657, Fayetteville, Arkansas 72702; Tel: 800-346-9140; Web site: http://www.attra.org/attra-pub/index.html

Danida Forest Seed Centre (DFSC) provides information resources, training, and consultancies on seed procurement, tree improvement, and gene resource conservation. Address: DFSC, Krogerupvej 21, 3050 Humlebaek, Denmark; Tel: +45-49 19 05 00; Fax: +45-49 16 02 58; E-mails:dfscdk@post4.tele.dk, dfsc@sns.dk; Web site: http://www.dfsc.dk

Educational Concerns for Hunger Organization (ECHO) has many online publications related to agroforestry, including an extensive offering of hard-to-find publications in its online bookstore. Address: ECHO, 17430 Durrance Rd., N. Ft. Myers, Florida 33917; Tel: 941-543-3246; Fax: 941-543-5317; E-mail: echo@echonet.org; Web site: http://www.echonet.org/

Farm, Community, and Tree Network (FACT Net) is dedicated to stimulating the use of multipurpose trees. FACT Net offers many publications at a reasonable cost, including comprehensive fact sheets on many important agroforestry tree species. Address: 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; Web site: http://www.winrock.org/forestry/factnet.htm

Forest, Trees and People Programme (FTPP) supports rural populations participating in developing forest resources. Address: FTPP Network, SLU Kontakt, Swedish University of Agricultural Sciences (SLU), Box 7034, 750 07 Uppsala, Sweden; Tel. +46 18 672001; Fax: +46 18 671980; E-mail: FTPP.Network@kontakt.slu.se; Web site: http://www-trees.slu.se/

International Center for Research in Agroforestry (ICRAF) has extensive worldwide programs in agroforestry research and training. Address: 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; Web site: http://www.cgiar.org/icraf/

The National Agroforestry Center (NAC) of the US Department of Agriculture supports practices which integrate trees and agriculture and publishes many practical agroforestry materials including Inside Agroforestry, a newsletter for natural resource professionals with a temperate focus. Address: 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/

Non-Wood Forest Products by the Food and Agriculture Organization of the United Nations (FAO) Forest Products Division has extensive information including organizational database and a broad range of publications in electronic form in English, French and Spanish: http://www.fao.org/forestry/FOP/FOPW/NWFP/nwfp-e.stm

Periodicals

Agroforestry Today carries practitioner-oriented reports from around the world on trees and crops on farms, and on the people who plant them. Published by International Centre for Research in Agroforestry (ICRAF). Address: Agroforestry Today, P.O. Box 30677, Nairobi, Kenya; Fax: +254-2-521001; E-mail: aftoday@cgiar.org

APANews, the newsletter of the Asia-Pacific Agroforestry Network (APAN), is dedicated to the exchange of information on agroforestry research, development, and training in the Asia-Pacific region. Address: APANews, FAO Regional Office for Asia and the Pacific, 39 Phra Atit Road, Bangkok 10200, Thailand; Fax: +66-2-280-0445; E-mail: fao-rap@fao.org

ILEIA Newsletter covers technical and social options for ecological and sustainable agriculture, and has frequent articles on tree-based systems. Address: LEISA, P.O. Box 64, 3830 AB Leusden, The Netherlands; Tel: +31-33-494 30 86; Fax: +31-33-495 17 79; E-mail: iliea@iliea.nl

The Overstory is a free e-mail journal covering concepts central to agroforestry practices in the tropics including up-to-date references and web links. Address: The Overstory, P.O. Box 428, Holualoa, HI 96725, USA; Tel: 808-324-4427; Fax: 808-324-4129; E-mail: overstory@agroforester.com; Web site: http://www.overstory.com

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Agroforestry Guides for Pacific Islands

Integrating Understory Crops with Tree Crops: An Introductory Guide for Pacific Islands is the fourth 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/afg