An Indigenous Pacific Island Agroforestry System: Pohnpei Island[1]

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Abstract: The indigenous agroforestry system on Pohnpei was studied using circular plots laid out in transect across 57 randomly-selected farms. Data were collected on species and cultivar presence, size, density, frequency, as well as soil type, slope, aspect, and other related information. Through farmer interviews, farm family demographic data was also recorded. Seasonality of major crops was observed. Analysis shows indigenous agroforestry on Pohnpei to be a complex, but extremely well ecologically and culturally adapted, production system.

Indigenous agroforestry is a dominant feature of both the landscape and culture on Pohnpei, the result of more than 2,500 years of development and refinement (Haan 1984). During this time, numerous crop and technology introductions have been made through continued waves of migration, and more recently, through direct and indirect efforts of colonial administrations (Barrau 1961). Currently, agroforestry both employs and provides sustenance to a large majority of the Pohnpei population.

The island of Pohnpei is located at 6°54' N latitude and 158°14'E longitude in the Caroline Islands group, about 4983 km southwest of the Hawaiian islands (fig. 1). It is the highest (772 m) and second largest (355 km^2) in the group and one of the few high islands. The island is of volcanic origin and is about five million years old (Keating and others 1984). Rainfall is high and temporally well-distributed, with an average of 4820 mm and 300 rainy days per year (NOAA 1987). At higher interior elevations, rainfall is estimated to reach 7,500 mm (Laird 1982, van der Brug 1984). Temperatures average 27°C year-round and humidity is high (NOAA 1987). The island is surrounded by a barrier reef and lagoon, with extensive mangrove forest development around most of the shoreline. Pohnpei Island is typically volcanic, with a majority of the land area characterized as steep and mountainous.

Vegetation is mainly upland forest (55.5 percent), mostly in the interior. Coastal areas and lower slopes are characterized by agroforest (33.4 percent) and secondary vegetation (5.2 percent). Agroforestry has been expanding rapidly in the last two decades, replacing primary forest and secondary vegetation (MacLean and others 1986).

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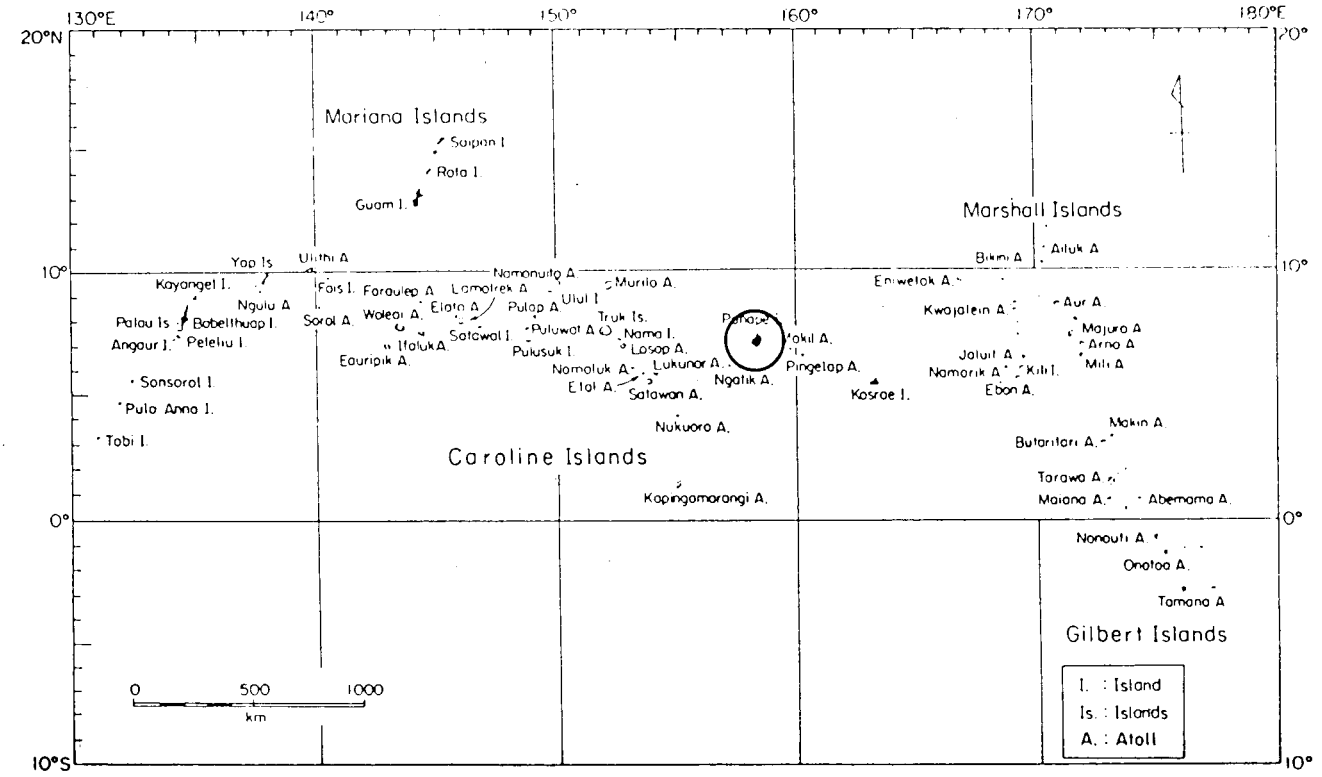


Figure 1-Location of Pohnpei in the Caroline Islands, Micronesia

Soils in areas under agroforestry are characterized by Typic Acrorthoxes in the lowlands and Typic Dystropepts on mountain slopes, with a few small areas of Typic Humitropepts (Laird 1982). Soils in the upland mountainous areas are generally deep, well drained, and commonly very stony. Use of these areas is limited by steep slopes and stoniness. Nearly level or gently sloping soils are generally moderately deep and moderately well-drained. Low fertility and wetness are limitations. Bottom land soils are generally poorly drained and are limited by wetness (Laird 1982).

Methods

Selection of Survey Sites

The area of this study was the entire agroforestry area on the island of Pohnpei. MacLean and others (1986), using aerial photos and ground surveys, estimated indigenous agroforestry to cover about 33.4 percent of the total land area of Pohnpei, or 11,865 ha as of 1984. It was desired to sample about 1 percent of the agroforest, so based on the reported area of agroforestry and assuming 2.5 ha as the average land parcel size, it was determined that about 50 farms would be surveyed. A map of Pohnpei was overlaid with a grid of intersecting lines corresponding to every 0.5 km, then 100 random pairs of numbers were generated, corresponding to x,y coordinates of farm survey points. Points that fell in the lagoon, mangrove, or uninhabited jungle areas of the island were discarded and farms on or nearest the remaining 57 survey points were identified (see map, fig. 2).

Field Survey Methods

In designing field methods, it was necessary to take into account that persons other than family members are not generally allowed to enter onto someone's land on Pohnpei. To alleviate this, all farmers were visited several weeks before the actual survey took place. The local extension agent explained the purpose of the study, people to be involved, and what would be done. If the farmer was agreeable, a date for the survey was set. Surveyors were limited to two people, the senior author and the extension agent, and survey methods were designed so that the farmer could accompany us on the survey.

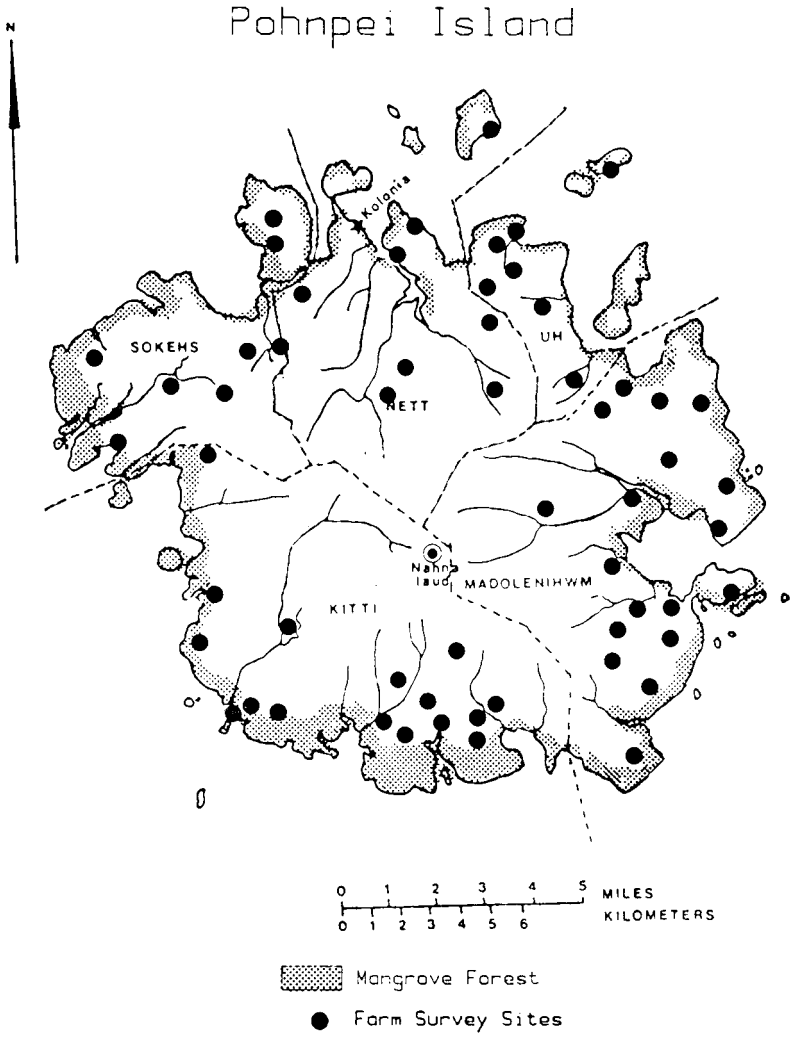


Figure 2-Map of Pohnpei Island showing farm survey sites

Upon arriving at a farm, the head of household, usually with his/her family, was interviewed using the prepared interview protocol (see Appendix). Then a rough land map, showing property boundaries, buildings, and vegetation types, was sketched. The survey route was then determined with the farmer before starting. A systematic plot lay-out was used, working along a compass line from corner to corner of the survey farm, passing through or near the center, with plots taken at 40 meter centers along the line. If the distance across the farm was too short to make 10 plots, a second compass line branching at a right angle from the first line near the farm center was set and the remaining plots laid out on 40 meter centers along this line.

Circular plots of 8 meter radius (201 m^2) were used for ease of layout. Slope and aspect were recorded with a clinometer and compass, respectively, and then weeds (grasses, ferns, and recognized weed species) were recorded by visual estimate of percent cover. All other species were recorded by local name, cultivar (if any), number and heights. On breadfruit trees, d.b.h. was measured. For bananas, taro, and sakau *(Piper methysticum),* number of stems were counted, and for yams, number of vines were recorded. This was repeated for each plot (see farm survey form in Appendix.)

Species Identification

Through farmer interviews, observation, and literature review, important data on each crop species were collected, including genus and species (Glassman 1952, Falanruw and others, in press), Pohnpei name (Rehg and Lawrence 1979, Falanruw and others, in press), life cycle (annual or perennial), seasonality, products, period of introduction (Glassman 1952, Bascom 1965), vegetation type group (Glassman 1952, MacLean and others 1986, Falanruw and others 1987), and other data, such as number of cultivars. Frequencies (percent of farms on which species occurred) and overall individuals per hectare were calculated for each species.

Horizontal Patterns

It was observed in the field that distance from the house affected agroforest management intensity, sex roles (women's vs. men's crops), crop security, and other important factors. Distance from the house was recorded for each plot, and then plots were grouped by agroforestry "zones." These "zones" were only roughly defined since topography and soils also influenced horizontal vegetation patterns. Zones were characterized as follows: Zone 1 - 0-20 meters from house, Zone 2 - 20-100 meters from house, Zone 3 -100-250 meters from house, and Zone 4 - 250 meters or more.

Characterization of Temporal Relations

As in other areas where long-term agroforestry is practiced, Pohnpei indigenous agroforestry could be described as a type of farmer-controlled succession. Farms were classed by a combination of reported farm age and estimated age of dominant existing vegetation types based on field observation. Farm age was determined by asking farmers when they first began fanning their land and which species of vegetation existed on the land at that time. Since reliability of reported farm ages was dependent on farmer memory, and age of different plots varied somewhat within farms, an attempt was made to identify general agroforest development or successional stages. These are reported in the results.

Seasonality of various crops was determined through on-farm observation during the farm surveys, and was augmented by a weekly market survey.

Results and Discussion

Farm Demographics

Age of head of household varied considerably (table 1), but was characterized by older farmers. This was mainly due to the extended family pattern of habitation in the rural areas. Land sizes, determined from land survey maps or estimation, also varied considerably. Most farmers controlled more than one piece of land, in most cases considerably increasing their landholdings. Family size also reflected the extended family structure. Access to paid off-farm employment varied widely. Nineteen families (33 percent) had no access to wage labor, and depended almost entirely on farming and fishing for livelihood. For the remaining farm families, labor varied from full-time government work to occasional carpentry or roadwork.

Agricultural Technology and Management

Farming technology was generally traditional, with the machete and metal digging stick being the most important tools. Only 8 farmers used commercial fertilizer, and only on black pepper *(Piper nigrwn)* and market vegetables. Farmers reported soil fertility decline over time affecting mostly annuals and herbaceous perennials, especially kava *(Piper methysticum)* and banana, with little effect reported on tree crops. Common strategies included rotation of annual and herbaceous perennial crops around the land, setting aside unfarmed portions of the farm for future use, and ultimately, movement to another land. Pesticides were used occasionally only by three farmers, on semi-commer-

Table 1-*Demographic data on 57 survey farms*

Characteristic	Average	Minimum	Maximum
Age of head of household (years)	54	30	76
Size of farm land parcel (Ha)	4.9	1.5	21
Number of land parcels controlled	2.1	1	5
Total number of family members residing on farm	14	2	41
-working on farm	4.2	1	12
-employed off farm	1.2	0	5

cial vegetables. Overall, farmers were satisfied that their traditional technologies were sufficient.

The Pohnpei farmer asserts considerable influence on the structure of the farm. This is accomplished through periodic slashing of undergrowth, selection of spontaneously generating trees and herbs, occasional planting of crops, and pruning, girdling, and topping existing trees.

Commercial Cropping

Many of the farmers occasionally sold produce in Kolonia, but few considered themselves commercial farmers. Interestingly, while 32 percent of farmers had been involved in the unsuccessful TTPI cacao project in the early 1960's, no introduced cash crop since then has attracted such a high percentage of farmers (table 2), including black pepper, which at present is a fairly lucrative cash crop. Petersen (1977) recorded similar findings in his research and attributed this to the general distrust that farmers have for new cash crop projects after a series of early failures in the 1960's and early 70's. Copra production has also fallen off considerably, with only 23 percent of the farm families still engaged in production. Most felt that copra was far more profitably used as pig feed. A few traditional prestige crops, including kava and yams, have also recently become cash crops, due to the increasing urban population in the district center, Kolonia. Pigs are also frequently marketed, and a number of farmers, especially those without wage labor income, reported much of their income from the marketing of pigs and sakau.

Livestock

Chickens were the most common livestock, most being kept free-run (table 3). Previous to European contact, dogs were the major prestige animal, and were consumed regularly at feasts, but currently, pigs are the most important livestock based on their high prestige value. The relatively low figure (81 percent) for farms on which pigs were recorded is slightly misleading since some families did not permanently reside on the survey lands. Numbers of pigs/ family were also lower than expected. This is probably due to recent enforcement of legislation requiring pigs to be fenced, thus discouraging large numbers of pigs because of the need for a greater investment of capital and labor. Pigs were fenced on 76 percent of the survey farms. Almost all farms with unfenced pigs were found in Kitti municipality, where the legislation has not yet been totally accepted.

Major Crop Species

A total of 161 species of plants were found on the Pohnpei survey farms, 102 of which are cultivated and uncultivated trees, shrubs, and crops. The rest are uncultivated herbaceous weeds (table 4). Of the 102 species, 16 were upper canopy, 24 were sub-canopy, and the remainder were understory. There were 58 cultivated agroforest species, 20 upland forest species, 18 secondary vegetation species, and 6 swamp, strand and mangrove forest species. Not all species were found on every farm. Twenty-six different species were found on the average farm, with 16 being the least and 37 being the most species found on a single farm. Although some of this difference reflects the variability between farms due to management, survey methods, due to the uneven number of plots per farm, probably had the greatest effect. Environmental gradients figured only slightly, since all gradients were generally small, and farmers all planted relatively the same basic complement of crops, regardless of location.

Cultivars

Several of the major crops have a number of cultivars. Cultivar names were collected from the literature (Bascom 1965) and farmer interviews. Cultivars were searched out, collected, and described during this study. Yam *(Dioscorea)* has the greatest number of cultivar names recorded (177), breadfruit the second most (131), followed by plantain and banana (55). Other crops having numerous cultivars include *Cyrtosperma* taro (24), *Colocasia* taro (16), *Alocasia* taro (10), coconut (9), sugarcane (16), and kava (3).

Out of 131 named cultivars of breadfruit, 28 (22.3 percent) were actually recorded in plots. One cultivar alone, "Meiniwe," made up more than 50 percent of all trees recorded. Five cultivars made up over 75 percent of trees recorded. For yam, a cultivar of *D. alata,*'Kehp en Dol', made up 18 percent of all yams recorded, followed in importance by several other varieties of *D. alata.* More than 15 percent of yam varieties were unidentified, due to the reluctance of some farmers to discuss their yams with us. Many of the commonly-occurring yam cultivars were introduced since European contact, reflecting the great number of yam introductions in the last 160 years (Bascom

Table 2-*Participation in commercial cash cropping of 57 survey farms*

Crop type	Farms (No.)	Farms (Pct)	Amount grown Unit	Avg.	Min.	Max.
Cocoa	18	31.6	Trees	268	25	1000
Copra	13	22.8	Trees	370	200	00
Sakau	11	19.3	Ha	1.1	0.4	1.6
Vegetables	10	17.5	Ha	0.3	0.1	0.8
Black Pepper	9	15.8	Plants	468	100	981
Pineapple	5	8.8	Plants	670	20	3000
Citrus	3	5.3	Trees	40	20	50
Betel Nut	3	5.3	Trees	140	20	200
Yam	3	5.3	Ha	0.6	0.4	1

Table 3-*On-farm livestock on 57 survey farms*

Livestock Type	Farms (No.)	Farms (Pct)	Amount/Farm Avg.	Min.	Max.
Chickens	48	84	20	2	95
Pigs	46	81	6.5	1	35
Dogs	44	77	3.5	1	12
Goats	4	7	9	1	20
Water Buffalo	2	3.5	1	1	1
Cattle	1	1.8	2	2	2

Table 4-*Common plant species In Pohnpei agroforests (by occurrence)*

Names English	Scientific	Pohnpei	Uses	#/HA
Upper Canopy Species (>8 m)				
Trees:				
Coconut	*Cocos nucifera*	nih	1,2,3,6,7,9,13	92
Breadfruit	*Artocarpus altilis*	mahi	1,2,7,10,13	72.4
Ylang-ylang	*Cananga odorata*	seirenwai	8,11,12,13	47
Mango	*Mangifera indica*	kehngid	1,2,12	14.4
Betel Nut	*Areca catechu*	pwuh	4	9.5
False Durien	*Pangium edule*	duhrien	1,2	9.4
Campnosperma	*Campnosperma brevipetiolata*	doling	7,11	6.7
Ivory Nut Palm	*Metroxylon amicarum*	oahs	6,7	4.4
Bamboo	*Bambusa vulgaris*	pehri	11,13	2.6
Polynesian Chestnut	*Inocarpus fragifer*	mwuropw	1,2,13	2.6
Mahogoney	*Swetenia macrophylla*	mahokani	11	2.5
Wild Nutmeg	*Myristica insularis*	karara	5,7,11	2.3
African Tulip	*Spathodea campanulata*	-	11	2.3
Blue Marble	*Elaeocarpus carolinensis*	sadak	7,11	2
Albizia	*Paraserianthes falcataria*	tuhk kerosin	12,13	1.8
Pittosporum	*Pittosporum ferrugineum*	kamal	11,12	1.8
Mountain Palm	*Clinostigma ponapensis*	kotop	1,11	1.6
Kapok	*Ceiba pentandra*	koatun	12,13,15	1.1
Eugenia	*Eugenia carolinensis*	kehnpap	7,11	1.1
—	*Parinari laurina*	ais	5,7,9,11	0.9
Mountain Palm	*Ptychosperma ledermanii*	kedei	1,2,11	0.5
Parkia	*Parkia korom*	kurum	11	0.3
Eugenia	*Eugenia stelechantha*	kirek en wel	7,11	0.2
Banyan Tree	*Ficus prolixa* var. *carolinesis*	aiau	7	0.2
Mangrove	*Rhizophora apiculata*	akelel	7,11	0.2
Vines:				
Rattan	*Flagellaria indica*	idanwel	7	2.9
Sub-Canopy Species (2.5-8 m)				
Trees:				
Plantain	*Musa* spp.	uht	1,2,7,14,15	110
Banana	*Musa* ssp.	uht	1,2	48.6
Hibiscus	*Hibiscus tiliaceus*	keleu	7,11,12,13,15	36.7
Indian Mulberry	*Morinda citrifolia*	weipwul	2,5,7,11,13	23.5
Macaranga	*Macaranga carolinesis*	apwid	7,11	19
False Sandalwood	*Adenanthera pavovnina*	kaikes	12	19
Soursop	Annona *muricata*	sei	1,2	17.2
Premna	*Premna obtusifolia*	topwuk	7,12,13,15	15
Glochidion	*Glochidion ramiflorum*	mwehk	7,12,13	13.8
—	*Aglaia ponapensis*	marasau	7,12	9
Papaya	*Carica papaya*	memiap	1,2	8.6
Lime	*Citrus aurantifolia*	karer	1,7,13	8.4
Pandanus	*Pandanus* sp.	mwatal	7,15	8
Tree Fern	*Cyathea nigricans/ponapensis*	katar	7,11,13	7.2
Rose Apple	*Eugenia jambos*	apel en wai	1,2,13	5.4
Strangler Fig	*Ficus tinctoria*	nihn	1,7,13	4.3
Ixora	*Ixora casei*	ketieu	7,11	4.1
Erythrina	*Erythrina fusca*	pahr	11,12,13	4.1
Barringtonia	*Barringtonia racemosa*	wih	11,12	4.1
Guava	*Psidium guajava*	kuahpa	1,7,13	3
Orange	*Citrus sinensis*	orens	1,13	2.8

Table 4-*Common plant species In Pohnpei agroforests (by occurrence) cont'd*

Names English	Scientific	Pohnpei	Uses	#/HA
Malay Apple	*Eugenia malaccensis*	apel en Pohnpei	1,2	2.5
—	*Claoxylon carolinianum*	kohi	7	2.1
Plumeria	*Plumeria rubra*	pohmeria	8,13,14	1.5
Oil Palm	*Elaeis guineensis*	nihn aprika	1,2,9	1.5
Cocoa	*Theobroma cacao*	kakao	1,13	1.4
—	*Garcinia ponapensis*	kehnpwil	7	1.3
—	*Alpinia carolinensis*	iuiu	7,14	1.3
—	*Glochidion* marianum	kewikid en lohl	7	1.2
Barringtonia	*Barringtonia racemosa*	wih	11,12	4.1
Barringtonia	*Barringtonia asiatica*	wihnmar	11,12,13	0.5
Pandanus	*Pandanus tectorius*	deipw	1,2,6,15	0.5
Screwpine				
—	*Fragraea berteriana* var. *sair*	seir en Pohnpei	8,14	0.5
Avocado	*Persea americana*	apokado	1,2,13	0.4
Starfruit	*Averrhoa carambola*	ansu	1,2	0.3
Commersonia	*Commersonia bartramia*	kahil	11,12,13	0.3
Guest Tree	*Kleinhovia hospita*	keleu en And	7,11	0.3
Pink Bauhinia	*Bauhinia monandra*	pilampwoia	14	0.2
Vines:				
—	*Freycinetia ponapensis*	rahra	7	0.5
Betel Leaf	*Piper betel*	kapwohi	16	0.2
Understory Species (<2.5 m)				
Shrubs:				
Kava	*Piper* methysticum	sakau	4,7,10	137
Pineapple	*Ananas cosmosus*	pweinaper	1,2	37.7
Sugarcane	*Saccharum ofcianarum*	sehu	1,10	9.7
Cassava	*Manihot esculenta*	dapioka	1,2	5.2
Ti Plant	*Cordyline terminalis*	dihng	14	4.9
Ornamental Hibiscus	*Hibiscus rosa-sinensis*	keleu en wai	14	3.9
Croton	*Codiaeum variegation*	korodon	14	3.2
Chili Pepper	*Capsicum annum*	sele	1,14	1.9
Gardenia	*Gardenia augusta*	iohsep sarawi	7,14	1.8
Tobacco	*Nicotiana tobaccum*	tipaker	4,14	1.4
Gloryblower	*Clerodendrum inerme*	ilau	7,14	1.3
Crinum	*Crinum asiatica*	kiup	14	1.2
—	*Pipturus ternatum*	nge	7	0.7
Dwarf Poinciana	*Caesalpinia pulcherrima*	sehmwida	1,14	0.7
Coffee	*Coffea arabica*	koahpi	3	0.4
—	*Psychotria hombroniana*	kempeniel	7	0.3
Basil	*Ocimum sanctum*	kadarin	4,16	0.3
—	*Boehmeria celebica*	kehrari	7	0.3
Bell Pepper	*Capsicum frutescens*	sele	1	0.2
Arnatto	*Bixa orellana*	—	5,14	—
Derris	*Derris elliptica*	peinuhp	7	—
Ageratum	*Ageratum conjugation*	pwisenkou	-	—
Devil Weed	*Chromolaena odorata*	wisolmat	-	—
Lantana	*Lantana camara*	randana	-	—
Melastoma	*Melastoma marianum*	kisetikimei	1,7	—
Pagoda Flower	*Clerodendrum buchananii*	—	14	—
Crotalaria	*Crotalaria pallida*	krodalaria	-	—

Table 4-*Common plant species In Pohnpei agroforests (by occurrence) cont'd*

Names English	Scientific	Pohnpei	Uses	#/HA
Aroids:				
Wild Taro	*Alocasia macrorrhiza*	oht	1,2,10,14	47.4
Sweet Taro	*Colocasia esculenta*	saws	1,2	47
Swamp Taro	*Cyrtosperma chamissonis*	mwahng	1,2,10	37.6
Dryland Taro	*Xanthosoma sagittifolium*	awahn Honolulu	1,2	2.9
Arrowroot	*Tacca leontopetaloides*	mokmok	1,2	0.3
Vines:				
Soft Yam	*Dioscorea alata*	kehp	1,2,10	28.5
Black Pepper	*Piper nigrum*	peper	16	16.6
Hard Yam	*Dioscorea nummalaria*	kehpeneir	1,2,10	10
Sweet Potato	*Ipomoea batatas*	pedehde	1,2	1.2
Watermelon	*Citrullus vulgaris*	soika	1,2	0.8
Yardlong Bean	*Vigna sesquidepedalis*	pihns	1	0.3
Pumpkin	*Cucurbita maxima*	pwengkin	1,2	0.3
Sweet Yam	*Dioscorea esculenta*	kehmpalai	1,2	0.3
Morning Glory	*Ipomoea trilobata*	omp	2,7	—
Wild Yam	*Dioscorea bulbifera*	palai	2,7	—
Merremia	*Merremia peltata*	iohl	7	—
Centrosema	*Centrosema pubescens*	—	2	—
—	*Piper ponapense*	konok	7	—
Passion flower	*Passiflora foetida*	pompom	1	—
Herbs:				
Turmeric	*Curcuma domestica*	kisiniohng	5,7,16	1.8
Ginger	*Zingiber officianarum*	sinner	16	—
Wild Turmeric	*Curcuma* spp.	auleng	5,7	0.3
Alpinia	*Alpinia purpureum*	iuiu en wai	14	0.2
Wild Ginger	*Zingiber zerumbet*	ong en pehle	7	—
Crape Ginger	*Costus sericea*	—	—	—
Wedelia	*Wedelia trilobata*	—	14	—
Day Flower	*Commelina diffusa*	—	—	—
Elephant's Foot	*Elephantopus mollis*	—	—	—
Garden Spurge	*Euphorbia hirta*	—	—	—
Aramina	*Urena lobata*	—	—	—
Clover	*Desmodium* spp.	—	—	—
Spanish Needle	*Bidens pilosa*	—	—	—
—	*Polygala paniculata*	kisinpwil	—	—
Jamaica Vervain	*Stachytarpheta jamaicensis*	—	—	—
Coleus	*Plectranthus scutelloides*	koromahd	—	—
Niruri	*Phyllanthus niruri*	limeirpwong	7	—
Sida	*Sida acutifolia*	—	—	—
Sowthistle	*Sonchus oleracea*	—	—	—
Grasses:				
—	*Cyrtococcum patens*	rehmaikol	7	—

Table 4-*Common plant species In Pohnpei agroforests (by occurrence) cont'd*

Names English	Scientific	Pohnpei	Uses	#/HA
Hilo Grass	*Paspalum conjugatum*	rehnwai	-	—
—	*Ischaemum polystachum*	rehpadil	7	—
—	*Chrysopogon aciculatus*	rehtakai	7	—
Marsh Cyperus	*Cyperus javanica*	use	-	—
Goosegrass,	*Eleusine indica*	rehtakai	-	—
Mapania	*Mapania pandanophylla*	pwohki	-	—
Napier Grass	*Pennisetum purpureum*	pukso	-	—
Crabgrass	*Digitaria radicosa*	—	-	—
Rice Grass	*Paspalum orbiculare*	rehnta	-	—
—	*Hypolytrum dissitifolium*	sapasap	-	—
—	unidentified	rehsemen	-	—
Foxtail	*Andropogon glaber*	rehnta	7	—
Miscanthus	*Miscanthus floridulis*	sapalang	-	—
Wild Sugarcane	*Saccharum spontaneum*	ahlek	7	—
Ferns:				
—	*Thelypteris maemonesis*	mahrek	7	—
Sword Fern	*Nephrolepis acutifolia*	Rehdil	7	—
Birds-Nest Fem	*Asplenium nidus*	tehnlik	14	—
Para Fern	*Marratia fraxinea*	paiuwed	7	—
False Staghorn Fern	*Gleichenia insularis*	mwatalenmal	—	—

Uses:
1. Food
2. Animal feed
3. Beverage
4. Narcotic
5. Dye
6. Thatch
7. Medicine
8. Flower
9. Oil
10. Prestige
11. Lumber, other wood products
12. Firewood
13. Trellis
14. Ornamental
15. Fiber
16. Spice

(Based on Raynor 1989)

1965.) For plantain and banana, the majority of cultivars of both were even more recently-introduced (within the last 50 years). Coconut was dominated by two cultivars, 'nih tol' and 'nih weita'.

The general impression of many farmers was that cultivar diversity is decreasing. It was admitted that several cultivars of yam had already been lost. The situation is most likely worse with some of the other crops that don't enjoy the high prestige value of yams.

Agroforest Vertical Structure

Vertical structure, or canopy stratification, was determined by grouping the major occurring species on the farms by height classes. Results are presented pictorially in a typical cross-section of a Pohnpei farm (fig. 3)

The main upper canopy rarely exceeds 20 meters, and is dominated by coconut (92 trees/ha) and breadfruit (72 trees/ha), with occasional mango, kapok, or forest remnants reaching to 26-28 meters. A patchy sub-canopy, more prevalent in areas in a semi-fallow stage, is dominated by Ylang-ylang *(Cananga odorata,* at 47 trees/Ha), yam *(Dioscorea* spp.) vines (29 plants/ Ha), and younger upper canopy species, and reaches 8-12 meters.

The main sub-canopy varies from 2.5 to 8 meters above the ground, and is made up mainly of plantains and bananas (110 and 49 plants/ha), Hibiscus *(Hibiscus tiliaceus,* at 37 trees/ha), Indian Mulberry *(Morinda citrifolia,* at 30 trees/ha), yam vines, soursop *(Annona muricata,* at 17 trees/Ha), Rose apple *(Eugenia*

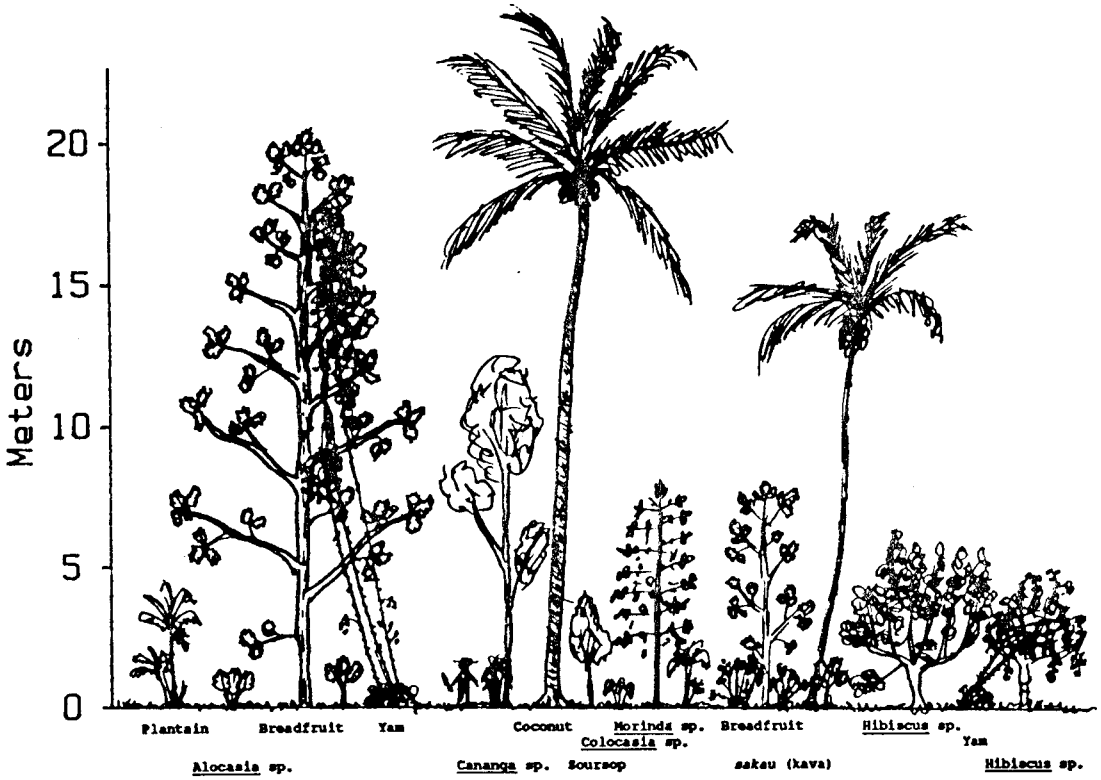


Figure 3-Cross-section of a typical Pohnpei Agroforest.

jambos, at 5 trees/ha), and several other secondary vegetation species that are allowed to grow.

The understory is characterized by numerous plants that reach maturity at below 2.5 meters. The aroids, mainly *Alocasia* sp. (47 plants/ha), and sakau (137 plants/ha) are the most common, along with pineapple, *Colocasia* and *Cyrtosperma* taros, and various herbs of *Curcuma* spp. Several low bush species, grasses, ferns, and herbs occur on the farms, and are considered as weeds.

Agroforest Horizontal and Temporal Structure

Based on a combination of reported farm age and estimated age of dominant existing vegetation types as noted in the field, four general agroforest successional or development stages were identified. The general characteristics of each of the stages are:

Stage 1 - Establishment - Farming is initiated on new land. Initial clearing of undergrowth, and girdling of large forest trees with fire or knife is done, working out from the house. Crops are usually characterized by banana, kava, and other fast-growing food crops. Perennial tree crops have been planted but are not yet bearing. Many secondary vegetation or upland forest species remain. This stage was represented by only one 2-year old farm in Nett municipality.

Stage 2 - Early Agroforest - Tree crops come into bearing and reach maximum yield, while farm expansion continues to land limits. Secondary vegetation and/or upland forest species are gradually replaced by agroforest species through slashing, ring-barking, and cutting. Stage 2 was represented by 17 farms in Kitti (2), Madolenihmw (6), Nett (4), Sokehs (4), and Uh (1). Farm ages varied from 14-41 years, with an average age of 29 years.

Stage 3 - Late Agroforest - Slow decline in production due to tree crop age, increased disease and pests, and possible soil fertility decline. Management begins to drop off. Stage 3 was represented by 25 farms in Kitti (9), Madolenihmw (5), Nett (3), Sokehs (2), and Uh (6). Farm ages varied from 23-100 years old, and averaged 78 years. Younger farms were those that had been started on land that had previously been in agroforestry, and had gone fallow.

Stage 4 - Abandonment/Secondary Vegetation Succession - Entire land or various large sections of farm are allowed to revert to secondary vegetation fallow. Some areas, especially near the residence, may continue to be farmed, but use is made of more intensive methods, i.e., mulching, clean weeding, addition of wood ash. Stage 4 was represented by 11 farms in Kitti (4), Madolenihmw (5), and Sokehs (2). Farm ages ranged from 24-100 years with an average age of 79 years. The younger farms had been abandoned for various reasons, most often a lack of available labor.

Density, or the number of individuals of a species per hectare, was calculated for the survey plots overall (table 4). Eight of the most important species (based on total number and frequency) were chosen, representing the three major vegetation types: agroforestry, secondary vegetation, and up-

land forest. These were then compared to determine variation in vegetation patterns over the distance zones (see "Methods") and successional stages.

The two most important species of agroforest root crops on Pohnpei are sakau and yams. Sakau, a plant which prefers fertile soil with high organic matter content (Lebot and Cabalion, 1988), shows a typical pattern of species requiring newly cleared land (fig. 4). It is especially prevalent on the new, or Stage 1, farms, where it is found close to the house. On older farms, sakau is spread more evenly over distance zones but at lower densities. Yam is grown more evenly across the farms, especially in the two middle age stages (fig. 5). This is probably due to the secrecy with which Pohnpeians regard yams, preferring to spread them out across the farm rather than grouping them where a casual passerby might see them. Again in newer farms, yam is found in close to the house in the

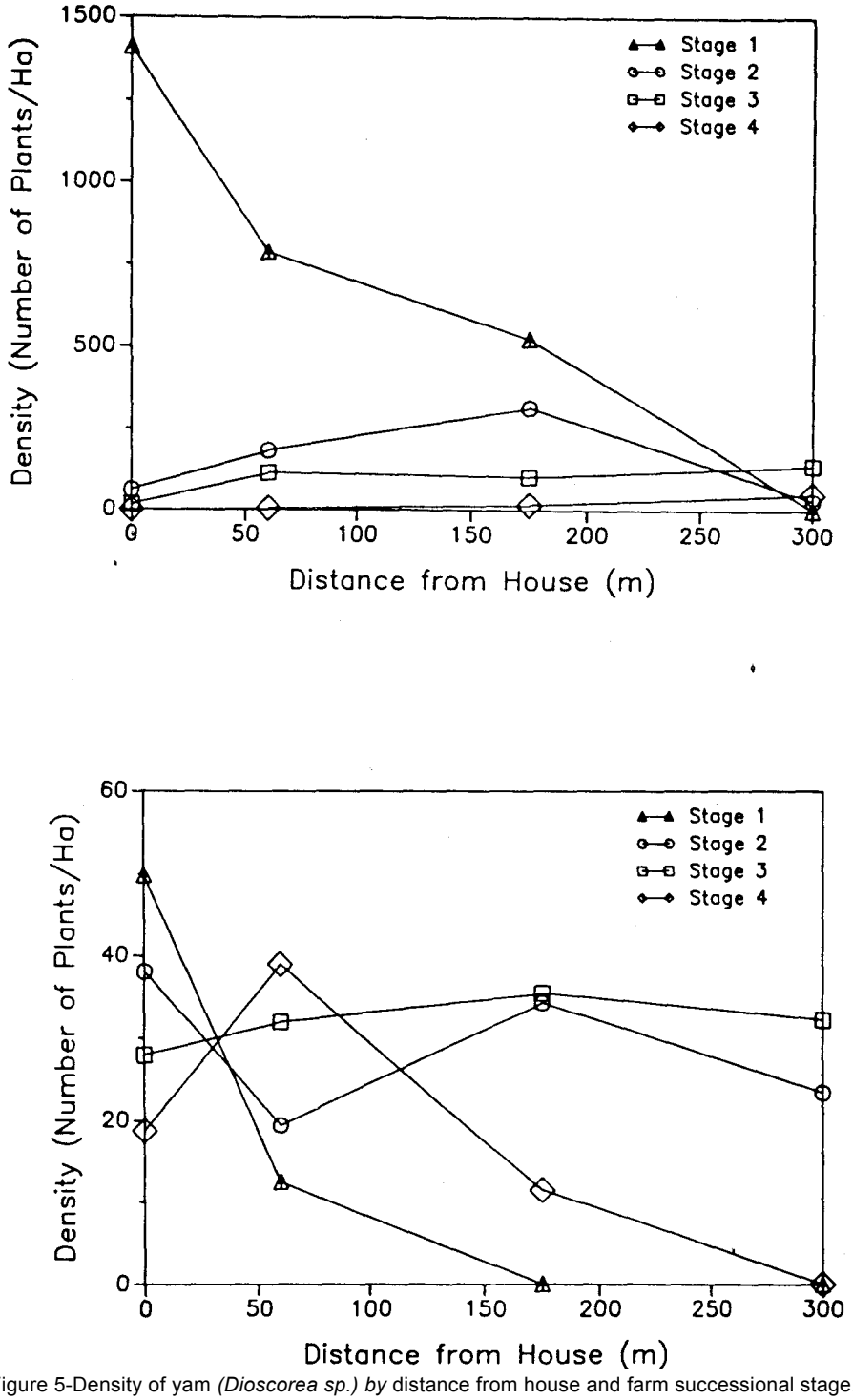
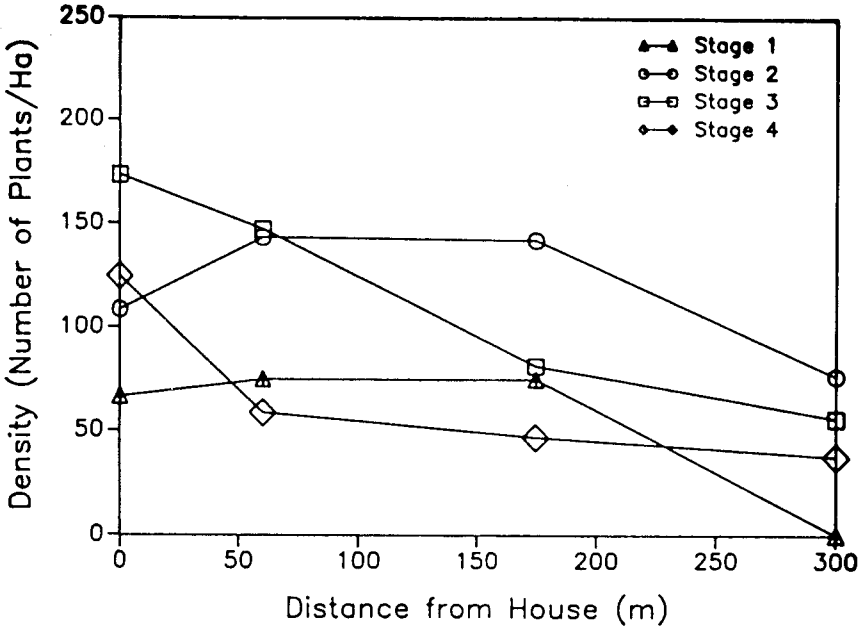


Figure 5-Density of yam *(Dioscorea sp.) by* distance from house and farm successional stage.

newest farm. Density is not affected by development stage as much since yam is intensively cultivated, including fertilization using a grass *(Cyrtococcum patens)* and various types of tree leaves, especially *Hibiscus tiliaceus.*

Agroforest tree crops are represented by plantain (fig. 6) and breadfruit (fig. 7). Generally, plantain is grown more densely near the house and falls off with distance from the house in all stages. Since plantain is more a "women's crop," this pattern would be expected, since women's child care responsibilities require them to work mainly near the house. Densities of the plantain also drop with age, perhaps due to the closing of the canopy, decreasing fertility, and increasing nematode populations (especially the banana burrowing nematode, *Radolphus* sp). Density of breadfruit in the young farm is very high close to the house, probably due to heavy planting to allow for some loss-all trees were very young and small. Density was rather



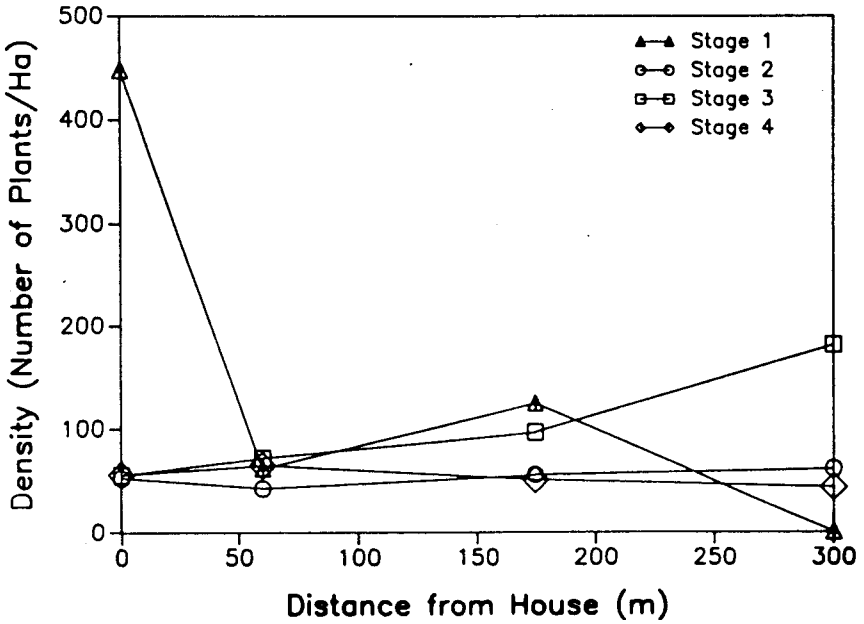


Figure 7-Density of breadfruit (*Artocaipus altilis*) by distance from house and farm successional stage.

consistent across other stages of farms, except that it increases in stage 3 farms with distance from the house, perhaps due to the increased suckering of older trees. Overall, results show that farmers plant breadfruit across the farm with little regard to distance from the house.

Secondary vegetation is represented by *Hibiscus (fig.* 8) and *Adenanthera* sp. (fig. 9). Hibiscus is typical of a secondary vegetation species that is allowed and even encouraged in the agroforest. Densities are fairly constant over both stages and distances, except for in stage 4 farms, where density is higher further from house, probably due to abandonment of land furthest from house. *Adenanthera,* on the other hand, is considered a "weed tree" in agroforest, and is usually cut when it is quite small. There was none on the youngest farms, and it was only found at relatively high densities in stage 4 farms that had been more or less allowed to revert to secondary vegetation.

The last vegetation type represented in Pohnpei agroforest was the upland forest type, represented by *Campnosperma* sp.

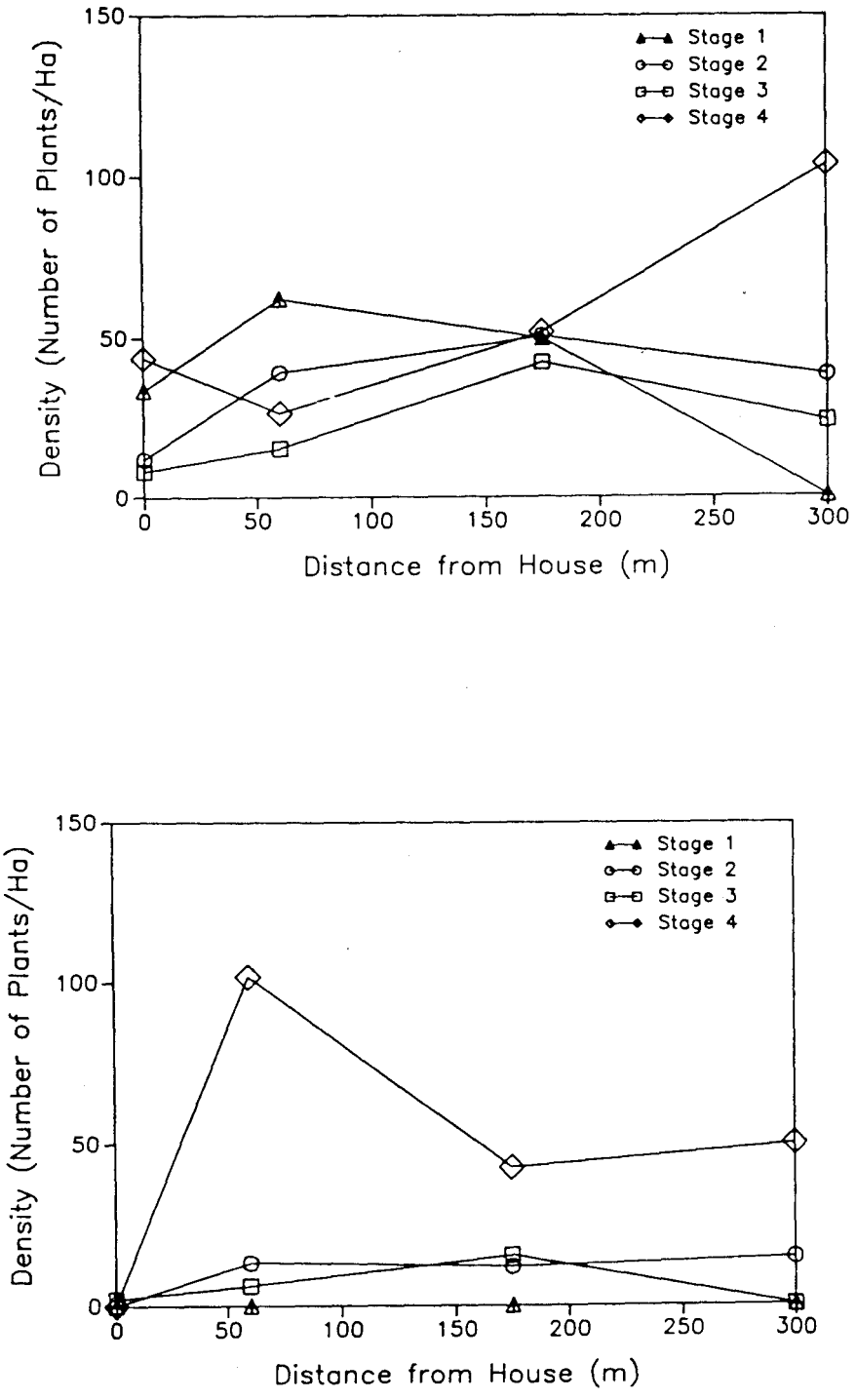


Figure 9-Density of *Dalbergia candenatensis by* distance from house and farm successional stage.

(fig. 10), a large jungle evergreen tree, and the smaller tree fern *(Cyathea* sp.) (fig. 11). *Campnosperma* shows a pattern typical of large remnant upland species. It is common in younger farms, is gradually cut out as farms get older, and then begins to come back as farms are abandoned. Large trees are not allowed to grow too near the house, for fear they will fall on the house during a typhoon, thus the low density or absence of *Campnospernma* near the house. Tree ferns show a similar pattern, gradually being replaced as farms are developed, and then coming back during abandonment and fallow.

Seasonality

Most of the herbaceous species and a few of the tree crops in the indigenous Pohnpei agroforest were not observed to be

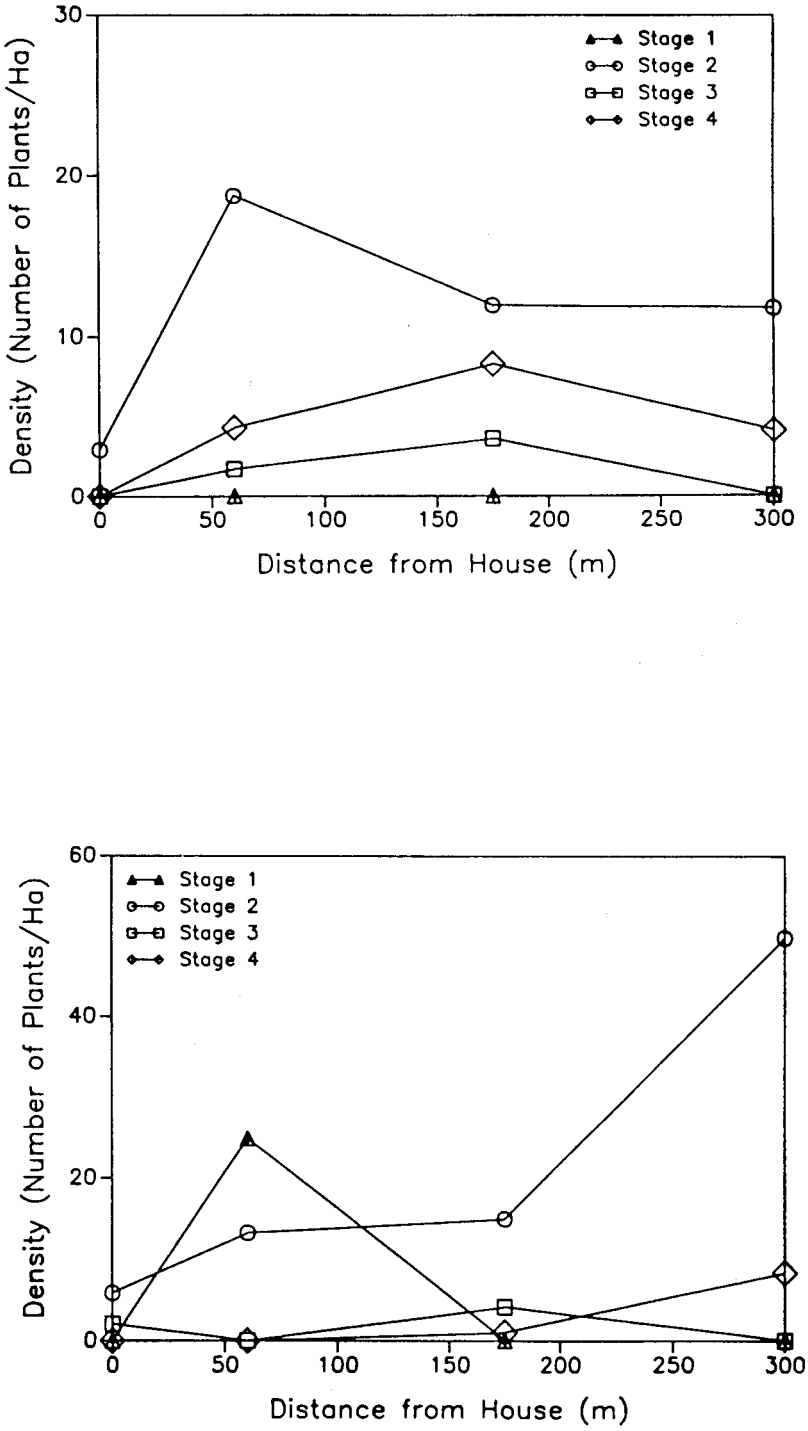


Figure 11-Density of tree fern *(Cyathea* spp.) by distance from house and farm successional stage.

seasonal in production. Several crops which were determined to be physiologically seasonal are shown in figure 12. Yam *(Dioscorea* spp.) was also found to be somewhat seasonal, although most Pohnpeians reported that certain cultivars could be grown all year. The major yam planting, however, corresponds with the dryer trade-wind season, and part of this is probably due to the higher incidence of a fungus disease, Anthracnose *(Colletotrichwn gloeosporioides),* on young vines of yams planted early, leading to decreased yields and loss of whole plants in severe infections.

Summary and Conclusions

The Pohnpei indigenous agroforestry system is the result of thousands of years of evolution. As a result, it has become highly integrated into both the environment and the culture of the island. Pohnpei indigenous agroforestry is similar to subsistence systems in other parts of the Pacific, many of which employ the use of few external inputs, effective accumulation and recycling of natural nutrients, and reliance on genetic diversity. The indigoenous agricultural technologies that make up these systems are the result of an understanding of local conditions and knowledge of the ways of managing local energy and material resources. These technologies are practical techniques that have been developed under a specific set of economic and social conditions.

On Pohnpei, the pressures of a rapidly increasing population and the growing desire to participate in the world cash economy are leading to a decline of the largely subsistence-oriented agroforestry system. Increased urban migration and rapidly increasing food and consumer imports are leading to stresses on the rural social system in general. The situation is no different from other island states in the Pacific.

The challenge facing Pacific island agriculturalists is to improve agriculture in ways that retain the ecological and social strengths of traditional agroforestry while meeting the needs of the present and future populations. One major opportunity may be the integration of cash crops into existing agroforestry systems. This is particularly appropriate since it does not entail major structural, land-use, or social changes, yet can improve the cash income of the rural population. Efforts are being made by the Pohnpei State Division of Agriculture to integrate pepper into the indigenous system by planting it under breadfruit and coconut trees. Other spice or specialty crops, such as ginger, cardamom, nutmeg, and cloves are also being introduced. A few of the indigenous crops, for example, sakau, may have export potentials. Sakau, together with yams and pigs, are already

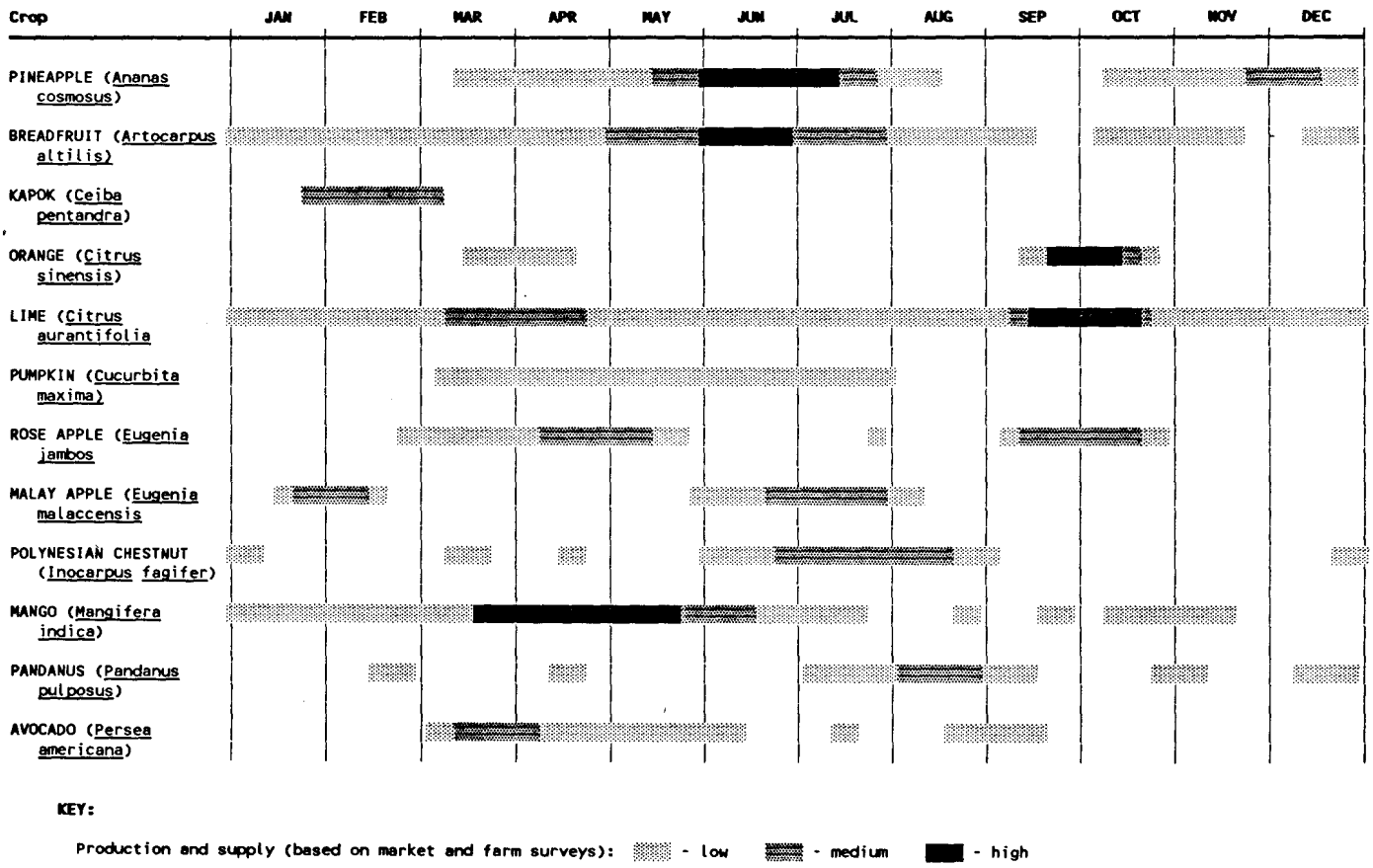


Figure 12-1988 seasonality of selected crops on Pohnpei Island.

becoming important cash crops in the local market. Increased efforts into developing these crops through cultivar selection, research on improved management, and expansion of markets are needed.

Opportunities for improving the indigenous agroforestry system also exist through improved research on optimal agroforest structural design, species interactions, and maintenance of soil fertility. Research into canopy dynamics and optimization of light capture by plants can be done on existing farms to make recommendations to farmers on optimal densities and mixtures of important crops. Increased studies of fertility dynamics under traditional management and under improved systems might help to -tend the cropping period and improve both sustainability and production from increasingly limited land resources.

Social research is also needed to determine availability and use of labor in the rural areas, as well as exploring the changing attitudes among the younger generations toward agriculture. Methods of preserving traditional agricultural knowledge must also be developed and applied to save this valuable, but quickly disappearing, resource.

Reliable quantitative data on structure, production, and seasonality is needed to improve existing systems in the Pacific islands. This study has attempted to address this need using fairly simple methods that can be applied on Pohnpei and other islands. It is hoped that other researchers will improve and expand upon these methods and apply them to further study of indigenous Pacific island agroforestry systems. Only then will the agricultural knowledge and technologies developed over thousands of years continue to serve Pacific islanders into the future.

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Appendix 1

MEHN PEIDEK OHNG SOUMWET
FARMER INTERVIEW PROTOCOL

Farmer name:
Title:
Age:
Location of farm:
Size of land (hectares):

I. Family:

Name	Sex	Age	Relation	Occupation (if any)

II. Farm History:

-How did you learn to farm?
-When did you start farming on this land?
-How long has this land been farmed?
-How much of this farm have you personally planted?
-Have you planted commercial crops?

III. Soils:

-What are the different types of soils on your farm?
-Were the soils more fertile in the past? How do you know?
-Which plants indicate good/bad soil?
-How do you maintain soil fertility?
-How much land can support your family?

IV. Animals:

Type	Sex	Number	Management	Other
Cattle				
Chickens				
Dogs				
Goats Pigs				
Water Buffalo				

V. Labor:

-What are the main labor inputs on your farm?
-How many of the family work on the farm? How often?
-Who is responsible for what tasks?

VI. Tools:

-What farming tools do you own/use?

VII. Other Inputs:

-Do you use fertilizers/pesticides on your crops?
-Do you purchase any inputs?

VIII. Fallow/Crop Mixes:

-Do you fallow your land? How often? Why?
-What are the main considerations in clearing land?
-Which trees/plants are most useful? least useful? why?
-What do you consider in spacing crop plants?
-Which plants are shade-loving? sun-loving?
-Which plants grow well together? poorly together? why?

IX. Planting:

-How do you decide how much to plant?
-What are the best locations for planting each crop?
-How often do you plant/replant perennials?
-What are the best times for planting specific crops?
-Where do you get planting material?
-How do you plant specific crops? (Tools, type of hole, etc.)
-What restrictions do you follow (taboos, magic)? Do they work?

X. Care of Agroforest:

-What are the main husbandry tasks that need to be done?
-How often do you carry them out?
-How do plants get their nutrients?
-What causes a healthy crop plant? unhealthy one?

XI. Crop and Cultivar Diversity Importance:

-Do you grow more than one cultivar of certain crops? How many?
-Are there yield and/or seasonality differences between cultivars?
-How do you differentiate between cultivars of important crops?

XII. Yield and Production:

-Does your agroforest produce enough for your family needs?
-Do you, market agroforest products? About how much/month?

XIII. Social/Prestige Participation

-Which first-fruit (nopwei) tributes do your kousapw do?
-Do you plant crops, raise animals for prestige purposes?
-How often do you attend feasts/related events? What do you bring?

XIV. Other:

-Why do you practice traditional agroforestry?
-Is agriculture changing on Pohnpei? Explain.
-What are your future plans for your land?
-What are some constraints in farming on Pohnpei?

Appendix 2

Farm Survey Form

A G R O F O R E S T S U R V E Y S H E E T

FARMER NAME:_____ DATE:_____

LOCATION:_____ ELEVATION:_____

PLOT NO:_____ SLOPE AND EXPOSURE:_____ SOILTYPE:_____

WEED COVER:_____

SPECIES	VARIETY	HT (M)	DBH (CM)	STMS/SKRS	COMMENTS