# A Review of Traditional Agroforestry in Micronesia[1]

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**Abstract:** For the many Micronesian islands, agroforestry was a sustainable land use system, and an integral component of the traditional subsistence system which provided the people with many of the necessities of life. Given the increasing pressures on limited land resources, the social and environmental problems associated with modern agriculture, particularly its use of pesticides and fertilizers, greater attention is being paid to agroforestry as a low-input sustainable agricultural system, appropriate to Micronesia and the rest of the Pacific. Unfortunately, relatively little detailed information exists on agroforestry systems. This paper is an overview of the agroforestry systems of Micronesia. It suggests that Micronesians developed a range of sustainable agroforestry technologies and systems appropriate to their varied socio-environmental contexts, systems which have applicability in today's Micronesia.

The geographic region of Micronesia is located approximately between 131.10°E and 176.54°E longitude and 20.33°N, and 2.39°S latitude and encompasses an oceanic area of slightly more than 7 million km$^2$ (Karolle 1988). The total land area, by contrast, amounts to only 2,707 km$^2$. Politically, Micronesia includes the Federated States of Micronesia (Kosrae, Pohnpei, Truk, Yap, and their affiliated atolls in the Caroline Islands), the Republic of the Marshall Islands, the Commonwealth of the Northern Marianas, the Territory of Guam, Republic of Palau, and the independent states of Kiribati, Tuvalu, and Nauru.

Within the region there are high volcanic islands, low coral limestone-based atolls, and more geologically complex islands. Soils range from deeply weathered oxisols on the high islands to entisols, particularly the psamments of the atolls. Average temperatures are in the mid-80s, while rainfall ranges between 1000 to more than 4000 mm per annum, depending on geographic location and elevation. The lowest rainfall totals are found to the east and south of the Marshall Islands in the "arid" Pacific, while most of the high islands receive adequate totals because of orographic effects. Tropical rainforest is the natural vegetation of the moister high islands, while a strand and salt tolerant woodland predominates on the atolls.

## Agroforestry Defined

While many definitions of agroforestry have been proposed (for example, see Wiersum 1981), for this discussion, agroforestry is defined as

> ... any form of permanent land use which combines the production of agricultural and/or animal products and tree crops and/or forest plants simultaneously or sequentially on the same unit of land, which aims at optimal sustained, multiple purpose production under the beneficial effect of improved edaphic and micro-climate conditions provided by simulated forest conditions, and management practices which are compatible with the cultural practices of the local population (Wiersum 1981, p. 6).

Given this definition, it will become apparent that most if not all of the traditional agricultural systems of Micronesia are, indeed, agroforestry systems.

The systems of agroforestry in Micronesia include the more permanent and stabilized systems of wetland taro agriculture, mixed tree gardening, backyard or kitchen gardens, and intermittent (shifting cultivation) tree gardening and open canopy culture (OTA 1987). On many Micronesian islands, more than one agroforestry system was used for the production of food and other necessities in conjunction with mangrove, reef, and ocean exploitation.

## Mixed Tree Gardening

The tree garden or agroforest, consisting of a wide range of cultivated and naturally occurring annual and perennial species, is a widely distributed and permanent form of traditional agroforestry in Micronesia (OTA 1987, Falanruw and others 1987, Raynor 1989) which provided Micronesians with an abundant supply of different tree crops and agricultural products from marginal lands. As indicated in table 1, these agroforests cover considerable areas of the high Micronesian islands.

The composition and structure of these forest gardens vary with habitat and island. Along the coast, these tree gardens are relatively simple (consisting of few species) and dominated by coconuts, while higher slopes are dominated by breadfruit. In Truk and Pohnpei, breadfruit is a dominant species of mixed tree

**Table 1-***Land-use classes in Micronesian high islands*

| Item | Palau | Kosrae | Pohnpei | Chuuk[1] | Yap |
|---|---|---|---|---|---|
| | | | Hectares | | |
| Forest | 28093 | 7066 | 19683 | 986 | 3882 |
| Secondary Forest and Vegetation | 594 | 1272 | 1843 | 252 | 553 |
| Agroforest | | | | | |
| Agroforest | 8 | 1659 | 1945 | 66 | 1515 |
| Agroforest with coconuts | 179 | 926 | 9796 | 2312 | 864 |
| Coconut plantation | 743 | — | 124 | — | 159 |
| Total Agroforest | 930 | 2585 | 11865 | 2378 | 2538 |
| Nonforest , | 8285 | 263 | 2102 | 554 | 2743 |
| Total area | 37062 | 11186 | 35493 | 4170 | 9716 |

Sources. Kosrae: Whitesell and others 1986. Palau: Cole and others 1987. Pohnpei: McLean and others 1986. Truk: Falanruw and others 1987. Yap: Falanruw and others 1987.

[1]Chuuk data is for the high islands of Weno, Dublon, Fefan and Eten only.

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gardening (Goodenough 1951, Raynor 1989). Raynor (1989) recorded 131 varieties of breadfruit on Pohnpei. On the steep and stony slopes of Pohnpei Island, trees and other food plants are grown in pockets of soil located between a pavement of boulders and large stones. These gardens are characterized by an upper canopy of breadfruit, coconuts, and other food trees; a secondary canopy of bananas and *Piper methysticum;* and a ground cover of *Cyrtosperma, Colocasia,* and *Alocasia* taros, and pineapple. Each breadfruit tree may also support between two to four yam vines (*Dioscorea* spp.). A detailed description of the composition and structure of Pohnpeian agroforests is found in Raynor (1989). On Guam, breadfruit, coconuts, and *Cycas circinalis* (*fadang*) were harvested from the mixed tree gardens. In Palau, these mixed forests or *chereomel,* contain timber trees, coconuts, mango, breadfruit, *Terminalia catappa,* and *Inocarpus edulis* (McCutcheon 1981). These agroforests are also sources of traditional medicines and other culturally valued products, building materials and firewood, and a habitat for feral and domestic animals.

On atolls, the pattern of agroforestry is arranged in zones and reflects the distribution of natural vegetation and the severity of environmental constraints (wind-generated salt spray, wave damage, saline ground water, and drought). The shores and beaches contain a sparse, salt tolerant herbaceous cover, backed by a fringing vegetation of shrubs and low trees which serve as a windbreak and buffer against hurricane-generated waves and salt spray. Species commonly found in this zone are *Scaevola taccada, Cordia subcordata, Tournefortia argentea, Pandanus tectorius, Soulmea amara,* and *Guettarda speciosa.* Moving inland, this fringing vegetation gives way to a taller strand forest, then a less salt tolerant, mixed mesophytic forest, a marsh or swamp forest in the central depression, and on the lagoon shore of the islet, a mesophytic-halophytic beach forest. Commonly found tree species of the strand and mixed mesophytic forests include *Pandanus tectorius, Pipturus argenteus, Calophyllum inophyllum, Pisonia grandis, Morinda citrifolia,* and *Premna obtusifolia.* On the larger islets, the strand forest is planted to coconuts, while the mesophytic forest is planted to both coconuts and breadfruit. The interior of the islet is often described as a breadfruit dominant zone, and as breadfruit is intolerant of salt, it is less commonly found on small and intermediate sized islets. In terms of percentages, coconut dominant woodlands and agroforests cover 50-70 percent of an atoll's area; mixed coconuts and breadfruit agroforests cover 30 percent; and the breadfruit dominant agroforests cover less than 10 percent. On the larger islets of Arno Atoll, Marshall Islands, coconut agroforests covered 69 percent of the area at a density of 95 trees per 0.4 ha; coconut and breadfruit agroforests cover 9 percent of the area at a density of 15 to 30 breadfruit trees per 0.4 ha (Anderson 1951, Hatheway 1953).

Many other trees and food plants are found in these agroforests. Understory species of the atoll agroforests include *Pandanus tectorius, Tacca leontopetaloides, Carica papaya, Crataeva speciosa, Musa* spp., *Syzygium malaccensis, Alocasia macrorrhiza, Xanthosoma brasiliensis, Mangifera indica, Ixora casei, Morinda citrifolia, Ananas cosmosus,* and *Capsicum frutescens* to name a few. While the focus of production is either the coconut or breadfruit, there is a substantial though yet unquantified cultivation of *Alocasia macrorrhiza, Xanthosoma brasiliensis,* bananas, and other food crops. Many other species of the agroforest are important as sources of timber, medicines, ornamentals, or other culturally useful product. Pigs and chickens are allowed to forage, and birds and crabs are hunted in these agroforests.

## Intermittent Tree Gardening

Intermittent tree gardening, also known as slash-and-burn cultivation, shifting cultivation, and swiddening, is practiced in secondary forest fallows on all the high islands of Micronesia. Structurally and functionally, this system of landuse is little different from the systems described for the other parts of the Pacific region, except that in Kosrae, burning was not used in garden clearing (Wilson 1968). Unlike the agroforests or mixed tree gardens described above, intermittent tree gardening is an impermanent form of land use that involves the short-term cultivation of crops in forest clearings and their abandonment to fallow after one to two years of production. Garden site abandonment results in succession to forest, the regeneration soil fertility and tilth, and the decrease of crop pests and diseases. Coconut and breadfruit trees are often planted in these sites and may be bearing when the site is again cleared for a garden, 15 to 40 years later.

As in the agroforests, a wide range of annual and perennial crops are grown in these gardens, but under different light and space conditions. More than 30 varieties of yams are grown in Yap for ceremonial presentation or subsistence consumption (Hunter-Anderson 1984). Bascom (1946) listed 156 Pohnpeian varieties. Recently, Raynor (1989) recorded 178 cultivars of yams but only 10 and 8 varieties of the lesser important *Colocasia esculenta* and *Alocasia* sp. respectively on Pohnpei. Other important agroforest species, for which there are many cultivars, are bananas, *Piper methysticum (sakau), Alocasia macrorrhiza, Cyrtosperma chamissonis, Colocasia esculenta,* sugarcane, *Hibiscus esculenta,* cassava, and sweet potatoes. Wilson (1968) recorded 8 varieties of coconuts, 26 of *Musa* spp., 13 of *Colocasia esculenta,* 14 of *Cyrtosperma chamissonis,* and 25 *ofArtocarpus altilis* on Kosrae. The many cultivars found in the intermittent and mixed tree gardens differed in their seasonality, productiveity, resistance to drought and other environmental constraints, and thus provided Micronesians with a fairly continuous supply of staple foods throughout the year.

Not much is known about the traditional intermittent agroforestry practices of Guam and the Northern Marianas. Underwood (1987) wrote that prior to the Spanish arrival, the Chamorros were mainly dependent on the ocean and by hunting for fruit bats, birds and land crabs. While slash and bum cultivation was practiced, the cultivation of root crops was rudimenttary. However, by the end of the 19th century, subsistence agriculture on the ranch or "lancho" became accepted as the Chamorro way of life (Underwood 1987). With modernization and development, most of these lanchos are now located in southern Guam, consisting of a "simply built cooking and sleeping house surrounded by food trees, chickens, pigs, and gardens"

(OTA 1987). Presently, few of these lanchos are cultivated without the use of fertilizers or pesticides, and burning of the short fallow forest is rarely practiced because of the difficulty in obtaining burning permits.

In the Northern Marianas islands, lanchos are more difficult to find because of the impacts of economic growth, division of family lands, food stamp programs, population increases (OTA 1987, Sproat 1968), and the early development of agricultural exports. For example, during the Japanese administration of the Northern Marianas, traditional subsistence agriculture was largely replaced by sugarcane plantations. During the 1930s, sugarcane was grown on more than 80 percent of the arable laud area on the islands of Rota and Saipan.

## Kitchen and Backyard Gardens

Kitchen (or dooryard) gardens, and backyard gardens are common features of most households throughout Micronesia. These gardens provide villagers a nearby source of food, fruit, spices, herbs, flowers, and medicinal plants. In urban households and villages, these agroforests supplement the wage income. Common fruit trees are *Annona muricata, Psidium guajava,* coconuts, breadfruit, bananas, and various species of citrus. *Cananga odorata, Plumeria rubra* and *Plumeria obtusa, Hibiscus hybrids, Cordyline fruticosa,* and *Codiaemum variegatum* and other ornamental trees and shrubs, some which have ritual or ceremonial significance, are other common introduced components of kitchen gardens of the high and low islands of Micronesia. *Colocasia esculenta, Cyrtosperma chamissonis, Alocasia macrorrhiza,* and cassava *(Manihot esculenta)* are fairly common undergrowth species. In the Central Carolines, *Crataeva speciosa* has special importance (Sproat 1968).

In Guam, *Averrhoa bilimbi* ("pickle" tree), *Averrhoa carambola,* mango, coconuts, *Carica papaya, Annona muricata, Capsicum frutescens, Bixa orellana, Citrus* spp., *Jatropha integerrima, Cycas circinalis, Plumeria rubra, P. obtusifolia, Araucaria excelsa* and *Dracaena marginata* are found in many houselots. *Piper betle, Areca catechu, Citrus mitis,* and *Muntingia calabura* are common trees found in many Palauan households (McCutcheon 1981).

## Wetland Taro Cultivation

Throughout the Pacific, taro, particularly *Colocasia esculenta* and *Cyrtosperma chamissonis,* are important staple and ritual foods. In the Micronesian islands, *Colocasia esculenta* is the favored aroid in Palau (McCutcheon 1981, Kramer 1929, Sugiura 1942) and Pohnpei (Hunter-Anderson 1984), while *Cyrtosperma chamissonis* (*lak*) is preferred in Yap (Hunter-Anderson 1984) and Truk (Alex 1965).

In Micronesia, the bulk of taro production of *Colocasia esculenta* and *Cyrtosperma chamissonis* taros takes place in permanent to semi-permanent lowland patches. On the high islands, the favored areas for the wetland cultivation of taro are the freshwater swamps and marshes located inland of the mangroves, and the alluvial bottomlands. Areas selected for planting are cleared of vegetation and drained. The soil is then dug up, and various leaves, twigs, and seagrasses are added as a mulch to increase soil fertility (OTA 1987). In Palau, the leaves of *Wedelia biflora, Carica papaya,* and *Macaranga* sp. are favored fertility enriching species (Sugiura 1942). The patch is then worked to produce a fertile muck of desired consistency, and planted with cormels or corm tops. Harvesting occurs six months or later, depending on the species *(Colocasia esculenta* or *Cyrtosperma chamissonis)* and varieties planted, and the purposes for which the taro was planted. For example, some varieties of *Cyrtosperma chamissonis* are grown for prestige and ritual presentations, and may remain in the patch for 10 years or more. In the main, however, *Cyrtosperma* taro is grown for consumption, and harvested within a few years of planting. The patch is almost immediately replanted, but allowed to lie fallow for a number of years if taro yield and quality was poor. Often certain tree species (for example, *Hibiscus tiliaceus* in Pohnpei and Puluwat Atoll) are left standing so as to provide shade for the young taro.

In the atolls, by contrast, both *Colocasia* and *Cyrtosperma* taros are planted in pits located near the centers of the larger islets where the hydrostatic freshwater lens is the thickest, the water is low in salinity, and the possibility of wind-driven salt spray and water contamination from storm waves is low. On Kapingamarangi Atoll, the taro pits are found on islets greater than 3.8 ha in size (Wiens 1962), and are absent on the smaller islets as the freshwater lens is poorly developed or absent. On these islets, coconuts and breadfruit are the principal tree food crops. In Kiribati, *Cyrtosperma* is planted in "bottomless basket" made from Pandanus or coconut leaves, and covered with layers of chopped leaves and soil (Lambert 1982). Preferred compost leaves are *Guettarda speciosa, Tournefortia argentea, Artocarpus altilis, Boerhaevia* sp., *Wedelia biflora, Triumfetta procumbens, Cordia subcordata, Hibiscus tiliaceus,* and *Sida fallax.* The *Cyrtosperma* is composted with leaves at least four times a year until it is harvested two to three years after planting.

The taro pits are of variable size. In the Marshall Islands and Ulithi Atoll, many of the pits are small and less than 100 $m^2$, while in Kiribati, they are approximately 20 m x 10 m and 2 to 3 m deep (Lambert 1982). In Mwoakilloa, Kapingamarangi, Nukuoro (Wiens 1962), Losap and Puluwat (Manner 1989), they are, several hectares in size, the result of continued excavation and coalescence over time.

On Puluwat Atoll, *Colocasia* and *Cyrtosperma* taro are also planted on oval mounds which have been built in the excavated depressions. These mounds, which stand about 0.5 m above the water table and measure about 50 $m^2$ in area, are made by anchoring coconut and pandanus trunks to form an oval base which is then filled with organic materials (Manner 1989). Plaited coconut fronds and carefully layered coconut husks are also used to keep the mound from eroding. In addition to taro, sugar cane, ornamental and other food plants (for example, *Ipomoea aquatica* and bananas) are grown on these mounds. In Kapingamarangi, limes, breadfruit, bananas, papayas, *Tacca leontopetaloides,* and other cultivated plants are grown in association with *Cyrtosperma* taro (Wiens 1962). Wiens (1964) noted that *Cyrtosperma* planted near the pit edges and in the shade of the trees were taller and more vigorous, while those planted in the middle of the taro field were smaller and yellowish brown.

Fallowing and mulching of the mounds and pits are common agroforestry practices. On Losap Atoll, the *Cyrtosperma* pits are alternately mulched with a layer of coconut fronds and *Digitaria violescens.* On Namoluk Atoll, the leaves of Wedelia biflora was used as a mulch for *Colocasia* taro (Marshall 1975). On Puluwat, fallowed and cultivated mounds were repaired with fresh organic litter and organic soils sieved from the water.

On Ulithi Atoll, *Cyrtosperma* and *Colocasia* taro are also grown hydroponically in abandoned landing barges, metal and concrete tanks, the latter measuring 2.64 m x 6.1 m x 0.8 m (l x w x h), and 0.1 min thickness. Little is known about these systems.

Agricultural mounds and terraces were also cultivated for long periods of time in the Micronesian high islands. In Pohnpei, earthen mounds and hillside terraces, with or without stone facing, are used to grow bananas, coconuts, *Piper methysticum* and *Alocasia macrorrhiza* (Hunter-Anderson 1987).

## Discussion and Conclusion

This review demonstrates that Micronesians developed a range of agroforestry systems capable of sustainable food production in widely differing ecosystems on high and low islands. Polyculture and the cultivar diversity (which minimized the impacts of seasonality and varietal failure) in the mixed agroforest, wetland taro fields, intermittent tree gardening, and the kitchen garden provided the islanders with a variety and perhaps surplus of foods throughout the year. Except in too few cases (for example, Bayliss-Smith 1982, and Raynor 1989), these systems have been incompletely studied. Little is known of the productivity of these systems, their contribution to the subsistence (and commercial) economies of the islands, and the structure (for example, species composition) and functioning (productivity, mineral transfers, successional dynamics) of these systems. Although these systems have been classified as sustainable, energetically efficient, and conservative of environments, there is little quantitative proof for these assertions.

The significance and practice of agroforestry in Micronesia is constantly changing. During the 19th century, the introduction of the copra and coconut oil trade resulted in the clearance of natural vegetation and agroforests for coconut plantations, and with the replacement of the subsistence economy by cash, the availability of trade goods, rice and flour, and depopulation of the atolls, taro patches were abandoned or converted to coconut plantations on many atolls and islands (Doty 1954, Hatheway 1953). World War lI also changed the value of agroforestry as labor migrated to wage employment opportunities, a process that continues to this day as migration from small to large islands and even larger continents is a viable alternative to remaining at home (Connell and Roy 1989).

Pohnpei is home to communities of atoll islanders from Kapingamarangi, Ngatik, Mortlocks, Pingalap, and Mwoakilloa. While it has been suggested that migration has economic and social consequences for the migrants who have formed new communities, and those who remained behind, there are few empirical studies on the impacts of migration on the agroforestry systems of these atolls, Pohnpei, and the other large islands of Micronesia. A few questions may be useful at this point, in setting an appropriate research agenda. For example, as migration is male-dominated, is the agricultural burden on atoll women or an aging atoll population increased? To what extent is the loss of traditional skills and knowledge in agroforestry attributable to migration? Or, how has the flow of remittances and the easier access of tinned and other foods affected the productivity of agroforestry systems? Needless to say, the agroforestry systems of the above atoll communities on Pohnpei and elsewhere are largely unknown.

The processes of change are also evident in the wetland taro patches of the high islands of Micronesia, where there is less wetland taro cultivation today than in the past (Hunter-Anderson 1984). In Palau, most, if not all, *Colocasia* taro was formerly grown in wetland patches. Today most taros are planted in the intermittent tree gardens *(dechel)* (McCutcheon 1981), and the abandonment of wetland taro cultivation has also been reported for Moen, Truk by Hunter-Anderson (1987). Reasons for the abandonment of wetland taro include the higher labor and time costs of production, altered consumption patterns (in particular, the increasing dependence on imported starches), typhoon and pest damage to taro, government encouragement of cassava and sweet potatoes production to alleviate the shortage of *Colocasia* (McCutcheon 1981), the time and labor constraints associated with an urban lifestyle (Hunter-Anderson 1984)), and the attracttiveness of modernization.

For Guam and the Commonwealth of the Northern Marianas, traditional agroforestry seems to be restricted to the kitchen or backyard garden. For the rest of Micronesia, it is still the most important, sustainable land use option. Hopefully, ADAP's interest in sustainable agriculture will provide the impetus for further research and education in agroforestry, as the agroforestry systems of Micronesia are indeed, sustainable. The agroforestry systems of the atolls are a case in point. Despite the poorly developed and often brackish ground-water resources, susceptibility to drought, hurricanes, and salt spray, infertile soils, and limited land area and plant resources, atoll agroforestry (and the exploitation of marine resources) have sustained atoll dwellers for millennia. We can only learn from studying it.

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