Micronesian Agroforestry: Evidence from the Past, Implications for the Future[1]

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Abstract: Traditional agroforest systems exist throughout Micronesia. The system found on one Micronesian group of islands, Yap, is described and evaluated in ecological terms. Implications for future development of agriculture in Micronesia are discussed and some specific recommendations are given.

Agroforestry has been defined as a deliberate association of trees or shrubs with crops and/or pastures on the same piece of land in time or space with a significant interaction (Borel 1988). Discussions of agroforestry systems also often refer to their sustainability and adaptability to the local environment and local cultures. The ecological parameters of an area shapes the types of agroecosystems that develop. In a study of agroforestry systems in major ecologic zones of the tropics and subtropics, Nair (1987) found the greatest concentration and diversity in humid lowlands. Most areas of Micronesia are humid lowlands and the native vegetation of most of the area was forest (Fosberg 1960). Thus we may expect a natural tendency for Micronesian agroecosystems to develop towards a forest physiognomy.

Micronesian Agroforests

In designing a vegetation classification to be used in mapping major vegetation types in Micronesia, it was apparent that some areas of forest were actually tree gardens and should be classified as "agroforest." The resulting vegetation maps (Cole and others 1988; Falanruw and others 1987 a, b; MacLean and others 1986; Whitesell and others 1986) showed some 20,700 hectares of this vegetation type in the mapped Caroline high islands. The nature of agricultural and . agroforestry systems present on islands of Micronesia varies with local conditions. Except for a thin border of strand vegetation, most of the vegetation of atolls consists of a mix of agroforest and atoll forest trees. Much of the four mapped high islands of Chuuk are covered with coconut/breadfruit agroforest. Considerable acreage on Pohnpei has been mapped as agroforest and a diverse integrated system is found on the high islands of Yap (Falanruw 1985). Raynor (1989) describes structure, production, and seasonality of agroforestry systems in Pohnpei. The farms he surveyed were from 2 to well over 100 years old, having been established mainly on land parcels distributed during the German administration of the island, and many are in the process of being developed. The traditional land tenure system of Yap has not been greatly altered by foreign administrations, and Yap's agroecosystems appear to have been in place for many generations. While ownership has changed within successive generations of families, the systems have remained in place and individual estates today include parcels of land in different ecological zones (Lingenfelter 1975). This condition results in integrated zones of agricultural/agroforestry systems made up of separately owned plots. A general description of these systems summarized from Falanruw (1985 & 1990) is given below.

A Micronesian Agroforestry System

Yap is a tropical island with a mean temperature of 81°F with average monthly temperatures varying but 2°F. Lying near the intertropical convergence zone, the island's rainfall pattern is irregular. Some years follow a monsoon pattern of spring drought followed by torrential rainfall in summer and fall. In other years, rain is dispersed more evenly throughout the year. The mean annual rainfall for the period 1949-1980 was 3028 nun. These climatic conditions present classical problems of how to use tropical soils without exposing them to erosion and nutrient depletion. As a high island, Yap provides for the collection of rainfall and the flow of water from uplands to lowlands and then into the sea. This has resulted in a series of natural habitat zones where rainfall is buffered and sediments and nutrients carried with fresh water runoff are filtered out in a series of biotic communities successively less tolerant of siltation (Falanruw 1981). The early inhabitants of Yap modified the islands into an anthropocentric food production system incorporating taro patches, tree gardens, mixed multi-layered gardens alternated with secondary tree cover and some open canopy agriculture without greatly changing the watershed system of the island. Tree gardens function like natural forests and taro patches function as silt traps.

Tree Gardens and Taro Patches

The most stable of Yap's food production systems are tree gardens and taro patch systems which generally occur about villages, mostly in coastal areas. Human activities in developing villages, gardens and paths between villages appear to have involved the deepening of low areas to obtain fill for house sites, raised gardens and paths. Useful trees were planted in the raised and drained areas along village paths and around home sites. These "home tree gardens" became confluent to form the agroforests of today. Preliminary results of ongoing studies have identified some 55 species of trees producing food or spice products. Commonly associated with these trees are another 62 species of useful shrubs and herbs. Other species are present growing wild or allowed to grow for uses or reasons not yet recorded. Such tree gardens provide food and other products

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while functioning like natural forests in intercepting rainfall and holding the soil.

Low areas were planted to *Cyrtosperma chamissonis* (Schott) Merr., the giant swamp "taro." Light is managed and water flow within and through taro patches is regulated to maintain a suitable growing media. *C. chamissonis* requires about 3 years to reach a good size, but it may be left to grow longer. Sucker corms are generally replanted at the time that the main corm is harvested. Some plants are left to grow especially large for presentation on special occasions. Taro patches are almost always fully stocked, thus there is minimal exposure of taro patch soils to erosive forces.

The culture of "true taro," *Colocasia esculenta,* is also important. When planted in taro pits, this crop is more seasonal, requiring initial preparation of the taro patch during the dryer part of the year. Culture is more intensive, and may include ditching, the working in of green manures and mounding of soil about the developing corms, which mature earlier than C. *chamissonis* but cannot be left in the ground indefinitely. In deep taro pits, or in areas with little soil, raised beds developed within "retaining walls" of woven coconut fronds may be used. *Colocasia* is also grown in mixed garden situations. So important are taro patches that the land tenure system provides for ownership of taro patches in areas which may be removed from the main estate. As a result, taro patch habitat is often divided into segments managed by different owners.

Intermittent Mixed Gardens In Forested Areas

Inland of villages, gardens are alternated with wild forest and bamboo cover. The species composition and production of these gardens is being evaluated in an ongoing study. The development of these gardens involves the burning of slash around tree trunks during the dry season to open a "skylight" in the forest. In addition to admitting light, this results in a fall of leaf mulch and removal of root interference with crops. Ashes contribute to soil fertility. Larger branches and stems that are not burnt are piled around the perimeter of the garden or across it. The burnt girdled trees are left standing to serve as trellises for yam vines.

Over 15 crops are commonly grown in today's mixed gardens. Cucurbits planted in ash soon after the burn grow especially fast. By the time the heavy rains come, a ground cover has generally become established. The fast growing herbaceous crops help to suppress weeds. Weeds in gardens made in forested areas are generally tree seedlings. Unless they interfere with crops, they are initially left growing as they help to suppress more noxious weeds and can be used as mulch at a later time. The crop species composition changes through the gardening cycle as harvesting is accompanied by a sequence of replanting.

No inputs are needed other than the biological inputs of the site, human labor, and planting material. Technology consists of a knife, matches, digging bar, and the gardener's experience. For about 19 person days of labor plus harvesting time, one gardener harvested 2,122 pounds of carbohydrate produce in 1 year. In addition, from about the second month on, greens of limited weight but considerable nutritional significance for her family of 7 were gathered daily to weekly.

A variety of *Dioscorea* yams planted at the end of one dry season are harvested about the next dry season. Some may be left to grow one or more additional years. If there is need, the gardener generally begins to prepare the next year's yam garden about this time. In this way, planting material from one garden will be recycled into the next, and the harvest from a first year garden is complimented by the harvest of longer term crops such as bananas from second and third year gardens.

Gardens are visited less frequently as less is harvested and they become more weedy. Nowadays at least, a common reason given for abandoning a garden is the work involved in weeding. The introduction of noxious weeds such as *Mimosa invisa* Mart. and *Eupatorium odoratum L.* is causing considerable problems. Species which grow up in abandoned gardens include trees which were cut and left to coppice, seedlings which were left growing and others sprouting from seed imported by birds and fruit bats from the nearby forest. Sometimes cuttings of *Hibiscus tiliaceus* are planted around the perimeter of raised garden beds to hold these banks and contribute to the fallowing process.

Once gardens are no longer maintained, a canopy of fast-growing species is established within 2 to 3 years. In 9 gardens observed over the last 2 years, the species composition of the secondary vegetation varied somewhat by site but includes a predictable set of species in common. A much longer period appears to be required for the development of a mature species-diverse forest, and the system results in a loss of primary forest species when the fallow period is shortened.

Scientists believe that too frequent burning of the forest canopy resulting in soil degradation led to the spread of the savanna grassland vegetation type (Fosberg 1960; Clarke 1971; Manner 1981 a, b). When questioned about the origin of the savanna, contemporary elders merely reply that it has always been thus, so if the area was once forested it was long ago. It seems likely that it was during times of high population in prehistoric times, land was cleared too often to allow for the re-establishment of forest canopy.

The inhibition of the formation of a forest canopy would result in decreased transpiration and percolation of rainfall into the soil. This increases the need for water management. Evidence of water management is abundant. Ditch drained garden beds can be found in many areas of Yap currently covered with forests, secondary vegetation, and savanna grassland. The presence of these beds is obscured by taller vegetation but in the savanna grasslands they can be identified on aerial photographs in some 23 percent of the area covered with this vegetation type.

Open Canopy Agriculture

Today at least, drained beds in savanna grasslands, mostly established at a time before contemporary elders can recall, are used mainly to grow sweet potatoes. Within each rectangular bed are often a series of ditches running perpendicular to the long axis of the garden. These ditches are closed at either end. They are said to drain water from the planted beds and, being closed at either end, also provide a reservoir of water to "cool the soil" and maintain moisture. When beds are prepared, tall grasses and other growth are first cut and left on site. Additional slash from surrounding areas may be added. Soil is then thrown on top of this mulch to cover it and prevent it from growing. The soil used to cover the mulch is evacuated from the ditches surrounding and within the bed. Thus, soil runoff from previous years is replaced on top of the gardens. Clumps of clay soil from the bottom of the ditches is sometimes piled around the perimeter of the garden bed to reduce erosion. When the "water reservoir ditches" within the beds become too deep or reach a zone of clay soil not suitable for use on the garden bed, they are filled with grass and soil and another ditch is prepared parallel to the old one. Sweet potato vines are planted in the beds and grow rapidly to further shade out grass.

The work involved in making such sweet potato gardens is more arduous than forest gardening, the harvest is less diverse, sweet potatoes are not as favored as yams, and they are increaseingly subject to pest and disease problems. Thus we may expect a decline in such gardening in favor of forest gardening.

Pros and Cons of the Traditional/Indigenous System

The traditional Yapese agricultural system provides an example of ecological adaptation. Rather than rearranging the environment and applying large inputs of energy, water, fertilizers, and other chemicals, it makes use of microhabitat and utilizes natural processes. I thus characterize it as "nature intensive" to contrast it with other major agricultural systems which are labor intensive or energy, chemical, and capital intensive.

The natural flow of water, and nutrients carried with this water are utilized. The tree canopy is manipulated first to provide sunlight for crops and biomass which is converted to ash fertilizer, and later to buffer rainfall and shade out weeds. The system is highly efficient in terms of human energy and requires no other input of energy from fossil fuels. Like a natural tropical forest, it is diverse and structurally complex, factors that result in resilience to perturbations, and thus stability in the long run. Despite irregularities in the weather, the system provides major staples throughout the year, the seasonal production of yams being counterpoint to the breadfruit season, with giant swamp taro providing a back-up throughout the year. Variety is provided by the mixture of tree crops and the mix of species grown in the intermittent gardens. The tree gardens provide long-term stability, and the mixed intermittent gardens provide a means to take advantage of seasonal conditions of drought and rainfall.

Finally, the traditional system of agriculture/agroforestry was integral to the culture. Micronesian cultures were adaptive to environmental conditions (Falanruw 1968, Fosberg 1987). Local conditions have changed however. Infusions of aid, goods, energy, and technology have made it possible to forestall the consequences of ignoring the basic rules of caloric self-sufficiency and sustainability of lifestyle so that anthropocentric indicators of the islands' limitations are now lacking. Scientists' recognition of the value of many traditional practices is coming at a time when there is a rush for development based on the Western development formula of applying lots of money, energy, strong chemicals, and powerful technology. The changes which are possible via the application of these resources are fast, spectacular, and so attractive that they lead people to disparage their own resources, technologies, and traditions of production. It is ironic that "nature intensive" systems of agriculture/agroforestry are today eroding as a result of development efforts based on applications of western science and economics which produced many of the problems that today's ecologists and planners are trying to alleviate and avoid.

Micronesia's population is increasing rapidly and after a long period of financial support from the United States, the end of the trusteeship period has brought increased need for exports to earn foreign exchange for this new island nation. This is placing increased and new demands on land, and this will eventually impact the traditional agricultural system which requires ample area and a long fallow period in order to be sustained. Modem development efforts generally begin with the bulldozing of land and result in considerable erosion and siltation of taro patches, mangroves, seagrass beds and marine life within the lagoon.

It is clear that there are problems with indigenous agriculture/agroforestry systems. Alternatives, however, are not clear. Despite considerable subsidy for agricultural "development," there have been few successful Western-type agricultural projects in Micronesia. This situation applies elsewhere in the humid tropics as well. Vermeer (1973) questions whether western systems of agriculture have been successful anywhere in the humid tropics. Industrial agriculture is known to be energy inefficient. For example, the efficiency ratio of highly industrialized corn production in the United States was 3.7 in 1945 and but 2.8 in 1970 (Pimental and others 1973). When the energy costs of the entire food system of the United States (including farm inputs, processing, transportation, and preparation) were calculated (Pimentaland others 1973, Clarke 1978), it was found to be-10, that is, it takes an average of 10 units of energy to put 1 unit of food energy on the table!

Mechanized agriculture cannot be used on steep slopes without great risks of soil erosion, and much of Micronesia is sloping land. Though mechanized agriculture reduces the direct human labor input per yield, it is energy inefficient, increases unemployment of farm personnel, and contributes to the depletion of soils, and other renewable and nonrenewable resources. It also increases pollution and disruption of natural habitat. If such hi-tech, energy inefficient agricultural technology could be transferred to Micronesia, it would require a subsidy that would be difficult to sustain.

Towards a Pacific Alternative

For nature-intensive-technology to work, a healthy natural system is needed. Odum (1972) suggests that it is necessary to leave about 40 percent of natural resources undeveloped in order to maintain a healthy natural system. "Critical" natural habitat—that which is essential to the functioning of the system—must be protected. In Micronesia, this effort is just beginning.

In a nature intensive system to work, people also need to be aware of natural processes. For Micronesians this was once a necessity. Today there are a growing number of distractions such as television and the schedule of the Government work day and fiscal year that take people's time and attention away from natural phenomena and food producing systems. Inasmuch as the agricultural revolution was brought about by farmers, not scientists (Richards 1986), it follows that the "agroecological revolution" required to alleviate many of today's environmental problems must draw upon existing examples of traditional agroecosystems. It thus behooves us to study, understand and build upon the systems of agriculture/agroforestry which have developed under Micronesians conditions.

Some of the steps which will help build upon existing systems in Yap are:

1. Tend existing systems. There is a need for "traditional technology transfer" to teach the younger generation "how." Given the great proportion of youth to adults, there is a tendency to remove knowledgeable adult women from the system to serve as baby sitters. In time their knowledge and experience will be lost.

2. Invest in the training of local personnel in ecological concepts so that the environmental costs of both traditional and modem technology will be recognized and taken into consideration in development efforts.

3. Address the "why" of traditional agroforestry in order to discover principles which may be used to extend the system.

4. Given limited forest resources and the importance of maintaining biodiversity and the ecological services provided by forests, it is important to reduce the area of forest that is converted to agriculture. This could be done by reducing the number of plots opened in shifting cycles by decreasing the time required for fallow. This could involve such measures as leaving seed trees, maintaining functional populations of agents of seed dispersal such as birds and fruit bats, alleviating erosion, and removing support for converting forest areas to agriculture.

5. Research on enhancing fallow periods such as with fast growing nitrogen fixing species is needed. For example, indigoenous people in Papua New Guinea and Java recognize that *Albizia falcataria, (Paraserianthes falcataria),* contributes to soil fertility (Clarke 1971, Stoney pers. comm.). This species grows well in Micronesia, but as it is not native, its impact on the native forest system of Micronesia should be evaluated first.

6. Research and trials on management of weed species. If weeds were easier to manage, gardens could be used for longer periods. This effort should be combined with efforts to prevent the entry of noxious weeds and to control noxious weeds such as the recently introduced *Mimosa invisa* and *Eupatorium odoratum.*

7. Native forests should be inventoried and critical areas protected.

8. Degraded savanna grasslands need to be revitalized.

9. Enrich the traditional system with additional adaptive elements and species such as *Hibiscus manihot.*

10. Evaluate the contributions of indigenous agriculture. The lack of support for the development of indigenous agroforestry systems may be due to lack of recognition of their contribution. The valuation of the products of traditional systems may result in more support for their development.

11. Support participatory research and access of field workers to laboratory facilities and technical expertise for soils and other tests.

12. Traditional agriculture/agroforestry, or any food production system cannot remain sustainable if the human population becomes too dense. Family planning is a must!

References

Borel, R. 1988. Agroforestry course, CATIE, Costa Rica.

Clarke, W.A. 1971. People and place: An ecology of a New Guinean community. Berkeley: University of California Press.

Clarke, W.A. 1978. Progressing with the past: Environmentally sustainable modifications to traditional agricultural systems. In: Fisk, E.K., ed. The adaptation of traditional agriculture: Socioeconomic problems of urbanization. Monograph No. 11. Development Studies Centre, Australian National University, Canberra. pp. 142-157.

Cole, T. G.; Falanruw, M. C.; MacLean, C. D.; Whitesell, C. D.; Ambacher, A. H. 1987. Vegetation survey of the republic of Palau. Resource Bulletin PSW-22. Berkeley, CA: Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture; 13 p. + 17 maps.

Falanruw, M.V.C. 1968. Conservation in Micronesia. Atoll Research Bulletin 148:18-20.

Falanruw, M.V.C. 1981. Marine environment impacts of land-based activities in the Trust Territory of the Pacific Islands. In: Marine and Coastal Processes in the Pacific: Ecological Aspects of Coastal Zone Management, UNESCO Technical Papers in Marine Science, Paris; 19-47.

Falanruw, M.V.C. 1985. The traditional food production system of Yap Islands. A paper presented at the First International Workshop on Tropical Homegardens, Bandung, Indonesia, Dec. 2-9,1985.

Falanruw, M.V.C.; Whitesell, C.; Cole, T.; MacLean, C.; Ambacher, A. 1987. Vegetation survey of Yap, Federated States of Micronesia. Resource Bulletin PSW-21. Berkeley, CA: Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture; 9 p. + 4 maps.

Falanruw, M.V.C.; Cole, T.; Ambacher, A.; McDuffie, K.; Maka, J. 1987. Vegetation survey of Moen, Dublon, Fefan and Eten, State of Truk, Federated States of Micronesia. Resource Bulletin PSW-20. Berkeley, CA: Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture; 6 p. + 3 maps.

Falanruw, M.V.C. 1990. Traditional adaptation to natural processes of erosion and sedimentation on Yap island, In: Zeimer, R.R.; O'Loughlin, C.L.; Hamilton, L.S., eds. Proceedings of a Symposium on Research Needs and Applications to Reduce Sedimentation in Tropical Steeplands, Fiji.

Fosberg, F.R. 1960. The vegetation of Micronesia. Bulletin of the American Museum of Natural History 119(1):1-75.

Fosberg, F.R. 1987. Commencement address, University of Guam.

Lingenfelter, S.G. 1975. Yap: Political leadership and culture change in an Island Society. Honolulu: Univ. of Hawaii Press.

MacLean, C.; Cole, T.; Whitesell, C.; Ambacher, A.; Falanruw, M. 1986. Vegetation survey of Pohnpei, Federated States of Micronesia. Resource Bulletin PSW-18. Berkeley, CA: Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture; 9 p. + 11 maps.

Manner, H. 1981 a. Ecological succession in new and old swiddens of montane Papua New Guinea, Human Ecology, Vol. 9(3).

Manner, H.; Lang, H. 1981b. A qualitative analysis of the induced grasslands of the Bismark mountains, Papua New Guinea.

Nair, P.K.R. 1987. Agroforestry systems in major ecological zones of the tropics and subtropics. ICRAF Working Paper No. 47, ICRAF, Nairobi.

Odum, E.P. 1972. Ecosystem theory in relation to man. In: J.A. Weins, ed. Ecosystem Structure and Function. Corvallis, OR: Oregon State University Press.

Pimental and others. 1973. Food production and the energy crises. Science Vol.182:443-9.

Raynor, W. 1989. Structure, production, and seasonality in an indigenous Pacific agroforestry system; a case study on Pohnpei, FSM. Unpublished M.A. thesis, University of Hawaii, HI.

Richards, P. 1986. The indigenous agricultural revolution: Ecology and food production in West Africa. University of California Press.

Stoney, C. 1990. Personal communication, Java Social Forestry Project.

Vermeer, D.E. 1973. Peasant agriculture: problems and prospects in the 21st century. Papers presented at a special session, Assoc. Amer. Geographers, Ann. Meeting, Atlanta, GA.

Whitesell, C.; MacLean, C.; Falanruw, M.; Cole, T.; Ambacher, A. 1986. Vegetation survey of Kosrae, Federated States of Micronesia. Resource Bulletin PSW-17. Berkeley, CA: Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture; 8 p. + map.