TAKING OVER WHAT BELONGS TO GOD: THE HISTORICAL ECOLOGY OF TONGA SINCE EUROPEAN CONTACT

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The New Zealand–sponsored banana export scheme of the 1960s and 1970s marked the first invasive agricultural techniques introduced in Tonga since its initial colonization. The scheme resulted in clear-cutting acres of old forest trees, tractor tillage, and fertilizer and pesticide application not previously known in the kingdom. After banana production ceased, introduced plant viruses remained, part of the hidden cost of doing business. The recent growing of squash for the Japanese market affords quick returns on farmers' labor investments and on the costs of intensive tractor tillage and costly chemical inputs. The monocropping of squash also results in desiccation, and compaction and acidification of soils; tractor tillage prevents the regrowth of deciduous trees, creates soil hardpans, and favors the infiltration of guinea grass in fallow fields. This article presents oral histories of Tongan farmers that document the replacement of sustainable agroforestry with farm-as-factory models of market-crop production.

Now, the act of a society remodeling the soil upon which it lives in accordance with its needs is, as anyone recognizes instinctively, an eminently historical event.

—Marc Bloch (1953:25)

The colonization of the oceanic Pacific is regarded as one of the most remarkable accomplishments of humanity, and archaeological research has made great strides in documenting the process and the ecological consequences of that colonization. Islands are characterized by a relative lack of biological diversity and great spatial isolation. They therefore are seen as

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fragile environments where ecological recovery from environmental damage may be protracted or impossible. Such environments would challenge the finest of agriculturalists bent on security of production. Yet, security of production over the long haul, without industrial inputs, is exactly what Polynesian farmers accomplished. The arrival of Europeans and the associated political-economic changes ushered in significant changes in land management. It is these historical changes, which are not well documented in the anthropological or geographical record of the Pacific Islands, that may represent the greatest alteration of topography, loss of biodiversity, and erosion of self-sufficiency since the initial colonization of the islands. This article presents the trends in land management in the Kingdom of Tonga since European contact.

A recent meeting of the Seventeenth Pacific Science Congress resulted in an edited volume that documents current archaeological understanding of the effects of human colonization of small and isolated land masses in the Pacific (Kirch and Hunt 1997). Kirch and Hunt's volume and other archaeological investigations in Oceania have gone a long way toward explicating the ecological disruptions that resulted from the transformation of islands from previously undisturbed natural environments into anthropocentric landscapes (see Steadman 1995; Steadman, Pahlavan, and Kirch 1990; Dye and Steadman 1990; Yen and Mummery 1990). While the original colonizers of the Pacific clearly had significant effects on the topography and biology (especially the bird life) of the islands they colonized, the islanders imported and rapidly established agroforestry systems that remained productive for as long as 2,500 years. These agroforestry systems represent impressively sustainable production systems despite the ecological attenuation of small oceanic islands and the destructive effects of colonization.

By the time the early Polynesians arrived in Tonga, they and their ancestors may have existed in oceanic environments for 7,000 years. Contemporary theories of the colonization of the Pacific describe a relatively rapid immigration of peoples from island Southeast Asia to the Bismarck Archipelago, where they incorporated aspects of indigenous Melanesian culture (including aspects of an independently developed Melanesian agroforestry) into their own distinctive Polynesian cultural and agricultural portmanteau (Yen 1990:265). At about 3000 B.P. there was a very rapid movement of people from the Bismarck Archipelago to Tonga and Samoa (Kirch 1997:17), which included the importation of some seventy-two species of edible and economically useful plants (Cox and Banack 1991:44–45). The colonists had developed an impressive cumulative knowledge of agroecology, and their skill at cultivation in circumscribed environments was considerable. The Tonga Islands, with their fertile soils, offered a particularly rich environment

for agriculture, and with some success, security of production over the long haul is exactly what many colonizers of Tonga managed to create.

The settlers brought with them what proved to be a very sustainable agroforestry, conditioned on some understanding of the productive limits of the environment. Population growth is presumed to have been maintained at small fluctuations around some optimum for a long time (Kirch 1984), and the reports of early European explorers depict well-maintained gardens and a highly productive agriculture. Whatever else these Polynesian farmers were doing, they seemed to be maintaining the productive capabilities demanded by social relations and necessary for surviving inevitable periods of scarcity. Polynesian farmers were extraordinarily skilled at imposing constancy of agricultural production on ecological systems more generally characterized by chaotic disruptions than by homeostasis.

Characterizations of indigenous islanders as guardians of nature have significant political ramifications (see Kirch 1997:19; Spriggs 1997:101–102; Trask 1993), but a clear conservation ethic was not evident among the Tongan farmers with whom I stayed for fifteen months between 1991 and 1993, and I found no evidence of nature or of agricultural production being closely linked to any religious beliefs. Moana, the volatile and unpredictable goddess of the deep ocean, had no terrestrial correlates. What Tongan smallholders are sustaining is duty and obligation, and agricultural resources are little more than a means of meeting these ends. The sustainable agricultural practices in the past may have been due to limits in population and technology as well as farmers' realization of the limits of the terrestrial environment. Environmental limits are less clear now with the availability of industrial inputs, and economic alternatives have enhanced smallholders' abilities to supply family needs and meet obligations to church, family, and state.

The agricultural system introduced by the first Tongan settlers was characterized by limited tillage, high cultivar diversity, intercropping and multicropping, the conservation of botanical diversity in the agricultural context, and the maintenance of rich soil. This regime contrasts in technique and in production with introduced banana and, more recently, squash cultivation for the external market, both of which require extensive tillage, monocrop production, and the addition of external inputs of pesticides, mildewcides, and fertilizers to produce a small variety of market crops that provide fast and potentially significant financial returns for smallholder agriculturalists. These two types of agriculture are the extremes of what is still a highly diverse agricultural system in Tonga, and the management techniques of farmers in the area of Nukunuku village on Tongatapu represent differential integration of indigenous and introduced cultivars, different fallow regimes,

and a host of partial and complete reliance on all productive alternatives available to smallholders.

Changes in agricultural management have been associated with decreasing yields and loss of soil fertility as farmers respond to increasing population pressures and demands for market-crop production. These changes are particularly evident since the 1930s, when population exceeded precontact levels, and since World War II, when the Tongan government sought to diversify agricultural production and engaged in agricultural development schemes with the aid of New Zealand (Needs 1988).

Precontact Land Management

The Tongan agroforestry system that impressed the European explorers was the product of a long migration history and process of agricultural experimentation by oceanic nomads with an extensive knowledge of island natural history. There has been increasing evidence of the efficacy of pre-European agricultural systems. Yen notes that "survival of crop plants [brought by the colonists] after landfall would be comparatively easy on high tropical islands" (1990). Similar sentiments have been offered by Ferdon, who suggests that early Polynesians were as competent in their horticultural expertise as they were at navigation (1987:205). In their migrations, the early Polynesians were traveling through a well-known island environment despite the endemism of island plant life.

Kirch (1984), Barrau (1961, 1965), Bellwood (1979), and Yen (1990) have argued that all subsistence crops were brought to the islands by the initial colonizers. Of the seventy-two species of plants brought to the islands, at least two dozen species and numerous varieties of crop plants appear to have been used by Tongan farmers (Faʻanunu 1977). Some of the more important plants brought to the islands and cultivated before European contact are listed in Table 1. No count of cultivar diversity was noted by European explorers, but the bush-fallow agricultural system was known to include yams, taro, giant taro, plantains, and sweet potato. Early ethnographic accounts note the presence of 121 varieties of yams (Whitcombe 1930). Of these varieties, 114 were still recognized and named by Tongan farmers in 1975 (Faʻanunu 1977), along with eight varieties of the lesser yam and eight varieties of giant taro. There were ten easily recognized and perhaps another fifteen less well known varieties of sweet potato and eight varieties of taro.[1] Many other plant species were introduced into the indigenous ecology for medicinal uses, but the plants listed in Table 1 are those that are known to have formed a significant portion of the subsistence of the early settlers (Thaman 1976: 46–75). Some of these, *teve,* the wild yam (*Dioscorea bulbifera),* and the

TABLE 1. **Important Plant Species Introduced by Polynesian Colonizers**

Common Name	Scientific Name	Tongan Name
yam	*Dioscorea alata*	*ʻufi*
sweet yam	*Dioscorea esculenta*	*ʻufi lei*
yam	*Dioscorea bulbifera*	*hoi*
yam	*Dioscorea pentaphyla*	*lena*
giant taro	*Alocasia macrorrhiza*	*kape*
sweet potato	*Ipomoea batatas*	*kumala*
taro	*Colocasia esculenta*	*talo Tonga*
breadfruit	*Artocarpus altilis*	*mei*
plaintain	*Musa paradisiaca*	*hopa*
plaintain	*Musa acuminata*	*pata*
banana	*Musa saientum*	*siaine*
coconut	*Cocos nucifera*	*niu*
hibiscus	*Hibiscus manihot*	*pele*
sugarcane	*Saccharum officinarum*	*to*
kava	*Piper methysticum*	*kava*
cordyline	*Cordyline terminalis*	*si*
Pacific aroid	*Amorphophallus* sp.	*teve*
paper mulberry	*Broussonetia papyrifera*	*hiapo*
arrowroot	*Tacca leontopetaloides*	*mahoaʻa*
pomelo	*Citrus maxima*	*moli Tonga*
mango	*Magnifera indica*	*mango*
Tahitian chestnut	*Inocarpus edulis*	*ifi*
Pacific lychee	*Pometia pinnata*	*tava*
Polynesian plum	*Spondias dulcis*	*vi*
Malay apple	*Syzygium malaccense*	*fekika*
swamp taro	*Cyrtosperma chamissonis*	*via*
Indian mulberry	*Morinda citrifolia*	*nomu*

Source: Stevens 1996:316.

Pacific aroid, for example, were maintained in the agricultural allotments and were specifically reserved for use only during times of scarcity. The Tongan proverb *"Api faʻa toe tuʻu ai a ʻe teve"* means "In the farm continues the *teve*" and refers to the wisdom of continuously maintaining in the bush those plants used only during times of scarcity.

Other species, such as the candlenut tree *(tuitui, Aleurites moluccana),* were introduced because of their utility for purposes other than as food; the candlenut, as the name implies, was useful because of its oil. Some species of pandanus *(fa, Pandanus* spp.*)* were not only used for making mats, sidings for houses, and sails, but also produced an edible berry eaten at times of scarcity. *Vavae* trees (*Ceibapenttandra* Linn.) have silky seed-pod fibers used for

making bedding, and these large trees with light-colored trunks and branches were used to mark the boundaries and entrances to agricultural allotments. Lists and descriptions of indigenous and introduced species in Tonga are discussed in some detail by Thaman (1976, 1994), Clarke and Thaman (1993), Barrau (1961, 1965), and Kirch (1994).

Of the plants listed in Table 1, about ten had particular importance as subsistence crops, and some of these required significant agricultural knowledge for successful propagation and crop production. For some of these crops, particularly the yam, a great deal of indigenous agronomic knowledge and belief is associated with successful cultivation, and ceremonial significance is connected with its distribution and consumption. For that reason, there is significantly more information about the cultivation of yam than there is about the other staple crops in the Tongan inventory. Agricultural practices included, as well, a symmetry of gardening patterns still practiced by Tongan smallholder farmers, making their allotments pleasingly scenic and well ordered. Bananas and plantains, of which Anderson, Cook's botanist, noted eighteen varieties (Ferdon 1987:207), were planted in straight rows, each plant three paces from its neighbor, presenting a regular pattern of crop arrangement in which were similarly arranged giant taro and yam mounds (ibid.). This pattern was present for the planting of all crops except that the distances between plants was less for aroids, which were planted one pace apart.

The spaces between the rows of staple crops were occasionally filled by the *mahoa'a,* the Polynesian arrowroot (*Tacca leontopetaloides* [L.] Kuntz), and the plantations included *ifi* (Tahitian chestnut, *Inocarpus edulis,* J. R. and G. Forster), sugarcane, *si* (*Cordyline terminalis* [L.] Kuntz), breadfruit (*mei, Artocarpus altilis* [Parkinson]), and a host of other tree crops (shaddock, coconuts, Malay apple, Polynesian plum, lychee, kava) and nonedible but useful plants. Garden plots closer to the homesteads were filled with flowering plants, some of which may have had medicinal utility. Anderson observed huge monocropped groves of paper mulberry, coconut, kava, and bananas (cited in Ferdon 1987:209), and these may correspond to the large plantations grown for the higher chiefs by *fatongia* (duty or obligation), essentially corvée labor.

The agroforestry system in Tonga at European contact, and presumably before it, was clearly designed for agricultural production beyond that needed for immediate consumption, suggesting that "inherent" limits of the productive environment were not being reached. With maintained population limits and understood environmental limitations, the complex and highly productive system remained sustainable and self-sufficient well into the twentieth century. The pressure experienced by precontact Tongans to intensify pro-

duction was not demographic but social and environmental in origin. The evidence for Tonga suggests that population growth leveled off at some time, perhaps a millennium before European contact (Kirch 1984), and that population was not the primary spur to agricultural intensification as presented by Boserup (1965). The original Polynesian settlers to the islands were already socially stratified, and therefore population pressure alone was not the precipitating factor to hierarchical social organization in Tonga.

In average years, production in Tonga was adequate to feed the 30,000 or so Tongans scattered on 576.7 square kilometers of arable land on thirty or forty islands (fifty-two people per square kilometer). Bad years, where agricultural production fell and the taboos of the chiefly classes ushered in times of scarcity, may have amounted to population checks themselves. Uncharacteristic of intensive agricultural schemes generally, the fallow periods in Tongan agroforestry were longer (five years) than cultivation periods (three years) (Ferdon 1987). This property of Tongan agriculture and its particular form of high production and wide resource distribution may blur its classification as a type of intensive agriculture, but the activities associated with sustainable Tongan agroforestry through the middle of the twentieth century (multicropping, intensive preparation of planting material, limited tillage) are labor-intensive practices that are also associated with sustainable agricultural practices used by smallholders elsewhere (Netting 1993; Altieri 1995; Gleissman 1998).

The Nineteenth Century: Export Production and Smallholder Manumission

The nineteenth century in Tonga was characterized by a protracted civil war, the establishment of a monarchy patterned after the British parliamentary system, and the granting of rights to land to commoner males over sixteen years old. As Marcus notes, the Tongan Constitution established in 1875 was a "manifesto for a new world order in Tonga" (1978:515). Under this constitution, the majority of Tongans would be a landholding peasantry living under the statutory authority of a centralized government administration. This pattern differed dramatically from the decentralized social organization of a multitude of chiefs directing land management by heads of commoner families. The Constitution of 1875 detailed the rules of inheritance and succession and ultimately extended land entitlement to Tongan males, but it was the Act of 1882 that established the right of each Tongan male of tax-paying age to be granted a town allotment *('api kolo)* in order to build a house and an allotment for agriculture *('api 'uta* or *'api tukuhau)* of 8.25 acres. The constitution and the centralization of power in the Tupou line (the lineage of the

monarchy) simplified class relations into monarchy, nobility, *matapule,* and commoners in legal description. The number and variety of ranks and the associated authority and power they represented were reduced or eliminated in legal definition. Effective control over land was granted to the Crown, while effective tenure was given to commoners, and many chiefs, over time, lost their base of authority. These legal prescriptions allowed independent commoner land management, and, with increasing population, introduced technology, and monocrop market production in the mid-twentieth century, the stage was set for a categorically different trend in land management.

In the nineteenth century a number of crop plants were added to the list of introduced plant species, including cassava *(Manihot esculenta),* cocoyam *(Xanthosoma* sp.*),* papaw/papaya *(Carica papaya),* pineapple *(Ananas comosus),* peanuts *(Arachis hypogaea),* and a multitude of vegetables favored in the European diet (tomatoes, coffee, lettuce, cabbage, bell peppers, and so on) (Cook 1993; Sauer 1993; Thaman 1976). The only plants introduced by Captain Cook in Tonga that had any lasting influence were the pineapple and the watermelon, but less than sixty years after Cook, sometime during the violent period of civil war (1799–1852) that rewrote Tongan political organization, two substantial changes affected Tongan agroforestry: (1) the introduction of a number of plant crops including cassava, apparently around 1830, and the *Xanthosoma* taro and (2) the introduction of market sales of copra. The significance of the first event was not fully realized until perhaps as late as the mid-twentieth century, when population increases accompanied the replacement of taro and yams as staple crops with cassava and the slower replacement of *Colocasia* taro with *Xanthosoma esculenta,* the cocoyam taro of American origin.

The spread of cassava into the Pacific Ocean is not well known (Sauer 1993:61), but Fa'anunu has it introduced by the middle of the nineteenth century (1977:198). Van der Grijp (1993) has its introduction in Tonga at 1830, and Thaman (1985) says it was introduced into the Pacific for famine relief, presumably after the civil war (1799–1852). It has, in any case, become the major food crop in Tonga, relegating taro mostly to use for its greens. Tongan farmers recognize eight varieties of *manioke,* and it is, as it is in most places where it is grown, the last crop grown before returning a field to fallow.

Under optimal conditions, cassava can produce over thirty tons of fresh tubers per hectare per season, and when intercropped with beans, it produces as much as thirty-five tons per hectare (plus 2.9 tons of beans).[2] In the tropics, it can be planted at any time of the year and harvested over a long period of time, and it will produce a crop in soils too poor to grow other crops. Cassava's production of calories, at 250 kilocalories per hectare per

day (Thung and Cock 1978:7), is higher than for any other staple food crop (Toro-M. and Atlee 1980:13). It is, understandably, a popular crop among smallholder agriculturalists everywhere in the tropics. *M. esculenta* is best suited to wet and constantly hot lowland ecologies, but it has been found as far south as thirty degrees south latitude in the Americas, where it originated.

The cocoyam was also introduced in Tonga during the nineteenth century (Thaman 1976:51). It is grown entirely in dryland areas, where it can remain in the fields for many years without deteriorating. The leaves of the younger plants are favored for *lu,* greens used to wrap meats. There are five known varieties in Tonga. *Xanthosoma* is more drought and shade tolerant than *Colocasia* taro and is less susceptible to diseases as well. Thaman says that the *Xanthosoma* taro surpassed the *Colocasia* taro in importance by 1970 in many areas in the Pacific, including Tonga (1985:113). As with cassava, the ease with which the *Xanthosoma* taro can be cultivated—where the plant remains in the fields and productive for long periods and labor-intensive planting in waterlogged environments is not necessary for good production—has made the plant favored for daily consumption, but it is not a suitable crop for feasts.

The immediate impact of cocoyams and cassava on the land management of Tongan farmers is difficult to gauge. Cassava nutritionally offers little more than starch, unlike taro, which provides a host of minerals and plant proteins. But canned meat imports and the addition of horse and cattle provided desired meat in the diet and an efficient source of protein so that nutrient aspects of the crops were not influential in their adoption by Tongan farmers. My experience with farmers suggests that the ease with which cassava can be grown and the high returns the crop affords to minimal investments of labor (relative to yams, for example) have relegated yams to ceremonial food items, and they are no longer stored on allotments for long periods or eaten as daily staples. The cocoyam may have contributed to a decrease in farmer knowledge concerning *Colocasia* varieties and the characteristics of these varieties that allow their production in a wide range of environments. But the newer crops have helped increase yields per unit of land and per unit of labor in Tonga.

The introduction of these two cultivars augmented the productive capabilities of the farmer, and both cassava and cocoyams were easily incorporated into Tongan agroecology. These two crops allowed for intensification of production, where farmers could postpone returning a field to fallow and continue production on the same plot for an additional year. Cassava would still produce in weak soils and was easily cultivated and harvested (again, particularly compared to the yam). This practice clearly would contribute to soil fertility decline, but such forms of agricultural intensification were not

necessary until well into the twentieth century, within the recollection of the contemporary Tongan farmers, and the introduction of these crops initially enhanced the productive qualities of a complex cultural ecology. Tongan agroforestry remained sustainably managed probably well into the twentieth century, and, according to the oral histories of Nukunuku that I gathered, extensive changes marking Tongan commoners' introduction to the global market economy began in earnest with the arrival of American troops in the kingdom in 1939.

Some of the other crops that were introduced in the nineteenth century include guava, *kuava (Psidium guajava);* the soursop, *'apeli 'initia (Annona muricata);* avocado, *'avoca (Persea americana);* and a number of other fruit trees (peach, fig, macadamia nut, cocoa, and cashew) that were rare or absent during my surveys of town and agricultural allotments. Guava is ubiquitous, and, while the plant is considered a weed, the wood is used as skewers for roasting pigs and for building temporary structures since it retains its rigidity and strength when dried. Additionally, guava is one of the few hardwood species that can successfully compete with guinea grass *(Panicum maximum)* in fallow fields. It is, in fact, the most likely dominant plant species to succeed guinea grass in a fallow left for more than five years.

A host of vegetable crops more closely associated with the European palate include corn, *koane (Zea mays);* tomato, *temata (Lycopersicon esculentum);* chili pepper, *polo fifisi (Capsicum frutescens),* which is found on virtually all allotments and used frequently to spice the otherwise bland Tongan diet; and cabbage, *kapisi (Brassica oleracea).* Additionally, papaya, *lesi (Carica papaya);* peanut, *pinati (Arachis hypogaea);* and tobacco, *tapaka Tonga (Nicotiana fragrans)* were also early introductions and are used by Tongan households, although tobacco is now purchased and papaya is not widely favored but sometimes fed to pigs. The introduced agricultural changes in the nineteenth century appear to have resulted in a reworking of the agricultural system in a similar way that introduced ideas of political design changed Tonga's social organization. The agroforestry system was pointed in the direction of market exchange of copra and coconut oil, but the mandated increase in coconut trees and the harvesting of an abundant and renewable resource did not alter land management or environmental resources in any significant way until the second half of the twentieth century. Until then, the system still remained oriented toward production within known limitations of the resource base, and the diversity of cultivars and the fertility of the soil was maintained until after World War II. Cocoyams and cassava added to the flexibility and resilience of agroforestry, as did pineapple, papaya, and a number of fruit trees that were easily integrated into both managed production and managed fallow. This system would persist until market production

schemes based on a small number of artificially raised cultivars required expensive external inputs and extensive mechanical tillage practices, thus significantly altering land-management practices.

The Institution of Production for the Market

Banana schemes were the first truly intensive market-crop production schemes in Tonga. The production of copra from the 1830s to the present was associated with government mandates for planting a certain number of coconut trees on each allotment, with the donation of coconut oil to the church, and finally, with the plowing, from 1966 to 1972, of many allotments to ease planting of trees in rows (every ten meters). But it was the banana scheme that required intensive land preparation, plowing and disking, the application of fertilizers ("every time the rain fell," according to Paula, a village historian), the use of pesticides, and the extension of market-crop production into land usually held fallow. While some fertilizers were used for watermelon production as well, the cultivation of watermelon was not as extensive an enterprise, perhaps because bananas were a crop plant familiar to Tongan farmers.

Needs (1988) studied the banana export schemes of the 1970s and 1980s, ending his study only a year or so before the collapse of bananas as a market crop in Tonga.[3] In fact, because of the resistant forms of bunchy-top virus and black leaf streak virus, bananas were scarce in Tonga during my last stay (1991–1993) and were found only sporadically at Talamahu market in Nuku'alofa. Although begun as early as the turn of the century, banana production in Tonga was a thorough boom and bust operation (see Figure 1).

Maude refers to a banana export trade from Tonga to New Zealand associated with the first shipping service between the two countries (1965, cited in Needs 1988:69). Bananas were far secondary to copra in export value. They evidently peaked around 1904 and thereafter declined as a result of diseases and the eventual consequences of World War I. Needs notes that persistent problems in shipping services and the inability of Tongan farmers to meet quotas doomed the success of banana production for the market until the Second World War. Then, production expanded to a high of 20,000 tons exported in 1967 (Needs 1988:69). The black leaf streak disease, whose resistant strains are now affecting plantains, dropped exports to 17,000 tons by 1969 (Figure 1). The boom in banana production in the mid-1960s stemmed from the Tongan Ministry of Agriculture's encouragement (ibid.: 13). The production could only be maintained, however, with continued application of external inputs in fertilizers and pesticides. In the 1970s New Zealand sought to increase its involvement in Tongan banana production

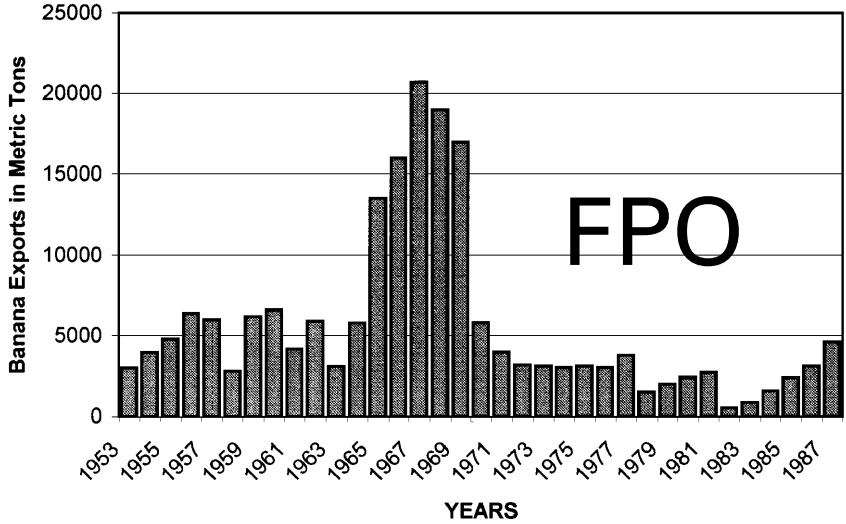

FIGURE 1. **Banana exports from Tonga, 1953–1987 (in metric tons)**

beyond the simple quota system that gave Tongan banana producers preferred access to the New Zealand market. Falling production in Tonga resulted in New Zealand's importation of bananas from Ecuador and the Philippines, and the 1971 Banana Export Scheme was initiated, where the smallest permissible acreage in banana production was two acres, effectively squeezing the small producer from competition.

Needs reports that there were forty-nine registered growers in the Nukunuku area (1988:71). The small growers recognized that a few banana producers controlled a disproportionately large proportion of land in banana cultivation. Needs refers to these as the bourgeoisie (ibid.:73), since these farmers had significant economic interests in a number of ventures and were able to secure larger landholdings by special arrangements with nobles. The small producers were required to change their allocation of scarce resources to maintain banana production and were, therefore, increasingly faced with disproportionate costs in their productive activities. The gale of February 1989 demonstrated the risks involved in capital and labor investments in this particular market crop. The significance of banana-crop production in Nukunuku was presented to me by three village historians, who confirmed its role in the changing political ecology of Tongatapu. The production of bananas for the New Zealand market required, for the first time in three millennia of Tongan agriculture, external inputs in the form of fertilizer, pesticides, and extensive mechanical tillage. One of the village historians recognized the

possible effects of population pressure on limited land area, but he presented details on the decline in soil fertility since the 1970s in Tonga, which he attributed to banana production. The following discussion broaches a number of subjects regarding the changing human-land relations that characterize the increasing involvement of Tongan farmers with production for export.[4]

Interviewer: When did people first recognize the soil fertility was declining?

Paula: Starting in the seventies.

Interviewer: Did all the farmers recognize it? How did they know?

Paula: Their crops no longer grew big and healthy in that soil. [So] chemical fertilizers are used to make crops grow big.

Interviewer: So, when they recognized the soil energy was declining. . . .

Paula: Soil energy. They start using plowing at their first planting, especially eastern farmers, for they usually grow peanuts and kumara. Also they use plowing because of the desertlike soils. They continue doing the same way, plowing, but still the soil stayed the same. Therefore they started using chemical fertilizers.

Interviewer: So, that started in the seventies?

Paula: Yes.

Interviewer: Did the farmers do other things in order for the soil to regain its fertility naturally or only use chemical fertilizer?

Paula: It's only the elders' method. They leave the soil in fallow [and] also use bush beans to grow in that piece of soil.

Interviewer: So, the farmer knows the decline in soil energy by recognizing that the crops no longer grow big and grow healthy, and produce fewer fruits?

Paula: Yes. They know when they see the crops didn't grow big, like taro, they didn't grow big, also cassava produce few fruits. But by the use of chemical fertilizer crops start to grow big and produce much fruit. If they stop using chemicals, it goes back to the same thing, so the only thing is to leave the soil in fallow for four years or five years.

Interviewer: What are some of the factors that cause the decline in the soil energy?

Paula: Mainly because of too much growing of banana and coconuts. Because banana and coconuts are the main sources of income for the people in Tonga. They start using fertilizers for the bananas, only with coconuts are fertilizers not used, to start from the forties up to now. If fertilizer is also applied to coconuts, it will produce much fruit and big ones. But for bananas, chemical fertilizers were used. Chemical fertilizers were divided up into every home, including myself. Every home had about ten to twenty sacks of fertilizers. And when rain fell, people applied fertilizer to the banana trees. But now, fertilizers are used for every crop.

Interviewer: How do they try to make soil more productive? Only by using chemical fertilizers and leaving the bush fallow?

Paula: Use fertilizers when the crops grow. If still infertile, then leave with bushes for four or five years.

Interviewer: Even plowing?

Paula: Leave with bushes four or five years. Now in Tonga, people usually use plowing for every crop like in the yam plantation. If people want to grow yams, they first plow the area, then dig the soil. Now it seems that without plowing the soil and crops will be bad, because the soil is not good.

Interviewer: When did people first grow bananas?

Paula: People started growing bananas when I was still a kid.

Interviewer: So in the forties!

Paula: No, in the forties I was a young man, for in forty-five I left the army. In 1933 I was ten years old. At that time bananas had been grown by people. That time, it was two shillings for a box of one hundred and fifty pounds.

Interviewer: So in approximately 1930 bananas were present here?

Paula: Yes, before 1930 up until now.

Interviewer: Did everyone in the village join in growing bananas?

Paula: Every man was free to do it [if he wanted to]. If a man wanted money for his family's needs, he grew bananas. However, there were some people who were too lazy to grow bananas, so they became poor, lacking clothes and food.

Interviewer: So bananas were Tonga's first export goods?

Paula: No, coconuts before 1930. First coconuts, then bananas.

Interviewer: So people of Tonga changed from growing yam plantations, their native plantation, to growing banana plantations in one acre.

Paula: Only some people grew bananas, for everyone was free to grow what he wanted. But only if a man wanted a lot of money he may grow many bananas. If he already had a lot of money, he may only have five to ten boxes.

Interviewer: Did people cut down the native trees of their allotment in order to grow bananas?

Paula: Oh yes! They did cut down the trees and cleared it off for banana plantation.

Interviewer: So they cut down the trees and also used chemical fertilizers?

Paula: Yes.

Interviewer: When were chemical fertilizers introduced to Tonga?

Paula: Chemical fertilizers were brought after the fifties. That's when the war finished in 1945. At the same time the population increased and goods were expensive. Like canned beef, it was fifteen cents, but today it is three or four dollars.

Interviewer: When did farmers start using insecticides?

Paula: It was the Ministry of Agriculture who first used it. That was in the 1940s when people grew melons. A lot of harmful insects attacked the melon, compared to the past when watermelons were grown and nothing happened and they bore a lot of fruit. I remember when I was a kid, Fisihopo grew a big melon plantation. The only thing he did was catch the flies flying around, but when the little watermelon has three or four leaves then nothing is done to it, no chemical fertilizers applied. In 1945 to 1950, if chemical fertilizers weren't applied, nothing would come from that watermelon, because lots of diseases were coming to Tonga during that time. Still people don't know what brings those diseases to Tonga. In the past, if we ate melons and threw the seeds anywhere, it would grow exactly in that area.

Interviewer: When people started growing bananas, did they also change their way of leaving their allotments fallow?

Paula: Yes, because people wanted money, they started using

other methods like plowing instead of leaving the land fallow. They plow and plow their allotments, at the same time using chemical fertilizers. Like what happened to the squash growers in the eastern districts, they have very bad production from their squash because of too much plowing; not like the western squash growers, they have good products.

Interviewer: Who grew bananas in Nukunuku in the thirties?

Paula: Almost everyone here had banana plantation in 1950. In 1960 every home had a banana plantation except only ten homes who didn't grow bananas. That includes 'Ikaihingoa's home, for they are lazy, only eating bananas from other people.[5] We can tell those people by seeing their living standards now. They have bad homes, bad clothes, and bad food, for they just rely on coconuts and don't grow bananas.

Paula's recounting of agricultural market production in Tonga reviews the significant developments: (1) copra, encouraged by Tauafa'ahau Tupou I's donations of coconut oil to the church, was the mainstay of Tongan exports until the boom years of the banana scheme; (2) watermelon growing coincided with the production of bananas for the market; and (3) bananas, until the advent of squash production for the Japanese market in 1987, led Tonga's agricultural market production into the late 1980s.

The ecological consequences of the banana scheme are hinted at when Paula notes the changing land-management activities of the farmers and the increased chopping down of hardwood trees to make room for the banana plantations. The introduction of chemical fertilizers, if used as the only means of maintaining soil fertility, destroys natural fertility and limits the organic content of the soil. This process leads invariably to dependence on chemical fertilizers to maintain productivity. Similarly, the use of pesticides disrupts natural balances between predator and prey insect species, increases the resistance of pests to chemical management, and fosters the increased dependency of farmers on external inputs.

Another elderly informant, Poupou, told of the denuding of the landscape by privately owned timber operations who arrived with the banana scheme to produce the shooks for shipping the bananas (see Shankman, this volume, for discussion of deforestation in Samoa). As Clarke and Thaman note, "In Tonga, during the height of the banana boom, so many trees were cut to provide shooks for banana boxes and to extend banana plantings, that saw-millers had to move from Tongatapu to the near-by island of 'Eua" (1993:

13). So, while the Tongan statistics show the financial returns from the now-bust banana production of the 1950s to the 1980s, these statistics do not include the environmental costs of one of the final stages of deforestation on Tongatapu. Tonga did not send only its soil fertility to New Zealand (and now to Japan), it sent much of the last of its old-growth trees as well, in the form of banana shooks. Because these sawmill operations were privately financed ventures, there are no government records of this stage of deforestation on Tongatapu. Poupou had a clear recollection, though, of the deforestation that accompanied the banana scheme.[6]

Poupou: This bush allotment was covered by *kotone* trees. All *kotone* from this area to that area.
Interviewer: So that's the native tree here?
Poupou: Yes, *kotone* is the tree here, but these other trees here have just been grown. But the *kotone* are very stout, you can't reach your hand around them. But later a woodcutter named Waters cut them down for banana boxes. He paid T$2.00 per tree, and a big truck came and took six or seven trees away [at a time].
Interviewer: Did you choose some of the trees to grow here like *'ifi* and those trees?
Poupou: *'Ifi* doesn't grow here, also breadfruit. I grow it, but it doesn't grow healthy because of the sea spray. These are the only trees of this coast, the *kotone.*

Kotone trees *(Myristica hypargyraea)* were known for providing strong and flexible boxes for shipping bananas (Thaman 1976:413), and most of these trees on the southern side of the island have long since disappeared. Their utility, known by indigenous farmers, came because they were salt tolerant and, therefore, shielded the tuber crops from the damaging effects of the salt spray. Since the harvesting of *kotone* for banana shooks, the agricultural productivity of the southern side of the island has diminished considerably. In terms of long-term management of agricultural resources, the preservation of *kotone* trees would have been far more economically significant than was their use as banana shooks for the short-term benefits of the banana scheme. In a sense, *kotone* trees were shipped to New Zealand in attempts for a favored balance of trade. The hidden costs of this scheme were the loss of many old stands of trees, the loss of tree biodiversity on Tongatapu, and the loss of agricultural productivity on those parts of Tongatapu affected by salt spray.

The government insists that banana production for the market has only

TABLE 2. **Banana Production and Export, 1985–1989**

	1985	1986	1987	1988	1989
No. of growers	324	244	224	153	143
Total acreage	1,711	1,139	1,103	709	656
Export tonnage	2,682	3,568	3,484	1,486	343

Source: Ministry of Agriculture, Fisheries and Forests 1991:120.

been temporarily suspended owing to the discovery of black leaf streak and fruit fly infestations, but the farmers I spoke with all agreed that banana production for the market was dead in Tonga. In terms of calculated returns to inputs, export banana production had the lowest returns of all crops in Tonga, returning T$2.25 per hour of labor input and T$1.45 per T$1.00 input of variable input costs (Delforce 1988:101, 103), a fact no doubt well realized by Tongan smallholders. Despite a number of technical bulletins on banana production and export banana production (Ministry of Agriculture, Fisheries and Forests 1982, 1988), farm management handbooks (Gyles, Sefanaia, Fleming, and Hardaker 1988), pesticide recommendations (Kingdom of Tonga 1984), and other government incentives, the evidence indicates that banana production may never again materialize. Table 2 shows the rapid decline in export banana production from 1985 to 1989. The number of farmers involved in production and, therefore, the number of acres in production show a general decline, but the most telling piece of information seems to be the decline in production per acre from the high of 3.1 metric tons per acre in 1986–1987, to 2.01 in 1988, and an abysmal 0.5 tons per acre in 1989.

A graphic representation of the boom and bust of banana export production is represented by the histogram in Figure 1, showing production in metric tons of export bananas from 1953 until 1987. The decline from around 17,000 metric tons exported in 1969, the last of five years of production boom, to around 6,000 tons in 1970, an amount never again to be reached, presents a rather ominous picture of boom and bust production schemes. The culprit in this instance was a resistant strain of black leaf streak virus and the insect vector of this virus, the fruit fly *(ngutu),* first recognized in 1968 (‘Amanaki 1974:11). The black leaf streak virus, along with bunchy-top virus, is now infecting plantains that are normally resistant to these two viral infections (Halavatau, pers. com., 1993). When I left Tonga in 1993, bananas were increasingly scarce at Talamahu market, and they are now rarely available in the local markets. A similar spread of mosaic virus and powdery mildew may be associated with extensive squash production.

Economic Growth and Agricultural Intensification on Tongatapu

In addition to growing for export, farmers in Nukunuku began growing traditional crops for Tonga's urban market by taking land out of fallow early or planting an additional crop of cassava before returning a plot to fallow. The influx of migrants to Tongatapu for educational and employment opportunities near the capital created demand for food crops produced by the farmers in the Nuku'alofa area. Pressure to produce for the market encouraged local farmers to shorten fallow periods, but productive yields were not noticed by farmers until the 1960s or 1970s. Farmers now complain of rapidly decreasing soil fertility, an inability to return land to fallow, and increased reliance on fertilizers.

Some analyses of Tongan agriculture for the Vava'u group, which had experienced significant out-migration, suggested as late as 1983 that agricultural production by traditional means could be intensified further without real threat to soil fertility (Schroder et al. 1983). Since that report, soil erosion on Vava'u has become a problem (Halavatau, pers. com., 1993), suggesting that changes in traditional forms of land management, such as limited tillage, that guarded against soil erosion have happened only recently, but the changes came rapidly. Tractor plowing reduces farmers' labor investments tremendously and is required for squash production. Under a regime of reduced periods of fallow, tractor tillage facilitates the intrusion of guinea grass into fallow areas, prohibits regeneration of deciduous woody plants by disturbing root systems and killing seedlings, and contributes to rapid soil leaching and erosion (Halavatau 1992; James 1993). Van Wambeke reports findings of soil scientists in tropical ecosystems that convincingly demonstrate that grass fallow returns less soil organic matter and regenerates soil fertility at a significantly lower rate than do fallow systems of deciduous plants and secondary forest growth (1992:88).

The coconut replanting scheme initiated in Taufa'ahau Tupou IV's (the current Tongan monarch) first five-year development plan in 1966 resulted in the linear planting of coconut trees now seen throughout most of Tongatapu. The planting of trees in this manner required plowing portions of a great number of agricultural allotments in Tongatapu and represents the first such extensive plowing of land in Tonga. It resulted in the planting of some 40,000 trees between 1966 and 1981 (Kunzel 1989:1). Tongan farmers, for the most part, were immediately impressed that a tractor could do in a few hours what it would take a smallholder household weeks to accomplish. Taufa'ahau's coconut planting scheme, an otherwise positive change in production, opened the door to farmers' use of tractors, the continuing use of which will have adverse effects on soil fertility (see also Kunzel 1989). A

village historian, Paula, noted that early market banana production did not include plowing, and several farmers, including Poupou (who still refuses to plow his land), recalled plowing on allotments happened first with the government coconut planting project in 1966.

In the Kingdom of Tonga's Sixth Development Plan (1991–1995), the ultimate aim of the government was to "induce improvements in the standard of living of Tongans in an equitable manner, with a view to protecting natural resources and preserving cultural assets." This goal requires private-sector development to "serve as the main engine of economic growth" (Ministry of Agriculture, Fisheries and Forests 1991:i). Recalling the "symbiosis" between Tongans and the natural environment as the source of Tongan *fiemalie* (feeling contented and relaxed), the plan calls for improving the management of natural resources in order to "attain optimal levels of exploitation, and allow sustainable development" and, while safeguarding these resources, to "enhance the contribution of natural resources to economic and social progress" (ibid.:75). In agriculture, the Sixth Development Plan had the long-term objectives of generating adequate local income for the rural population, allowing agribusiness profitability, securing a steady food supply in the kingdom, and ensuring that "the natural resources and the environment that relate to agriculture will not be harmed by farming activities" (ibid.:117). The short-term goals were to allow for "accelerated growth in private agricultural production" and to diversify export markets for agriculture.

Some crops exported from Tonga in small amounts (less than ten tons) include pineapple, breadfruit, sugarcane, and kava, and government efforts are presumably oriented toward encouraging market-crop diversity. Copra has remained somewhat constant in its contribution to the export economy of the kingdom, although the effects of Hurricane Isaac in 1982 are clear in the drop in exports for 1983 and 1984. Cassava, taro, and other root crops are becoming increasingly attractive market crops for local farmers. The benefits of cassava as an export crop, in the form of peeled and frozen tubers meant for human consumption, rather than dried cattle feed, is an excellent alternative market crop for the farmers in Nukunuku, because refrigerated freight containers can be brought to the village, and, in a matter of a week, a half-dozen smallholder households can contribute enough cassava for a quick cash return (around T$1,000.00) without a great deal of effort. The crops, in this case, are sent to Polynesians residing in Auckland, and the farmers appreciate that the sales are negotiated with other Tongans and that the produce contributes to a form of maintaining *angafakatonga,* the Tongan way, among Tongan expatriates in New Zealand. The Tongan connection in this way may, along with remittances, contribute to a more stable though limited

export market, and tuber production does not yet require adding chemical fertilizers to ensure marketable returns.

It is easy for farmers to plant a little extra cassava in case a need for extra and quick cash were to arise. One farmer, who had marketed watermelons and squash in the past, planted an area 17 by 55 meters (935 square meters) in cassava for family consumption and possible market sales. Requiring extra cash to make an acceptable donation to a relative's wedding, this farmer harvested 512 plants and marketed 1,250 kilograms (fifty 25-kilogram sacks of peeled cassava), for which he received T$750.00, or T$15.00 per 25-kilogram sack. In the process, he gave sixty kilograms (or so) to the young men who helped him prepare the crop for export, and another fifty (or so) kilograms were thought unfit for export and were taken to be given to pigs or tossed aside in the bush.

The same field was replanted in cassava using the stalks from the recently harvested plants as planting material. The remainder of the original cassava crop (450 plants, or about 1,100 kilograms) was consumed in the household over the next four or five months, during which time that area returned to fallow as the second planting was beginning to be ready to harvest. The entire plot was slowly returned to fallow as the second planting was harvested as needed. Cash cropping cassava in this way fits nicely into existing crop management and does not require any imported inputs or changes in technology to produce reasonable returns on an ad hoc basis. One farmer and worker for the government's Central Planning Division suggested that two market-cropping strategies were developing in Tonga; one was the growing of cassava for occasional, as-needed sales and vanilla for a once-per-annum substantial sale, and the other was the once-per-year sale of as much squash as one could possibly produce.

Growing vanilla as a cash crop seemed to be gaining some popularity with farmers in Nukunuku, since significant returns are realized after two or three years invested in putting the crop in and letting it develop sufficiently to bear a marketable crop. The crop also requires labor-intensive pollination of flowers to ensure production, but it can be grown in a relatively small area, and it requires few external inputs once established. In 1989, 25,057 kilograms of vanilla were exported to the United States. The area under vanilla production, around 400 acres across the kingdom, has not increased appreciably in those five years.

The introduction of squash for the Japanese market in 1987 became the latest and the most damaging of the export schemes in Tonga's development in the international marketplace. The impact of the squash market on Tongan agriculture may well have been the most significant disruption of the environment on Tongatapu since the initial colonization of the islands. The effects

of the mosaic virus, which favors cucurbits generally, had curtailed the cultivation of squash in Mexico. Tonga's favorable climate presented a window of opportunity to grow squash (up to 18,566 tons in 1991) in the period between the season in California, which ends in October, and the season in New Zealand, which begins in December (*Tonga Chronicle* 45, no. 3 [November 1991]: 27). The crop provides a very fast return on investments of labor and capital, and so has become a highly favored way for many farmers to gain easy money just before the church offering *(misinale)* and the Christmas feasting season. Plans have been formulated to extend squash production to Haʻapai, and the number of growers in Vavaʻu and on ʻEua has been increased (Fonua 1992:11).

Squash production for the Japanese market began in 1987, when a New Zealand marketing firm came to Tonga to organize production for the time period between seasons elsewhere for growing these squash (Delica variety of *Cucurbita maxima*). The crop gained immediate popularity, in part because of the T$0.50 per kilogram price that the squash fetched for farmers, but also because the financial returns on recommended investments of ground preparation, chemical fertilizers, pesticides, and fungicides of T$650.00 per acre were significant, with an expected minimum yield of three tons per acre and average yields around seven or eight tons per acre.[7] News reports of extraordinary yields, such as those by a Kolovai farmer who produced 18.8 tons, harvested, selected, and sold for a return of T$8,160.00 from 1.3 acres of squash (*Tonga Chronicle* 6, no. 7 [February 1991]: 7), fueled farmer interest.

In arranging loans for squash production through the Tonga Development Bank, government involvement in negotiations among four export companies in 1991 secured 6,000 tons of an allotted 10,000-ton production limit to an agency called Tonga Multipurpose Cooperative, the managing director of which was Prince Maliefihi Tukuʻaho. The remainder of the allotted production was divided up among the other export companies, who were displeased with their allocations and decided to extend their production limits and negotiate their own shipping and marketing arrangements. Growers' fears of flooding the market were alleviated by government announcements that, it was alleged, led producers to believe that the market could take 30,000 tons (Fonua 1992:21). The government's enthusiasm for squash production was clear and reflected in the minister of finance's proclamation that "if we could grow 100,000 acres, it would bring in about T$300 million. That would end the trade deficit" (*Tonga Chronicle* 45, no. 3 [November 1991]: 7).

The number of growers increased from 40 in 1987 to 392 in 1991 and 1,300 in 1993, with the number of acres in squash cultivation increasing from 200 acres in 1987 to 1,617 acres in 1990 and 3,000 acres in 1993 (Tonga Develop-

ment Bank 1991:3; Fonua 1992:11). The organization of production and marketing through one, then four, then twenty-one exporting companies by 1992 resulted in logistical and transport problems that oversupplied the Japanese market with poor-quality fruit, much to the displeasure of the Japanese business interests in the scheme. Additionally, miscommunication created freight delays, and fruit rotted in shipping warehouses in Tonga and on board freighters on their way to Japan. As of November 1991, over 20,000 tons of Tongan squash had arrived in Japan when 8,000 tons were expected, creating alarm among buyers but elation among growers, who had been given assurances of favorable returns on their production (as much as $T0.56 per kilogram). Exporters withheld payment to growers after dead freight charges, poor-quality crops, and optimistic forecasting led to a significant but temporary decline in the crop's profitability.

By the end of the 1993 season, several voices of concern were being heard about the damage squash production was doing to the environment (James 1993; Fonua 1994). Workers at the government's Ministry of Agriculture complained that farmers were not following their directives and were either overfertilizing the land in hopes of increasing production or underfertilizing in order to save on input costs. Overfertilizing can change the timing of flowering of male and female flowers on the squash plant, and productive yields usually decline. In the case of underfertilization, first-year yields are adequate, but subsequent yields drastically decline and soil fertility is heavily affected. In the process of applying fertilizers to maintain yields, spraying pesticides to prevent aphid infestation and the spread of viral diseases, and applying fungicides to prevent powdery mildew, Tongan farmers were using 150 tons of fertilizers and 25 tons of pesticides every growing season (Fonua 1994). The head of the research division of the Ministry of Agriculture stated in 1994 that the squash industry in Tonga had reached the crisis stage and might enter a disaster stage if controls in production were not initiated. The last, unconfirmed report that I received about growing squash was that increased production had again occurred in 1994, with growers now in all major island groups and that, on Tongatapu, so many piles of unmarketable squash were rotting in the fields that a severe infestation of houseflies had followed, requiring the importation of insecticides to kill them.

While crop production for export has been the mainstay of Tongan economics, supplying around 27 percent of its GDP (Sturton 1992:8), there is concern that the agricultural techniques required for producing a profitable crop cannot be long maintained. The greatest concern is with the consequences of extensive harrowing and plowing of Tongan soils. Halavatua (1991, 1992) has evidence that a decrease in water-stable aggregates and loss of organic matter in the soil result from frequent plowing and harrowing. The

rich Tongan soils are left exposed during squash production for periods as high as three months, if Ministry of Agriculture guidelines for early land preparation are followed, resulting in severe leaching of minerals and the possibility of a hardpan formation between the topsoil and clay layers. Such a hardpan could prevent effective draining of the soil following rain and could lead to waterlogging of some soils (Furness, pers. com., 1992). Additionally, the application of fertilizers and pesticides required first for bananas and watermelon and essential now for squash production could damage the freshwater horizon from which municipal water is now drawn. Although there is no evidence that the groundwater is contaminated (James 1993), continued use of these chemicals in the quantity needed for successful squash production could lead to severe groundwater contamination. With government support for any manner of improving the balance of foreign trade, the continued importation and use of chemical and mechanical land-management techniques is likely to continue as long as farmers' returns are kept high.

Conclusion

The historical ecology of the village of Nukunuku and the agricultural lands that surround it demonstrates the increasing simplification of Tongan agroforestry. Beginning with decreasing fallow periods to meet the needs of an increasing population and continuing with the adoption of monocropping and industrial agricultural techniques for the market, the trend in Tongan agriculture is increasingly in the direction of increased dependence on industrial inputs and possible entrapment in the pesticide treadmill (Gleissman 1998:5; Altieri 1997). The agricultural techniques now being adopted in Tonga enhance the ability of smallholders to meet family and social obligations, but the cost of adopting capital-intensive methods may be the long-term sustainability of Tongan agroforestry (Halavatau 1992; Clarke and Thaman 1993; Stevens 1996).

Since squash production is a relatively recent introduction in Tonga and the returns on farmer investments are fast and often significant,[8] it appears to present a solution to Tonga's trade deficit and to farmers' desires for improved standards of living. The evidence on squash production in the Nukunuku area indicates that farmers have taken fields out of fallow, sometimes long-term fallow, to grow squash. Because of this fact and because of the added inputs of fertilizers and urea to already rich soils, the initial years of production have been impressive. The Tonga Development Bank expected squash yields of four metric tons per acre in Tonga, and their loans to farmers were based, in part, on that expected yield. The returns have been substantially higher, contributing to the flood of Tongan squash on the Japanese

market. One farmer had gross returns of T$24,600.00 on his second squash crop. Farmers were paid about T$0.56 per kilo of squash in 1992, meaning that this farmer produced almost forty-five metric tons on eight acres, an average yield of 5.6 tons per acre.

Farmers were clearly impressed with the production and with the short time, about four months from plowing to harvesting, that was required for significant monetary returns. Some farmers in my research were concerned about using the necessary chemicals to ensure productive squash yields. Other farmers felt that plowing was inherently damaging to the soil and chose to sell cassava or vanilla in the market. The initial success of squash production influenced the farmers' perspectives, and few appeared aware that yields may never be as high as those associated with the first three or four years of production, when the effects of plowing were not yet apparent and dependency on fertilizers not fully established.

Halavatau (1991, 1992) and Halavatau, Manu, and Pole (1992) provide data on the consequences of agricultural production on the soils in Tongatapu. Halavatau's greatest concerns are the loss of organic matter and the decrease of water-stable aggregates in the soil. Halavatau, Manu, and Pole state, "The major threat to the Tongan agricultural systems is the breaking of the nutrient cycling system by cutting of forests and loss of nutrients as a result of logging, increased frequencies of shortened fallow period, or permanent cultivation (1992:108)." The history of ecological change in Tonga is one of continued environmental degradation. The inclusion of Tongan smallholders in a global economy has provided farmers with opportunities for access to cash that enhances their ability to meet family and household obligations, which, to the exclusion of concerns for the ecology, is what Tongans are most interested in sustaining. How long Tonga can continue to base its export agriculture on industrial forms of agriculture remains to be seen, but the evidence suggests that the present course of action will result in the continued loss of biological diversity and, in all likelihood, soil fertility and the eventual degradation of the mainstay of Tonga's economic capabilities, its agricultural resources.

Land preparation for squash and reliance on plowing in subsistence-crop production are regarded by some farmers as damaging the soil. While distinctively Tongan relations of production and the maintenance of obligations between families and among households may be well sustained by these trends, Tongan agroforestry may be becoming increasingly unsustainable. Sustaining social relations of production could lead to the loss of sustainable human-land relations. One of the most philosophical statements made by a farmer came from Poupou, the old farmer who refused to plow his fields and who could grow taro in a drought: " *'Oku tau teka atu fohi 'o hange 'oku*

tau fiepotoʻi ʻae meʻa ʻa e ʻOtua. Ko ko poto ʻo e tangata ko e vale ka koe poto ia ʻo mamani ka koe vale pe ki he ʻOtua." (We sometimes take over what belongs to God. We felt smart in these things, [but] to God men seem stupid about the world.)

NOTES

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1. See Sauer 1993 on the origin of the sweet potato in tropical Central America.

2. The land equivalent ratio, the amount of a crop grown in intercropping compared to the amount of the same crop grown as a monocrop, is consistently higher than 1.0 for cassava, and land equivalent ratios of 1.5 are feasible (Thung and Cock 1978:16). In smallholder production, cassava is almost always intercropped and multicropped with maize, pigeon peas, plantains, and sugarcane.

3. While I was in Tonga, a gale hit Tongatapu at the end of February 1989, a month that set the record for rainfall at 726 millimeters. The storm came as a surprise, because it had been forecast to miss the islands but, instead, raked down the entire island chain. Although *merely* a gale, the banana crop, which would have been ready for harvest but one month later, was destroyed. The storm brought down power lines and uprooted trees from waterlogged soil. It damaged other crops as well, but the subsistence crops survived, the banana scheme did not.

4. This interview was held on 28 November 1992, with ʻAisea ʻEukaliti and Stevens asking the questions.

5. The name ʻIkaihingoa is a pseudonym.

6. Poupou was interviewed on two occasions. I was told of Poupou's expertise in farming at a *faikava* in Nukunuku by a young man from the same village as Poupou. During a period of drought, Poupou was selling ninety bundles of *lu* (taro leaves) in Talamahu market every week when the lack of rain had made taro leaves very rare. Poupou refused to plow his allotment and used old techniques to ensure productive taro when other farmers had no taro at all. Poupou was ninety-one years old and still working in his allotment six days per week when ʻAisea ʻEukaliti and I talked with him at his bush allotment.

7. Smallholders who grew squash on from less than one to no more than two acres obtained an average yield of 3.4 marketable tons per acre, while farmers growing on larger plots received increasingly lower yields per acre but larger gross yields (Tonga Development Bank 1991:3). In the last few years, these yields have increased to eight tons per acre (Fonua 1992:13).

8. Some farmers had poor experiences growing squash and, after an initial attempt, have decided not to pursue further squash production. Toetuʻu, one such farmer, now grows tubers, principally cassava, for the market.

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