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Cultivated Landscapes of the Southwest Pacific

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Cultivated Landscapes of the Southwest Pacific

The adaptability of farmers, using a diverse range of strategies, is a central issue. It is still greatly undervalued in a wide professional literature on agricultural development. Yet the circumstantial evidence of longer-term adaptability is overwhelming. (p. 54)

... the farm does not end where the field meets the wood. We need to look at the continuum between the two and examine the manner in which the managed and unmanaged wild elements relate to the cultivated land and plants. (p. 55)

... cultivated forests are created in some parts of the world. They range from forests in which only a few key species are actually planted, leaving everything else to natural process, to highly complex agroforests in which everything is created by the farmer. Often, it is not easy for an observer to know what is natural and what is planted, and errors are common. (p. 140)

Two common strands run through most of these themes. First is the importance of trying to establish the historical basis of dynamism in agrodiversity, its adaptation and innovations. Second is the use and management of the biophysical diversity in the land. (p. 57)

— H. C. Brookfield, *Exploring Agrodiversity*, (2001)

Brookfield's comments about farmers would seem unexceptionable to geographers and anthropologists who have lived in and come to know the landscapes of smallholders in the tropics. High modernists and many development specialists might accept that smallholder farmers plant trees within their territories, but would balk at Brookfield's further argument that the landscapes in question have long been subject to a dynamic management wherein "nature" and human productive activities are not antithetical. In such smallholder landscapes the farmers — though often tagged "traditional" — are constantly experimenting and learning and then modifying their productive technologies. Adaptation — development if you like — has been and is going on all the time. And today, the changes most useful to smallholders still arise largely from local initiative, not from external projects.

The particular aspect of tropical landscapes that we examine in this paper is the humanisation of forests, a process that creates Brookfield's "cultivated forests." But that term does not imply stasis because on any particular site there is a shifting and merging over time of different sorts of vegetation, each subject to different degrees of management. The primary focus of our examination is the southwest Pacific, but similar productive techniques are found throughout the tropical world. We begin the paper with examples of the management of productive landscapes of which trees are an integral part. That these examples are drawn from ethnographic and ethnobotanical rather than agricultural or agronomic sources is significant but not surprising. We then review archaeological evidence of tree crops in New Guinea prehistory and focus on five taxa of significant tree and tree-like crops, to show that landscapes which include managed assemblages of tree species are of great antiquity throughout the New Guinea region, and that recurrent associations among particular useful tree species, far from being happy accidents of provident nature, are the result of long-term selection and deliberate agricultural practice, extending beyond the confines of the "garden" in both space and time.

Traditional Agroforestry

It remains generally the case that land occupied by something called forest is seen to be segregated functionally and conceptually from land occupied by something called garden. That there are intimate connections between the two is not, however, a new idea. In writing more than sixty years ago about the island of Tikopia, Solomon Islands, Raymond Firth (1936; 1939) revealed how it only

slowly became evident to him that rather than being “. . . heavily wooded with small and infrequent patches of cultivation in the neighbourhood of scattered villages . . .” the whole of Tikopia “. . . is in a high state of economic utilisation, that gardens are made right up in the mountain, and that what appears to be bush is really a collection of trees and shrubs, each having its own value to the people, either for its food or in their material arts” (1936:374-375). Fifty years later Kirch and Yen (1982:25) elaborated on Firth’s observations on Tikopia, noting that the “. . . terrestrial environment of Tikopia is virtually its agricultural system. Its forest-like canopy, from the shorelines to the ridges and summits of the volcanic massifs of the incomplete crater rim, acts as a camouflage of the ‘high state of economic utilization’ ”.

Barrau (1955; 1956) and Yen (1974) both stressed the significance of tree crops in the Pacific several decades ago. Yen’s 1974 paper was a landmark in its exposition of the cultivated status in Santa Cruz (Solomon Islands) of many tree crops otherwise described as gathered or wild in Melanesia, and of the integration of tree and field crops. Yam gardens might be turned into “breadfruit plantations”, village gardens were virtually tree gardens, and roadside trees were planted. Transplanted or tended seedlings marked by twigs were ubiquitous. Arboriculture, at first sight a haphazard enterprise conducted by men with minimal investment of labour, in contrast to fields maintained by women, nevertheless made a considerable contribution to subsistence. It was integrated into most forms of agricultural procedure, acting as insurance and stabiliser of the seasonal spread of production, varying diet and aiding hunting and animal husbandry (Yen 1974:275-278).

Clarke (1971), writing about a Maring community in the Simbai valley in Papua New Guinea, described a flowing process whereby people turn plots of land occupied by aging gardens into orchards of four valued food- and fibre-producing tree species (*marita* [*Pandanus conoideus*], *Gnetum gnemon*, breadfruit, and a fig species). The orchards then, over decades, slowly meld into secondary fallow, which in turn is eventually cut to make new gardens, with relict cultivated trees serving to validate rights of use by a man whose father or grandfather planted the trees. Conklin (1957) described a similar complex succession in the Philippines among the Hanunóo, for whom dryland rice was an important crop.

A further example of the integration of trees and garden is provided by McEldowney (1995:97-147), who found 23 taxa of tree crops (17 of them fruit- or nut-bearing) prominent across the landscape of Baluan Island in Manus Province, Papua New Guinea. All 23 taxa were present in the three spatially distinct arboreal assemblages: village tree gardens (growing within the active settlement grounds), orchards (dense, structurally diverse plant communities outside of settlements), and valued tree crops scattered throughout the gardened land.

On Fergusson Island, in Milne Bay, Flavelle described “a complex polyphase agroforestry system . . . [of which] the vegetation phases are ecologically integrated in both space and time” (1991:111), and provide a continuous harvest of products. Fruit and nut trees and species used for medicine and construction are tended or transplanted in fallow yam gardens, and grow at higher densities close to the coastal hamlets, so they form a nearly continuous coastal ribbon. More or less pure stands of betelnut and coconut are planted, as are rather more mixed sago groves (1991:56-61).

An example of how domesticated or maintained trees (the nut-bearing *Pangium edule* and species of mid- and high-elevation *Pandanus* species) within a forest territory are integrated into everyday sociability as well as into ritual life is provided by Bonnemère and Lemonnier (2002) in their comparative description of the vegeculture systems of two Anga populations (Menyamy region of Papua New Guinea). Kelly (1993) provides an extended discussion of the complex patterns of integration of tree and other crops including sago, banana, breadfruit and *marita* pandanus in the economic, social and ritual life of the people of the Strickland-Bosavi area.

In another part of Papua New Guinea, people around Amanab, in the Border Mountains of West Sepik (Sandaun) Province, combine the planting of root and tree crops including sago, their main staple (Huber 1973; 1977; Juillerat 1982; 1983; 1984). Huber (1977) comments provocatively on the landscape management of Anggor-speaking people, who live south of Amanab. Having heard

contradictory reports about the Anggor to the effect that (a) they are primarily sago-processors and (b) they are really very good gardeners, Huber examines more deeply what the Anggor are doing within their territory. To put his subtle argument briefly, Huber concludes that the Anggor are neither primarily sago workers nor primarily gardeners; rather, both activities are integrated into a single pattern of landscape management. Outsider observers may see sago working as peripheral and casual because the sago palms occur in isolated, dispersed stands, and sago working can be taken up or dropped at any time. Gardening of tubers and other crops may be seen as peripheral because sago is the people's commonest food and they cultivate only a small area of land compared with many other Papua New Guineans. But in the land planted to gardens, as among the Maring mentioned above, the maturing annual crops are replaced by orchards, the components of which include breadfruit, nuts, *marita* pandanus, and most importantly *Gnetum gnemon* (*tulip* in Tok Pisin), the leaves of which are the common accompaniment of sago as the staple of the diet. The primary goal of creating gardens is not the production of short-term crops but the long-term management of orchards. The taro, bananas and other garden crops are a pleasant dietary supplement. Huber also explains how these productive processes are central to Anggor social life. His argument further suggests that "management" is the wrong word because as commonly used the word refers to a technical process, separated from the rest of life. If one thinks in terms of the dichotomies of garden/forest, work/social life, management/absence-of-regulation, the daily activities of people like the Anggor remain a puzzle.

Looking more widely, Clarke and Thaman (1993) survey the incorporation of a great many tree species into the diverse abundance of traditional agroforestry systems to be found in Melanesia, Micronesia, and Polynesia. More recently, in their book *Fruits of Oceania* Walter and Sam describe "traditional arboriculture in Oceania", as found in four case-study regions in Vanuatu, Tonga, Papua New Guinea, and Samoa. Noting arboriculture's millennia-old presence in Oceania, Walter and Sam (2002:76–77) discuss the way it has modified landscapes and call attention to its endless transformations and its significance as one facet ". . . of the considered management of the whole territory."

Slow as these studies in ethnography and ethnobotany have been to penetrate the contemporary milieu of economic- and sustainable-development activities, there are signs of a lessening in the contrast between the productivity of trees or forest, on the one hand, and gardens or fields, on the other. Influential in this change is the work of Harold Brookfield, notably his chapter "Managing plants in the fallow and the forest" in *Exploring Agrodiversity* (2001). In that chapter, Brookfield reviews some of the large body of work from Latin America on managed successional fallows and some of the fewer works on that topic from Southeast Asia. He looks too at "complex multistorey agroforests" in Southeast Asia and asks with regard to various manipulations of vegetation "What is natural and what is human-made?" In conclusion he observes that in modern science, until very recently, fields and crops were the domain of agricultural science, and trees were the domain of forestry. By contrast, farmers do not draw a distinction between trees and crops; they treat the whole farming space as one, thus providing an integration of field and wood that is central to agrodiversity as well as to soil-fertility management and erosion prevention.

We argue that elaborated systems of fallow and forest management in conjunction with gardens and field crops are not only widely in use today — they are also ancient. Perhaps the broadest evidence for this assertion comes from Amazonia, an area of forest often assumed to be "virgin". Smith *et al.* (1995) have reviewed the research that is contrary to this "myth of virginity", concluding that many of the forests of tropical America, including the Amazon, are anthropogenic, having been subject to sporadic clearing and enrichment with valued species over many thousands of years. It can even be argued that such was the enhancement of forest with useful products prior to European entry, that following the great population decline in Amazonia after that entry, some peoples gave up farming entirely and gained a livelihood through hunting and from gathering foods on migratory treks — using the resources created by formerly agricultural peoples (Brookfield 2001:142).

The many studies of Amazonian forests cited in Smith *et al.* (1995) and other works cited by Brookfield in *Exploring Agrodiversity* (2001) all point to sophisticated and complex manipulations of

short-term crops and trees involving such things as mulching, using the ash from specific trees to enhance the growth of specific plants, transplanting, or managing complicated sequences of shifting cultivation far removed from the simple concept of chop forest/burn debris/plant crops/“abandon” garden site to natural fallow. Although details and levels of intensity may differ, none of this is alien to anyone familiar with Melanesian landscapes and their management.

For another part of the world Fairhead and Leach in their book *Misreading the African Landscape: Society and Ecology in a Forest-Savanna Mosaic* (1996) meticulously demonstrate how village people in the transitional forest-savanna zone of Guinea in West Africa have created, within open expanses of grassy savanna, patches of dense, verdant, semi-deciduous rainforest. These forest islands are generally circular, a kilometre or two in diameter. Most of the forest islands contain a village at their centre. Aside from the forest islands, dense forest is found only along stream sides or swampy valley bottoms. Since the first French occupation in 1893, Guinea’s administrators have been convinced that these forest patches are the relics of an original dense humid forest that once covered the whole landscape. They supposed that the inhabitants had progressively converted this forest into savanna through their shifting cultivation and fire-setting practices, preserving only narrow belts of forest around their villages. This belief has aroused a policy concern for Guinea’s government, and now the presumed degraded landscape attracts international funding for environmental rehabilitation.

The village elders living surrounded by the forest islands bluntly reverse the institutional orthodoxy and say that their landscape is filling with forest, not emptying of it — a view that Fairhead and Leach (1996) convincingly demonstrate through historical analysis, local study, and air photographs. In short, the forest islands are not relics of destruction but were formed in savanna by villagers or their ancestors. Treating the forest as relic and the savanna as derived is the misreading of the landscape. The forest islands are growing and, remarkably, as population density has increased, so has the area of forest.

The villagers actively enrich the diversity of their forest by planting, transplanting, and encouraging desired plants in a variety of ways. The forest species provide an expectable range of useful materials, and the forest itself offers significant advantages such as fire protection and a shelter for tree crops such as coffee, cola, and fruit trees that could not survive in the savanna. The villagers encourage the islands to develop and to expand to some extent by planting but more by fire management and by creating soil conditions that encourage forest development at the savanna edge.

As Fairhead and Leach note (1996, 191):

Villagers consider the vegetation communities in their landscapes in strongly dynamic terms, aware of the sequences through which certain species or formations of different characteristics often succeed each other, and of how various ecological processes — fire, water movements, soil changes, animals — can influence this, whether in the course of a year, a fallow cycle, or the lifetime of a settlement. They work with and manipulate these processes in ways which influence vegetation.

This African example meshes with a view expressed by Hviding and Bayliss-Smith (2000:23) in *Islands of Rainforest: Agroforestry, Logging and Eco-tourism in Solomon Islands*, where they argue that the

... “horticultural” view of the Melanesians as “gardeners” may have dominated the overall ethnographic view of Island Melanesian agriculture and obscured the complex and finely-tuned, short- and long-term interrelationships between root crop gardens under cultivation and the surrounding fallows and forests. (Hviding and Bayliss-Smith 2000:23).

The book is focussed on Marovo Lagoon region in Solomon Islands where, as the authors express it (2000:17), the secondary growth of old and recent fallows forms part of the continuous harvest of crops. Shifting cultivation systems (yam, taro, sweet potato, cassava) interact closely with the surrounding forest. Older secondary growth contains a great variety of medicinal plants and other useful trees and shrubs, some of which are planted and others of which are part of regrowth

succession. The tall, mature and less disturbed forest is part of the agroforestry complex, containing planted groves of two species of *Canarium* nut trees, which remain fundamentally important in Marovo people's lives. Their importance is evidenced by the universal use in Marovo of the word *buruburu* (the word for *Canarium* nut tree) for "year" in the sense of the time between each *Canarium* harvest. Moreover, *Canarium* nuts have now shifted from their traditional use in inter-island networks of ceremonial exchange to become prized commodities for urban markets.

Hviding and Bayliss-Smith describe Marovo ethnoscience relating to plants, animals, geology, and soils. Particularly relevant to a discussion of landscape is their description of how Marovo people categorise the parts of their total environment. The categories include conceptualisation of forest as domesticated and "wild", the latter word being interpreted to mean no longer under explicit human control (2000:49). There is also a term for tracts of forest that people agree have been left uncut for something like 50 years but that show signs of previous cultivation and habitation such as stone terraces for taro irrigation, *Canarium* groves, and *Areca* palms. The planted trees and garden remnants are known to have been built or planted by certain named persons. As is often now the case in Melanesia, land-dispute cases require knowledge of such ancestral connections, and people can be challenged to display their rights by locating old trees and relating them convincingly to a known ancestor.

Arboriculture and Agriculture in New Guinea Region Prehistory

We have so far used terms such as orchard, garden and field, arboriculture and agroforestry, horticulture and agriculture without defining them. With respect to the pair horticulture/agriculture, we follow Brookfield (2001:xv) and Purseglove (1974:1) and disregard the distinction. As Harris (1989:19) has noted, the term horticulture in Oceania is often used as a synonym for agriculture. We use agriculture as an inclusive cover term for productive activities, of which the other terms describe specific components.

But this terminological simplification does not help us grapple with the conceptual thicket of agricultural prehistory. As Brookfield notes, many now "reject even the possibility of any single world-wide model for agricultural origins or plant domestication" (2001:64). Even the multilinear, non-deterministic model of Harris (1989), which attempts to encompass the full range of people-plant interactions from foraging to agriculture, makes assumptions, such as the development of systematic tillage before domestication, which may be untrue. But more serious problems with such general schema include these: first, their inevitable end point being cereal monocrops, they have little to offer in explicating the persistence of other modes of agriculture, such as those based on tropical root crops, often assumed to have developed separately (Leach 1997), and earlier (Sauer 1952; Spencer 1966:112-114). Second, the thresholds hypothesised to segment what is otherwise a continuum may not have general applicability. Third, they confuse particular agricultural practices or techniques with whole agricultural systems, which often comprise several integrated and interdependent parts. Thus, general models of the origins and development of agriculture explain neither "the diverse ways in which modern small farmers manage their resources" nor how deeply the resilience of agrodiversity might be embedded in agricultural history (Brookfield 2001:59). Consideration of these in any given area requires descriptive detail rather than typological conciseness (Dornstreich 1977; Etkin 1994:3), as well as evidence for local sequences and processes of change rather than assumption of generalised processes, such as intensification or degradation (Brookfield 2001:54; Leach 1999).

In the Pacific, early hypotheses of agriculture as wholly introduced from Vavilov's Indo-Malaysian centre have long since given way to a much more complex view, in which the role of New Guinea domesticates, including tree crops, is crucial (Barrau 1963:6). This was initially argued on the grounds of plant distributions and more recently given chronological definition by archaeological and palaeo-environmental evidence, especially at the Kuk site in highlands New Guinea (Denham *et al.* 2003; Haberle, Hope and De Fretes 1991; Hope and Golson 1995; Golson 1977; 1989; Golson and Hughes 1980; Powell 1982). Yen's (1974) pioneering paper, cited above, had shown that tree crops commonly reported as gathered in New Guinea and Island Melanesia were cultigens in Santa Cruz. He concluded that although concentration on "the arboricultural sector of land exploitation"

in Santa Cruz had encompassed local domestication, this was a “continuation **and** intensification of an already established (or perhaps formulating) tradition in western Melanesian agriculture.” (Yen 1974:281-282, original emphasis). Subsequent ethnobotanical work by Yen (1982; 1985; 1990; 1991a; 1991b; 1993a; 1993b; 1995; 1996) and others (in addition to the studies outlined above, see also Ambrose, Golson and Yen 2000; Bourke 1996; Flavelle 1991; Gorecki 1989a; Hyndman 1984; Juillerat 1982; Kirch 1989; Kocher Schmidt 1991; Latinis 2000; Lemonnier 2002; Lepofsky 1992; Panoff 1972; Stevens, Bourke and Evans 1996; Terrell 2002) has shown that concentration on arboricultural species and practices occurs widely throughout the Southwest Pacific region. Thus, as Golson has put it,

By virtue of the plants on which it is based and the vegetative reproduction by which many of them are propagated, the agriculture of New Guinea, and of the wider Pacific world of which it forms part, has a special character (Yen 1982:283-286, 288; 1990:261-262). As described by Yen, it is dominated by the field cultivation of root crops ... in important, if variable association with a variety of trees and tree-like plants, some of them with the capacity to become staples.... (Golson 1991a: 48).

But the historical processes underlying this regional unity remain a matter of debate. Intrusion of speakers of Austronesian languages into the northern coastal and island New Guinea region about 3500 years ago is conventionally associated with the distribution of archaeological sites bearing distinctive Lapita pottery and representing an agricultural population (Bellwood 1997:123; Kirch 1997, 2000). The nature and significance of this putatively intrusive agriculture are contentious. Some emphasise the areal extension of Southeast Asian practices and crops into an area of lowlands and islands previously barely agricultural (Kirch 1989; Spriggs 1996a; 1996b); others see the continuation in the Lapita period of older island and coastal Melanesian practices and crops (Gosden 1992; 1995; Groube 1989; Matthews and Gosden 1997; Spriggs 1993). Latinis (2000), Latinis and Stark (1998) and Terrell (2002) also argue for long-standing continuity of arboriculture throughout the contiguous regions of Wallacea and New Guinea. For Yen, the blending in the New Guinea region “of two independently developed agricultures. . . [and the] coming together of Asian and New Guinea species was the basis for the confluence of genetic materials and cultural ideas of environmental adaptation that were given expression in Oceanic subsistence systems.” (Yen 1993b: 91). These views about the agricultural prehistory of the northern lowlands and islands differ in the degree to which they accept the implication that New Guinea highland agriculture is historically derived from the New Guinea lowlands (Golson and Hughes 1980; Golson 1991b). They also differ in their definitions of agriculture, especially whether arboriculture constitutes agriculture or “wild-food production” (Spriggs 1996a). Two possible discontinuities are thus implied in the New Guinea region: between sets of agricultural resources (especially domesticates) characterised as indigenously developed and as introduced from Southeast Asia; and between historically and culturally separate traditions in highland and coastal/island New Guinea.

The cultivated or wild status of New Guinea tree crops is the source of much confusion, both in this debate about agricultural prehistory and in the more general descriptive literature (Matthews and Gosden 1997:129-131). Just as foraging, cultivation and agriculture may be represented as a continuum, so wild, tended, planted and cloned may represent stages in a continuing process of plant domestication, and these stages then stand as indices of the continuum from foraging to agriculture (Etkin 1994; Hope, Golson and Allen 1983:42). But as Yen (1990) makes clear, identifying the degree to which a particular plant species is under genetic control is no simple matter. Furthermore, New Guinea agricultural systems of the present day incorporate wild forms of progenitor species alongside domesticated forms as an essential genetic component (Yen 1990:566). Domestication may not be a useful index of agricultural systems that are not dominated by annual seed plants. Brookfield, in his summary discussion of archaeological evidence bearing on domestication and agrodiversity, cites Nishida’s (1983) argument that throughout the long Jomon period of Japan (10,000-2300 years ago), fishing, hunting and gathering from wild and managed trees were integrated in a farming economy, notwithstanding the lack of domestication (Brookfield 2001:64-65).

We argue that, in the New Guinea region, the integration of different modes of cultivation of mainly perennial plants in complex polycultural production systems justifies the designation of these systems as agricultural. It makes no sense to segregate parts of these systems as non-agricultural on the grounds that one or more of the plant species involved is wild rather than domesticated, foraged rather than harvested, because landscape management, resource ownership and planning encapsulate such resources as part of the overall system. Furthermore, as will be shown below, tree crops occur in repeated associations; there are many examples of clusters of species within a genus, rather than single species; and reports of their active planting are often overlooked in the literature, and probably under-reported as well. The critical historical questions thus include when and how the parts of agricultural systems were assembled, and their relative significance, as much as when individual species were taken into cultivation or domesticated.

Macrobotanical evidence of tree crops

For the Lapita period (c. 3500-2500 BP) and earlier in the Southwest Pacific region, although there is little archaeological evidence of the standard field crops of the region (Denham *et al.* 2003; Hather 1992; Yen 1995), a number of sites have produced evidence of tree crops. Latinis (2000) discusses this evidence for the wider region, from Maluku and Timor to the Solomons. He argues that arboriculture should be treated as a separate class of subsistence economy “rather than as a peripheral component of swidden, horticulture or agriculture” (Latinis 2000:42). Table 1 shows the list compiled by Latinis, abbreviated and revised, of trees represented by macrobotanical remains (seeds, fruit stones and skins, leaf and wood fragments etc, preserved anaerobically or carbonised) in archaeological sites across the region. It is striking that almost all the genera listed have widespread economic value (Burkill 1935; Powell 1976) and that so many of them contain edible species. The predominance of sites in Papua New Guinea rather than Indonesia reflects simply the contrasting intensity of research in the two regions, and points up the inadequacy of the data available for cross-regional comparisons.

Macrobotanical remains from sites in three areas of the New Guinea north coast and islands region have been identified more precisely than is shown in Table 1, many to species level (Table 2). These sites span the period during which the effects of the hypothesised introduction of Austronesian agriculture should be evident and new crops might be expected, especially in the Mussau Lapita site, Talepakemalai. As in Table 1, most of the remains are of edible plants still widely eaten. Their archaeological contexts suggest coastal human habitation and/or refuse disposal in site areas subsequently permanently waterlogged, resulting in anaerobic preservation. Although the remains come from areas of unambiguous human activity, their interpretation as simple assemblages of proximately discarded food refuse is not straightforward. Low energy wave action may accumulate and rework similar deposits, incorporating both natural coastal vegetation (Peekel 1984:592-597) as well as dispersed human refuse, which may be indistinguishable in the absence of evidence for human action, such as distinctive breakage patterns of nut shells (Matthews and Gosden 1997). Nevertheless, the conjunction of so many familiar edible species in these fragmentary assemblages is suggestive of long-term continuity of their dietary importance, from pre-Lapita times to the present.

Of the subset of species present in the Lapita site of Talepakemalai but not in the earlier sites (*Bruguiera* sp., *Burkella obovata*, *Corynocarpus cribbeanus*, *Diospyros* sp, *Inocarpus fagifer*, *Nyssa fruticans*, *Pangium edule*, *Spondias dulcis*, *Terminalia catappa*), some are insufficiently identified to be informative. Others such as *T. catappa* are strand species which probably spread without human assistance. *Inocarpus fagifer* and *Pangium edule* are distributed far enough west to be possible candidates for novel introduction by Lapita colonists (Walter and Sam 2002). However, on the evidence of macrobotanical plant remains from dated sites, tree crops were an important component of pre-Lapita subsistence in the northern New Guinea coast and islands region.

Spriggs (1996a; 1996b) argues that the Lapita period in the New Guinea region is nevertheless marked by significant introductions from Southeast Asia, including tree crops as part of the agricultural component (Table 3). His reasoning is that integration of Melanesian pre-Lapita elements into Lapita is not demonstrated if such elements were already present in Southeast Asia.

Table 1: Macrobotanical remains of trees from early archaeological sites in Wallacea and the southwest Pacific, based on Latinis (2000:Table 1), abbreviated and revised

Genus	age BP	location
<i>Aleurites</i>	13,000	Timor
	10,800 – 5810 (?)	New Ireland
	5830 – 5690 ¹	New Guinea, lower Ramu
	4000 – <1000 ²	New Britain, Arawes
<i>Areca</i>	3200	Mussau, Eloaua
	13,000	Timor
<i>Bruguiera</i>	5830 – 5690 ¹	New Guinea, lower Ramu
	3200	Mussau, Eloaua
<i>Burckella</i>	3200	Mussau, Eloaua
<i>Calophyllum</i>	4000 – <1000 ²	New Britain, Arawes
	3200	Mussau, Eloaua
<i>Canarium</i>	14,000	New Guinea, middle Sepik
	12,000	Manus
	10,800 – 5810 (?)	New Ireland
	10,000 – 3000 (?)	N. Maluku, Morotai
	9400 – 6600	Solomons, Buka
	8000	New Ireland
	6000	Solomons, Guadalcanal
	5830 – 5690 ¹	New Guinea, lower Ramu
	4000 – <1000 ²	New Britain, Arawes
	4850 – 3650 ³	Solomons, Nissan
<i>Casuarina</i>	3200	Mussau, Eloaua
	9000 – 6000	New Guinea Highlands
	3200	Mussau, Eloaua
<i>Celtis</i>	20,890	New Ireland
	11,000	Manus
<i>Cocos</i>	5830 – 5690 ¹	New Guinea, lower Ramu
	4850 – 3650 ³	Solomons, Nissan
	4000 – <1000 ²	New Britain, Arawes
	3200	Mussau, Eloaua
<i>Cordia</i>	5830 – 5690 ¹	New Guinea, lower Ramu
	4000 – <1000 ²	New Britain, Arawes
<i>Corynocarpus</i>	3200	Mussau, Eloaua
	3200	Mussau, Eloaua
<i>Cycas</i>	4000 – <1000 ²	New Britain, Arawes
<i>Diospyros</i>	3200	Mussau, Eloaua
	3200	Mussau, Eloaua
<i>Dracontomelon</i>	4000 – <1000 ²	New Britain, Arawes
<i>Inocarpus</i>	3200	Mussau, Eloaua
	3200	Mussau, Eloaua
<i>Metroxylon</i> ⁴	5830 – 5690 ¹	New Guinea, lower Ramu
	4850 – 3650 ³	Solomons, Nissan
<i>Nypa</i>	3200	Mussau, Eloaua
<i>Pandanus</i>	12,100	New Guinea Highlands
	10,000	New Guinea Highlands
	9760	New Guinea Highlands
	5830 – 5690 ¹	New Guinea, lower Ramu
	4000 – <1000 ²	New Britain, Arawes
	3200	Mussau, Eloaua
	3200	Mussau, Eloaua
<i>Pangium</i>	5830 – 5690 ¹	New Guinea, lower Ramu
<i>Pometia</i>	3200	Mussau, Eloaua
	5830 – 5690 ¹	New Guinea, lower Ramu
<i>Spondias</i>	3200	Mussau, Eloaua
	4000 – <1000 ²	New Britain, Arawes
	3200	Mussau, Eloaua
<i>Sterculia</i>	5830 – 5690 ¹	New Guinea, lower Ramu
<i>Terminalia</i>	4000 – <1000 ²	New Britain, Arawes
	3200	Mussau, Eloaua

Notes: (see Latinis 2000 for sources)

1. Revised date range (Swadling *et al.* 1991).
2. Revised date range (Matthews and Gosden 1997).
3. Revised date range (Spriggs 1991).
4. Identifications tentative.

Table 2: Macrobotanical tree remains from middle-late Holocene sites in 3 areas of the PNG northern coastal and islands region.

Species	Site		
	Dongan ¹ (lower Ramu) 5830-5690 BP	Arawe Islands ² W New Britain 4000-<1000 BP	Talepakemalai ³ Mussau Islands 3150-2750 BP
<i>Aleurites moluccana</i>		3	x
<i>Areca catechu</i>	x		
<i>Bruguiera</i> sp			x
<i>Burckella obovata</i>			x
<i>Calophyllum inophyllum</i>	x		x
<i>Canarium indicum</i>	x	3	x
<i>Canarium</i> spp	x	p	
<i>Casuarina equisetifolia</i>			x
<i>Cocos nucifera</i>	x	3	x
<i>Cordia subcordata</i>		3	x
<i>Corynocarpus cribeanus</i>			x
<i>Cycas circinalis</i>		2	x
<i>Diospyros</i> sp ?			x
<i>Dracontomelon dao</i>		2	x
<i>Inocarpus fagifer</i>			x
<i>Metroxylon</i> sp ?	x		
<i>Nypa fruticans</i>			x
<i>Pandanus</i> spp	x	3	x
<i>Pangium edule</i>			x
<i>Pisonia</i> sp	x		
<i>Pometia pinnata</i>	x		x
<i>Spondias dulcis</i>			x
<i>Sterculia</i> sp	x		
<i>Terminalia catappa</i>			x
<i>Terminalia</i> sp		3	

Notes:

1. Includes identification confidence range from confident to lowest usable identification (Swadling, Araho and Ivuyo 1991).
2. Present in 1, 2 or 3 sites, or (p) present, sites not specified (Matthews and Gosden 1997).
3. Kirch 1989.

As shown in Table 3, Spriggs accepts words reconstructed for the Austronesian proto-language ancestral to that associated with Lapita (proto-Oceanic) as evidence for the early presence of tree taxa in Southeast Asia. This is a dubious argument on a number of grounds. The identity of the named taxa cannot be assumed where identification at species level is uncertain and genera are represented by multiple species across the Malesian region. This is made more complex because changes both in cultivated forms and in their past distributions are likely to have occurred, so that assigning archaeological specimens to modern species is frequently problematic.

At best, linguistic reconstructions for the past distributions of plant taxa can be no stronger than the botanical identifications on which they are based. But Spriggs (1996b: 335), in arguing that Yen, in particular, is mistaken about the biogeographic and ethnobotanical data which he used to suggest domestication of a number of important tree species in the New Guinea region, is prepared to accept at face value identifications which lack any reference to the botanical literature.

Reconstructed terms for *Artocarpus*, *Canarium*, *Pandanus* and *Musa*, for example, are meaningless

unless they take into account the taxonomic and distributional complexities which Yen and others have demonstrated (these taxa are further discussed below). Rather than direct inheritance, transfer of terms between homologous domesticates, such as closely related species of *Canarium*, or borrowing of terms (e. g. breadfruit, *Artocarpus altilis*, [Wolff 1994:523]), could explain the linguistic evidence. Linguistic reconstructions of plant terminologies for the whole southwest Pacific region need revision in the light of the emerging ethnobotanical and biogeographical data.

Table 3: Pre-Lapita distribution (botanical remains and linguistic reconstruction) of edible tree and tree-like species present or inferred present in Lapita sites (based on Spriggs 1996b:Table 22.3).

	pre-Lapita distribution				
	Melanesia		SE Asia		
	Bismarcks	New Guinea	pre-Neolithic	reconstruction ¹	domestication ²
Lapita macrobotanical remains					
<i>Aleurites moluccana</i>		?	x	x	SEA/NG?
<i>Canarium indicum</i>	x	x	?	x	NG
<i>Cocos nucifera</i>	x	x	x	x	SEA/NG
<i>Inocarpus</i> sp			x	x	NG
<i>Metroxylon</i> sp	x	?		x	NG
<i>Pandanus</i> spp		x		x	SEA/NG
<i>Pometia pinnata</i>		x		x	NG
<i>Sterculia</i> sp	?	x			?
<i>Terminalia</i> sp	?	x		x	NG
Lapita presence inferred					
<i>Areca catechu</i>		x	x	x	SEA
<i>Artocarpus altilis</i>				x	NG
<i>Musa</i> sect. <i>Eumusa</i>				x	SEA

Notes:

see Spriggs 1996b for sources.

1. Proto-Malayo-Polynesian reconstructions from Pawley and Green (1984).

2. Area of putative domestication based on Yen (1982, 1985, 1990, 1991a).

While it is clear that macrobotanical evidence for Southeast Asian archaeological sites is woefully thinner than the record for the New Guinea region and cannot at present provide a comparative base, biogeographic, ethnobotanical and archaeological evidence nevertheless suggest that there are complex linkages, probably involving multidirectional transfers of people and resources rather than a simple west-to-east transplant (Gosden 1992:60).

Because of the rarity of the special conditions under which macrobotanical remains are preserved in archaeological contexts, inventories such as those discussed above can present only a very incomplete picture of resource use, which needs to be supplemented by other lines of evidence. Environmental reconstruction based on pollen cores and studies of plant microfossils including pollen, starch grains and phytoliths from archaeological contexts are also important. As yet, there is only a little such evidence available for lowland and island regions of New Guinea (Haberle 1994; Hope and Tulip 1994; Lentfer, Therin and Torrence 2002; Loy 1994; Loy, Spriggs and Wickler 1992; Spriggs 1991; Therin, Fullagar and Torrence 1999).

The Kuk site: multiple lines of evidence for diverse agricultural practices

In the New Guinea highlands, there are no anaerobically preserved archaeological plant assemblages like those discussed above, and a very restricted range of carbonised plant remains has been recovered from only a few sites (see Table 1). However, pollen cores from the highlands provide a strong record of environmental change that is strongly suggestive of human modification of the landscape (Haberle 1994; Haberle, Hope and De Fretes 1991; Hope, Golson and Allen 1983; Hope and Golson 1995; Powell 1982). The swamp site at Kuk, near Mt Hagen in the Western Highlands, provides much the best archaeological evidence of plants, based on the application of a range of analytical techniques to sediments from the early part of the sequence of archaeological phases (Denham *et al.* 2003). Table 4 shows the tree and tree-like species present. Most of these remains are from contexts that predate the first suggestion of human-constructed features such as ditches, and are thus indicators of what was growing in surrounding forest rather than in swamp gardens. While the record is sparse compared with the range of highlands tree species that might have provided food (Powell 1976), it reflects significant taxa, especially the bananas (*Musa* spp) and pandanus. Although the identified tree species are not necessarily cultivated (or domesticated), their combination with herbaceous taxa such as taro (*Colocasia*) and proximity to the modified swamp is suggestive of an integrated polycultural landscape incorporating tree crops.

Table 4: Trees and tree-like species with edible parts from early contexts at Kuk, based on Denham *et al.* (2003:Table S3).

taxon	parts preserved	earliest record	parts eaten today
<i>Castanopsis</i> sp	wood, pollen?	Pleistocene	nut
Elaeocarpaceae	pollen	phase 1	nut
<i>Ficus cf copiosa</i>	seed	Pleistocene	fruit, leaf
<i>Ficus</i> spp	seed, wood	Pleistocene	fruit, leaf
<i>Garcinia</i> sp	wood, pollen?	Pleistocene	fruit, leaf, bark
Musaceae ¹	phytolith, starch	Pleistocene	fruit, corm
<i>Musa</i> sect. Eumusa sp	phytolith	phase 1	fruit, corm
<i>Pandanus antaresensis</i>	pollen	Pleistocene	drupe
<i>Pandanus brosimus</i>	pollen	Pleistocene	drupe
<i>Pandanus</i> sp	pollen, seed	Pleistocene	?
<i>Syzygium</i> sp	wood, pollen?	Pleistocene	fruit

Note:

1. includes wild species *Ensete* sp and *Musa ingens*

The striking presence from the early Holocene of bananas of Eumusa section undermines the standard view that such bananas were domesticated in Southeast Asia and introduced to Papua New Guinea. The new archaeological evidence for early Eumusa bananas supports recent genetic work, discussed below. This presence also reinforces the case long made by Golson (1977; 1991b; Golson and Hughes 1980; Hope and Golson 1995) for the dependence of highlands agriculture on plants more at home in the lowlands, argued on the grounds of post-glacial climatic changes. Thus, the linkage of highlands and lowlands in New Guinea crop assemblages is not dependent on the argument that agriculture in the highlands began with the introduction of an agricultural package derived from Southeast Asia and consisting of lowland crops (Spriggs 1996a).

The pandanus species identified at Kuk, on the other hand, are of highlands origin. Pandanus species, further discussed below, like the bananas suggest the overlap of highland and lowland elements. Despite the lack of early Holocene evidence in the New Guinea lowlands for either widespread environmental disturbance or localised environmental management, comparable to that at Kuk, the overlap of tree crops argues against the isolation of agricultural developments in the

highlands (Hope and Golson 1995:825, 829), and hints at the nature of lowlands agriculture, in which tree crops probably played a significant part.

Five Significant Taxa in New Guinea Traditional Agroforestry

One of the lessons of the fragmentary archaeological record of plant remains discussed above is manifest in the dates of its publication: such evidence has only recently been looked for in archaeological sites. Despite the long-established significance of tree crops in the literature on the Pacific region, archaeologists in the New Guinea region have only just begun to discuss arboriculture. Some of the analytical techniques are new, and so are some of the questions (Denham *et al.* 2003).

Despite archaeologists' current interest in Pacific tree crops, much of the archaeological literature makes only cursory reference to the rich ethnobotanical literature, and shows little awareness of taxonomic and genetic complexities and revisions. Furthermore, the division in the New Guinea region between archaeological research agendas concerned with Lapita-related questions (increasingly described as "Austronesian" research) and the rest imposes a cultural divide between research fields. This divide converts primary questions for research into hidden assumptions: the prehistories of the islands and northern lowland/coastal regions of New Guinea may diverge sufficiently to justify treating them separately, but this is yet to be demonstrated. Yen (1991a: 564) has pointed out the mainland New Guinea derivation of many crops familiar throughout the islands region. Most notably, many of the tree crops now widespread in coastal and island village environs throughout the region have their origin in the lower montane forest of New Guinea. The archaeological record (Table 2) hints that this linkage between mainland and offshore islands is not recent.

Examination of five taxa of tree and tree-like crops illustrates how crucially useful it is to cross-check knowledge of the distribution, ethnobotany and taxonomy of food plants with archaeological data. Two, banana and sago, are starchy staples (banana eaten as ripe fruit being rarely important). Fruit are represented by two kinds of pandanus (and occasionally by breadfruit) and nuts by another pandanus type, breadfruit and the genus *Canarium*.

All five taxa contain species of widespread importance in modern agricultural systems of Papua New Guinea, recently distinguished and defined by country-wide survey in the Mapping Agricultural Systems Project (MASP) (Bourke *et al.* 1998). Table 5 shows the importance of each taxon in each province as the percentage of the number of systems per province in which it is listed. The table thus shows the distributions within as well as between provinces. It is important to note that MASP listings are based on common and important occurrence, not mere presence (for definitions see Bourke *et al.* 1998:7-9). The two staples are almost ubiquitous, and banana is significant in nearly every system. Of the three kinds of pandanus, one is significant only in the islands, the other two on the mainland. The pandanus nuts known in Tok Pisin as *karuka*, very important at high altitude (above 2000m), are in complementary distribution with the lowland *Canarium* nuts. Breadfruit, for its nuts rather than flesh, is of widespread importance.

These taxa occur in repeated associations, both spatially with other tree crops and sometimes sequentially with annual garden crops. These associations as well as the individual distributions need investigation, in the past as well as the present.

Table 5: Selected tree crops commonly eaten in PNG: significant presence in number of agricultural systems per province (per cent), based on Bourke *et al.* 1998.

Province	no. of systems	staples..... fruit..... nuts.....						
		<i>Pandanus spp.</i>						
		sago	banana ¹	marita ²	raw fruit ²	karuka ²	breadfruit	Canarium
Western	16	88	100	50	6	6	94	6
Gulf	14	64	100	79	0	29	79	0
Central	22	41	100	45	5	23	91	0
Milne Bay	30	33	100	37	0	10	93	27
Oro	13	62	100	77	8	23	92	46
S Highlands	23	35	87	65	0	61	39	0
Enga	13	15	85	38	0	85	15	0
W Highlands	12	8	92	75	0	83	42	0
Simbu	14	14	100	100	0	86	21	0
E Highlands	24	4	100	92	0	75	17	0
Morobe	40	28	95	75	0	38	75	33
Madang	32	53	100	69	0	31	84	50
E Sepik	20	95	95	70	0	0	95	40
Sandaun	11	55	100	73	0	45	64	27
Manus	7	57	100	0	43	0	100	100
New Ireland	14	57	100	0	14	0	93	79
E New Britain	10	0	100	0	20	0	90	70
W New Britain	18	17	100	6	6	0	100	78
Bougainville	9	11	100	0	11	0	100	89

Notes:

1. Eaten cooked as staple. Raw fruit important in only 4 systems of Sepik provinces.
2. See *Pandanus* section for explanation.

Metroxylon Rottboell: sago palms

The true sago palms are members of the Gondwanan genus *Metroxylon*, its six species distributed from the New Guinea region, the Bismarck archipelago and Solomon Islands (*M. sagu*, *M. salomonense*), Vanuatu (*M. warburghii*), Fiji (*M. vitiense*) and Samoa (*M. paulcoxii*) to the Caroline Islands (*M. amicarum*) (Baker *et al.* 1998:247-248; McClatchey 1999, 2002; Rauerdink 1986; Schuiling 1996). Revision of the genus has reduced the number of species, subsuming much variability in single species, especially in *M. sagu* (Flach 1997:8-11). Recent investigation (by amplified fragment length polymorphism) of the patterns of genetic variation in this species has confirmed their lack of correlation with the patterns of morphological variation, including presence/absence of spines, which the older taxonomies reflected. In 76 accessions from seven localities along the north coast of Papua New Guinea, geographic distance accounted for most of the genetic variation (Kjær *et al.* 2002).

All six *Metroxylon* species are important sources of building material, especially thatch, and all store harvestable starch in the pith of the trunk. They vary in reproductive mode. All but the Micronesian species flower only once per stem (hapaxanthic), after a long period of starch storage (10-20 years). All propagate by seed, but *M. sagu* also produces suckers. Only *M. sagu* is important as a staple food, on which there is a very large literature concerning aspects of processing and productivity, for industrial as well as subsistence use (Kainuma *et al.* 2002; Ruddle *et al.* 1978). Probably native to

New Guinea, it has been dispersed widely by humans in Southeast Asia (Barrau 1959; Flach 1997; Schuilung 1996; Schuilung and Jong 1996).

The inclusion of the genus in a discussion of arboriculture is justified by the probability that domestication has had a significant role in altering both the characteristics and the distributions of the genus, and by widespread evidence of cultivation, especially of *M. sagu*. Yen uses the genus to “demonstrate best the development of domesticated taxa of the wide Melanesian-Polynesian border region that discriminates the New Guinea region of origin and the Polynesian region of agricultural diffusion.” (1990:269). In New Guinea, domestication of *M. sagu* has involved selection for starch production and suckering to produce clonal planting material. In the islands to the east of New Guinea, Yen (1990) suggests a reversal of priorities, with concentration on single-stemmed forms and leaf production at the expense of starch, which remained as a fall-back resource rather than a staple and is now of little importance. *M. salomonense*, distributed from eastern New Guinea through the Bismarcks and Solomons, may be the progenitor of the more easterly species (Schuilung 1996; Yen 1990). McClatchey’s morphologically based studies (1999, 2002) of the five eastern species, distinguished as a separate section *Coelococcus* of the genus, also suggest an important role for human selection in the differentiation of these species, two of which might be anthropogenic. McClatchey (2002:124) also raises the possibility that *M. sagu* might have evolved from the eastern section *Coelococcus*.

The common image of *M. sagu* is that of the dark, nearly impenetrable lowland riverine sago swamp, exploited as a wild resource by mobile gatherers. However, sago is more productive in seasonally dry mixed forests, where greater numbers of large trunks develop (Schuilung and Jong 1996:124). Transplanting of sago suckers is widespread, and may take the palm well beyond its natural limits. Sago is quite unlike other cultivated starch staples in that cultivation demands far less labour, the return is delayed by years rather than months, and the establishment of a sucker produces a new stand by the formation of new suckers, the development of which is enhanced by harvesting of the first trunk (Huber 1973:72; Rhoads 1982). Transplanting of seedlings is also recorded, though rare in New Guinea (Rhoads 1982:24). The other species of *Metroxylon* can only be propagated by seed (Yen 1985: 323; 1990). Natural dispersal by birds or bats is possible, but not well established (Ehara 2002; McClatchey 2002).

Almost 10 percent of the population of Papua New Guinea today depends on sago as a dominant staple (Hanson *et al.* 2001:297). For West Papua, Garnaut and Manning’s (1974:6) estimate of 25 percent of the population as dependent on staple sago probably needs revision, given subsequent pressures on the resource, which include commercial ventures such as industrial extraction of sago (Flach 1997:51), replacement by oil palm plantations (Mambrasar 1984), forestry concessions and pollution by mining. Local trade in sago is very widespread. Raab (1990), Roscoe (2002) and Townsend (1969; 1974; 1982; 2003) summarise New Guinea sago production in comparative ethnological, economic and social context. Rhoads (1982) provides a useful review of the scale of intensity of management in New Guinea, and argues for the antiquity of sago cultivation. Although described as undemanding, casual and easily overlooked (Roscoe 2002:154), transplanting of sago suckers is nevertheless probably the most risky part of sago management (Brouwer 1998:382, n.27). If successful, a new grove is established, which may then pass in and out of active management and use. Thus, sago stands described as wild may in fact be feral (Rhoads 1982:24). Quite often, wild (or feral) and transplanted clumps co-exist (Ohtsuka 1985:345; Townsend 1974:222). To complicate matters further, sago varieties described by informants as wild and normally self-propagating may also be transplanted, while others described as planted may receive minimal attention (Dwyer and Minnegal 1994:86). Neither morphology nor management practices provide a clear basis for distinguishing wild or feral from cultivated or domesticated sago (Ellen 1978 72; 1979:51-52; Yen 1990). Multiple varieties of sago are commonly distinguished; differences in starch colour, taste, yield, ease of processing, storage potential as well as spininess of various parts are all reported.

While the distinction between wild and cultivated sago is anything but transparent, the significance of transplanting goes beyond mere local extension of the palm in lowland swamp habitats. It exemplifies the general pattern of adaptation by translocation (in this case to coasts and islands) that

Yen (1991a:Table 2; 1995) identifies as characteristic of New Guinea agriculture. The establishment of sago at altitudes up to 1250 m (Hide 1994:222) suggests expansion of the range of coastal/island adaptation shown in Yen's list. At high altitudes, sago may be slower to mature, yield less starch and be harder to process, as in the Strickland-Bosavi area (Dwyer 1990:64; Kelly 1993: 96-100). Gorecki (1989a:70-71) noted sago in the Jimi valley at 1100 m, supplied with water for processing by bamboo pipes. The importance of transplanted sago is also exemplified by widespread individual ownership and restrictions on its use, as in Asmat village plantings for special distributions (Eyde 1967:65). It is transplanted as a legacy (Barth 1975:42; Juillerat 1996:150-155; Kelly 1993:130-131; Kuchikura 1997), sometimes with specific prohibition against cutting or consuming by the planter (Huber 1973:72), and to establish claims to land (Moraes-Gorecki 1983:237).

Sago is often associated with other tree crops. Dwyer and Minnegal (1994), Huber (1973) Juillerat (1983; 1996) and Kelly (1993) describe the intricate balances between sago production and other crops including trees. Rhoads (1982:22) recorded lowland sago plantings in secondary rainforest among fruit, nut and fibre species (breadfruit, *Broussonetia papyrifera*, *Dracontomelon* spp, *marita* [*Pandanus conoideus*], *Pometia* sp, *Spondias* sp, *Syzygium malaccense* and *Terminalia* spp). In the Mountain Ok area, sago, breadfruit and *marita* groves are common (Barth 1975:41-42; Hyndman 1982:223-225; Morren 1986:72-74). McEldowney (1995:479) recorded sparse sago plantings for thatch on Baluan. In an area of karst in central Manus Island, Kennedy (1981) recorded planted sago stands interspersed among fruits, nuts and other useful trees, including bananas, breadfruit, mango, *Canarium decumanum*, *Gnetum gnemon*, *Pometia pinnata* and *Syzygium* spp. Planted sago in the Krisa area of Sandaun Province, also on limestone, is associated with other important cultivated trees including coconut, betelnut and *Gnetum gnemon* (Klappa pers. comm.). Hughes (1970) described sago planted in steep karst limestone country west and south of Mt Karimui, to maintain domestic pigs away from areas of human settlement. Other useful trees, including breadfruit, *marita* pandanus, *Terminalia kaernbachii*, *Pangium edule* and *Gnetum gnemon* were often planted nearby.

Metroxylon, then, is an important arboricultural taxon, the prehistory of which in the southwest Pacific is likely to have been very complex. Rhoads (1982) discusses the implications of his hypothesis that sago was exploited by the earliest humans to reach the Sahul shelf, for which there is still no direct evidence. The archaeological record so far provides barely a hint of the presence of sago. As well as the tentatively identified specimens listed in Tables 1 and 2, sago remains were preserved in mid to late Holocene swamp deposits in the Jimi Valley (Gillieson, Gorecki and Hope 1985). Sago pollen is rarely recorded (Haberle 1994:184). Yen's model of extension of the genus by translocation and differential selection suggests questions for further genetic and archaeological research. While powerful techniques of DNA analysis are already available for the former, the latter presents a challenge (Kjaer *et al.* 2003; Haberle 1994; Loy 1994). Among the questions needing archaeological research are the timings of the implied spread of *M. sagu* to the west as well as upwards and offshore within the New Guinea region, and its incorporation with other tree species in polycultural cropping systems.

Canarium L. (Burseraceae)

In stark contrast to *Metroxylon*, the genus *Canarium* is very prominent archaeologically in the New Guinea and wider Southeast Asian region, from Sri Lanka, Thailand and Viet Nam to Tikopia and Vanuatu (Tables 1-3; Fredericksen *et al.* 1993; Kirch 1989; Maloney 1996; Matthews and Gosden 1997; Spriggs 1993; 1997; Wickler 1990; Yen 1996). However, *Canarium* rarely receives more than passing mention in the New Guinea ethnographic literature, despite its importance there (Table 5). It is better described in Solomon Islands and Vanuatu (Evans 1999; Hviding and Bayliss-Smith 2000; Stevens, Bourke and Evans 1996; Walter and Sam 2002; Yen 1974). The genus comprises about 100 species of Old World tropical trees, mostly of lowland rainforests, centred on the Malesian region. The oily seeds of many species are edible, as are the fruit of some. At least 12 species are in cultivation for a variety of uses including timber, oil and resin as well as food (Leenhouts 1955; 1956; 1959; 1965). Cultivation is always by seed, which is cross-pollinated even in monoecious species, so that variability remains high. Clonal reproduction is unknown in wild or cultivated species of New Guinea and islands further east (Yen 1985:323; 1991a: 565); it is described only for the Philippine commercial species *C. ovatum* (Coronel 1991:107).

Recognising the potential variability, distinctiveness and durability of carbonised *Canarium* nut shell in archaeological deposits, Yen (1977; 1985; 1990; 1991a; 1991b; 1993a; 1995; 1996) has made extensive ethnobotanical study of the genus in Southeast Asia and the Pacific. He comments that the complex history of *Canarium* in the western Pacific has produced “more domesticated species as recognised botanical taxa than any other tree genus in the region” (Yen 1996:37). The distributions of western Pacific domesticated species used as food are shown in Table 6. Other species of uncertain status are locally significant, such as *C. kaniense* in Oro Province. *C. indicum*, the most widespread species, is represented in New Guinea by both wild and domesticated forms, both of them cultivated (Yen 1991a: 565). The three domesticated species of the vulgare group (Table 6) may represent separate domestications of ancestral forms whose differentiation began in the eastern Indonesian region. *C. indicum* and *C. vulgare* are very similar and frequently confused (Henty 1982; Leenhouts 1959). They overlap in Maluku according to Leenhouts (1959; see Table 6), but this may represent recent spread (Yen 1995:839; 1996:39). Carbonised endocarps, mostly of *C. indicum*, from archaeological sites date the process of differentiation back to the late Pleistocene, and imply that people began transporting selected forms as early. The range of domesticated *C. indicum* may thus have been extended from mainland New Guinea to islands west, north and east, overlapping the distributions of other wild and domesticated species. The other domesticated species of the New Guinea region are more localised. The wild progenitors of all these domesticates are uncertain (Yen 1996:39-41).

Table 6: Distribution of domesticated *Canarium* species in the western Pacific by sections and groups, based on Leenhouts (1959) and Yen (1996).

section	group	species	
Canarium	maluense	<i>C. lamii</i>	New Guinea (north coast)
		<i>C. salomonense</i>	east New Guinea, ?Woodlark, Solomon Islands
		<i>C. harveyi</i>	Solomons, Vanuatu, Tonga, Fiji, Samoa
	vulgare	<i>C. vulgare</i>	Bawean, Kangean, Flores, Timor, Wetar, Tanimbar, Sulawesi, Talaud, Morotai, Sula, Seram, Banda, Aru
		<i>C. indicum</i>	north Sulawesi (probably naturalised), Seram, Ambon, Sula, Ternate, Kai, New Guinea, New Britain, New Ireland, Solomons, Vanuatu
<i>incertae sedis</i>	decumanum	<i>C. ovatum</i>	south Luzon, Polillo, Samar, Leyte, Mindanao
		<i>C. decumanum</i>	east Borneo, Seram, Bacan, Ternate, Morotai, Vogelkop, Manus

Like sago, *Canarium* is often categorised in the ethnographic literature of New Guinea and eastern Indonesian as wild food, gathered from natural forests, with no recognition of the existence of domesticated (and feral) forms, and of multiple species. Descriptions of gathering, tending, planting, harvesting or processing are rare and sometimes inconsistent. On Seram, Ellen (1978:72-73) listed two varieties of *C. commune* (synonymous with *C. vulgare*) among non-domesticated plant resources, but also noted that the trees were of value, were spared during garden clearance and may have been transplanted (1978:150). Wolff and Florey (1998:272, 275) also describe *Canarium* spp on Seram as planted but list them among wild foods. In the Strickland-Bosavi region, Suda (1997) and Kuchikura (1997) describe *Canarium* spp as gathered from the wild, while Shaw (1990:42-43) and Minnegal (1994) describe them as planted along with other tree crops, such as *Terminalia*, *Pandanus conoides* and breadfruit. In the same area, according to van Beek (1987:23), *Canarium* and other nut trees are left standing when gardens are cleared. Shaw names *C. indicum*, Kuchikura *C. kaniensis* (= *kaniense*) and van Beek *C. acutifolium*; multiple species are probably present, but the identifications are uncertain. On the Oriomo plateau, further east, Ohtsuka (1983:89-90) described *Canarium vitiense* trees as so abundant and fast growing that they were harvested by cutting them down. The fruit was eaten boiled. This is remarkable, not only for the profligacy of the harvesting technique, but also for

the fact that the fruit were boiled. Although Leenhouts (1955, 1965) noted the small fruit of the species as edible in Fiji, Ohtsuka's (1983) record is the only one that it is eaten in New Guinea (Leenhouts 1955, 1965). All these descriptions are from areas in which *Canarium* was rarely of sufficient importance to be recorded in the Mapping Agricultural Systems Project/MASP (Bourke *et al.* 1998; Table 5).

In West Sepik Province, Yen's informants in the Torricelli Mountains distinguished wild from cultivated *C. indicum*, but drew on both populations for seedlings to transplant. They regarded *C. lamii*, another large-seeded species, as cultivated only (Yen 1991a: 565). In the Border Mountains near Amanab, Juillerat (1984:5; 1996:166-167) described three named kinds of *Canarium* as "semi-cultivated." In the southwest Sepik basin, Townsend (1969:187) noted that nuts of an unnamed wild *Canarium* species were harvested by felling the trees. Henty (1982) described *C. indicum* as widespread in Papua New Guinea, with cultivated races particularly important in the Bismarcks and Madang Province. He also noted that a form of the New Guinea endemic species *C. kaniense* was cultivated in Northern and Morobe Provinces.

Canarium is of widespread importance on smaller islands north of New Guinea, and *C. indicum* the dominant species. On Kairiru, off the Sepik coast, two wild, small-fruited species are recorded and two forms of *C. indicum* in cultivation as well as wild (Borrell 1989:60). Nuts were traded by people of Wogeo (Hogbin 1978:25) and Siassi (Harding 1967:129). Mountain Yupno of Nokopo in the Finisterre range import *Canarium* nuts from the lowlands; they are the favourite food of souls and are important in sorcery (Kocher Schmid 1994:345).

In Manus Province, *Canarium indicum* grew on Baluan in gardens as a scattered emergent and in orchards that have been replaced by coconut plantations, its former locations still marked by pitted stones used as anvils to crack the nuts (McEldowney 1995:477). In the karst of central Manus, *C. decumanum* trees planted by named ancestors were privately owned but their produce freely available (Kennedy 1981). On Mussau, where the nuts of *C. indicum* are no longer so favoured, they were stored and were important in trade (Lepofsky 1992:195). Peekel (1984:280-283) illustrates various New Ireland forms, described as greatly valued. Womersley (1960:108) commented that the numerous *C. indicum* trees on the Gazelle Peninsula were the result of selective planting of seedlings. Noting seasonally large quantities in the markets of Rabaul and Madang, he described *C. indicum* as probably the most delectable of all tropical nuts (1972:230). Evans (1994) surveyed the marketing potential of nuts of the genus in two districts of West New Britain. Although the literature refers to *Canarium indicum* as the only significant nut species there, he notes the possibility that other nut species might also be present. For Kaulong of the Whiteman ranges of southern West New Britain Province, Goodale (1995:113-114, 182) noted the importance of groves, including *Canarium*, breadfruit and other fruit trees, in both the establishment of hamlets and their long-term maintenance by appropriate descendants of the founders. *Canarium* nuts were a highly prized food in northern Bougainville, where the trees were planted or carefully conserved, and owned as heritable personal property (Blackwood 1935:11, 275, 277-280, 301, 454). Processing for storage is described by Spriggs (1997:56-57) for Bougainville and by Ross (1973:172) for Malaita, where most trees were owned and some were planted. Aspects of production and storage in the Solomons and Vanuatu are further discussed by Evans (1999), Hviding and Bayliss-Smith (2000), Stevens, Bourke and Evans (1996), Walter and Sam (2002), and Yen (1974).

Yen comments that *Canarium indicum*, *Pometia pinnata*, and *Burckella obovata*, all deriving from the lower montane rain forest of New Guinea, form a triad of fruit and nut trees "that heavily influenced the indigenous agricultural systems of coastal, lower altitudinal and small island environments of Melanesia . . . , manifest not only in food patterns but in trade and cultural significance." (1996:37). As noted above, archaeological evidence suggests that this process began in the Pleistocene, and it probably continues to the present. An increase in selective pressure is a likely consequence of the extended range, but it is by no means clear what directions this may have taken. Seed size is but one possibility (Lepofsky, Kirch and Lertzman 1998). The selection process has also adapted originally forest species to coastal sandy and limestone soils (Yen 1991b: 83). Mixed varieties of *Canarium* frequently co-occur and, as Yen (1996:42; 1993b) points out, this is no

accident but rather a consistent feature of Pacific Island crop systems. So too is the recurrent association of tree crops of different species. Both these features seem also to characterise tree assemblages in parts of mainland New Guinea where *Canarium* species are less clearly cultivated.

The genus *Canarium* is of great importance in the prehistory of subsistence in the western Pacific because it is so visible archaeologically. However, interpreting this archaeological record is problematic, because of the botanical complexities involved, not the least of which is the uncertain ancestry of the large-seeded cultivated forms. Further study of macrobotanical remains and pollen is needed (Maloney 1996), and genetic evidence might sort out the complicated relationships of wild, feral and cultivated forms (Yen 1996:41-42).

Pandanus Parkinson (Pandanaeae)

“*Pandanus* is probably the most unsung of agricultural genera in the Pacific.” (Yen 1996:37). At least 600 species are distributed throughout the palaeotropics from Africa and Madagascar, India, tropical Southeast Asia, Malesia and tropical Australia to virtually all the tropical and some subtropical Pacific Islands. Many are useful, their leaves for matting, wrapping and fibre, their fruit for food, and there are many local cultivars. Yen (1995:840) comments that the genus “has the widest of ecological ranges of adaptation and probably the most domesticated forms of any native Pacific plants. Occurring in New Guinea in the subalpine mountains at nearly 3000m, in mid-altitudinal rainforest, on riverine and coastal flats, the ubiquitous ‘screwpine’ may be found with domesticated forms, wherever there are human settlements.” *Pandanus* taxonomy is therefore very complex. The distinctive trees, often making thickets of stilt roots entangled with spiny leaves, are strictly unisexual. Their female fruits are drupes, forming finger-shaped syncarps which are further agglomerated into large cylindrical or globose heads. In the New Guinea region, there are at least 68 species, perhaps 80 per cent of them endemic, in five of the eight subgenera and 23 of about 60 sections (Stone 1974; 1976; 1982, 1984; 1991; 1992).

Fruit of New Guinea cultivated and wild *pandanus* species yield two distinctive kinds of food, both of them important in modern diets. These are respectively mesocarp and seeds (commonly called nuts, *karuka* in Tok Pisin) and flesh consisting of oily pericarp (often called fruit or oil *pandanus*, *marita* in Tok Pisin). As well, the juicy, sweet or starchy, sometimes fragrant pericarp of other species is widely eaten, constituting a third type not much elaborated in New Guinea (Lepofsky 1992:201-202; McEldowney 1995:475), but very important in Micronesia (Englberger, Fitzgerald and Marks 2003; Stone 1963). The distribution of all three types in New Guinea agricultural systems is shown in Table 5. The taxonomy, status and distribution of species eaten in New Guinea are summarised in Table 7.

Although all three types are quite commonly mentioned in the New Guinea ethnographic literature, there is often confusion among species, and whether they are cultivated or wild. There is no comprehensive ethnobotanical study of the New Guinea species. Gaffey (1978) reviewed the literature for Australia and New Guinea. Hyndman (1982; 1984), Stone (1984) and Hyndman and Menzies (1990) discuss material collected from the Ok Tedi region, where, as Barth (1975:187; 1987:69-71) has noted, local people are interested in the whole genus. Other discussions of the genus include Clarke (1971) for the Maring area, Herdt (1981) for the Sambia of the Menyamya area, Gorecki (1989a) for the Jimi, Kocher Schmid (1991) for the Finisterre Ranges, Sterly (1997) for Simbu and Sillitoe (1983) for the Southern Highlands in Papua New Guinea. In West Papua, Boissière (1999), Claire (1998/99), Hiepko and Schiefenhövel (1987), Hiepko and Schultze-Motel (1981) and Purwanto (1997) describe *pandanus* in the Dani and Yali areas, and Cook (1995) for the Amung. In the Bismarcks and Solomons, ethnobotanical descriptions include Lepofsky (1992) for Mussau, Peekel (1984) for New Ireland and Yen (1974) for Santa Cruz. The *karuka* and *marita* types, both distinctively New Guinean in their importance (though *marita* extends to eastern Maluku) are discussed separately.

Table 7: Taxonomy, status and distribution of New Guinea edible *Pandanus* species (French 1986; Hyndman 1984; Peekel 1984; Stone 1976; 1982; 1984; 1991).

	subgenus	section	species	status ¹	distribution
karuka type					
	Pandanus	<i>Excavata</i>	<i>P. antaresensis</i>	c, w	New Guinea
	Lophostigma	<i>Karuka</i>	<i>P. brosimos</i>	c, w	New Guinea
			<i>P. iwen</i>	?c	New Guinea
			<i>P. julianettii</i>	c, w	New Guinea
		<i>Liniobtutus</i>	<i>P. foveolatus</i>	w	east New Guinea
marita type					
		<i>Maysops</i>	<i>P. castaneus</i>	w	New Guinea
			<i>P. krauelianus</i>	w	New Guinea, ? Bismarcks
	Kurzia	<i>Kurzia</i>	<i>P. cominsii</i>	w	New Ireland, Micronesia
			<i>P. englerianus</i>	c, ?w	New Ireland
			<i>P. hollrungii</i>	w	east New Guinea
		<i>Microstigma</i>	<i>P. conoideus</i>	c	New Guinea, Manus,
			<i>P. erythros</i>	?	West New Britain,
			<i>P. magnificus</i>	?	Halmahera, Bacan,
			<i>P. ruber</i>	?	Obi, Seram,
			<i>P. plicatus</i>	c	Kei, Aru ²
					east New Guinea
raw fruit type³					
	Pandanus	<i>Fagerlindia</i>	<i>P. kaembachii</i>	w	New Guinea, Bismarcks
		<i>Pandanus</i>	<i>P. tectorius</i>	c, w	widespread Pacific
	Rykia	<i>Hombronina</i>	<i>P. dubius</i>	w	widespread Malesia & Pacific
	?	?	<i>P. lamekotensis</i>	w	New Ireland

Notes:

1. c=cultivated, w=wild
2. distribution of section *Microstigma*
3. juicy pericarp, chewed raw, occasionally cooked

Karuka

The fruits of *Pandanus brosimos*, *P. iwen* and *P. julianettii* of the section *Karuka* (see Table 7) are “massive subglobose heads composed of large single -seeded drupes. The large and fat-rich endosperm is the edible portion.” (Stone 1982:413). The three species, and perhaps others of the same endemic section, probably include cultivars of the single species *P. brosimos*. Trees grow wild as well as tended and cultivated in the montane zone of New Guinea (Stone 1982; 1984). Cultivars vary in growth habit, in the thickness of the bony endocarp enclosing the “nut,” and in the development of edible basal mesocarp which forms when no endosperm develops (Donoghue 1988:52). The Tok Pisin term *karuka* applies especially to this group of species, but is sometimes extended to species with edible nuts in other subgenera, for example *P. antaresensis* (Hyndman 1984).

Karuka is a very important food in many parts of the highlands (Table 5), where trees are cultivated or tended in groves and many wild trees are also owned. The drupes, dried over smoky fires, are storable for months though they are usually consumed rapidly. Nutritional analyses of *karuka* (in dry matter, 37% fat, 32% carbohydrate and 14% protein) show it is nutritionally better than coconut (Rose 1982).

Multiple *karuka* cultivars are commonly recognised (Donoghue 1988; Haberle 1991; Hyndman 1984; Sillitoe 1983). In the Tari area, Rose (1982) recorded 17 varieties of *Pandanus julianettii*, two of which accounted for nearly 75% of his sample of trees. Huli of the Haiyapugwa area recognised eleven cultivated varieties, two of them self-sown and transplanted into gardens, the rest planted from cuttings. There were also other varieties in the forest which were harvested (Powell and Harrison 1982:80). In Enga Province, many varieties of both *P. brosimos* (growing wild in high forest) and *P. julianettii* (planted near houses) were recognised. According to some Engans, planting *karuka* near houses began recently (Wiessner and Tumu 1998:65). In the Wurup valley, near Mt Hagen, Christensen (1975:27; Donoghue 1988:49) described groves of many locally named varieties of *Pandanus julianettii*, planted, regularly weeded and preserved by smoke-drying. Non-cultivated *P. brosimos*, at higher altitude, was not given any such care, but cutting down trees to harvest its fruit nevertheless produced groves, by resprouting of felled branches. People camped in huts or rockshelters to harvest *P. brosimos*, which was usually processed and eaten on the spot, not preserved (Christensen 1975:27). For Kalam, all pandans were important, but especially the uncultivated nut-bearing pandanus growing in beech forest, of which they recognised over 20 varieties. This is either *Pandanus brosimos* or *P. julianettii*. Nuts of another wild form, probably *P. antaresensis*, and of cultivated trees (probably *P. julianettii*) were also eaten (Majnep and Bulmer 1983). In the Menyamya area, where pandanus species were ritually important (Herdt 1981), Baruya named eight cultivars, and planted both sprouted nuts and cuttings. Up to a quarter of the population, men, women and children, moved en masse to processing camps in the high forest for the harvest. They stayed in sturdy plank-built houses in the pandanus groves, where the nuts were smoked (Bonnemère and Lemonnier (2002). In the Dani area of West Papua, where three types of *karuka* were named, Purwanto (1997:234-237) reported that *Pandanus julianettii* and *P. brosimos* were being actively cultivated near houses to compensate for their loss in the wild. In the Sina Sina area of Simbu Province, the nuts from planted and self-sown *karuka* groves in secondary forest between sweet potato gardens and *Nothofagus-Castanopsis* forest were an important resource for prestige exchange (Hughes 1966:36, 41).

Karuka has been identified archaeologically at sites in the Manim Valley, near Kuk in the Western Highlands. A change over time from thick-walled to thin-walled endocarp fragments in the 9000 year archaeological sequence suggested a shift from wild to cultivated nuts (Christensen 1975:24). Donoghue (1988:94) argued that this morphological change represents not the process of domestication, but rather the position of sites in relation to forest zones and habitats of the wild species *Pandanus antaresensis*, *P. brosimos* and *P. inen*. These sites did not provide conclusive information about the significance or chronology of the rare recovered specimens of cultivated *P. julianettii*. The archaeology of the genus is further discussed below.

Marita

The red fruits of *Pandanus conoides*, oblong-cylindrical, up to one metre long, are spectacular. They consist of closely packed, small single-seeded drupes with red (or occasionally yellow) oily pericarp. The species, in section *Microstigma* of subgenus *Kurzia*, is a cultivar, propagated by cuttings. Widely cultivated in New Guinea, trees and groves that appear to be wild are more likely to have originated from older plantings. Male trees are extremely rare (one 19th century herbarium specimen of uncertain provenience). Viable seeds of *P. conoides* have not been found. Other closely related species of the sections *Microstigma* and *Kurzia*, and also of section *Maysops* in a different subgenus, are used in the same way (Table 7; Stone 1974; 1982). The botanical identification of *marita* species is quite uncertain in the ethnographic literature, and it is unclear how much variation is accounted for by multiple species rather than cultivars. It is possible that there is greater variability of *marita* in the eastern New Guinea lowlands and islands, where species of the section *Kurzia* are distributed and their cultivation and use recorded for New Ireland (Peekel (1984).

The cooked pericarp mashed with water produces an oily red sauce, sometimes strained to remove endocarp and fibre fragments, which is widely appreciated in the New Guinea region as an addition to vegetables and meat (see Table 5 for its distribution). It is nutritionally important as a source of both fat and protein. According to Odani's calculations, *marita* contributes 15% of the energy requirement, 11% of protein and 44% of fat in the diet of the Bosavi people (Odani 2002:56).

Purwanto (1997:218) cites an analysis done at Bogor of fruit composition: 36% oil made up of 80% oleic acid, 19.5% palmitic acid, 0.5% stearic acid.

The ethnographic record of *marita* in mainland New Guinea is relatively rich. It is ritually important (Barth 1975; 1987; Boissière 1999; Bonnemère 1996; Haberle 1991; Majnep and Bulmer 1977:162). Named cultivars are commonly distinguished: Sterly (1997:250) reports 26 in the Simbu area, and Yoshida and Yoshizawa (1994) 23 from Lumi District, West Sepik, three of which are said to have fertile seeds. *Marita* is sometimes described as wild or semi-cultivated, and the botanical status of *Pandanus conoides* as a sterile cultivar is seldom recognised ethnographically. Records for West Papua are rarer (Boissière 1999; Claire 1998/9; Cook 1995; Hiepko and Schiefenhövel 1987; Hiepko and Schultze-Motel 1981; Pospisil 1972; Purwanto 1997; Serpenti 1965) and give the possibly misleading impression that *marita* is less important there.

Planted groves of *marita* are widespread (Bonnemère and Lemonnier 2002; Hide 1984; Huber 1973; Juillerat 1983; 1984; Kocher Schmid 1991; Morren 1986; Powell and Harrison 1982; Stewart and Strathern 2002), associated with a wide range of other tree crops, including banana, betel palm, breadfruit, *Canarium* spp, *Ficus* spp, *Gnetum gnemon*, sago, *Pometia pinnata* and *Terminalia* spp, and sometimes established in aging gardens, as described by Clarke (1971) and Huber (1973). In the Strickland-Bosavi area, Kelly (1993:65-66) described Etoro establishment of *marita* -- breadfruit groves in sections of taro or sweet potato and banana gardens. Once the root crops and bananas were harvested, the *marita* trees were tended to prevent overshadowing and would bear for a lifetime. Men and boys made daily harvesting trips during the three month season during which *marita* was eaten daily by everyone. In the same area, Dwyer (1990:61-62) described *marita* orchards ranging from a few to hundreds of trees, and their active expansion by planting large numbers of cuttings, producing an estimated 37-46 trees per person, occupying 10 hectares. Miyanmin plantations of sago, breadfruit and *marita* were started by teenage boys (Morren 1986:72-74). *Marita* was imported by Kalam (Majnep and Bulmer 1977:197), and traded into the Wahgi from both north and south (Hughes 1977:71). Exchanges of *karuka* and *marita* were widespread in the highlands (M. Bourke pers. comm., as between Pangia and Ialibu (Stewart and Strathern 2002).

Descriptions of *marita* are rare for the islands region of Papua New Guinea. Peekel (1984) and Lepofsky (1992) discuss New Ireland and Mussau respectively, where the species include *Pandanus englerianus* and *P. cominsii*. Ambrose (pers. comm.) and Kennedy (1978) have both encountered *marita* in Manus, where it was eaten with relish, said by informants to be traditional and subject to traditional food taboos. It is not clear whether this is *P. conoides*, which Stone (1974) recorded for Manus. However Yen (1991a: 566) was told that *marita* was introduced to Manus from Goroka. McEldowney (1995:475) recorded *P. englerianus* as perhaps a recent introduction on Baluan.

In Maluku, *Pandanus conoides*, first recorded by Rumphius (Yen 1990:265), was described by Ellen for Nuaulu of south-central Seram as variously gathered, wild, planted and of minimal importance (1978:68, 73, 150). Similarly, for Alune of West Seram, Wolff and Florey (1988:311) described as wild a pandanus clearly of *marita* type.

Pandanus conoides and perhaps other similar species are excellent candidates for New Guinea domesticates. Like most of the domesticated tree crops so far identified by Yen and others, the progenitor of *Pandanus conoides* probably belongs in the lower montane rainforest (Yen 1991a). But its domestication seems to follow a different pattern from some other tree crops, such as *Canarium indicum*, *Pometia pinnata* and *Burckella obovata*, which are more strongly selected on the coasts and small islands. In *P. conoides*, as in sago, the widespread presence of clonal planting and multiple varieties that constitute the best evidence for human selection are concentrated on the New Guinea mainland. And like sago, *P. conoides* is frequently planted in groves with other tree crops. Genetic study of the *marita* complex of species would be very useful.

***Pandanus* prehistory**

The only archaeological records of *marita* are endocarp fragments of uncertain age in sites the Jimi and Yuat valleys (Gorecki 1989b:138, 170). Such residues should be readily identifiable where *marita*

has been processed or eaten in quantity. As noted above, *karuka* is also identifiable archaeologically. Its use is inferred at the Kosipe site in the Owen Stanley Range, dating to the late Pleistocene (White, Crook and Ruxton 1970). The archaeological remains listed in Tables 1-3 are unidentified to species level. Except for the New Guinea highlands specimens in Table 1 (Bulmer 1982:193), they are more likely to represent coastal species rather than either *karuka* or *marita*, and there is nothing to suggest they represent food remains. Pandanus described as edible, not otherwise identified, was preserved in late Holocene swamp deposits in the Jimi valley (Gillieson, Gorecki and Hope 1985:33). Haberle (1994:186, 188; 1995) has shown that pandanus pollen may be identifiable to section level, and sometimes to species. This suggests that a combination of palynological and archaeobotanical analysis will be valuable in elucidating the prehistories of all three types of edible pandanus.

***Musa* L. (Musaceae): bananas (and plantains)**

Bananas do not grow on trees, and the plants do not have a productive life as long as those of the tree crops so far discussed. Their cultivation in the New Guinea region ranges from intensive garden plantings to more dispersed planting, for example on the fringes of root crop gardens, extending the garden's productive life. They may also be planted in mixed orchards and near houses. We include them because they are an extremely important perennial staple crop with arboricultural significance, and because of their importance in New Guinea prehistory, recently confirmed by genetic studies (Table 5; Denham *et al.* 2003; Yen 1982:285; 1993a: 4; 1995:837-838; Carreel *et al.* 2003).

If the genera outlined above are taxonomically somewhat complex, *Musa* is a nightmare. Some recognition of this, and the familiarity of the fruit perhaps combine to explain why ethnobotanical descriptions of bananas and their cultivation are relatively rare in the literature on the New Guinea region. The genus *Musa* comprises about 40 species of large perennial tropical herbs of Southeast Asia and the Pacific, mainly of lowland areas of high temperature and humidity. (The related genus *Ensete* comprises six or seven species in Africa and Asia, one of which is found in India, the Philippines and New Guinea, none of them producing edible fruit.) Most *Musa* species are intolerant of low light intensity and root competition, especially from grasses, and of poor drainage and drought. Wild bananas are “‘jungle weeds’ that spring up in transient, often man-made, habitats; without human disturbance they would be rare plants confined to talus slopes, unstable hillsides liable to landslip or to forested areas devastated by periodical storms” (Simmonds 1962:34). The wild species are divided among four sections, with a few species of uncertain affiliation. Edible bananas belong to two of these sections, Australimusa and Eumusa, the former of note only in the Pacific and the latter containing all the bananas that are staples of tropical subsistence and of commercial fruit production. Both sections also include wild species.

The fruit of wild bananas are berries full of hard seeds, with almost no pulp. They propagate by seed, probably spread by bats. Edibility developed independently in both Eumusa and Australimusa sections, by complex mechanisms that first enabled fruit to develop pulp without pollination (parthenocarpy) and then suppressed seed development (eventually leading to both female and male sterility). These mechanisms, which seem to be largely independent of each other, together produce fruit highly attractive to humans, with lethal consequences for the unmanaged plant. Human selective pressure on both sets of mechanisms has therefore included the vegetative propagation of plants. Parthenocarpic fruit that develop a few seeds on pollination have produced crosses that include diploid, triploid and tetraploid interspecific hybrids, increasing variability and productivity while further suppressing fertility (Purseglove 1975; Simmonds 1962; 1966).

The parentage of edible bananas involves at least three species of the section Eumusa, and an unknown number of the section Australimusa. All these wild species are present in the New Guinea region. They are listed by section in Table 8, which shows their distributions and conventional genome label, after the system of nomenclature introduced by Simmonds and Shepherd (1955), which distinguished clones according to morphological characters and chromosome counts. This system provides a way of naming banana clones according to their constituent genotypes, useful because it can accommodate the rapid revisions of banana phylogeny being brought about by

analyses of DNA, and necessary because of “the almost hypnotic effect exercised by the Linnaean names, *Musa sapientum* and *M. paradisiaca*; [which] by singular mischance both refer to closely allied (but superficially different) triploid interspecific hybrids—they are not ‘species’ in any biologically reasonable meaning of the word.” (Simmonds 1962:101).

Wild and cultivated banana plants are widely used for products other than fruit: leaves and bracts for wrapping, petioles for fibre, flowers and stem as food, seeds as ornaments and sap for dye.

Table 8: Taxonomy of wild *Musa* species contributing genomes to edible bananas (and plantains), dominant species bold (Argent 1976; Sharrock 2001; Simmonds 1962).

genus	section	species	genome	distribution
<i>Musa</i>	Australimusa ¹	<i>M. angustigemma</i>	T	New Ireland
		<i>M. boman</i>	T	N New Guinea
		<i>M. lolodensis</i>	T	N New Guinea, Halmahera
		<i>M. maclayi</i> ²	T	N New Guinea, New Ireland, Solomons
		<i>M. peekelii</i>	T	N New Guinea, New Ireland
	Eumusa	<i>M. acuminata</i> ²	A	mainland and island SE Asia, W Pacific ³
		<i>M. balbisiana</i>	B	Sri Lanka, India, Sikkim, N Burma, S China, Philippines, E New Guinea, New Britain
		<i>M. schizocarpa</i>	S	N and E New Guinea

Notes:

1. species affiliations of edible clones uncertain; *M. maclayi* likely (but not necessarily sole) parent of Fe'i bananas
2. multiple subspecies
3. 3 outliers in Polynesia and Pemba are probably human introductions

Eumusa bananas

Within the more important section Eumusa, parthenocarpy and seed suppression developed in one or more subspecies of *Musa acuminata*, producing diploid (AA) fruit with edible pulp without the stimulus of pollination, which have relatively few seeds even when pollinated. Cross-pollination then produced triploid AAA fruit, the genotype shared by the dessert bananas of international commerce. Cross-pollination also occurred between *M. acuminata* diploids and *Musa balbisiana*, producing the hybrid diploid and triploid genomes AB, AAB (to which both the Linnaean binomials refer) and ABB. *Musa acuminata* is a genetically diverse species with a number of geographically distinct subspecies. Its centre of diversity in the Malayan area has been interpreted as the primary centre of origin of the cultivated bananas with the A genome, the subspecies *M. acuminata* ssp. *malaccensis* the primary though probably not the only candidate (Simmonds 1962:30, 134, 140). Since the distribution of *M. balbisiana* does not overlap this centre, human expansion of the range of the initial AA diploids has been assumed to have preceded the development of A x B hybrids.

M. balbisiana seems to be much less diverse across its wide range. It is at home in monsoonal climates and is more drought tolerant than *M. acuminata* (Simmonds 1962:47, 134-143). Whether *M. balbisiana* followed a parallel course towards edible diploids and triploids (parthenocarpy, seed suppression and cultivated-wild crosses) has been disputed (Espino *et al.* 1991; Simmonds 1966). This question, and the diversity of the species are the subject of current research (PROMUSA 2002; Ude *et al.* 2002a).

In New Guinea, the *Eumusa* section is represented by three wild species (Table 8), perhaps four if the subspecies *Musa acuminata* ssp. *banksii* is raised to species rank as suggested by Argent (1976). *M. balbisiana* is possibly a human introduction to New Guinea (Argent 1976:86). *M. schizocarpa* x *M. acuminata* ssp. *banksii* hybrids include both wild and edible types. New Guinea has long been of interest to banana specialists because it retains much the greatest diversity of edible diploid *M. acuminata* cultivars (AA). The standard explanation of this is hypothesised isolation of the area from developments taking place to the north and west until quite recently, and current replacement of the diploids by more productive triploids (Simmonds 1962:142; 1966). A number of problems with this view will be discussed below.

Australimusa bananas

The five species found in the New Guinea region are listed in Table 8. The remaining two *Australimusa* species are *M. jackeyi* (Australia) and *M. textilis* (Philippines). The latter yields the commercial fibre *abacá*, and is perhaps a complex of cultivars rather than a natural species (Purseglove 1975:378). Genetic studies suggest that the section *Australimusa* is not highly diverse (Sharrock 2001; Ude *et al.* 2002b). Parthenocarpic, sterile cultivars developed by processes paralleling those of the *M. acuminata* series, but quite independently. These cultivars, known as the fe'i bananas, are distinguished by the coppery-orange skin colour of ripe fruit, pink to violet sap and sometimes erect bunches. They are, or were, important in Polynesia, and are widespread but never abundant in the New Guinea region. Several characters, including extreme parthenocarpy, decreased fruit number and increased fruit size, malformed flowers and loss of male bud suggest that human selection has been intense (Simmonds 1962:159-151). Their ancestry is unclear, but almost certainly lies in the New Guinea region. The considerable genetic diversity of cultivars suggests interspecific hybrid origin, involving at least *Musa lolodensis*, *M. maclayi* and *M. peekelii* (Sharrock 2001). Cultivars that are hybrids between *Australimusa* and *Musa acuminata* are also known in New Guinea.

The *Australimusa* bananas have interested New Guinea prehistorians because of the possibility that they were an early indigenous staple crop (Golson 1977; Yen 1985; 1990; 1993b; 1995). Their prehistory is further discussed below.

Bananas of the New Guinea region

Edible bananas in New Guinea are far more diverse genetically than anywhere else. This is often overlooked because most of the cultivars are of no commercial interest. As shown in Table 5, bananas eaten as a cooked staple are important in every province of Papua New Guinea. Despite this, they are neglected in the ethnographic literature, where passing reference to their presence is far more common than discussions of production (reviewed by Dwyer and Minnegal [1993]; Malinowski 1935 Vol.1:312-315) or description of planting and cultivars (but see Amano *et al.* 1994; Clarke 1971 Appendix C; Juillerat 1984; King *et al.* 1989; Kocher Schmid 1991:83-91; Lepofsky 1992; Malinowski 1935 Vol.II:114; Mogina 2002:143-144, 162; Pospisil 1972:127; Purwanto 1997:404-407; Sillitoe 1983:116-120; Waddell 1972:54, 132; Yen 1974). Unfortunately most of this literature ignores the work of Simmonds and others on cultivated bananas.

Recently renewed interest in the characterisation and conservation of *Musa* germplasm resulted in new collections being made in Papua New Guinea (Sharrock 1995), and the publication of an extensive descriptive catalogue of 242 wild and cultivated banana accessions (Arnaud and Horry 1997). This remarkably useful database makes it possible to outline the genetic constitution of banana cultivars in Papua New Guinea. It is often assumed that bananas eaten cooked constitute a single species, often labelled "plantain" or *Musa paradisiaca*. Table 9 shows that there is no simple relationship. Although bananas used cooked are far more common than those eaten raw, every genotype is represented, and only two genotypes are not represented in the cultivars eaten raw. Table 10 shows that genotypes are well distributed by province. It is very striking that the AA diploids which Simmonds (1962; 1966) thought in the 1950s were rapidly being replaced by more vigorous triploids are still widespread and numerically dominant in the late 1980s. These cultivars are not only less productive but may also be more labour intensive, because suckers need to be

transplanted rather than left to regrow on the same site, as triploids are (French 1986:25; Mogina 2002:162). This suggests that the diploids are being actively conserved, despite the availability and use of more productive varieties. Such retention of multiple forms is characteristic of New Guinea tree crops, as well as root crops (Yen 1993b).

Table 9: Culinary use of Papua New Guinea bananas by section and genotype, based on *Musalogue 1* accessions (Arnaud and Horry 1997).

section	genotype	use				total
		cooked	raw	both	?	
Eumusa	AA	92	16	12	3	123
	AAA	8	1	3		12
	AAB	24	7	4		35
	AB	1	2			3
	ABB	9	1	1		11
	AS ¹	2	2	1	1	6
Australimusa	Fe'i	3	3	1		7
Australimusa x Eumusa	AAT	5				5
	ABBT	1				1
	total	145	32	22	4	203

Note:

1. *Musa acuminata* x *M. schizocarpa*

Table 10: Distribution of cultivated bananas¹ by genotype and province, based on *Musalogue 1* accessions (Arnaud and Horry 1997).

Province ²	genotype										total
	AA	AAA	AAB	AB	ABB	AS	Fe'i	AAT	ABBT		
Western	6		2				1				9
Gulf	6										6
Central					2						2
Milne Bay	8		4		1			2			15
Oro	13				1			2			16
S Highlands	4		7			1					12
W Highlands	8	3	5								16
E Highlands	2	1	7				1				11
Morobe	5										5
Madang	19		1		3	2	1	1	1		28
E Sepik	8	1	3			1	1				14
Sandaun	4		2								6
Manus	1						2				3
New Ireland	8	1	3				1				13
E New Britain	31	6	1	3	4	2					47
total	123	12	35	3	11	6	7	5	1		203

Notes:

1. most of these are distinct cultivars: *Musalogue* includes only 34 duplicates in 242 accessions.
2. collections were not made in Enga, Simbu, West New Britain and Bougainville.

Banana genetics and New Guinea prehistory

Since the Eumusa diploid cultivars of *Musa acuminata* were assumed to originate in the region of the Malay Peninsula and must therefore have been introduced into New Guinea, the attention of New Guinea prehistorians has been drawn to the possibility that the indigenous Australimusa section might have provided an early indigenous staple crop (Golson 1977:614; Yen 1985:317; 1990:262; 1993a: 4). This was investigated by Wilson (1985), in an early analysis of phytoliths at the Kuk site. He argued that phytoliths of Australimusa bananas were distinctive and very rare, while the phytoliths of Eumusa and the wild indigenous species *Musa ingens*, which Argent (1976) placed in a separate section, were more common but indistinguishable. In designating the section Eumusa as introduced, he overlooked the three wild indigenous Eumusa species.

Subsequent research on Eumusa phytoliths in the Kuk site by Bowdery (1999) and Lentfer (Denham *et al.* 2003) has shown that they are distinguishable from phytoliths of Australimusa, *Ensete*, and *Musa ingens*, and are present throughout the Holocene sequence. Because bananas, unlike grasses, do not produce abundant phytoliths, the phytolith frequencies in the Kuk sediments are highly suggestive of human interference from about 10,000 BP and of deliberate planting within grassland by 6950 BP. Denham *et al.* (2003:192) identify phytolith morphotypes from the early Holocene with *M. acuminata* ssp. *banksii*, corroborating recent research on banana genetics, further discussed below.

The introduction of cultivated Eumusa bananas to the New Guinea area by Austronesian colonists has been inferred from linguistic data (Table 3; Spriggs 1996b). But given the complexities of cultivars as well as wild types, an enormous amount of expert ethnobotanical work would need to be done before banana terminologies could provide a trustworthy source of evidence. De Langhe and de Maret (1999; Vrydaghs and De Langhe 2002; Vrydaghs *et al.* 2003) have hypothesised the spread of edible diploid *M. balbisiana* (BB) from mainland Southeast Asia by speakers of Austronesian languages, and hybridisation with edible diploids of *M. acuminata* ssp. *banksii* in the region of the southern Philippines and Maluku to produce the Pacific plantains. This is problematic, for as noted above, both the existence of edible BB types and the imputed restricted genetic diversity of *M. balbisiana* remain to be demonstrated. The distribution of *M. balbisiana* in the New Guinea region does not support this either, for it is recorded in East New Britain, Madang, Morobe and Northern Provinces but not in Manus Province, West New Britain, Mussau, New Ireland, or Solomon Islands (Argent 1976; Sharrock 1995). Also, the proposed isolation of Austronesian-speaking colonists of the Bismarck Archipelago (carrying AAB cultivars) from mainland New Guinea populations with AA diploids is not evident in the Musalogue accessions (Table 10). While later diffusion might be argued for AAB and ABB cultivars in New Guinea, the presence of AA diploids in the Bismarck islands is not explained. De Langhe and de Maret's hypothesis also seems to imply that the same Austronesian-speaking colonists spread Australimusa cultivars from the Solomons into Polynesia. The Musalogue data suggest rather that Australimusa cultivars, though not abundant, are in fact quite widespread in mainland New Guinea; there are also hybrids with both AAT and ABBT genotypes.

While the New Guinea AA diploids have conventionally been explained as an early introduction from the Malayan centre, the probability that they are indigenous cultivars of the New Guinea subspecies has been raised by several recent studies of genetic relationships. The discovery that the enzyme variations of triploid AAB "Pacific plantains" matched those of *M. acuminata* ssp. *banksii* more closely than the Malayan subspecies implied derivation of the triploids from New Guinea edible diploids. The same study matched enzyme types of AAA triploids from New Guinea with local diploids, contradicting the view that all the New Guinea triploids are introductions (Lebot *et al.* 1993; Lebot 1999; 2002).

In a study of 71 wild, 131 edible diploid and 103 triploid clones, Carreel *et al.* (2002) used restriction fragment length polymorphisms (RFLP) to characterise both maternally inherited chloroplast and paternally inherited mitochondrial DNA. This enables the lineages of individual clones to be assessed, and showed differentiation within the AA diploids and within hybrid groups such as the Pacific plantains, some of which are related to the African plantain group. Edible clones resulting

from crosses of *Musa acuminata* ssp. *banksii* with both *M. schizocarpa* and *Australimusa* are confirmed. The major conclusion is that most banana cultivars are related maternally or paternally to New Guinea accessions of *M. acuminata* ssp. *banksii* or to *M. acuminata* ssp. *errans*, a single specimen collected from the Philippines, thus linking parthenocarpy with these eastern subspecies rather than with the Malayan centre.

The proposition that the New Guinea edible diploid AA bananas are a geographically isolated genetic outlier is not supported by these studies. Early spread of parthenocarpic, partially fertile AA diploids west from the New Guinea-Maluku-southern Philippines region was probably the first stage of banana domestication (F. Carreel pers. comm.). This accords with archaeological evidence of movement of plant, animal and mineral resources between the New Guinea mainland and islands in the late Pleistocene, and there is good reason to suppose that these movements included islands to the west (Bellwood *et al.* 1998; Gosden 1992; 1995; Kennedy 2002). The evidence from Kuk dates human interference with bananas back to the beginning of the Holocene in the highlands. There is as yet no archaeological evidence of bananas in the lowlands, but it is highly likely that they interested people there at least as early as in the highland valleys.

The continuing presence of AA diploid cultivars (and the AS and AAT hybrids) in Papua New Guinea suggests not only that these are actively conserved, but also that new clones may become established. Mogina (2002:158) records the clearance of wild plants to suppress the seediness of a favourite Milne Bay cultivar. This sort of association between wild and cultivated populations suggests not primitive stasis but active regeneration of the genetic diversity of the cultivated stock.

All these complexities suggest that the prehistory of bananas in New Guinea will not be reducible to simple scenarios, and that there are abundant opportunities for future research, ethnobotanical and genetic as well as archaeological.

***Artocarpus* Forst. (Moraceae): breadfruit**

Breadfruit (*Artocarpus altilis*) and coconut are the classic tree crops of the South Pacific. Bligh's transport of breadfruit to the West Indies in 1792 was among the earliest economic development projects in the Pacific. This was not a great success, perhaps because Polynesian breadfruit is a highly selected parthenocarpic domesticate with a narrow genetic base. Despite early and continuing interest in the crop, the genetic diversity of breadfruit in the western Pacific, especially New Guinea, remains largely untapped (Yen 1996). Whereas Polynesian breadfruit is virtually seedless, breadfruit of the New Guinea region is valued primarily for its seeds, which are very widely eaten in Papua New Guinea, Solomon Islands and Vanuatu, and provide a seasonally significant storable food. Though often described as wild in New Guinea, cultivated breadfruit is very widespread (Table 5; Lebot 1999; 2002; Ragone 1997; Walter and Sam 2002; Yen 1974; 1991a). It is archaeologically almost invisible in the New Guinea region, its probable centre of origin (Barrau 1976; Yen 1995).

The genus *Artocarpus* comprises about 50 species of the lowland tropics of India, Southeast Asia and the Pacific. They are mostly monoecious trees with compound fruit formed from the female inflorescence, often with edible flesh and/or seeds. As well as breadfruit, jackfruit (*Artocarpus heterophyllus*) and chempedak (*A. integer*) are widely cultivated as commercial fruit, both of them generally grown from seed (Jansen 1991; Soepadmo 1991). Other minor species are locally cultivated for fruit and seeds throughout Southeast Asia (Seibert and Jansen 1991).

Although the familiar seedless breadfruit of Polynesia is now widespread, there is considerable morphological variation throughout the Pacific "ranging from true seedless fruits to fruits with numerous, minute, aborted seeds, to fruits with one to few viable seeds, to fruits with numerous seeds. Many authors take the broad view and encompass all of this variability within one species." (Ragone 1997:8). This was the view taken in Jarret's (1959) revision of the genus. However there are problems with this simplifying approach. A second Pacific species with seeded fruit, *Artocarpus mariannensis*, is a wild endemic in the high islands of the western Micronesia. This species, morphologically different from *A. altilis*, hybridises with it, producing numerous Micronesian

cultivars. A third type, with many-seeded fruits and more or less spiny skin, has been distinguished by some, especially in the Philippines, as a separate species, *A. camansi*. This type is both wild and cultivated in New Guinea and perhaps Maluku. There is no definite evidence of its wild presence in the Philippines. Sometimes known as breadnut, it was first described from Philippine specimens and is now also cultivated widely in the tropics, especially in the Caribbean and Central and South America, but only rarely in Polynesia and Micronesia (Ragone 1997; Rajendran 1991; Zerega 2003).

The genetic relationships among these three types have recently been resolved by analysis of amplified fragment length polymorphisms (AFLP), suggesting that *Artocarpus camansi* (collected from Papua New Guinea) and *A. mariannensis* are distinct species, both of which have contributed to *A. altilis* (Zerega 2003). Thus, the variability and human dispersal of all three species needs to be examined, along with the selective pressures that accompanied dispersal. An earlier genetic study had linked *A. altilis* with *A. elasticus*, a species of western Indonesia and the Malay Peninsula. This was based upon specimens collected within Thailand, not including either *A. mariannensis* or *A. camansi* (Kanzaki *et al.* 1997).

Yen (1991a; 1995) has suggested that breadfruit originated from the same lower montane rainforest zone of the northern slopes of New Guinea as *Canarium*, *Pometia* and *Burckella*, and like them was progressively adapted by human intervention to tolerate coastal and island conditions on sandy and limestone soils. Breadfruit was then increasingly selected for flesh rather than seeds along a west to east gradient from New Guinea to the eastern Solomons and eventually Polynesia. The implication is that this trend preceded hybridisation with *Artocarpus mariannensis*, but when and where this might have occurred is unknown. Given the genetic complexities and the absence of comprehensive knowledge of the variation in New Guinea cultivars (there is no collection of breadfruit varieties from New Guinea), it would be quite unwise to assume that the only significant trend is progressive extension eastwards (Yen 1991b). One archaeological record of nut fragments in a Yuat Gorge rockshelter is from a probably recent mortuary context (Gorecki 1989b: 170). One claim to identify *Artocarpus* pollen in the Philippines is disputed (Maloney 1994:145). In its putative area of origin, then, breadfruit is yet to register in the prehistoric record. In the wider Pacific region, there is an archaeological record of breadfruit charcoal and pollen from Kosrae, interpreted as the introduction of a set of food plants with a strong arboricultural component at first settlement, about 2000 years ago (Athens *et al.* 1996). This conclusion implies the existence by this date of breadfruit of Polynesian type, seedless and propagated by suckers like that of Kosrae today, but there is no direct evidence of this.

The ethnographic and ethnobotanical literature on breadfruit in the Pacific is richer for Polynesia and Micronesia (Ragone 1991; 1997; 2002) than for the New Guinea region, where breadfruit is often mentioned in passing but seldom described. Throughout Papua New Guinea and most of Solomon Islands, breadfruit seeds are far more important than the flesh, though both are eaten (Barrau 1958; Blackwood 1935; Bonnemère and Lemonnier 2002; Clarke 1971; French 1986; Haley 2001; Hyndman 1982; Kelly 1993; Lepofsky 1992; Malinowski 1935:314; McEldowney 1995: 136; Morren 1977; Peekel 1984; Townsend 1969:56; 1974; Wiessner and Tumu 1998). Seeds may be stored by smoking. Storage by drying of baked or boiled flesh is recorded for Bipi Island in Manus Province (McEldowney 1995:136), Misima in Milne Bay (Whiting 1975:11) and in the eastern Solomons (Yen 1974). In Vanuatu, breadfruit is cultivated for its flesh though almost all fruits are seeded. Preservation by fermentation, as in Micronesia and Polynesia, was widespread but the many techniques are now being forgotten (Walter and Sam 2002:109).

Records are rare for West Papua and Maluku. Eyde (1967:65) recorded that Asmat eat the seeds from planted trees, Wolff and Florey (1998:302, 308) that seeds are eaten as a snack in West Seram. The trees are described as noncultivated, and the mature fruit inedible. It is possibly a different species of *Artocarpus*.

Breadfruit is a minor component of the *marita*-*Gnetum* orchards of the Bomagai Angoiang (Clarke 1971:80). It is widely associated with sago and *marita*: planted in groves with them in the Mountain Ok area (Barth 1975; Hyndman 1982; Morren 1977; 1986), and with sago, *marita* and *Pangium edule*

by Hewa people (Haley 2001). In the Strickland-Bosavi, area, Minnegal (1994:93) noted its scattered occurrence, mostly planted, with *marita*, *galip* (*Canarium* spp) and *okari* (*Terminalia* sp). Breadfruit, *Canarium* and *marita* were also transplanted into sections of root crop/banana gardens (Kelly 1993:65-66; Shaw 1990:43), and protected when gardens were cleared (van Beek 1987: 23). Rhoads (1982) recorded the association of breadfruit with a wide range of useful trees including sago (discussed above).

Yen (1991a: 565; 1991b) drew attention to the planting of breadfruit by seed throughout New Guinea, in contrast to the transplanting of suckers in Polynesia. Planting by both seed and suckers is reported in Mussau (Lepofsky 1992:198) and in Vanuatu (Walter and Sam 2002:108). In West Sepik, Juillerat (1983:24-25; 1984:8-9) described breadfruit seeds planted in a seed bed, then transplanted into orchards with *Gnetum gnemon*, *marita*, the shrub *Hibiscus manihot* and sago. Different varieties were recognised, and in-marrying women brought seeds from their home groups (Juillerat 1996:151).

Yen's (1991a; 1995) hypothesis that breadfruit originates from the rain forests of the northern New Guinea foothills suggests that, in common with the other tree crops with which it is so often associated in New Guinea, breadfruit probably has a complex history within the New Guinea region as well as beyond it. Ohtsuka (1983:100) and Williams (1936, cited by Yen 1995:837) both suggest that breadfruit is a relatively recent introduction in southern New Guinea. Its importance there is of course no guarantee of antiquity. This may serve as a general caution: it is important to confirm by direct evidence the localised presence of tree crops, as well as the trends of their domestication and spread. The seeded breadfruit of New Guinea poses a challenge unlikely to be met without intensive interdisciplinary research. Its transition from wild rainforest tree to Polynesian cultivar encompasses a prehistory more complex than the culturally mediated processes of domestication that produced those cultivars.

Conclusion

The five taxa of trees or tree-like plants described above begin to reveal how complex have been the long-term interactions of humans with vegetation outside the garden fence (and often inside it as well). The five taxa are geographically widespread and extend altitudinally from the coast and small islands to the highest areas of settlement in mainland New Guinea. The taxa range from sago, in the common understanding a wild or natural plant belonging to a gathering economy rather than to a food-production system, to breadfruit, one of the archetypical domesticated trees of Oceanic settlement. As well as the five taxa described, there are many other trees with similarly intricate and long-term relationships with people, for example *Gnetum gnemon*, *Pangium edule*, *Pometia pinnata*, and *Inocarpus fagifer*. A notable characteristic of the arboriculture of both mainland New Guinea and the smaller Melanesian Oceanic islands is that similar assemblages have a very widespread occurrence, with, for instance, breadfruit, *Canarium*, and *Pometia* widely associated in the islands and also in the Torricelli Mountains on the mainland. Similarly, sago, breadfruit and *Gnetum* occur together in many places. But the assemblages also vary, with *Gnetum* strongly associated with *Pandanus conoideus* in the Simbai Valley, where there is no sago. The widespread occurrence of these similar assemblages of trees, some of them appearing in Pleistocene contexts and many of them of probable New Guinean origin, together with the variety of the patterns, point to the time depth of arboriculture and to its indigenous origin in the Melanesian region, rather than translocation from farther west.

Our understanding of the tree assemblages within Melanesian landscapes leads us to agree with Hviding and Bayliss-Smith that none of the English words used to describe Melanesian cultivation practices are wholly satisfactory. For lack of a better word, Hviding and Bayliss-Smith (2000:17) settle on "agroforestry" in connection with the use and management of trees, but restrict the term to its indigenous referents rather than to the modern institutional meaning. They favour "agroforestry" because the term

. . . suggests a functional integration between cultivation practices (including the cultivation of tree crops) and the management of the forest itself. This integration not only matches the practice of food production from the land in Marovo and how it is conceptualised

locally; it also conforms to current scientific understanding of how these systems of production are maintained.

Hviding and Bayliss-Smith add that although the agricultural activities of the Marovo people may, at first glance, appear to be dominated by garden crops grown after a tree fallow, the secondary growth of old and recent fallow forms part of the continuous crops harvested. Given the wide distribution as well as the time depth of these sorts of practices, a new taxonomy of productive practices seems called for. Several conceptual obstacles need to be cleared away before such a taxonomy can be achieved. Until then there will remain a widespread lack of appreciation for the productive capacity of the intricate associations of plants to be found in Melanesian landscapes.

One conspicuous obstacle is the prevalence in modern management systems of the segregation of trees and short-term crops — one to the domain of forestry, the other to the domain of agronomy. Consequently, it is difficult for managerial practitioners in either field to conceive how both activities can be part of a single integrated system of production. Beyond that, gardens are often considered to be human artifacts (part of culture) that are embedded in forest (part of nature). It then follows that culture and nature are incompatible whereas in truth human thought and manipulation over generations have woven forest and garden into a single fruitful fabric. More broadly, as Yen (1989) put it, the present landscapes are the result of a long-term “domestication of the environment” begun by the first occupants, whether these were cultivators or hunters and gatherers.

Related to the bureaucratic segregation of annual crops and trees is the inability of modernist managers and developers to go beyond simple categories that are too coarse to do justice to the actual complexity of natural and social processes. James Scott, writing about why large, state-sponsored development schemes so often fail, comments with regard to agriculture (1998:262):

The simple “production and profit” model of agricultural extension and agricultural research has failed in important ways to represent the complex, supple, negotiated objectives of real farmers and their communities. That model has also failed to represent the space in which farmers plant crops — its microclimates, its moisture and water movement, its microrelief, and its local biotic history. Unable to effectively represent the profusion and complexity of real farms and real fields, high-modernist agriculture has often succeeded in radically simplifying those farms and fields so they can be more directly apprehended, controlled, and managed.

It is also difficult for managers who hold such views to accept that ecosystems are contingent and dynamic (Scoones 1999). Economic management as well as management for “sustainable development” focus on stability, whether for maximum production or for steady production over a long term. In contrast, local people in the landscapes where they live see the fluidity of the many ever-shifting parts. They also recognise its “altogetherness” as they work and walk in it, fine-tuning its bits and pieces. They “feel the pulse” of their land. Their concern is less with maximum production than it is with keeping the productive system turning over. They can allow for fluctuation of production because they have such a variety of resources and fallback capabilities. This variety and the people’s knowledge of it gives the system resilience, which many now consider a more significant — or meaningful — concept than sustainability.

An irony in the current debate about “biodiversity” is that vast sums are spent on projects to protect and preserve biodiverse regions by limiting or eliminating human activities. Less attention, or no attention, is paid to how biodiversity has been increased by human action. Such creation of biodiversity occurs at four levels in Melanesian landscapes:

In whole landscapes. Because these are made patchy by the complex shifting of gardens, orchards, and managed fallow, landscapes have an overall structural complexity that offers a variety of habitats. Fox *et al.* (2000) use an example from Vietnam to explore the effects on biodiversity and other ecological characteristics of the change from what may have been a fairly homogeneous forest to a more heterogeneous and fragmented cover of secondary vegetation.

Locally. Biodiversity is encouraged by the variety of niches in the transition zones between types of vegetation.

In crop assemblages, including trees. New associations among plant species are created by interplanting of different crops, by management of successions from garden to fallow or orchard and by the alteration of forest composition by interventions such as selective weeding.

In the genetic diversity of individual crops, including trees. Because of constant selection and distribution by past generations of tropical cultivators, a wide diversity of cultivars or varieties has been created, as is demonstrated in the discussion above and by many ethnographic sources (e.g., Kocher Schmid 1991, 1998). The potential genetic diversity of some cultivars is further enhanced because their wild counterparts are also conserved.

Perhaps it is the case that the cultivated Melanesian landscapes we are concerned with are an anachronism in today's world. Perhaps they cannot be appreciated because it takes too long for outsiders to come to recognise the subtle character of their productive worth. And there are too few detailed studies of what might be called landscape ecology. There are considerable conceptual difficulties in developing models to encompass the very different scales and criteria of definition by which landscapes and various component systems of land use may be described.

It can of course be argued that Melanesian cultivated landscapes, which have no legally delineated individual rights of ownership, which feature such a fine-grained structure of diverse plants and fecundity both temporally and spatially, and which are not designed for monocultural maximisation, do indeed have no place in the world today. To modern eyes there may seem to be no way to exploit cultivated landscapes except through their transformation to other forms of production that better fit the contemporary scheme of things. Nonetheless, to lose landscapes that have for so long embodied so much human thought, that are so strategically managed, and that have provided a heterogeneous sustenance for generations of people would be a tragedy.

While not always being aware of what may be lost, development enthusiasts in rural areas often face a long-existing puzzle in that when local people are offered a project based on the commercial production of a crop that will increase income locally while also acting to boost national development, they may not seem eager to take up the work required or will take it up only at the low level necessary to bring in enough cash to meet a few vital needs. A long-standing explanation for this situation in Melanesia is that people living in resources-rich landscapes such as we have described are in a state approaching "subsistence affluence". Their economy is not limited by resource shortages; in fact, it could be argued that they under-use their resources. As Huber (1977:4) wrote, the general problem of rural development in Papua New Guinea is one of finding ways to increase the use of local resources by increasing the application of labour in such a way that (a) any surplus production that results can be channelled into the national economy and (b) any changes that this brings about will not undermine the self-reliance of the local communities.

As Huber (1977:10) further notes, however, what may look like "laziness" is not an attempt by people to maximise leisure at the expense of productivity. Rather, the rural Papua New Guineans he wrote about are as eager to convert free time into cash as most rural people throughout the tropics. The problem is, as suggested above, that the labour input necessary to manage cultivated landscapes may appear to outsiders to be casual and sporadic, not real work. But it is this pattern of modest activity carried out by people circulating through the landscape that keeps the productive processes working and that, as Huber describes, is also an integral thread in the fabric of social life. Just as the dichotomy of garden/forest is not applicable, neither is work something separate from social life and sense of community.

Without intending to romanticise villages and small communities (we all know the schisms that exist therein), they have been recognised to possess desirable qualities often lacking in our contemporary world, where some people are burdened by poverty and unemployment while others are exhausted or deprived of leisure and social life by excessive hours of work. Some thinkers (e.g. Hamilton 2003; Gorz 1994) now urge us to moderate the worst effects of consumer capitalism and

to recover the integration of pre-modern societies, societies in which life and work are unified, in which the economy has a moral basis, in which maximum production and consumption are not the highest goals, and in which the inhabitants of a landscape have knowledge of its workings and are concerned to manage it as a whole.

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